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# Proceedings

Mitropoulos Ioannis (Ed)

# OR in public and private services

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# Digital Transformation and User Acceptance of Information Technology in the Banking Industry

Ioannis Giatsidis

*School of Information Sciences, Department of Applied Informatics, University of Macedonia 156 Egnatias st, 54636 Thessaloniki, Greece*

Fotis Kitsios

*School of Information Sciences, Department of Applied Informatics, University of Macedonia 156 Egnatias st, 54636 Thessaloniki, Greece*

Maria Kamariotou

*School of Information Sciences, Department of Applied Informatics, University of Macedonia 156 Egnatias st, 54636 Thessaloniki, Greece*

**Abstract**

During the last decades information and communication technologies (ICTs) in the banking sector have been increased. The banking industry has spent a lot of money in order to use new technologies for the improvement of financial services. Traditional business model of banks in the financial service industry have changed by the increasing digitization. New players, either financial or non-financial companies have already entered into incumbent's markets in order offer more effective services with increased quality. Furthermore, customer relationships with banks and employees workload have changed with the use of digital technology and impact on customer service performance. Despite the fact that this field has attracted the interest of several scholars and practitioners, and the money that have been spent to improve the quality of services in the banking sector through the use of ICTs are increased, the studies that examine the digitalization of financial services are limited. Thus, the purpose of this paper is to synthesize and analyze the findings of the existing literature review in order to answer the following question; how do digital technologies shape the landscape of the financial service industry?. A conceptual framework is developed in order to present the diverse aspects of IT enabled transformation in the financial service industry as well as their relationships.

## 1. INTRODUCTION

A contemporary phenomenon for the banking industry is the necessity to improve its infrastructure and to be more digital. During the recession of 2008 and above, the banking industry make huge loss in earnings. Despite the different views for the correlation of IT with profitability (Shu & Strassmann, 2005), the majority of the researchers support that there is a positive correlation. Banking profitability is negative due to the explosion of Non Performing Exposures. The solution to the problem for the industry was to be digitally transformed (Worthington & Welch, 2011). Moreover, through digital technologies is much more effective for banking industry to approach new clients (Cziesla, 2014).

In the existing literature there are a lot of reviews that they are trying to define digital transformation (Vial, 2019). Digital transformation is "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies" (Vial, 2019). It includes a wide range of tasks, as digitalization of papers, e-signature, e-learning, tele-conference, e-trading, e-statements, m-payments (Yip & Bocken, 2017).

 Professionals in the banking industry make investments three-times more than any other industry in IT (Gartner, 2012). The majority of the researchers have studied the acceptance of the digital transformation with the customer view (Mishra & Singh, 2014). The main findings of these studies are that user acceptance is the key issue for the acceptance of the new technology. The most common findings in these studies are that perceived manageability, perceived usefulness, subjective norms, trustiness, attitudinal intentions affect customer acceptance (Alsajjan & Dennis, 2010).

In contrast, there is not sufficient research from the view point of employees of the financial organizations. According to the Hellenic Banking Association, during the last decade (2008-2018), 20.000 employees get retired or lose their jobs, and a number of 50.000 are still working at the Greek banking industry. Thus, the purpose of this paper is to synthesize and analyze the findings of the existing literature review in order to answer the following question; how do digital technologies shape the landscape of the financial service industry?. A conceptual framework is developed in order to present the diverse aspects of IT enabled transformation in the financial service industry as well as their relationships.

The paper is structured as follows. The next session describes the literature review methodology, and presents the research framework session. The last session contains the conclusion and the final suggestions for future research.

## 2. LITERATURE REVIEW METHODOLOGY

The literature review methodology was adopted by Webster and Watson (2002). In the first step of the methodology a research of previous literature review studies was done. According to the subject of digital transformation and the

employee acceptance of information technology, nine literature reviews were used, which describe the keywords that were used in searching articles as well as databases they searched into.

Scopus and Web of Science were the databases for the research. The keywords were the following: "bank* or financ* and digital* or "Information Technology" and transform* or change or strategy*", "effort reward imbalance", "bank* and transformation", "financ* and transformation", "bank* and information technology", "financ* and information technology", "effort reward imbalance", "bank* and change and employee", "new technologies and employee", "change and management and bank", "IT enabled organizational transformation", "IT enabled business transformation". Articles were only in English. Papers were published journals, conference proceedings and book chapters in the field of business management. From the initial pool of 1.608 articles, only 31 fulfilled the above criteria. Figure 1 presents the article selection process.

Figure 1 Article selection process
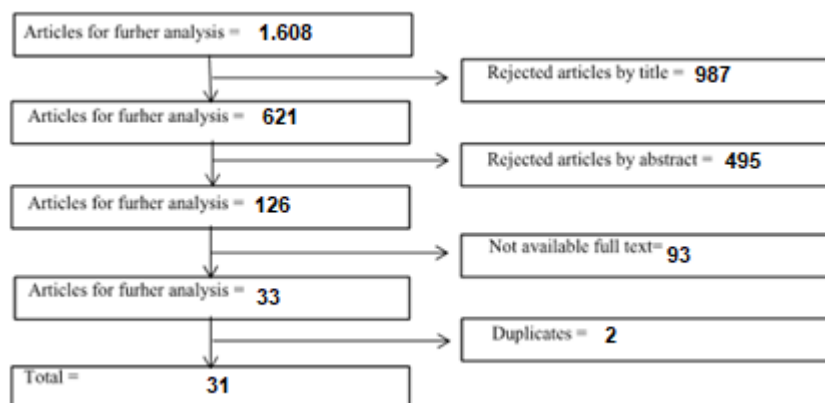


The final sample of 31 articles was classified to two categories according to their main subject. The first one was the acceptance of digitalization either by customers or by employees, and the second one was the employee behavior towards change management and organizational reform.

## 3. DIGITAL TRANSFORMATION AND ACCEPTANCE OF IT IN BANKING

Many researchers have focused on the transformation of financial sector and have studied the critical success factors that affect the development of new services (Angelopoulos et al., 2008; Kitsios & Kamariotou, 2019; 2017; 2016; Kitsios et al., 2008; Mitroulis & Kitsios, 2016). Branchless digital banking is related with the implementation of digital means in the banking transactions without bank branches and bank employees. Digital transformation seems to create a new era in banking. The implementation of branchless banking has also effects in the workforce of the industry. Despite the huge investments in IT infrastructure, there is no clear evidence about the increase of productivity in banking employees (Ho & Mallick, 2010).

Perceived ease of use describes the level of understanding of the new branchless banking system by its users. According to Hakim Suhaimi & Bin Abu Hassan, (2019) there is significant influence between this variable and acceptance of digital banking. On the other hand, experience, has negative impact on acceptance of digital banking (Venkatesh & Bala 2008). Apart from the perceive usefulness and perceive ease of use (described in TAM model), there are also some other variables that should be taken into consideration for acceptance of digital banking (Hakim Suhaimi & Bin Abu Hassan, 2019).

Perceived usefulness describes the level of the extent to which new technologies will empower the client/user in the execution of a task. According to Hakim Suhaimi & Bin Abu Hassan, (2019) there is no significant influence between perceived usefulness and acceptance of digital banking. In contrast Davis (1993) indicated that perceived usefulness is 50% more crucial in contrast with perceived ease of use. According to Venkatesh & Bala (2008) job relevance has a positive effect on perceived usefulness. On the other hand, experience has a negative impact.

Perceived self-efficacy is the level of self-motivation for someone who has to complete successfully his work. It is referred to the personal belief for someone who has to complete his own task. According to Hakim Suhaimi & Bin Abu Hassan, (2019) there is no significant influence between perceived self-efficacy and acceptance of digital banking.

## 4. METHODOLOGY

Based on the analysis of the existing literature review (Hakim Suhaimi & Bin Abu Hassan, 2019; Venkatesh & Bala, 2008), the following hypotheses are defined in order to measure the relationship among perceived usefulness, perceived ease of use, perceived self-efficacy, intention to use and usage behavior:

H1: There is no positive effect between perceived usefulness and intention to use digital banking.

H2: There is no positive effect between perceived ease of use and intention to use digital banking.

H3: There is no positive effect between perceived self-efficacy and intention to use digital banking.

H4: There is no positive effect between intention to use digital banking and usage behavior.

A questionnaire was developed for employees (professionals) in Greek banks in order to measure perceived usefulness, perceived ease of use, perceived self-efficacy, intention to use and usage behavior. The questionnaire was based on previous similar studies (Amin, 2012; Davis, 1993; Hakim Suhaimi & Bin Abu Hassan, 2019; Legris et al., 2003; Venkatesh & Bala, 2008). 5 point likert scale ranging from "5=strongly agree" to "1=strongly disagree" was employed. Figure 2 presents the conceptual model of the survey and Table 1 presents the variables of the questionnaire.

Figure 2 Conceptual model and hypotheses
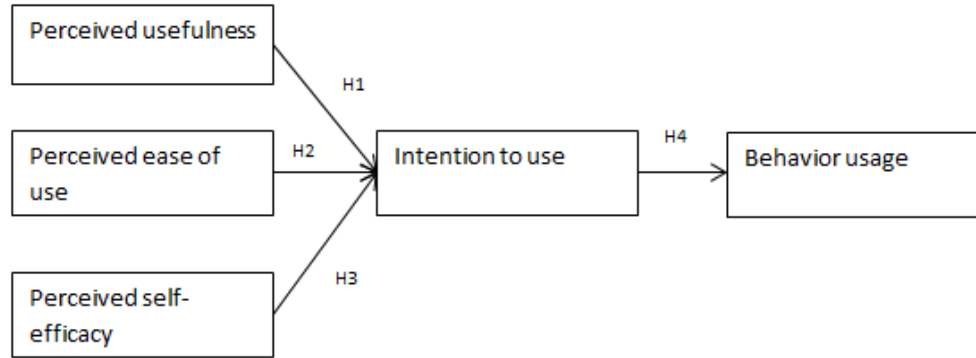


Table 1 Variables

| Variables | Questions | References |
|---|---|---|
| Perceived usefulness | Using applications/systems of digital banking improves the quality of the work I do<br>Using applications/systems of digital banking gives me greater control over my work<br>Applications/systems of digital banking enable me to accomplish tasks more quickly<br>Applications/systems of digital banking support critical aspects of my job<br>Using applications/systems of digital banking increases my productivity<br>Using applications/systems of digital banking increases my job performance<br>Using applications/systems of digital banking allows me to accomplish more work than would otherwise be possible<br>Using applications/systems of digital banking enhances my effectiveness on the job<br>Using applications/systems of digital banking makes it easier to do my job<br>Overall, I find applications/systems of digital banking useful in my job | (Amin, 2012; Davis, 1993; Hakim Suhaimi & Bin Abu Hassan, 2019; Legris et al., 2003; Venkatesh & Bala, 2008) |
| Perceived ease of use | I find applications/systems of digital banking cumbersome to use<br>Learning to operate applications/systems of digital banking is easy for me<br>Interacting with the applications/systems of digital banking is often frustrating<br>I find it easy to get the applications/systems of digital banking to do what I want to do | (Amin, 2012; Davis, 1993; Hakim Suhaimi & Bin Abu Hassan, 2019; Legris et al., 2003; Venkatesh & Bala, 2008) |

| | | Applications/systems of digital banking are rigid and inflexible to interact with | |
| | | It is easy for me to remember how to perform tasks using applications/systems of digital banking | |
| | | Interacting with applications/systems of digital banking requires a lot of mental effort | |
| | | My interaction with applications/systems of digital banking is clear and understable | |
| | | I find it takes a lot of effort to become skilful at using applications/systems of digital banking | |
| | | Overall, I find applications/systems of digital banking easy to use | |
| Perceived self-efficacy | | I could complete the job using applications of digital banking… | (Amin, 2012; Venkatesh & Bala, 2008) |
| | | …if there was no one around to tell me what to do as I go | |
| | | … if I had just the built-in help facility for assistance | |
| | | …if someone showed me how to do it first | |
| | | …if I had used similar applications before this one to do the same job. | |
| Intention to use | | Assuming I had access to applications of digital banking I intend to use them | (Hakim Suhaimi & Bin Abu Hassan, 2019; Legris et al., 2003; Venkatesh & Bala, 2008) |
| | | Given that I had access to applications of digital banking, I predict that I would use them | |
| | | I plan to use applications of digital banking in the next <n> months | |
| Usage behavior | | On average, how much time do you spend on applications/systems of digital bankingeach day? | (Amin, 2012; Hakim Suhaimi & Bin Abu Hassan, 2019; Legris et al., 2003; Venkatesh & Bala, 2008) |

## 5. CONCLUSIONS

The majority of the existent survey is referred to the level of acceptance of digital transformation and new digital technologies only by the customers of banking firms. The purpose of the research is to fulfill this gap in the academic research, and to provide information about bank employees' perspective and intentions towards digitalization.
Administrative executives and HR departments could make use of these findings in order to control and manipulate the negative consequences of this kind of change and to cultivate and empower the positive effects of digitalization in banking industry. Training programs could be used in order to provide to the users all the necessary knowledge for the harmless transformation to the digital era. Taking into consideration that the effort of the financial institution to establish branchless banking will be intensive (Kadlag, 2012), a continuous interest for research on acceptance of digital transformation in the banking industry will exist the following years. Managers and practitioners could also make use of the findings to imply more employee friendly tactics in order to facilitate the transition of conventional banking to branchless banking era.

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# Commercial & Military Turbofan Aero-Engine Efficiency Assessment: An Application of VSBM Two-Stage Network DEA

Angelos T. Kottas
*Aristotle University of Thessaloniki, School of Economic Sciences, MSc Programme in Logistics and Supply Chain Management*
*University Campus, 54124, Thessaloniki, Greece*
*atkottas@econ.auth.gr*

Michail N. Bozoudis
*NATO Communications and Information Agency (NCIA)*
*Boulevard Leopold III*
*1110 Brussels, Belgium*
*michail.bozoudis@ncia.nato.int*

Michael A. Madas
*University of Macedonia, Department of Applied Informatics*
*Information Systems and e-Business Laboratory (ISeB)*
*156, Egnatia Str., 54636, Thessaloniki, Greece*
*mmadas@uom.edu.gr*

**Abstract**

Data Envelopment Analysis (DEA) constitutes a widespread efficiency benchmarking methodology with a multitude of applications in production process efficiency of enterprises belonging to the same industrial sector. Despite the fact that research relevant to DEA has mainly focused on the efficiency of production systems, limited attention has been given to the efficiency evaluation of engineering systems with similar structural and functional features (e.g., automobiles, power plants). Moreover, the pretty scarce previous literature dealing with the efficiency evaluation of engineering systems has implemented basic DEA models of low discriminatory power, mainly due to the existence of a quite high portion of efficient Decision Making Units (DMUs). In the current research effort, a methodological framework incorporating non-oriented Variable Returns to Scale (VRS) Variable intermediate measures Slacks-Based Measure (VSBM) Two-Stage Network DEA is implemented, aiming to assess the efficiency of turbofan aero-engines, currently utilized by active-duty commercial and military aircraft. On top of investigating the positive correlation of DEA efficiency with engineering efficiency, we also pursue the evaluation of DEA efficiency of near-future turbofan designs. Major conclusion of the current paper is the alignment of the selected DEA model efficiency with propulsive efficiency. More specifically, the aero-engine features positively associated with increased DEA efficiency are also associated with increased propulsive efficiency. The developed methodological framework could potentially evolve into a tool for efficiency assessment of any turbofan aero-engine being in the conceptual or preliminary design stage, thus offering an alternative pathway for defining the features which render a turbofan aero-engine competitive or even superior to the existing offered range.

## 1. INTRODUCTION

Research pertinent to production systems in the manufacturing and service sector has extensively dealt with production efficiency evaluation. Although there has been a quite wide variety regarding methods for evaluating production efficiency, Data Envelopment Analysis (DEA) prominently stands as one of the most popular among researchers. Its popularity can be mainly attributed to its inherent capability to comparatively assess efficiency with minimal prerequisites, along with the multitude of methodological variations which can be applied on an ad hoc basis. As a matter of fact, Liu et al. (2013) state that the sectors on which research deploying DEA methodology has been predominantly applied are the banking sector, the health care sector, the agricultural sector, and the transport sector.

However, research dealing with engineering assets/systems evaluation has gained a quite limited attention. Within the framework of assessing and potentially improving the performance of engineering products, very few scholars and practitioners have attempted to benchmark conceptual and/or preliminary designs against existing engineering products, thus lacking a proper outlook of how well these newly developed products stand amongst competition (Triantis, 2011). Within this context, the current paper attempts to evaluate the efficiency of turbofan aero-engines utilized by contemporary commercial and military aircraft, thus comprising an enhanced evolution of the previous research of Bulla et al. (2000). With respect to the primary research objectives of the herewith presented paper, these are reported as follows: i) to evaluate the efficiency of turbofan aero-engines within an advanced DEA framework, along with a subsequent comparison against engineering efficiency ii) to evaluate the efficiency of commercial and military turbofan aero-engines over time and designate its association with certain technological features, and iii) to create a fundamental framework in order to develop a methodology for benchmarking turbofan aero-engines being in the conceptual/preliminary design stage, or even bound to enter service in the near future. The remainder of the paper is comprised of four sections. Section 2 describes the previous research relevant to engineering systems' efficiency evaluation implementing DEA. Section 3 provides a brief technical description of the turbofan aero-engine and an outline of the DEA methodological framework which stems from its functional architecture. Section 4 presents the obtained DEA results along with the conducted post-

hoc analysis and the respective discussion. Finally, Section 5 makes a summary of the conclusions drawn from the conducted research.

## 2. PREVIOUS RELEVANT RESEARCH

Research pertinent to comparative efficiency evaluation of engineering assets/systems is definitely scarce, thus designating the reduced attention among researchers and engineers. However, Triantis (2014) states that engineering design and development stages preceding the production of an engineering asset, should adopt a methodology to evaluate its performance in a more extensive context. The thorough search that took place in the framework of the current paper confirmed the aforementioned scarcity of previous relevant research. In fact, 14 instances of research were found dealing with engineering asset/system benchmarking deploying DEA methodology. It is important to stress that all previous research efforts implement single-stage basic DEA models, except for the research of Zhao et al. (2011) which is differentiated, thus implementing multistage network DEA model.

An important portion of the previous relevant research evaluates the efficiency of power plants, specifically focusing on power plants producing electrical power (e.g., Färe et al., 1987; Golany et al., 1994; Chitkara, 1999; Cook and Zhu, 2007; Meenakumari et al., 2009). Also, there are two research efforts dealing with passenger vehicle efficiency evaluation, namely Lo Storto (1997) and Papahristodoulou (1997). Other research efforts are quite diverse regarding the type of engineering systems under evaluation. In particular, Hjialmarson and Odeck (1996) and Odeck (1996) deal with the construction sector, thus evaluating the efficiency of trucks and rock-blasting units. According to Triantis (2011), the research of Bulla et al. (2000) which deals with efficiency evaluation of commercial turbofan aero-engine, comprises a prominent research effort pertinent to evaluation of engineering systems using DEA. Other research efforts are Doyle and Green (1991) which benchmark computer printers, Sun (2002) which benchmarks Computer Numerical Control (CNC) machines, and Lee and Lee (2009) which deal with building energy efficiency. In addition, the quite recent research effort of Zhao et al. (2011) is considered as novel, thus evaluating the efficiency of a Downtown Space Reservation System (DSRS) for 28 scenarios, with each scenario comprising an individual DMU.

## 3. TURBOFAN AERO-ENGINE DESCRIPTION AND IMPLEMENTED DEA MODEL

Turbofan aero-engine is the most widely adopted propulsion system type, thus utilized by the majority of commercial and military aircraft. Its major sections are the fan unit section, the compressor section, the combustion section, and the turbine section (El-Sayed, 2008). The operational concept can be concisely described as follows (El-Sayed, 2016): i) Air is initially fed into the fan section which compresses it to a low pressure ratio (1.3-1.5), ii) subsequently a portion of compressed air is expanded to produce thrust ("bypass" or "cold stream" thrust), while the remaining portion is routed into the compressor section (or "core airflow") in order to be further compressed iii) the core airflow after exiting compressor section enters the combustion section and is mixed with fuel, thus ignited for initiating the combustion process iv) combustion gases are routed into the turbine section for the purpose of driving the multistage turbine rotors and subsequently expanded to the atmosphere via the exhaust nozzle to produce additional thrust ("hot stream" thrust). Taking into account the aforementioned operational concept, we duly construct the functional model depicted in Figure 2, in order to adopt it for benchmarking the aero-engine sample.

**Figure 1:** Network DEA Functional Model for Turbofan Aero-Engine (Source: Own elaboration)
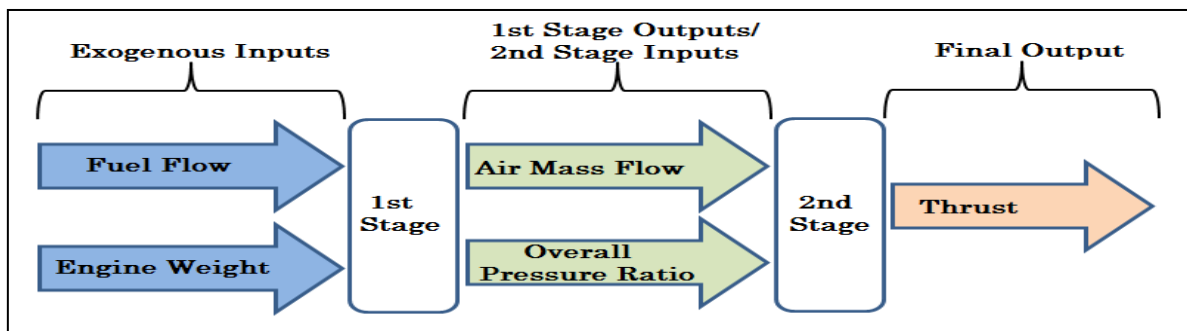


The justification of the selected exogenous inputs, intermediate measures (1st stage outputs, 2nd stage input), and final output is discussed below:

Exogenous Inputs

▪ Fuel Flow: Fuel is stored in the aircraft tanks and subsequently fed to the engine through pumps. Although it is the crucial element for sustaining combustion and consequently thrust generation, it is provided as an exogenous energy resource.

- <u>Engine Weight</u>: Irrespective of the thrust performance and fuel efficiency of an aero-engine, increased weight reduces the payload-carrying capability. Hence, weight is deemed as an exogenous input, as weight essentially represents resource consumption in the form of materials and energy.

<u>Intermediate Measures</u>

- <u>Air Mass Flow</u>: Sufficient air mass is the main prerequisite for any turbofan aero-engine to produce thrust, regardless of the portion allocated to bypass and core engine flow. As power for air induction comes from the turbine section, air mass flow is in essence an intermediate product of turbofan aero-engine operation.

- <u>Overall Pressure Ratio (OPR)</u>: In a similar fashion to air mass flow, OPR also represents the potential of an aero-engine to produce thrust, as higher pressure exhaust gases are inherently of higher energy, thus resulting to higher power extraction by the turbine section and produced thrust.

<u>Final Outputs</u>

- <u>Thrust</u>: It comprises the final desirable output of a turbofan aero-engine, thus propelling the aircraft in all flight phases i.e. taxi, take-off, climb, cruise, descend, and landing.

After extensive study pertinent to Network DEA models, the DEA model that has been selected in order to conduct the turbofan aero-engine benchmarking is the *Variable intermediate measures Slacks-Based Measure (VSBM)* model, which has been developed by Chen et al. (2016). More specifically, the *Variable Returns to Scale (VRS)* approach of the particular model is implemented. The justification behind implementation of the aforementioned DEA methodology is reported as follows:

- It comprises a non-radial model, which excludes the assumption of proportional changes in inputs and outputs, while it additionally deals with slacks (Tone, 2017).
- It is non-oriented, thus aiming to both minimize inputs and maximize outputs (Tone, 2017). Consequently, it is deemed ideal for benchmarking of engineering systems, where designers apply optimization techniques in order to both reduce expended resources and maximize performance.
- The VRS approach is inherently suitable for evaluating pure technical efficiency (Ramanathan, 2003), which is by definition the efficiency involved within the framework of converting inputs into outputs, thus rendering pure technical efficiency as the type of efficiency embedded within engineering systems.
- The particular DEA methodology enables concurrent assessment of stage efficiency and overall efficiency, along with computation of frontier projections for all inputs, intermediate measures, and outputs. In this way, inefficiencies are precisely located and quantified.

Data regarding the selected exogenous inputs, intermediate measures, and outputs were primarily collected from Jane's Aero Engines 2018-2019 (Daly, 2018), while additional sources were ICAO Aircraft Engine Emissions Databank (ICAO, 2018), El-Sayed et al. (2016), Farokhi (2014), Roux (2007), and Jet Engine Specification Database (http://www.jet-engine.net/miltfspec.html). For the purpose of evaluating a near future engine, General Electric GE9X was also included in the sample. The specific engine shall soon enter service onboard the Boeing 777X airliner, with the data figures being approximate values provided by the aforementioned sources.

## 4. DEA RESULTS AND POST-HOC ANALYSIS

In order to calculate the efficiency scores, Wolfram Mathematica v10.3 along with LINGO 17.0 have been utilized accordingly. The resulting overall efficiency and stage efficiency scores, along with the resulting frontier projections for exogenous inputs, intermediate measures, and final output are contained in Table 1.

By performing an initial investigation to the obtained efficiency scores, it can be deduced that the attained discriminative power is very satisfactory. In particular, none of the engines within the sample has achieved ideal overall efficiency (equal to 1), while the instances of ideal stage efficiency are quite few, i.e. four regarding the first stage and five regarding the second stage (7.27 and 9.09 percent of DMUs respectively).

The first part of the conducted post-hoc analysis uses non-parametric statistical analysis. Given that theoretical distribution of DEA efficiency scores is in general unknown, the implementation of non-parametric statistical tests is designated, thus considered as proper for instances where observations are statistically independent (Cooper et al., 2007). Initially, we evaluate the existence of statistically significant differences between commercial and military engines, which attain mean values of 56.49% and 28.66% respectively. We test the hypothesis whether commercial and military engines have identical mean efficiency, by performing the Mann-Whitney test, which gives a p-value far less than 0.01 (Z = -5.942). Hence, we reject the above hypothesis at 0.05 significance level, drawing the conclusion that commercial engines outperform military engines. The particular finding is aligned with the engineering approach regarding propulsive efficiency for subsonic speed region. Next, the sample is grouped by Entry Into Service (EIS) year, namely 1980s & earlier, 1990s, and 2000s & beyond, to investigate the association of EIS with DEA efficiency. In this case, we perform the Games-Howell statistical test in order to assess the existence of statistically significant differences among the above mentioned groups. The test designates statistically significant pairwise differences between the first group and the others, thus confirming a major technological

leap from 1990s and onwards. In addition, we further investigate the association of BPR with DEA efficiency. Taking into account the classification stipulated by Encyclopaedia Brittanica (2015), we group the sample into low-BPR engines (BPR≤ 2), medium-BPR engines (2 < BPR ≤ 5), high-BPR engines (5 < BPR ≤ 8), and ultrahigh-BPR engines (BPR > 8). Similarly to EIS, we perform the Games-Howell statistical test, which provides statistically significant differences among most groups (the null hypothesis is not rejected only between second and third group). The particular finding is in line with the engineering approach regarding the positive association of BPR and propulsive efficiency (El-Sayed, 2008).

Table 2: DEA Efficiency Scores & Frontier Projections

| Model | Overall Efficiency | Stage Efficiencies | | Frontier Projections* | | | | |
| | | 1st Stage | 2nd Stage | Fuel Flow | Weight | Overall Pressure Ratio | Air Mass Flow | Thrust |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ALF502R-6 | 0.35014 | 0.45837 | 0.89177 | 2,657.4 | 1,376.0 | 22.9 | 274.7 | 18,601 |
| D-30F6 | 0.23984 | 0.23984 | 1 | 3,034.1 | 1,605.8 | 23.5 | 326.6 | 21,948 |
| CFE738-1-1B | 0.38181 | 0.94221 | 0.43960 | 2,201.5 | 1,101.9 | 22.2 | 212.8 | 14,194 |
| CFM56-3C | 0.38278 | 0.73280 | 0.64998 | 3,275.1 | 1,753.4 | 23.8 | 360.0 | 23,500 |
| CFM56-5B3/P | 0.52680 | 0.80122 | 0.72558 | 5,380.1 | 3,042.1 | 26.8 | 651.3 | 33,300 |
| CFM56-7B26 | 0.39114 | 0.71387 | 0.67726 | 3,792.5 | 2,070.1 | 24.5 | 431.6 | 26,300 |
| GP7270 | 0.63064 | 0.98121 | 0.64944 | 13,696.4 | 8,133.9 | 38.8 | 1,802.3 | 70,000 |
| EJ200 | 0.31976 | 0.35895 | 0.96081 | 3,014.7 | 1,593.8 | 23.4 | 323.9 | 21,757 |
| CF34-80C1 | 0.37565 | 0.89518 | 0.48047 | 3,034.3 | 1,605.9 | 23.5 | 326.7 | 21,951 |
| CF6-80C2B6F | 0.62867 | 0.70239 | 0.92628 | 11,438.0 | 6,751.8 | 35.5 | 1,489.8 | 60,030 |
| CF6-80E1A3 | 0.64905 | 0.67122 | 0.97783 | 13,651.1 | 8,106.1 | 38.7 | 1,796.0 | 69,800 |
| F101-GE-102 | 0.26241 | 0.38635 | 0.87606 | 3,034.3 | 1,606.0 | 23.5 | 326.7 | 21,951 |
| F110-GE-100 | 0.25699 | 0.33296 | 0.92403 | 3,033.5 | 1,605.4 | 23.5 | 326.6 | 21,942 |
| F110-GE-129 | 0.26424 | 0.35593 | 0.90831 | 3,032.9 | 1,605.1 | 23.5 | 326.5 | 21,937 |
| F110-GE-132 | 0.27635 | 0.35552 | 0.92084 | 3,034.4 | 1,605.9 | 23.5 | 326.7 | 21,950 |
| F118-GE-100 | 0.32035 | 0.44028 | 0.88007 | 3,034.3 | 1,605.9 | 23.5 | 326.7 | 21,950 |
| F404-GE-400 | 0.25797 | 0.33736 | 0.92061 | 3,034.1 | 1,606.1 | 23.4 | 326.7 | 21,947 |
| F414-GE-400 | 0.31400 | 0.36923 | 0.94477 | 3,034.2 | 1,605.9 | 23.5 | 326.7 | 21,950 |
| GE90-110B1 | 0.84959 | 1 | 0.84959 | 27,009.4 | 16,747.1 | 42.3 | 3,364.8 | 110,100 |
| GE90-115B1 | 0.93637 | 0.93637 | 1 | 32,456.3 | 19,316.0 | 42.0 | 3,618 | 115,540 |
| GE90-85B | 0.63619 | 0.82903 | 0.80716 | 16,953.7 | 10,363.4 | 40.6 | 2,307.0 | 84,700 |
| GE90-94B | 0.68004 | 0.82145 | 0.85859 | 18,935.8 | 11,739.5 | 41.5 | 2,619.0 | 93,700 |
| GE9X | 0.69864 | 1 | 0.69864 | 21,280.6 | 13,559.7 | 41.7 | 2,989.6 | 102,000 |
| GEnx-1B70 | 0.64309 | 0.89209 | 0.75100 | 13,651.9 | 8,106.9 | 38.7 | 1,796.1 | 69,800 |
| TFE731-60 | 0.40219 | 1 | 0.40219 | 2,025 | 988.0 | 22.0 | 187.0 | 12,424 |
| V2533-A5 | 0.52327 | 0.72595 | 0.79732 | 5,312.7 | 3,000.8 | 26.7 | 641.9 | 33,000 |
| D-18T | 0.57809 | 0.71313 | 0.86496 | 9,544.1 | 5,591.5 | 32.8 | 1,227.5 | 51,660 |
| RD-33 | 0.24148 | 0.27945 | 0.96203 | 3,034.3 | 1,605.9 | 23.5 | 326.7 | 21,951 |
| AL-31F | 0.29145 | 0.30036 | 0.99109 | 3,034.3 | 1,605.9 | 23.5 | 326.7 | 21,951 |
| AL-37FU | 0.28939 | 0.30141 | 0.98798 | 3,034.3 | 1,605.9 | 23.5 | 326.7 | 21,950 |
| F100-PW-220E | 0.25915 | 0.31360 | 0.94555 | 3,033.5 | 1,605.9 | 23.5 | 326.6 | 21,939 |
| F100-PW-229 | 0.26678 | 0.33941 | 0.92737 | 3,034.3 | 1,605.9 | 23.5 | 326.7 | 21,950 |
| F119-PW-100 | 0.39777 | 0.39777 | 1 | 3,951.7 | 2,167.5 | 24.8 | 453.6 | 27,000 |
| PW2040 | 0.54910 | 0.75917 | 0.78992 | 7,283.0 | 4,207.1 | 29.6 | 914.6 | 41,700 |
| PW4056 | 0.60947 | 0.69364 | 0.91583 | 10,698.9 | 6,298.9 | 34.5 | 1,387.3 | 56,750 |
| PW4084 | 0.65962 | 0.67099 | 0.98863 | 16,930.5 | 10,347.8 | 40.6 | 2,303.4 | 84,600 |
| PW4090 | 0.66097 | 0.69562 | 0.96535 | 18,514.0 | 11,446.6 | 41.3 | 2,552.7 | 91,790 |
| PW4098 | 0.67973 | 0.68122 | 0.99852 | 20,401.1 | 12,783.7 | 41.7 | 2,854.1 | 99.040 |
| PW4462 | 0.63498 | 0.70084 | 0.93414 | 11,883.2 | 7,023.7 | 36.2 | 1,551.3 | 62,000 |

**Table1(contd):** DEA Efficiency Scores & Frontier Projections

| Model | Overall Efficiency | Stage Efficiencies | | Frontier Projections* | | | | |
| | | 1st Stage | 2nd Stage | Fuel Flow | Weight | Overall Pressure Ratio | Air Mass Flow | Thrust |
|---|---|---|---|---|---|---|---|---|
| PW6122A | 0.34131 | 0.62403 | 0.71728 | 3,057.6 | 1,620.4 | 23.5 | 329.9 | <u>22,100</u> |
| TF33-P-103 | 0.29632 | 0.40430 | 0.89202 | 3,030.7 | 1,603.7 | 23.4 | 326.0 | 21,894 |
| AE3007A3 | 0.33705 | 0.74335 | 0.59371 | <u>2,841.0</u> | 1,524.9 | 22.7 | 308.5 | 20,479 |
| BR715-C1-30 | 0.35312 | 0.69952 | 0.65360 | 3,033.5 | 1,605.5 | 23.5 | 326.6 | 21,941 |
| F402-RR-408 | 0.30095 | 0.30095 | 1 | 3,321.6 | 1,781.8 | 23.9 | 366.4 | <u>23,800</u> |
| RB211-535C | 0.46843 | 0.59399 | 0.87445 | 6,309.4 | 3,611.3 | 28.2 | 779.9 | <u>37,400</u> |
| Tay 620-15 | 0.29720 | 0.47487 | 0.82233 | 3,026.5 | 1,604.0 | 23.4 | 326.2 | 21,888 |
| Trent 1000C | 0.72058 | 1 | 0.72058 | 14,368.3 | 8,569.4 | 39.5 | 1,900.8 | <u>73,000</u> |
| Trent 556 | 0.58662 | 0.80296 | 0.78366 | 10,523.9 | 6,191.5 | 34.2 | 1,363.2 | <u>56,000</u> |
| Trent 700 | 0.67064 | 0.71373 | 0.95690 | 13,948.9 | 8,288.8 | 39.1 | 1,837.2 | <u>71,100</u> |
| Trent 895 | 0.75641 | 0.75641 | 1 | 19,222.3 | 11,938.2 | <u>41.6</u> | <u>2,664.0</u> | <u>95,000</u> |
| Trent 970 | 0.61876 | 0.86287 | 0.75589 | 13,697.9 | 8,134.7 | 38.8 | 1,802.5 | <u>70,000</u> |
| M88-2 | 0.28890 | 0.34019 | 0.94871 | 3,034.2 | 1,605.9 | 23.5 | 326.7 | 21,939 |
| M88-3 | 0.33281 | 0.36358 | 0.96923 | 3,033.4 | 1,605.3 | 23.5 | 326.5 | 21,939 |
| RB199 Mk105 | 0.26789 | 0.39447 | 0.87342 | 3,034.3 | 1,605.9 | 23.5 | 326.7 | 21,951 |
| RM12 | 0.27320 | 0.33668 | 0.93653 | 3,034.3 | 1,605.9 | 23.5 | 326.7 | 21,951 |

*Underlined numerical values represent frontier projections equal to actual values

The second part of the post-hoc analysis uses regression analysis and in particular the following methodologies: i) the Generalized Linear Model (GLM) equipped with the quasi-binomial family and logit link function, in order to separately test the null hypothesis that DMU efficiency is independent of the DMU grouping based on BPR and EIS and ii) the Standard Linear Model (LM) on BPR and EIS raw data, to test the null hypothesis which claims independency of DMU efficiency with respect to BPR and EIS. The results obtained by the aforementioned regression analysis methodologies are shown in Table 2.

**Table 3:** Regression Analysis Results

| Model | Explanatory Variable | Intercept (p-value) | Slope (p-value) | Linearity Assumption (p-value) | Null Deviance Reduction | Adjusted Coefficient of Determination |
|---|---|---|---|---|---|---|
| GLM | BPR-based Groups | $-1.492$ ($2.95 \cdot 10^{-15}$) | $0.598$ ($4.44 \cdot 10^{-15}$) | Not Applicable | 69.93% | Not Applicable |
| GLM | EIS-based Groups | $-1.125$ ($6.44 \cdot 10^{-5}$) | $0.468$ ($2.12 \cdot 10^{-4}$) | Not Applicable | 22.88% | Not Applicable |
| LM | BPR | $0.251$ ($4.13 \cdot 10^{-16}$) | $0.051$ ($< 2 \cdot 10^{-16}$) | 0.844 | Not Applicable | 72.57% |
| LM | EIS | $-17.868$ ($1.76 \cdot 10^{-4}$) | $0.009$ ($1.25 \cdot 10^{-4}$) | 0.502 | Not Applicable | 23.01% |

Obtained results designate that DEA efficiency and BPR are highly correlated, mainly highlighted by the fairly significant null deviance reduction value and the fairly high value regarding the adjusted coefficient of determination for LM. As far as EIS is concerned, fairly low explanatory potential is denoted when regressed against DEA efficiency, compared to BPR. The particular conclusion is ascertained by the quite low values of null deviance reduction (GLM) and adjusted coefficient of determination (LM). Nevertheless, for the case of LM, efficiency is found to be significantly correlated with EIS at 5 percent significance level, while it is evident that the assumption of linearity is not rejected at the 5 percent significance level for both BPR and EIS (p-value equal to 0.502 for efficiency against EIS and equal to 0.844 for efficiency against BPR). In addition, we investigate the potential of DEA efficiency improvement within technological limitations. We assume a technological limit of five percent for the reduction of fuel flow and weight, along with a five percent increase limit in

thrust. The particular assumption applies for technological improvement over the end of the next decade (i.e. 2030), taking into account the claim of Birch (2000) regarding specific fuel consumption of aircraft propulsion systems. Within this framework, we perform a simulation generating 106 sets of pseudo-random variables representing exogenous input and final output improvement within the five percent threshold. Subsequently, the generated pseudo-random variables are used to compute the resulting DEA efficiency. The whole procedure is executed using Wolfram Mathematica v10.3, which designates the feasibility of GE90-110B1 and GE-90115B1 to attain ideal efficiency score within the prescribed thresholds. It is important to stress that both GE90-110B1 and GE-90115B1 attain unity efficiency score without reaching any threshold for either exogenous inputs or final output, thus denoting the increased likelihood of using those engines as baseline designs to build a future benchmark. Moreover, it is worth mentioning that GE9X can attain a maximum efficiency of 0.822276, which is achieved by improving both exogenous inputs and final input to the five percent threshold.

## 5. CONCLUSIONS

The current paper attempts to assess the efficiency of in-service and near future turbofan aero-engines by implementing an advanced network DEA methodology, which could comprise an alternative to the various engineering methods mainly implementing thermodynamics and aerodynamics. However, engineering methods usually assume that the propulsion system is developed in isolation, while they simultaneously exclude particular features negatively affecting usability (e.g., excess weight, increased size) and marketability (e.g., high noise, increased pollutants). The primary novelty of the current paper lies in the fact that without resorting to extremely complex computational methods, it renders feasible to conduct turbofan aero-engine efficiency evaluation with a satisfactory degree of objectivity, which is confirmed by the alignment of DEA efficiency with respect to propulsive efficiency, along with the consistence of both non-parametric statistical analysis and regression analysis. Moreover, the developed methodology introduces a framework that could enable aero-engine designers to evaluate conceptual and/or preliminary designs against the existing range of turbofan aero-engines, thus comprising a complementary tool for the design optimization process.

## ACKNOWLEDGEMENT

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# Analyzing Consumers' Behavior and Purchase Intention: the case of Social Media Advertising

*Eva Kyriakopoulou*
*School of Information Sciences, Department of Applied Informatics, University of Macedonia*
*156 Egnatias st, 54636 Thessaloniki, Greece*

*Fotis Kitsios*
*School of Information Sciences, Department of Applied Informatics, University of Macedonia*
*156 Egnatias st, 54636 Thessaloniki, Greece*

*Maria Kamariotou*
*School of Information Sciences, Department of Applied Informatics, University of Macedonia*
*156 Egnatias st, 54636 Thessaloniki, Greece*

**Abstract**

During the last decades users of social media are dramatically increased creating profiles in different social media in order to spend their free time on, sharing their opinion, warnings, experiences or information, in a virtual place. Another important activity for users of social media is the purchase of products using online channels. As a result, social media has become a most valuable part of everyday activities for people. So, companies use them in order to interact with their consumers, create a networking marketing opportunity and sell their products. As a result, the social and commercial experience of consumers is widely enriched online, while online channels offer to companies the opportunity to promote and sell their products in a direct way to consumers. In recent years, many academic papers have been published focusing on different topics regarding to social networking platforms. However, there is a lack of studies that examine consumers' purchase intention, their behavior and their need to discuss their experience about a product or a service that they have used. Thus, the purpose of this paper is to examine the effect of social media advertising on consumers' behavior, on their purchase intention and their wish to spread their personal experience by using a product. Data were collected using online questionnaires to 221 consumers who use social media. Data were analyzed using Regression Analysis. The results of this study show that both social media and branding influence customers' habits and their purchase intention. Also, social media and branding motivate consumers to use techniques such as the Word of Mouth in order to discuss about the characteristics of products that they have bought.

## 1. INTRODUCTION

The invention of social networks, online communities, video and emails, blogs and forums enables information to be distributed more quickly than ever before (Haryani and Motwani, 2015). Social platforms effectively place consumers at the heart of business by providing them with a new range of interactive tools. The internet allows more interactivity, targeted communication, increased reach and more valid evaluation of results, at a low cost (Derbaix and Vanhamme, 2003; Kozinets et al., 2010). Social media have dramatically transformed the distribution of information between companies and customers, facilitating the take-up of information online (Akrimi and Khemakhem, 2012).

According to Erdoğmuş and Çiçek (2012), social media marketing differs from traditional marketing methods, and therefore companies have to pay special attention on the development of social media strategies in order to increase brand loyalty. At the same time, Zynman (1999) claimed that "*traditional marketing does not die, it is already dead*". Social media marketing is related to relationship marketing, in which brands have to shift from "selling" to "creating relationships" with consumers (Gordhamer, 2009). This endeavors come to strengthen the social networking pages, which at the same time are also a powerful marketing tool that is widely used to link and communicate between businesses and consumer users. Marketers have used a variety of tools to preserve consumer fidelity in the brand, including brand features, classic mixes of marketing variables, and new methods such as events, sponsorships, personalized marketing, and a combination of online and social media marketing (Erdoğmuş and Çiçek, 2012; Kotler and Keller, 2007).

The existing literature indicates that there is a direct perception of the lack of extensive research into the degree of influence of consumer behavior from advertisements displayed on social media as well as the relationship of this advertising with the ultimate intention to purchase. Previous studies have attempted to perceive the extent of social media influence on the attitudes of consumers towards the brand (Abzari et al., 2014) as well as brand loyalty (Erdoğmuş and Çiçek, 2012). Furthermore, in a later study conducted by Ertemel and Ammoura (2016), an attempt is made to understand the role of advertising in social media as a function of purchase intention. In these studies it is obvious that there is an effort to delimit the issue by examining individual aspects of the wider social media marketing sector in relation to consumers' behavior.

The purpose of this paper is to examine the effect of social media advertising on consumers' behavior, on their purchase intention and their wish to spread their personal experience by using a product. The findings of the survey aim to help businesses understand the perceptions and intentions of consumers, as they shape through their attitudes towards advertising. Although there are several surveys that provide a significant amount of information in this field (Qualman,

2009; Ryan and Xenos, 2011), there are few to examine the effectiveness of advertising in social media from consumers' perspective (Kodjamanis and Angelopoulos, 2013).

The structure of this paper is as following: after a brief introduction to previous researches, next section includes the literature review in order to highlight the issues which are discussed in this paper. Section 3 describes the methodology, while Section 4 shows the results from the implementation of the proposed approach. Finally, Section 5 discusses the results and concludes the paper.

## 2. LITERATURE REVIEW

Competitiveness achievement in the rapidly changing business landscape requires a robust social media strategy (Erdoğmuş and Çiçek, 2012). In addition, the pressure of competitiveness coupled with the conviction of marketers that they should dominate the client-driven social media platforms has prompted more and more companies to create a marketing mix based on social media (Barwise and Styler, 2003) or to formulate strategies focusing on the marketing activities of this sector in the near future (Constantinides, 2014). Within a company, the main goal through the use of social media is to focus consumers' attention on its products. More and more companies hire consultants and social media specialists to define the content and characteristics of their social media offerings and activities in order to fully gain consumers and achieve the desired fidelity (Coon, 2010). On the one hand, studies regarding the experience of marketers in defining social media strategies and marketing policies remain limited. On the other hand, other academic researchers claim that marketers are positively predisposed to the use of social media in the marketing plan (Steinfield et al., 2009).

The high levels of social media communication efficiency compared to other traditional channels of communication have prompted industry leaders to create a systematic and coordinated presence in social media to achieve digital environments (Kaplan and Haenlein, 2010). De Bruyn and Lilien (2008) studied the interaction of consumers through their communication with each other in the decision-making process of viral marketing. An eMarketer survey has shown that consumers tend to visit pages in social media to stay informed about a company's products and promotions (Mangold and Foulds, 2009; Leggat, 2010). While an Info-graphics survey suggested that nearly half of Twitter and Facebook users tend to comment, recommend, or buy a company's products after interacting with themselves through social platforms (Jackson, 2011). Marketers are positively positioned to offer products tailored to consumers' needs, while at the same time interact with consumers to develop and launch new products, a process known as co-creation (Kitsios and Kamariotou, 2019; 2016; Kitsios et al, 2009a; b; Constantinides, 2014).

Purchase intention refers to the decision-making process where the consumer chooses to buy the product of a brand (River et al., 2010). It is crucial for companies to understand consumer behavior in order to develop products that meet customers' needs. At the same time, brand loyalty is the success of a business that comes through customer satisfaction (Kyriakopoulou and Kitsios, 2017). Companies achieve brand loyalty when develop products that create images, positive impressions or even feelings for consumers. Specifically, consumers, with an emphasis on millennials, are looking for markets that are easy and fast (Forbes, 2017). They are looking for easy and effective communication with the brand through social media to meet their wishes by saving time.

According to the literature review, the following hypotheses where stated for the purpose of this survey:

H1. Social media have a positive impact on consumer behavior in choosing a product / service.
H2. Social media have a positive impact on the evaluation of product information.
H3. The internet has a positive impact on consumer behavior in choosing a product / service.
H4. The internet has a positive impact on the evaluation of information about a product.
H5. The brand has a positive effect on consumer behavior in choosing a product / service.
H6. The brand has a positive impact on the evaluation of product information.

A common parameter in H1, H3 and H5 cases is the extent of influence of consumer behavior, while in hypotheses H2, H4 and H6, the extent of influence of social media, the Internet and brand on the evaluation of product information. Figure 1 presents the conceptual model based on the previous hypotheses.

Figure 1 Conceptual model
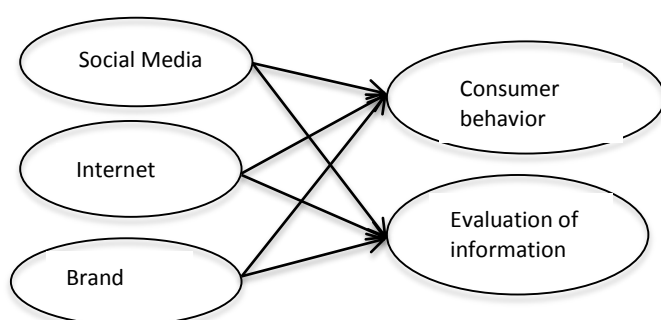
## 3. METHODOLOGY

Having an exclusive focus on serving the purpose of research and finding answers to research questions, an online questionnaire was developed to collect the required data. The questionnaire's structure was based on previous researches, relative to this research area (Abzari et al., 2014; Kodjamanis & Angelopoulos, 2013; Trainor et al., 2014). A pilot questionnaire was created, which was answered by 30 respondents in order to identify any faults, ambiguities or omissions. The final questionnaire was sent via email and facebook. The required number of responses was collected and analyzed by the multiple regression analysis (Chi, 2011; Mandilas et al., 2013; Erdoğmuş and Çiçek, 2012) to disseminate the results of the survey.

The data collection was made via a standard questionnaire online form and addressed to the users of social media. The survey was conducted from May to July 2017 and April-June 2018. A key condition for completing this questionnaire was that respondents would have at least one active account in any social networking. Otherwise, it is not possible to complete and submit the questionnaire. The final sample was 221 subjects and the data were analyzed using the regression analysis.

## 4. DATA ANALYSIS

Analyzing the profile of the respondents who participated in the survey, the majority of respondents was men and had a degree. It is also noted that among the age groups surveyed most respondents come from 18-24 years of age. One possible explanation for this could be that young people are more familiar with social media than older ones. Finally, most of the respondents to their educational background have answered that they have completed their tertiary education.

The path coefficients for the research constructs are expressed in a standardized form. The path coefficient between social media and consumer behavior was positive and statistically significant. Also, the path coefficient between brand and consumer behavior was positive and statistically significant. Thus, H1 and H5 were supported. There was a significant positive relationship among social media, brand and evaluation of information, supporting H2 and H6. This indicates that the brand of a product can significantly affect consumer intention to purchase this product or not. Also, consumers who use social media are informed about the characteristics and the usage of a product. They can communicate with other users in order to discuss about a product and evaluate this information. Tables 1 and 2 show the results for individual paths and results and Table 3 summarizes the results for hypotheses testing.

Table 1 Regression Analysis for the first model

| Coefficients<sup>a</sup> | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 1.638 | .239 | | 6.849 | .000 |
| | Brand | .448 | .143 | .207 | 3.122 | .002 |
| 2 | (Constant) | 1.474 | .278 | | 5.308 | .000 |
| | Brand | .426 | .145 | .197 | 2.946 | .004 |
| | Internet | .153 | .133 | .077 | 1.151 | .251 |
| 3 | (Constant) | .709 | .453 | | 1.563 | .119 |
| | Brand | .466 | .145 | .216 | 3.219 | .001 |
| | Internet | .154 | .132 | .078 | 1.170 | .243 |
| | Social Media | .238 | .112 | .141 | 2.126 | .035 |
| a. Dependent Variable: Consumer Behavior | | | | | | |

Table 2 Regression Analysis for the second model

| Coefficients<sup>a</sup> | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | ,625 | ,489 | | 1,278 | ,203 |
| | Social Media | ,462 | ,120 | ,252 | 3,841 | ,000 |
| | Internet | -,049 | ,142 | -,023 | -,344 | ,731 |
| | Brand | ,429 | ,156 | ,182 | 2,754 | ,006 |
| a. Dependent Variable: Evaluation of information for products | | | | | | |

Table 3 Summary of hypotheses

| Hypothesis | Results |
|---|---|
| H1 | confirmed |
| H2 | confirmed |
| H3 | rejected |
| H4 | rejected |
| H5 | confirmed |
| H6 | confirmed |

## 5. CONCLUSION

The results of this paper have shown that social media marketing and branding has a significant influence on both consumer behavior and product evaluation. As social media has the ability to influence consumers' purchase intentions, managers are given the opportunity to get in touch with potential consumers in order to achieve company's goals. Through virtual interaction and interaction with consumers, companies have the opportunity to improve their products, their brand image and their overall presence on social networks, achieving consumers' needs and expectations. Additionally, businesses have the opportunity to interact with their consumers in order to develop and launch products to the market that meet consumers' needs. If consumers are satisfied the business value and revenues are increased. Also, company's reputation will is enhanced.

A limitation of this paper stems from the fact that many hypotheses have not been confirmed. It is therefore proposed for future researchers to analyze why these hypotheses are rejected. It is also recommended for future researchers to enlarge the amount of participants in order to conduct the survey at minimal deviation. This inadequacy of the sample size is likely to have some effect on the values of the variables to be studied and the final form of the relevant models.

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# A Single User Model for Circular Economy Driven by the Internet of Things

Nikolaos Christodoulakis
*Institute of Computer Science*
*Foundation of Research and*
*Technology - Hellas*
*Heraklion, Greece*
nchristod@ics.forth.gr

Nikolaos Petroulakis
*Institute of Computer Science*
*Foundation of Research and*
*Technology - Hellas*
*Heraklion, Greece*
npetro@ics.forth.gr

Nikos Tsotsolas
University of West Attica
Aegaleo, Greece
ntsotsol@unipi.gr

**Abstract**

This paper presents an approach on how Internet of Things (IoT) can support Circular Economy (CE) with the use of sensors in an interconnected environment. A background investigation of related works is provided, focusing on synergies and challenges of IoT and how CE can assist on overcoming these challenges. Based on that, the main part of this work is focused on the description of a new method for Circular Economy with IoT support for a small environment – for a Home CE – IoT place. This method is called Ariadne and applies techniques from Operations Research in order to assist the decision maker (for example the house keeper) about the use of the products where are considered as assets.

**KEYWORDS**

Circular Economy, Internet of Things, Interconnected Devices, Multicriteria Decision Aid, Decision Support.

## 1. INTRODUCTION

During the last decade developing consideration has been created to the world the new idea and the improvement model of Circular Economy, CE, with the expectation to give a new option to the predominant monetary advancement display, called "take, make and dispose" [1]. The bad results of the latter are weakening the power of the economies and the honesty of ordinary natural groups that are essential for mankind's survival [2][3][4][5]. So far many of this kind CE studies (case studies, reviews, scientific reports, etc.) had been published worldwide [6][7][8][9]. CE is proposed as a new business model predicted to result in an extra sustainable development and a harmonious society [10][11].

At the other side, the future design of the Internet of Things applications will depend crucially on the improvement of sophisticated platform architectures for smart objects, embedded intelligence, and smart networks [12][13][14]. However, most of the today's IoT systems are mainly focused on sensors, whereas in the future actuation and smart behaviour will be the key points. Research based on ambitious assumptions of the use and benefits of innovation in new components, systems, networking and web technologies must be implemented to meet the ever-increasing needs of future internet systems in terms of scalability, heterogeneity, complexity and dynamics [15][16][17].

The overall aim of this paper is to identify the state of the art in the correlation of CE and IoT technology and to propose the application of an aggregation-disaggregation method concerning the classification of devices in a CE approach. The remainder of this paper is organized as follows. In Section II, an overview of the related work is presented. In Section III we discuss the challenges and constraints of IoT that CE will try to address. In Section IV a CE-IoT framework is proposed consisting of UTAdis method and evaluated in an IoT use case with LED lamps. We conclude this paper in Section VI.

## 2. RELATED WORK

Ellen MacArthur gave an overall explanation for the CE system [25] and why we need to incorporate a brand-new way of producing and consuming products. IoT and intelligent assets, capable of detecting, communicating and storing information for themselves, will allow the merging of production and digital technology, creating products that can mark any problem, decide when you want to repair and plan their own maintenance.

IoT integrates perfectly [26] into the CE because it allows the profitability and durability of an asset or resource to be increased. How IoT can bring a cyclical economy. The CE describes sustainable business models [27], according to which components and raw materials are always recycled. By reusing them, the substances keep their costs and this reduces the need to spend more valuable sources.

One way of switching the conventional value chain [18] is the IoT lease model. Rather than selling luxury equipment or a car, manufacturers can prematurely produce them for the purpose of hiring by customers. By integrating these assets with IoT, producers can disclose the asset's circumstances; thus, seeking dynamic property repair at specific times. In principle, the big asset will be strengthened as it is in the producer's interest to make it long lasting rather than available and replaceable. IoT has the ability to transform integrated cities [19] using the definition of routine issues. Extended sensors, community connections and data processing capabilities provide a way to tackle congestion and reduce noise, crime and pollution. for example, the sensors were deployed at the positions of the lamp posts to come across gunshots and inform the police even faster than someone is capable of. Site visitors lighting fixtures can alter to the go with the flow of site visitors and relay these records to other areas, to offer alternative routes and smoother travel.

## 3. CHALENGES AND CONSTRAINTS

### 3.1 Production

The CE model, with the help of evaluation, is described as a restorative character [28] and "regenerative by design", meaning that it seeks to maintain commodities, components and materials with maximum application and value at all times - cycling or conversion to energy or disposal. The Ellen MacArthur Foundation [29] defines a technical and an organic cycle - the so-called "butterfly" diagram illustrating how in a CE the products are designed to allow "disassembly and reuse" and therefore decreasing or getting rid of waste.

### 3.2 Consumption

The embrace of the CE system is the most important opportunity in our lifetime [30]. The common adventure for an additional viable destination requires new views on consumption and obligations. Achieving long-term balanced growth can be made worse through partnership. No company can fix the complete problem. Collaboration with providers, stores, start-ups, governments, cities and civil society will allow businesses to develop products, services and fashions that make a huge contribution to the internet at a global level.

### 3.3 Waste Management

European Union (EU) directives and guidelines have defined the framework among the other transposition coverage devices [31] to be implemented and will therefore be considered as the most complete drivers of changes in waste control throughout the Europe. The general framework for waste control in the EU is provided by Council Directive 2008/98/EC on waste (Waste Framework Directive). For all the waste streams covered of this record, the Waste Framework Directive:

- installed the waste hierarchy as a secret for waste management decisions;
- defines the basic definitions of waste management as well as when a is not waste and the reputation of stop-of-waste repute;
- requires Member States to take effective measures to better exploit, reuse and recycle waste, incorporating separation, wherein feasible, of waste streams,
- controls hazardous waste through a ban on the incorporation of unsafe waste, with the exception of household waste;
- establishes principles along with the responsibility of the polluter and extended producer responsibility (EPR)

### 3.4 Secondary Raw Materials

"Secondary raw materials" are recyclable substances that can be used in manufacturing techniques instead of virgin unwoven substances [32]. The use of secondary raw materials provides certain advantages, which consist of improved security of supply, reduced use of fabrics and strengths, reduced effects on the climate and the environment and reduced manufacturing costs. But with the use of secondary undesirable substances it faces a few obstacles as well as the absence of desirable requirements for sensitive materials (together with plastics), the difficulties associated with the marketing of secondary raw materials across the EU and the presence of chemicals problem in recycled products.
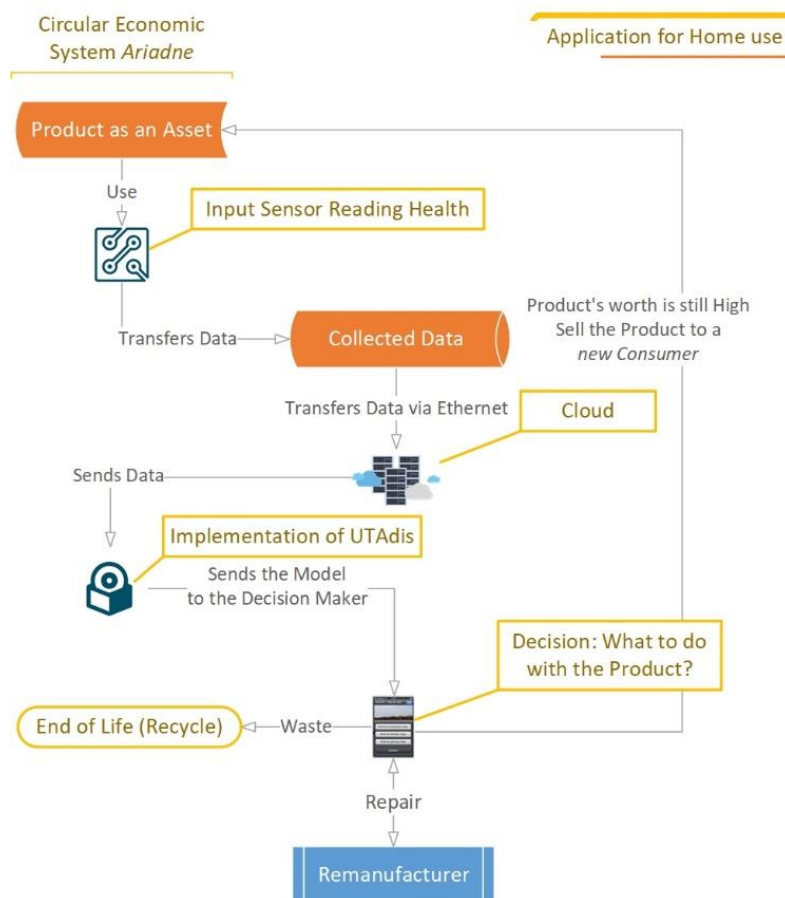
## 4. CE-IOT FRAMEWORK

To address the above challenges and constraints, a CE system driven by IoT framework is proposed. The framework is based on a decision support system using an aggregation-disaggregation method to classify different devices (alternatives of a set A) into homogenous ordinal groups namely: Sell, Repair, Recycle. This method is called UTAdis.

## 4.1 The Aggregation-Disaggregation approach

The philosophy of aggregation-disaggregation approach, also referred as preference disaggregation approach, in the context of the multicriteria analysis lies in the estimation of a preference model, which emerges as a conclusion from a given expression of overall preference on alternative activities. The aim is to provide support for decision-making actions using operational research models [23]. In the traditional form of the synthetic approach [24] followed by the majority of the Multicriteria Analysis problems, the composition model of the individual criteria is a priori known, while the overall preference is unknown. According to this approach applies the principle of linearity and causality, i.e. the logic that the decision is determined by the criteria and the way of synthesis thereof.

The UTA methods (Utilités additives) proposed by the Jacquet-Lagrèze & Siskos in 1982 [21] aims to estimate on or more value additive functions from a given pre-order on an $A_R$ reference set. The method uses special linear programming techniques to infer the specific functions so that the rank obtained through these functions in the $A_R$ is as compatible as possible with the original given pre-order. The method was introduced in 1978 in an issue of the Notebooks series of the Lamsade Laboratory and marks the beginning of the analytical-synthetic approach as a stream of multicriteria analysis. The extension of the UTA method, the UTAdis, in the case of a discriminant analysis model has been developed initially by Jacquet-Lagrèze & Siskos, in 1978 [22]. The main objective of such a method is the induction of a value function $U$, from examples of classification of reference actions, in the context of problematic $b$.

Figure 1: Proposed CE-IoT Framework

## 4.2 Application in the CE-IoT Framework

The presented method can be used in an interconnected environment with sensors on the products which send data about their lifecycle to a cloud. The home cloud collects information about the "health" of each product and the decision support system using the UTAdis method proposes if it needs to be disposed, repaired, or sold as an asset to another consumer. The products are considered as assets and can re-entered to the CE with a price depending from the market request. For the induction of the value function U that will be used for the classification of the products into the three groups, an initial reference set of devices shall be used, which will be classified into the groups by an expert or a group of experts.

The data collected from the sensors can be translated into evaluation grades on different criteria. Each sensor may evaluate one or more criteria. In the general case where, different sensors evaluate the performance of the product on more than one criterion the evaluation of a product a is given as a vector of distributional evaluations of this product. In order to serve this general case, we are going to propose a stochastic version of the UTAdis method.

Sensors send data to a cloud which collects also data from other CE users and from the market. The collected data are saved to a home server. These data are used from the decision support system using aggregation-disaggregation approach in which a Decision Maker has to take the Decision. As is shown in the Figure 1, each product is considered as an asset. The consumers buy this product because of their needs. In CE system with IoT applications, products have special sensors to calculate some of their futures. The CE is applied to the steps that the products is defined as an asset. The price of this asset could be also calculated by using the sensors of an IoT environment. UTAdis is applied when we want to classify the alternatives.

## 4.3 Mathematical Explanation

The method that we chose to apply is a specific form of UTAdis method, which encompasses the notions of Stochastic UTA [33] in order to deal, if necessary, with uncertain evaluations of some criteria. From this point further, we will call our modified approach as Stochastic UTAdis.

Stochastic UTAdis will be used to deal with the problem of assigning a finite set of m alternatives (devices) $A = \{a_1, a_2, \dots, a_m\}$ into the 3 aforementioned predefined groups, let's say $C_s, C_{rp}, C_{rc}$. The alternatives are described using a vector of n criteria $\boldsymbol{g} = (g_1, g_2, \dots, g_n)$.

The performance of alternative $a_j$ on criterion $g_i$ will be denoted by $g_i^j$. Therefore, each alternative can be considered as a vector $\boldsymbol{a}_j = \left(g_1^j, g_2^j, \dots, g_n^j\right)$. In our case the groups are defined in an ordinal way, $C_s$ will denote the group consisting of the most preferred alternatives, while $C_{rc}$ will denote the group of the least preferred alternatives.

UTA methods use in general an unweighted additive value function for each action $a$ having the following form:

$$u[\boldsymbol{g}(a)] = \sum_{i=1}^n u_i[g_i(a)] \,, \tag{1}$$

where $n$ is the number of the criteria and $u_i[g_i(a)]$ are non-decreasing real valued functions, called marginal value or utility functions, subject to normalization constraints:

$$u_i(g_{i*}) = 0, \sum_{i=1}^n u_i(g_i^*) = 1, \quad \forall \, i = 1, 2, \dots, n \tag{2}$$

where $g_{i*}$ is the worst level of the evaluation scale of the *ith* criterion and $g_i^*$ is the best level of the *ith* criterion. The evaluation scales of each criterion are discretized in $r_i$ set of points: $G_i = \left\{g_{i*} = g_i^1, g_i^2, \dots, g_i^j, \dots, g_i^{r_i} = g_i^*\right\}$. In the specific case of measurable criteria where $g_i(a)$ lays within one of $r_i - 1$ intervals of the scale, the utility functions of the action $a$ are calculated using linear interpolation.

For our specific case, where probabilistic evaluations of the actions are present, instead of function (1) we use an additive utility function of the following form:

$$u(\boldsymbol{\delta}^a) = \sum_{i=1}^n \sum_{j=1}^{\alpha_\iota} \delta_i^a\left(g_i^j\right) u_i\left(g_i^j\right) \tag{3}$$

where $\delta_i^a$ is the distributional evaluation of action $a$ on the $ith$ criterion, $\delta_i^a\left(g_i^j\right)$ is the probability that the performance of action $a$ on the $ith$ criterion is $g_i^j$, $u_i\left(g_i^j\right)$ is the marginal value of the performance of $g_i^j$, $\boldsymbol{\delta}^a$ is the vector of distributional evaluations of action $a$ and $u(\boldsymbol{\delta}^a)$ is the global utility of action $a$.

The necessary classification will be performed through the comparison of the global utilities of the actions to some utility thresholds that define the lower bound of each class, as follows:

$$\left.\begin{array}{r} u(\boldsymbol{\delta}^a) \geq u_s \Longrightarrow a \in C_s \\ u_s > u(\boldsymbol{\delta}^a) \geq u_{rp} \Longrightarrow a \in C_{rp} \\ u_{rp} > u(\boldsymbol{\delta}^a) \Longrightarrow a \in C_{rc} \end{array}\right\} \tag{4}$$

where $u_s > u_{rp}$ are thresholds defined in the global value scale $[0,1]$ to discriminate the groups. $u_s$ is the lower bound of group $C_s$ (devices to be sold) and $u_{rp}$ is the lower bound of group $C_{rp}$ (devices to be repaired).
Stochastic UTADIS method has five algorithmic steps for our problem which are the following:

**Step 1**: Select the subset of reference actions $(A_r \subset A)$ and sort them into the three categories.
**Step 2**: Express the global expected utility of reference actions $u(\boldsymbol{\delta}^a)$ in terms of variables:

$$w_{ij} = u_i\left(g_i^{l+1}\right) - u_i\left(g_i^l\right) \geq 0, i = 1,2,\dots,n, l = 1,2,\dots,r_i - l \tag{5}$$

which automatically takes into account the monotony of marginal utilities. Let us note that, for $j = 1, w_{i1} = u_i(g_i^2)$ because: $u_i(g_i^1) = u_i(g_{i*}) = 0 \ \forall \ i = 1,2,\dots,n$

Conversely: $u_i\left(g_i^l\right) = \sum_{t=1}^{l-1} w_{it}, \forall \ i \ and \ l > 1 \tag{6}$

**Step 3**: Introduce two error functions $\sigma^+(a)$ and $\sigma^-(a)$ as follows:

1. $\sigma^+(a) = max\{0, u_k - u(\boldsymbol{\delta}^a)\} \ \forall a \in C_k (k = s, rp)$ is the error associated with the violation of the lower bound $u_k$ of a group $C_k$ by an action $a \in C_k$
2. $\sigma^-(a) = max\{0, u(\boldsymbol{\delta}^a) - u_{k-l}\} \ \forall \ a \in \ C_k (k = rp, rc)$ is the error associated with the violation of the upper bound $u_{k-1}$ of a group $C_k$ by an action $a \in C_k$

**Step 4**: Solve the following linear program aiming to minimize the errors:

$$\min z = \sum_{a \in C_k} \sigma^+(a) + \cdots + \sum_{a \in C_{rp}} [\sigma^+(a) + \sigma^-(a)] + \cdots + \sum_{a \in C_{rc}} \sigma^-(a)$$

*subject to*

$$u(\boldsymbol{\delta}^a) - u_s + \sigma^+(a) \geq 0 \ \forall \ a \in C_s,$$
$$\left.\begin{array}{r} u(\boldsymbol{\delta}^a) - u_s - \sigma^-(a) \leq -\delta \\ u(\boldsymbol{\delta}^a) - u_{rp} + \sigma^+(a) \geq 0 \end{array}\right\} \ \forall \ a \in C_{rp},$$
$$u(\boldsymbol{\delta}^a) - u_{rp} - \sigma^-(a) \leq -\delta \ \forall \ a \in C_{rc},$$
$$\sum_{i=1}^{n}\sum_{l=1}^{r_l-1} w_{il} = 1,$$
$$u_s - u_{rp} \geq s, u_{rp} - u_{rc} \geq s,$$
$$w_{il} \geq 0, \sigma^+(a) \geq 0, \sigma^-(a) \geq 0, \forall \ i, l, a$$

$\delta$ being a small positive number.

**Step 5**: Proceed with a robustness analysis of the solution, by taking into consideration the existence of multiple or near optimal solutions, to calculate a centroid solution as a unique utility function, provided that it is considered as a more representative solution of a particular problem. This representative utility function is used for the overall evaluation of all potential actions (extrapolation output).

## 4.4 Numerical Case Study

In our numerical case study, we evaluated LED lamps using 5 criteria (4 quantitative and 1 qualitative) that have been proposed by the US Department of Energy (DOE) [34]. Information about these criteria is given in Table 1.

Table 1: DOE's LED lamp criteria

| Criterion | Units | Best value | Worst value |
|---|---|---|---|
| Color temperature (CCT) | kK | 4.0 | 2.5 |
| Color Rendering Index (CRI) | % | 100 | 0 |
| Lumen Output (LO) | % (lm) | 100 | 0 |
| Actual use/Useful life (AU/UL) | % (h) | 0 | 100 |
| Visual Evaluation (VE) | qualitative | 10 | 0 |

In our example, we used a reference set of 10 LED lamps $(A_1, A_2, \dots, A_{10})$, which are evaluated on the five different criteria $(C_1, C_2, \dots C_5)$ using metric devices and human observation. The evaluation on these criteria is considered as a distribution of probabilities (stochastic evaluation) on a 5-point ordinal scale using ranges of criteria values as shown in Table 2.

Table 2: LED lamp criteria discretization

| | + | ++ | +++ | ++++ | +++++ |
|---|---|---|---|---|---|
| CCT | 2.5-2.8 | 2.8-3.1 | 3.1-3.4 | 3.4-3.7 | 3.7-4.0 |
| CRI | 0-20 | 20-40 | 40-60 | 60-80 | 80-100 |
| LO | 0-20 | 20-40 | 40-60 | 60-80 | 80-100 |
| AU/UL | 80-100 | 60-80 | 40-60 | 20-40 | 0-20 |
| VE | 0-2 | 2-4 | 4-6 | 6-8 | 8-10 |

The multicriteria stochastic evaluation table for lamp $A_1$ is shown as an example in Table 3.

Table 3: Stochastic evaluation of $A_1$

| Product $A_1$ | + | ++ | +++ | ++++ | +++++ |
|---|---|---|---|---|---|
| CCT | | | 0.9 | 0.1 | |
| CRI | | | 0.1 | 0.8 | 0.1 |
| LO | | | 0.1 | 0.9 | |
| AU/UL | | | 0.1 | 0.8 | 0.1 |
| VE | | | 0.1 | 0.8 | 0.1 |

The 10 lamps of the reference set are classified in the 3 different groups as follows: $Sell(A): \{A_1, A_2, A_3, A_4\}$, $Repair(B): \{A_5, 6, A_7\}$ and $Recycle(C): \{A_8, A_9, A_{10}\}$.

By solving the UTAdis method and after applying a robustness analysis we calculated the centroid additive utility function and we got the following criteria weights:
$p_1: 0.197, p_2: 0.083, p_3: 0.520, p_4: 0.131, p_5: 0.068$, which show that the most important criterion is Lumen Output.

The global utility of each LED lamp is shown in Table 4.

Table 4: Global utilities of actions

| | |
|---|---|
| $u(\delta^1) = 1.000$ | $u(\delta^6) = 0.537$ |
| $u(\delta^2) = 1.000$ | $u(\delta^7) = 0.375$ |
| $u(\delta^3) = 0.949$ | $u(\delta^8) = 0.273$ |
| $u(\delta^4) = 0.895$ | $u(\delta^9) = 0.246$ |
| $u(\delta^5) = 0.588$ | $u(\delta^{10}) = 0.160$ |

The utility threshold for "devices to be sold" is 0.895 and for "devices to be repaired" is 0.357.

## 5. CONCLUSIONS

In this paper we presented how IoT can supply CE in a single user model. Existing synergies and the related work were presented. Furthermore, the existing challenges and constraints were also detailed. To provide a solution of the above challenges, a new model for CE-IoT synergy was proposed. This model is new in use and therefore some indexes are necessaries to calculate the stability of the hierarchy model that exports. For that reason, the Average Stability Index (ASI) is proposed as the main index whereas higher it is the better hierarchy model is. As future work we intend to apply the proposed framework in small environments by conducting real time experiments.

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# Supply Chain Performance Measurement: The case of Fresh Fruits and Vegetables sector

Sidiropoulos George*

*University of West Attica, School of Administrative, Economic & Social Sciences, Department of Business Administration\**

*Petrou Ralli & Thivon 250*

Tsotsolas Nikos*

*University of West Attica, School of Administrative, Economic & Social Sciences, Department of Business Administration \**

*Petrou Ralli & Thivon 250*

**Abstract**

The purpose of this paper is to present the current state of the research in performance measurement in relation to managing the supply chain of Fresh Fruits and Vegetables (FFV) sector and to discuss the need and importance for a new supply chain evaluation model. The major problem is the difficulty in finding a suitable set of KPIs for measuring the supply chain performance of this specific sector. This research proposes the Supply Chain Operations Reference (SCOR) Model as an appropriate approach to deal with the performance measurement of Fresh Fruits and Vegetables (FFV) sector. There is a considerable amount of literature which is concentrated on the description of value or supply chain of the examined sector for each country separately but there is a lack of total evaluation models of these chains. Thus, there exists a necessity of estimating and evaluating the overall performance of such a supply chain. This review fills partially this gap in the extant Supply Chain Performance Measurement (SCPM) literature. Future work will concentrate on examining specific information from companies that operate in this same sector. Towards the development of a weight function model and in order to estimate the weights of SCOR's Level 1 KPIs that have been selected as the proposed evaluation criteria in our case, Weights Assessment through Prioritizations (WAP) method was applied. Results indicated that the suggested approach will help decision makers and various stakeholders involved in the supply chain management of Fresh Fruits and Vegetables (FFV) sector to understand the importance of an integrated supply chain for better evaluation and management.

**KEYWORDS**

Fresh Fruits and Vegetables (FFV), Supply Chain Operations Reference Model (SCOR Model), Supply Chain Performance Measurement (SCPM), Weights Assessment through Prioritizations (WAP), Key Performance Indicators (KPIs).

## 1. INTRODUCTION

Current researches indicate that the agri-food supply chain has a continuous development against many unexpected challenges and requirements (Saitone and Sexton, 2017). From the aspect of consumption structure, fruits and vegetables sector has grown significantly over the years (Reynolds et al., 2014). Especially Fresh Fruits and Vegetables (FFV) as a subcategory of agri-food sector hasn't been studied yet for constructing a unique supply chain model and evaluating its performance to make specific decisions in relation to other competitors. Uncertainties in supply, demand and longer lead times in the supply chain of fresh fruits (Soto-Silva et al., 2016) reflect the need for the implementation of a better tool to manage this specific sector.

## 2. LITERATURE REVIEW

The most widely recognized approach in the field of Supply Chain Management (SCM) is the Supply Chain Operations Reference (SCOR) model (Akkawuttiwanich and Yenradee, 2018). It is a process reference framework which combines business process improvement, performance benchmarking, best practices analysis and organizational design to evaluate and compare supply chain activities for improving performance (Alomar and Pasek, 2014) and company's overall business process. The SCOR model uses these four techniques that are combined with four components (Process, Performance, Practices, People) into a single integrated approach (Rotaru et al., 2014).

Figure 1: Combined techniques used in the SCOR framework into a single integrated approach
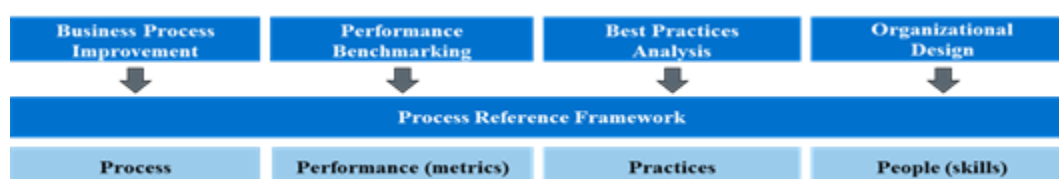
It was developed in 1996 by the Supply Chain Council as a useful tool for improving supply chain and since then several companies have adopted the SCOR model and its methodology (Persson, 2011). Also, it is globally accepted as an industry standard and is characterized as a cross-functional framework (Long, 2014) that has the advantage of mapping a supply chain in terms of business process (Palma-Mendoza, 2014). According this model, Supply Chain Management (SCM) consists of the following six integrated processes: Plan, Make, Source, Deliver, Return and Enable. Since today, the most recent version was published in 2017. Figure 1 shows these primary management processes that have the advantage to make the communication and information between partners more easy than any other proposed approach:

The SCOR model is also characterized as a diagnostic tool that assists stakeholders to identify the most important features that affect customer satisfaction (Ntabe et al., 2015) and can be used for the supply chain performance evaluation by any company (Dissanayake and Cross, 2018). This model uses Key Performance Indicators (KPIs), which is a useful tool to estimate the company's goals achievement (Thunberg and Persson, 2014). There are over 250 SCOR metrics that are organized from level 1 to level 3. In level 1, there is a total of 10 metrics. These strategic KPI metrics are categorized in five performance attributes: reliability, responsiveness, agility, costs and asset management efficiency.

## 3. METHODOLOGY

This study presents an analysis based on a ranking of SCOR's Model Level 1 KPIs (except Overall value at risk) analysis, based on a business executive of the Fresh Fruits and Vegetables (FFV) sector with great skills and knowledge, before the application of WAP method to estimate the weights of the proposed criteria:

Table 1. Ranking of the criteria

| SCOR Metrics | Ranking |
|---|---|
| Perfect Order Fulfillment (%) | 1 |
| Order Fulfillment Cycle Time (days) | 2 |
| Total Cost To Serve | 3 |
| Cash to Cash Cycle Time (days) | 4 |
| Return on Supply Chain Fixed Assets (%) | 7 |
| Upside Supply Chain Flexibility (days) | 5 |
| Upside Supply Chain Adaptability (%) | 6 |
| Downside Supply Chain Adaptability (%) | 8 |
| Return on Working Capital (%) | 9 |

In SCOR model, Value at risk (VAR) is the only risk measure that has a negative impact on estimating and reacting to unpredictable events (Rotaru et al., 2014). Furthermore, because this metric is even more difficult to be estimated by companies and, is excluded from the present research. SCOR model has the ability to change the processes or even the structure of an existing used model to an end-to-end view and this presupposes a mindset change in people (Girjatovics et al., 2018). This new perspective will positively contribute to knowledge sharing between the involved people based on a common language and better communication. Figure 2 shows that the proposed model for the supply chain of fresh fruits and vegetables simulates with SCOR model. The first stakeholder is the producer / supplier who is responsible for the production of the goods and constitutes the first link with the next supplier who acts as the intermediary-supplier of the company. He is located at the center of the model and undertakes the storage, transport, packaging and distribution of the products to the retailer or wholesaler, who takes place in the fortunate position and undertakes the delivery to the final customer. Every stakeholder is responsible for the transfer of goods and information in the right time and place. This is the reason for why it is so crucial and important to understand better the supply chain management of this specific sector and the factors and issues that affecting the quality of the goods.

**Weights Assessment through Prioritizations (WAP) method**

The WAP method (Tsotsolas, et al., 2016) is based on Simos Method approach incorporating specific processes that are focused on robust concern of the inferred results. WAP method enriches the preferential information used in a friendly and comprehensive by the DM way and at the same time it leads to the estimation of weighting vectors with higher robustness in comparison to Simos method (Spyridakos, et al., 2018). The flow diagram in Figure 4 shows the main steps – processes of WAP Method. For the application of the method the WAP software tool was used (Spyridakos, et al., 2018).

Figure 2: Simulating the Supply chain of Fresh Fruits and Vegetables to SCOR model
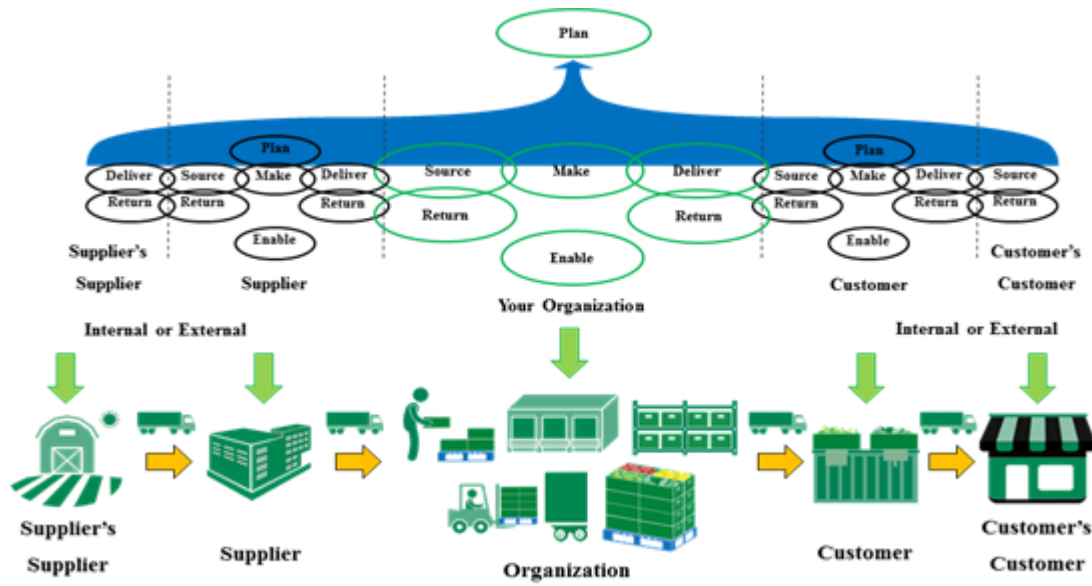


## 4. RESULTS

The FFV business executive, acting as the DM, is interviewed using a dedicated structured questionnaire, while he was guided to use the WAP method software. Initially, the decision analysts make an introduction to the DM, regarding the process that is going to be followed throughout the interview. The DM is asked to confirm that he understands and agrees with the process. The DM is asked to express his preferences about the importance of the points of view and criteria in various ways: ranking, pairwise comparisons of consecutive attributes in ranking, relative importance of consecutive attributes in terms of range of ratios. The adopted approach is hierarchical, starting with the estimation of the weights for the points of view and concluding with the estimation of the weights for the criteria.

For the application of the method the WAP software tool was used (Spyridakos, et al., 2018).

Through this approach the relative importance of the nine criteria was estimated. Table 2 includes the ranking of the main points of view, the ranges of the $Z_r$ indices, the estimated weights barycentre and the minimum and maximum weights estimated by post-optimality analysis. In addition, it includes the values of indices $\mu_j$ and ASI. Based on their values, the estimated value system is considered very robust (ASI=0.9825).

Table 2: Estimation of weights and robustness analysis for the 9 criteria

| SCOR Metrics | Ranking | [Zmin, Zmax] | Weights BC | Weights Min | Weights Max | Index $\mu_j$ |
|---|---|---|---|---|---|---|
| **Perfect Order Fulfillment (%)** | 1 | [1.04, 1.15] | **0.1554** | 0.1818 | 0.2090 | 0.0536 |
| **Order Fulfillment Cycle Time (days)** | 2 | [1.15, 1.25] | **0.1469** | 0.1657 | 0.1853 | 0.0384 |
| **Total Cost To Serve** | 3 | [1.15, 1.25] | **0.1244** | 0.1381 | 0.1531 | 0.0287 |
| **Cash to Cash Cycle Time (days)** | 4 | [1.04, 1.15] | **0.1041** | 0.1152 | 0.1278 | 0.0237 |
| **Return on Supply Chain Fixed Assets (%)** | 7 | [1.15, 1.25] | **0.0942** | 0.1053 | 0.1181 | 0.0238 |
| **Upside Supply Chain Flexibility (days)** | 5 | [1.04, 1.15] | **0.0740** | 0.0855 | 0.0984 | 0.0243 |
| **Upside Supply Chain Adaptability (%)** | 6 | [1.04, 1.15] | **0.0656** | 0.0784 | 0.0924 | 0.0268 |
| **Downside Supply Chain Adaptability (%)** | 8 | [1.20, 1.30] | **0.0576** | 0.0720 | 0.0875 | 0.0298 |
| **Return on Working Capital (%)** | 9 | - | **0.0445** | 0.0579 | 0.0726 | 0.0281 |

Figure 4: WAP method flowchart (Tsotsolas, et al., 2016)
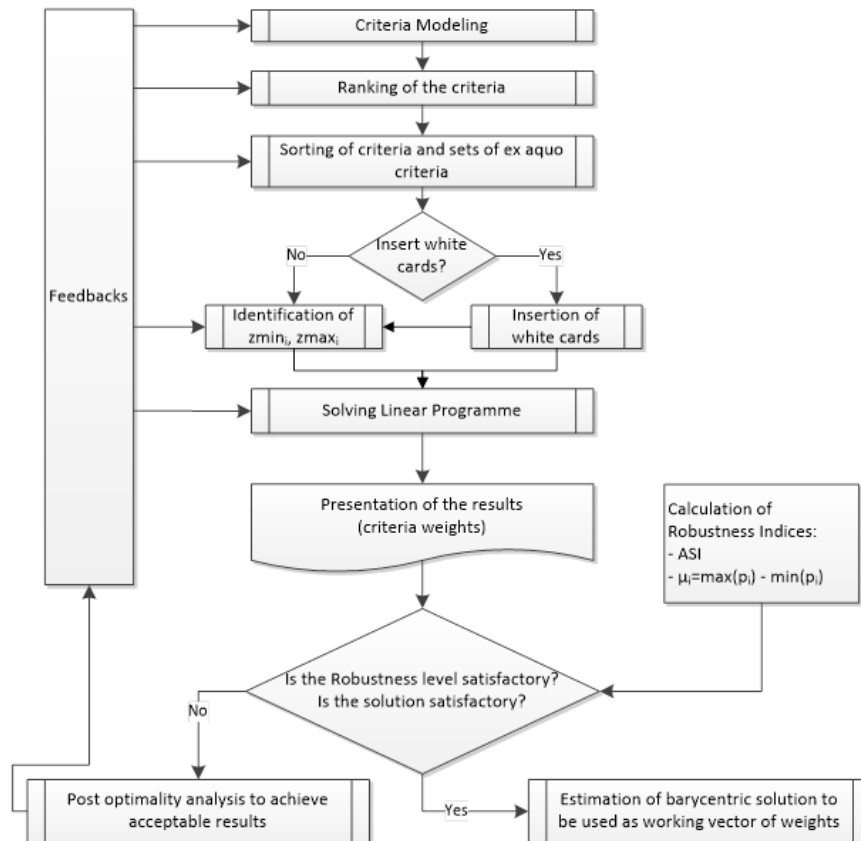
## 5. CONCLUSIONS

Based on the results, it can be concluded that the supply chain of Fresh Fruits and Vegetables (FFV) can be adapted by the application of Supply Chain Operations Reference (SCOR) model through its processes. The importance of modeling the supply chain of fresh fruits and vegetables in order to measure and evaluate its performance using the SCOR model was showed.

The next stage of this research will be the examination of a company in the sector of Fresh Fruits and Vegetables (FFV) as a case study to compare its performance with other competitors in order to propose specific directions and solutions, based on the SCOR model. The use of the techniques and methodologies of SCOR model could be useful tools to estimate and solve many of the problems of the examined sector.

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# Open innovation in SMEs: Intention and Influence to contemporary entrepreneurship

Kasaris Emmanouil
School of Information Sciences, Department of
Applied Informatics, University of Macedonia
*156 Egnatias st, 54636 Thessaloniki, Greece*

Fotis Kitsios
*School of Information Sciences, Department of
Applied Informatics, University of Macedonia
156 Egnatias st, 54636 Thessaloniki, Greece*

**Abstract**

For over 15 years, Open Innovation (OI) has been a trending strategic approach to the process of innovation of enterprises. The number of studies that have been carried out indicate that this approach has positive effects on the Innovation Performance of Small and medium-sized enterprises (SMEs). These studies highlight both the importance of the adoption of the OI, and its synergy with Entrepreneurship Orientation (EO) for SMEs. The purpose of this study is to cover the research gap by studying the factors that impede and motivate SMEs to adopt OI as well as to examine the effect of OI and EO on Innovation Performance of Greek SMEs. After a thorough literature review using Webster's and Watson's (2002) methodology, 68 articles were collected in order to create a conceptual framework. This framework shows the relation between OI, EO and the impact of these variables synergy on Innovation Performance of SMEs. The survey is conducted in Greek SMEs and aims at promoting policies and guidelines to enhance the level of Innovation and competitiveness. The main finding of the study is that the extent of the positive effect of OI depends on the roles of Entrepreneurship Orientation in the improvement of the Innovation Performance. It is found that the mentality of the leadership of a company affects OI and EO, and therefore the new way of profit generation. It is also noted that "too much" or "too fast" OI may have negative results on Innovation Performance of SMES. The results of this study have theoretical and practical implications for managers in the improvement of the innovation process in SMEs. Thus, the positive effects of the synergy of EO and OI, which are examined in this study, indicate the importance of Entrepreneurship to the successful adoption of Open Innovation.

## 1. INTRODUCTION

Open Innovation (OI) has been an increasing and interesting research topic since 2003 when Henry Chesbrough, 2003 defined it as "…the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for the external use of innovation" (Chesbrough, 2003, 2006). Researchers suggest that SMEs who adopt and act openly have great benefits on their Innovation Performance in comparison with other firms. However, the existing literature focuses more on the effects of OI on Large companies than on SMEs (Gassmann et al., 2010), thus there is a gap that this paper tries to fill.

Most researchers speculate and believe that OI have positive effects on the Innovation performance of the company. The basis behind this speculation is natural: the more a firm communicates with different outsiders, other companies, institutes, universities etc. (Dodourova and Bevis, 2014; Lee et al., 2010; Wynarczyk, 2013), the higher will be its entrance to their technology, ideas, skills and other useful resources, the higher will be its odds to innovate effectively (Greco et al., 2016). While other authors highlighted the positive effects and benefits from cooperating with partners besides organizations, such as customers, users, suppliers and also competitors (Baldwin and von Hippel, 2011; Fu, 2012). Additionally, researchers found that collaboration networks help companies-members to cooperate and network with others in order to buy, sell or develop a project together, this can also boost the firm performance (Lee et al., 2010; Li et al., 2010)

A large portion of these studies are based in countries that are members of G20 or whole continents, for example in our literature review the five most studied countries or continents are United Kingdom and Italy with 6 studies and Global, Europe and South Korea with 5 studies (Greco et al., 2016; Laursen and Salter, 2006; Yun et al., 2016). According to the suggestion of this study, it is vital to study countries or areas that are outside of the G20, countries such as Greece, other areas, or continents like the Balkans, Africa, Asia or South America etc (Parida et al., 2012). It is important and interesting to study these areas because we will have a more complete picture on how these countries adopt and open their innovation processes in order to generate revenue and what are the effects on their performance (Parida et al., 2012).

There is a need of more specific and focused research on country or continental level (Parida et al., 2012). This study aims to research the OI adoption, its synergy with Entrepreneurial Orientation (EO) and their effect on Innovation Performance of Greek IT SMEs. The main purposes of this study are: to examine the adoption of the OI approach as well as the factors that affect positively and negatively SMES to adopt it. A conceptual model was developed in order to analyze the synergy between OI and EO and the effect on Innovation Performance in SMEs.

The structure of this paper is the following: after a brief introduction to the field of OI, the analysis of the existing literature was presented. The next section describes the conceptual model and the methodology of this paper. The last section concludes the paper.

## 2. LITERATURE REVIEW METHODOLOGY

The literature review methodology which was suggested by Webster and Watson (2002) was used in order to search for papers in the field of OI. This methodology was used by other researchers in the field of Innovation Management and consists of three steps that support researchers to conduct a complete literature review (Kitsios and Kamariotou, 2019; 2018; 2016; Kitsios et al., 2017). These steps are the "Main Search", which contains keyword definition, database selection and criteria application, the "Backward Search" and the "Forward Search". Then the last step is the synthesis of the main concepts.

Previous literature reviews were studied in order to select the keywords that they used. In this paper keywords such as "Open innovation", "Open innovation AND Small and Medium Businesses", "Open innovation AND SMEs", "Adoption AND open innovation AND Small and Medium Businesses", "Adoption AND open innovation AND SMEs", "Adoption AND motives OR practices OR barriers", "Open innovation AND innovation performance", "Open innovation AND business model", "Open innovation AND entrepreneurship AND Orientation" were used in four databases; Scopus, Science Direct, Web of Science and IEEE Xplore. 1751 papers were yielded from these searches. Criteria such as the source of publication and the subject area were applied and papers were reduced to 938. Then, a scanning in titles and abstracts of these 938 papers were implemented and 45 papers were selected for further analysis. 23 papers were added from backward and forward research. Thus, 68 papers were analyzed.

Based on the analysis of these papers the emerging concepts in the field of OI are the difference of Closed and Open Innovation Models, the three OI Dimensions, the OI Adoption motives and barriers and the synergy of OI and firms' Entrepreneurial Orientation on Innovation Performance, which are analyzed bellow.

## 3. OPEN INNOVATION AND ENTREPRENEURSHIP IN SMES

SMEs that have closed boundaries make investments to their R&D department in order to develop innovative services or products. These companies launch their products to the current market. On the other hand, companies that open their boundaries, have more knowledge bases due to the ability of networking and cooperating with others (Chesbrough, 2003, 2006). This strategic approach gives them the opportunity to buy or sell unused knowledge or technology to other companies (Enkel et al., 2009).

SMEs have three options (or dimensions) in adopting open innovation. These dimensions are: the "Inbound Open Innovation" or outside-in process which is the opening up of the internal processes which allows the entrance of external knowledge and technologies. The second option is the "Outbound Open Innovation" or inside-out process which is the externalization or commercialization of unused internal knowledge or technologies or ideas in order to find new ways of generating revenues for the firm. In addition, the third OI Dimension named "Coupled Open Innovation" is the combination of the previous two (Enkel et al., 2009; Gassmann et al., 2010; van de Vrande et al., 2009).

Moreover, regarding the adoption of OI by SMEs, there are six main motivations that push them to open up their barriers. These motivations are reduced research costs, access to external resources and knowledge, the ability to cooperate and network in order to develop or commercialize new products, the capability of purchasing this knowledge as well as selling the unused internal technology, better management of the whole innovation process, instead of just a part of it and less bureaucracy, willingness to take risks and ability of easy and quick reaction in changing environments (Brunswicker and Vanhaverbeke, 2015; Burcharth et al., 2014; Enkel et al., 2009; Gassmann et al., 2010; Lee et al., 2010; Parida et al., 2012; Spithoven et al., 2013; van de Vrande et al., 2009; Yun et al., 2016).

However, there are many barriers that impede the OI adoption by SMEs in order to develop innovative services. The most common barriers are economic factors, organizational & administrative factors, cooperation factors and knowledge & information factors (Bianchi et al., 2010; Birkle and Gewald, 2013; Carvalho and Moreira, 2015; Chesbrough and Crowther,

2006; Enkel et al., 2009; Gassmann et al., 2010; Kitsios et al., 2015; 2009; Laursen and Salter, 2006; Parida et al., 2012; Rahman and Ramos, 2010).

Other researchers that investigated OI in SMEs, focused on its synergy with EO. According to their studies, they suggest that entrepreneurial SMEs that open their barriers in their innovation processes have great effects on their Innovation Performance (Laursen and Salter, 2006; Yun et al., 2016). SMEs that are characterized by EO and adopt OI are more likely to maximize their innovation gains by networking and cooperating with others (SMEs, large enterprises, institutes or universities etc.). Zhao et al., (2016) found that there are 7 main factors that have positive impact on the firms' Innovation Performance. These factors are the technological search, technological selection, technological absorption, technological learning, technological innovation, technological transformation and technological diffusion (Zhao et al., 2016). Researchers found that SMEs' upper management attitude towards on adopting OI and Entrepreneurship have a notable role on the impact of their synergy (Laursen and Salter, 2006; Parida et al., 2012; Yun et al., 2016). Another interesting finding is that the positive effect of the synergy of OI and EO on Innovation Performance does not apply in the case of SMEs from emerging economies, such as in South America or Asia. The reason is that firms that operate in these countries focus more on the optimization of the effectiveness and efficiency of their current processes and less on their innovation processes (Cunningham, 2015).

## 4. RESEARCH METHODOLOGY

Based on the existing literature, a conceptual research model three main hypotheses were developed in order to examine the relationship among OI, EO and Innovation Performance. The relationship between variables is presented in Figure 1, which illustrates the conceptual model.

H1: OI efforts have positive effect on the increase of new products' revenue ratio and the addition of new business models.

H2: the increase of EO has positive effect on the increase of new products' revenue ratio and the addition of new business models.

H3: the synergy of OI and EO and their positive moderating have positive effects on Innovation Performance (Greco et al., 2016; Laursen and Salter, 2006; Parida et al., 2012; Vahter et al., 2014; Yun et al., 2016).

Figure 1 Conceptual Research Model (adapted from Yun et al., 2016)
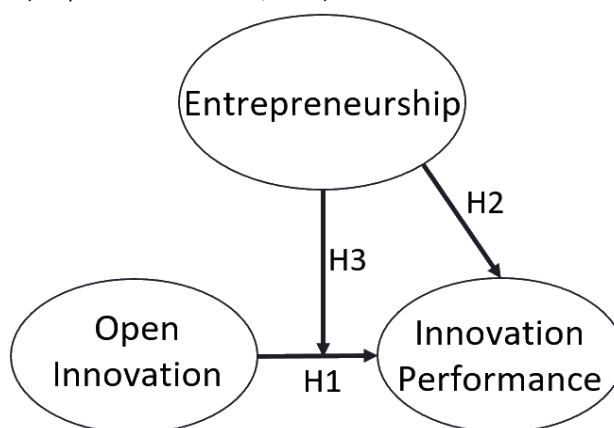


A questionnaire that is based on previous surveys such as Laursen and Salter (2006), Greco et al. (2016) and Yun et al. (2016) was developed in order to evaluate the variables from the conceptual model. Questionnaire's answers are measured with a 5-point Likert scale and some Yes or No questions. The survey focuses on Greek SMEs that operate in IT sector, both software and hardware. Questions aim to measure the degree of acquisition of external technologies and knowledge. The next section of the questionnaire deals with company's processes and ease on decision making and it measures how the company operates and make decisions. Then, questions about the OI adoption factors by SMEs and the effects of OI adoption are included. Economical and innovative performance of the companies after the adoption of OI and firm's satisfaction are also measured. Finally, questions about the introduction of new business model innovation in the firms and the difficulties of entrepreneurs to create start-ups (Greco et al., 2016; Laursen and Salter, 2006; Parida et al., 2012; Spithoven et al., 2013; Yun et al., 2016).

## 5. CONCLUSIONS

OI is a very trending topic nowadays. The most researchers focused on specific countries and very little on the others. Their main finding is that OI and Entrepreneurship have great synergy and effect positively the firms' Innovation Performance (Greco et al., 2016; Laursen and Salter, 2006; Parida et al., 2012; Yun et al., 2016). This study proposed a conceptual model that will support the future survey on Greek IT SMEs in order to fill the literature and research gap that currently exist. This study is estimated to raise the awareness of Greek IT SMEs on the OI paradigm. This paper focuses on SMEs; however, future researchers could examine and compare these results with large enterprises

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# Procurement of a Public Address System (PAS) in an urban rail transport company with the support of a PROMETHEE II multicriteria decision-making process

Nikolaos Panayiotou *
*National Technical University of Athens*
*Iroon Politexneiou 9, 15780, Zografou, Athens, Greece*

Vasileios Stavrou
*National Technical University of Athens*
*Iroon Politexneiou 9, 15780, Zografou, Athens, Greece*

Vasileios Aggelopoulos
*Urban Rail Transports S.A.*
*Athinas 67, 10552, Athens, Greece*

**Abstract**

The procurement of specialized systems which are meant to serve many stakeholders at the same time is a complex and multifactorial process. Usually, during the procurement process a number of potential suppliers are assessed. In many cases, products or services which are finally chosen does not satisfy the stakeholder needs due to the nature of the process or the failed criteria selection. The aim of the article is to present an alternative method for evaluating and selecting the optimal Public Address System (PAS) in order to be implemented in an urban rail transport company.

Based on the methodology followed, five possible alternatives (PAS) were initially rated in a series of 40 go / not go criteria. The four alternatives that met the necessary conditions passed to the second evaluation round. At this point of the process, the PROMETHEE II method and the corresponding VISUAL PROMETHEE software were used in order to rank the alternatives using a set of 42 criteria, each one with its own weight, classified in three groups (Functional, Technological and Financial Requirements).

In order for the final (ranking) result to be more reliable and stable, two different scenarios were analyzed, in each of which different criteria weights were used. The results of the two scenarios were combined into a final evaluation result. The PROMETHEE method which was applied in the presented case study reduced the degree of uncertainty during the selection process of the PAS. The methodology followed helped to structure the problem in a better way, which is a crucial fact, as only the appropriate criteria and appropriate weights can lead to the right decisions. In addition, based on the way the PROMETHEE method algorithm calculates the ranking of the alternatives, the final result is rendered acceptable to all stakeholders without any misunderstandings or objections.

## 1. INTRODUCTION TO PUBLIC ADRESS SYSTEMS AND URBAL RAIL TRANSPORT COMPANIES

### 1.1 General Use of Public Address Systems

A Public Announcement system (PAS) could be defined as an electronic system which includes microphones, amplifiers, loudspeakers and related equipment, aiming to increase the volume of a human voice, musical instrument or other audio source or recorded audio or music. PAS are used in any public space, which requires a speaker or performer to be heard at a distance or in a large area. Typical applications include sports stadiums, vehicles and public transport facilities, as well as live music events (Fu and Tan, 2010). A PAS can include many microphones or other audio sources, mixing consoles which combine and modify multiple sources and multiple amplifiers and loudspeakers for wider audio transmission.

More specifically, multi-speaker PAS are widely used to make announcements in public, institutional and commercial buildings and locations - such as schools, stadiums, ships and commercial aircrafts (Hung and Wu, 2014). Some PAS have loudspeakers which cover more than one building, covering for example the entire campus, an industrial area, a sports stadium or the entire urban rail network (Lin, 2013, Lin et al., 2013). A large PAS implementation can also be used as an alarm system during an emergency. Usually PAS meet specific requirements based on the environment in which they are about to be installed, consist of analogue and digital tiers, incorporating different technologies and used for the transmission of either information messages or emergency messages which are automatically excited.

### 1.2 Use of Public Address Systems in Urban Rail Stations

The need for control and safety at urban rail stations is growing during the years as more and more passengers choose urban rail as their main way of transport. The transmitted message in PAS must be reliable, clear and comprehensible. Urban rail facilities should be capable to transmit all kinds of messages and warnings to the public. The solutions provided (PAS) should allow connection from one station to the Operation Center (in all cases these systems are controlled centrally) and from passenger information mode to passenger warning mode (Kim, 2012 (1)). Different techniques and systems are interconnected to produce and transmit the appropriate message to the public. System operation is continuous and

uninterrupted. Usually these systems have the capability to operate locally from the station manager and remotely from the Operations Center, which also has the supervision of the whole system. The PAS usually offers functions such as regular announcements, scheduled announcements and notification broadcast in eligible zones. In many installations PAS are connected to fire alarm systems so that if smoke or fire is detected the PAS will deliver automatic announcements or signals in order to guide public (Awale and Deskmukh, 2014, Kim, 2012 (2)). Based on the abovementioned statements, it is concluded that the procurement of such a system is a complex process, focused on the satisfaction of many different specifications, while methodological support is needed for decision making.

## 2. METHODOLOGY

### 2.1 Description of the Case Study

This article deals with the selection of a new PAS in order to replace the existing obsolete system, which will be installed in an existing urban rail line in a European large city. The abovementioned urban rail line is managed by a company established in 2011. The company consists of 3 urban rail lines and one tram line. Line 1, which will be studied in this article, is depicted on the maps in green color. The largest part of the line is grounded and only a small part of the line extends into an underground tunnel. In 2019 line 1 comprises of 24 stations and one Operation Center, performing a route of a total length of 25.7 km. It is considered one of the world's oldest urban rail lines.

At each station of the line there is a PAS terminal which interconnects with the Operation Center. The person in charge in each station (station manager) has the ability to make local announcements via a microphone and an analogue and digital tier structure. The same structure is used remotely by the Operation Center. The use of this structure is performed under certain rules which are automatically controlled by the central system installed in the Operation Center. Certain rules regulate the priorities that system users have. For example, if a station manager who has local supervision wants to make an announcement at his own station, he/she should be able to do so even if at the same moment the PAS is busy by the Operation Center. In addition, the rule states that the station manager has the priority and can interrupt communication at any time (only locally) between Operation Center and the station. This means that Operation Center's announcement will not be heard at this station, but it will normally be broadcast to the other stations.

Likewise, local structures have interfaces which allow interconnection with other systems. For example, at a certain station due to the curved platform design, when the train stops there is a gap between the train and the train platform. In order to address this issue, an infrared system detects the presence of the train and instructs the PAS to transmit to the loudspeakers a recorded message. Finally, in the Operations Center there is a central console from which the Operation Center manager regularly transmits information messages regarding passengers at a specific station or all the stations or activates the transmission of a music carpet.

The Operations Center also has the option to transmit scheduled announcements which are repeated automatically based on a specific list. Such messages for example may refer to the ban of smoking and food within the stations, issues regarding ticket duration and much more. Quite often during the day, certain announcements are transmitted in order to inform the public about the change or delay of routes, the availability of lifts or escalators, etc. From all the above mentioned circumstances, it is understood that a PAS usually follows specific and predetermined operating procedures based on the environment being installed. Because the existing operating system in the presented case is obsolete and spare parts are no longer available for maintenance or repair, the company wants to replace it with a new system which fully meets its current needs and standards. This process can be implemented in a number of different ways, but in this case it was assisted using a Decision Making Software.

### 2.2 Public Address System Selection Steps

In order to select the appropriate PA system, a two-step methodology was used. At the first step, a number of criteria (40 go/not go criteria) were assessed. The systems offered should definitely meet these criteria before proceeding with further evaluation. At the second step of the methodology, alternatives which have passed the first step had been evaluated using PROMETHEE method using a pool of 42 criteria.

The PROMETHEE (Preference Ranking Organization METHod for Enrichment Evaluations) method was developed in the mid-1980s and is one of the most popular methods of multicriteria analysis (Bezhadian et al., 2010). It belongs to the category of outranking methods and the classification of the alternatives is possible through pairwise comparisons. It is used worldwide in a wide variety of scenarios in areas such as business, governmental institutions, transport, health care and education. PROMETHEE helps decision makers find the alternative best suited to their goal, providing an integrated framework for the decision problem. It is considered very useful when groups of people are working on complex problems, especially problems involving many criteria and many human perceptions. In the case which was analyzed, the PROMETHEE II method was used.

As regards the requirements of the new system (decision making criteria), they were described by the relevant departments which, based on the amount of information they had for the requested system, exported and finalized their perception. The PAS will be selected based on three main criteria groups:

- The functional requirements in order to transmit voice messages to the public. These requirements were analyzed into a number of corresponding criteria based on which the system will be chosen. For these requirements the main stakeholder is the Operations Department.
- The technological requirements set by the Maintenance Department. The Maintenance Department, in order to meet the demand of Operation Department, seeks a state-of-the-art system of specific technologies and specifications, easily accessible and customizable and especially a flexible system to meet future needs without additional costs. These requirements were also further analyzed in order to form well-defined criteria.
- The financial requirements were set by the Financial Department which is the third and final stakeholder.

In order to evaluate the alternatives, groups of requirements were deconstructed into smaller subgroups resulting in the last level where the evaluation criteria appear. The Departments involved exchanged opinions and finalized the selection criteria for the decision system as shown in the following lists:

- Functional (31 criteria)
- Technological (44 criteria)
- Financial (2 criteria)

The technological criteria from their part were divided into five sub-groups of requirements:

- Network Controller (17 criteria)
- Power Amplifier (8 criteria)
- Zone Selector (3 criteria)
- Microphone Unit (10 criteria)
- Interconnection Unit (6 criteria)

Some of the above criteria are binary criteria (YES - NO type), but some other get distinct values (quantitative). At this specific point of the process, the research team, discussed with the others stakeholders and finalized the selection of criteria which will participate in the first phase of the evaluation, as opposed to the others who will participate in the second evaluation phase. at that point, there were 40 criteria selected as go/not go criteria while 42 criteria will be included in the evaluation of the second phase through the PROMETHEE II method. This practically means that five criteria will be involved in both evaluations (in the first assessment if an alternative scores below a threshold is excluded, while in the second phase the remaining alternatives will be assessed based on quantitative methods).

As a next step, criteria weights were defined. Criterion weight is considered the relative importance of a criterion compared to others criteria weights. Each criterion has a positive weight, and all weights are summed up to 100. The weighting process of the criteria is defined by the parties involved on the basis of their requirements and needs and basically reflects their system of values and preferences. In the case study analyzed, two scenarios will be considered. In the first scenario the alternatives will be evaluated, giving to the Functional requirements a weight of 40%, to the Technological requirements a weight of 30% and to the Financial requirements a weight of 30%. These percentages should be transferred to corresponding criteria. The same way, 30% of the technological requirements will be allocated to the five subgroups (Network Controller 13%, Power Amplifiers 6.4%, Zone Selector 1.6%, Microphone Unit 6%, Interconnection Unit 3%) and the subgroup percentage to the corresponding criteria and 30% of the Financial requirements to the two remaining criteria.

In the second scenario the alternatives will be evaluated, giving to the Functional requirements a weight of 30%, to the Technological requirements a weight of 40% and to the Financial requirements a weight of 30%. These percentages should also be transferred to corresponding criteria, which means that 30% of the Functional requirements will be divided to the corresponding criteria. The same way, 40% of the Technological requirements will be allocated to the five subgroups (Network Controller 17%, Power Amplifiers 8,5%, Zone Selector 2,1%, Microphone Unit 8%, Interconnection Unit 4,4%) and the subgroup percentage to the corresponding criteria and 30% of the Financial requirements to the two remaining criteria. The weight of the two scenarios is equal (50% each).

It should be noted that the Financial criteria, such as Cost of Acquisition and Maintenance Costs, include indifference threshold (Q) and preference threshold (P). It is considered that the P variable (corresponds to the smallest definition that is considered as definitely important when two alternatives are compared) in the Acquisition Cost criterion is defined as P = 20,000 euro while Q variable (represents the largest deviation that is considered as negligible in the comparison of two alternatives) is Q = 5,000 euro. Similarly, for Maintenance Costs it was defined Q = 1,000 and P = 4,000.

In the case study examined, five possible alternatives were assessed. The first alternative is a solution from an Italian company with extensive experience in transmitting audio messages over Ethernet infrastructure. Its systems deliver full two-way communication between all active positions. The second alternative is a solution from a Belgian company which manufactures systems based on IP networks. All of its devices (amplifiers, alarm boards, microphone consoles, access

devices, etc.) can connect old technologies with new ones through a wide variety of Ethernet interfaces and networks. It uses open protocols to facilitate the general supervision of the system. The third alternative is a solution from a Spanish manufacturer of high quality PAS. With more than 35 years of experience, the technology developed in the European Union has provided advanced audio solutions to meet the customer needs. Its systems use open protocols and open standards to provide a high level of flexibility. The fourth alternative is a solution from a company, founded in 1989 as an electronic design consultancy, started its activity in the voice alarm market by designing top technology systems for a well-known urban rail in 1999. The company is now established as a major supplier to a large transport industry. It covers many facilities such as stadiums, airports, hospitals, retail, commercial buildings, nuclear, oil and gas, roads and tunnels. The last alternative is provided by a company founded in 1934 in Japan, and has extensive experience in researching, developing and selling professional audio and security equipment. Since 1972 specializes in the manufacturing of automatic announcement systems for use in railway sector, providing a variety of solutions which help improve passenger service increasing the efficiency of railway companies, including announcement systems and safety cameras for both stations and vehicles.

## 3. SELECTION OF THE BEST AVAILABLE SOLUTION

The first evaluation stage was based on the assessment of the five alternatives regarding the prerequisite criteria (go –not go criteria). This assessment was performed in MS Excel software. Based on the evaluation of the five alternatives, only one alternative (number five) was excluded and the remaining four alternatives passed to the next evaluation step. During the next step, all the necessary data were imported in VISUAL PROMETHEE (the software which was used in order to implement the PROMETHEE II assessment) and all the available parameters were defined. The available criteria and their weights, the four remaining alternatives and the two scenarios, each one with its one weight were imported to the software while criteria groups were created. After the import of the variables, the scores in each criterion were inserted for each scenario, and then the evaluation process was performed with the use of the VISUAL PROMETHEE software. The results of the assessment are depicted in table 1:

Table 4: PROMETHEE Table Results

| Rank | Action | Phi | Phi+ | Phi- |
|------|--------|-----|------|------|
| 1 | Alternative 3 | 0,1271 | 0,3237 | 0,1966 |
| 2 | Alternative 1 | -0,0159 | 0,2198 | 0,2357 |
| 3 | Alternative 4 | -0,0463 | 0,2894 | 0,3357 |
| 4 | Alternative 2 | -0,0649 | 0,2374 | 0,3023 |

Figure 5: PROMETHEE Ranking Results
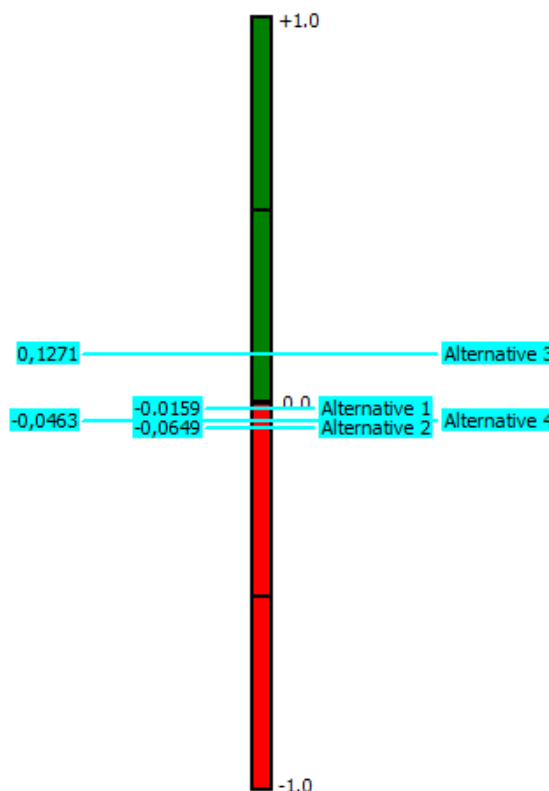
As shown in the table, alternative 3 is the optimal PAS with a positive Φ equal to 0,1287, followed by alternative 1 with negative Φ (Φ = -0.013), alternative 4 (Φ = -0.0356) and the last option is alternative 2 (Φ = 0.0801). The first key observation arises from the fact that the best solution proposed is not the solution with the lowest purchase price, taking also into account a number of additional parameters. This is considered a main differentiation from the current situation where, although legally a cost-benefit analysis is possible and feasible, in practice the choice is made taking into account the lowest price criterion, a fact which can lead to a number of future problems. The results are depicted graphically on Figure 1:

## 4. CONCLUSIONS AND FURTHER RESEARCH

The selection of complex systems which are meant to serve many stakeholders at the same time is a complex process given that the global market offers a lot of solutions with the same or slightly different characteristics. In addition, the responsibility of the final choice belongs to the person or persons who will make the choice. MCDA theory and tools can support the final choice using scientific methods, reducing the likelihood of human error.

Procurement processes often end up with a selection which does not satisfy the stakeholders needs because the selection is based on a single criterion, the financial one. Certainly, the financial view of a procurement decision is of great importance, but it is not the only one because the value offered by the selected solution has also to be taken into account. For this reason, a method was applied which evaluates the PAS offered item so that along with the price the final choices are assessed on a number of issues related to their operation. The suggested "value-for-money" calculation goes beyond the traditional evaluation methods used in similar case, offering decision support in a transparent, analytical and fair manner.

The present study attempted to find a way in order to ensure that any future procurement of PAS will be taking into account a number of parameters addressed by the stakeholders. In this way, and using decision-making tools, there is no room for misinterpretation in the final choice, so all stakeholders involved are confident about the alternative which is proposed using the evaluation process and the way this result arises.

The research effort should be intensified in the comparison between different MCDA methods in order to identify the parameters that determine the use of the most appropriate approach to be used, based on the nature and the specific characteristics of the decisions involved.

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# Measuring consumers' e-shopping and delivery service experience within a behavioral context

Alexia Irakleous [1]
*Department of Shipping and Trade, University of the Aegean, 2a Korai Street, 82132 Chios, Greece*

Panagiotis Karsiotis [2]
*Hellenic Post S.A. Stadiou 60 str., 10188, Athens, Greece*

Seraphim Kapros [3]
*Department of Shipping and Trade, University of the Aegean, 2a Korai Street, 82132 Chios, Greece*

**Abstract**

An online business should be aware of what e-shopping and delivery service elements satisfy consumers' needs. Understanding consumers' e-shopping and delivery services experience can contribute to e-retailers' business success as well as to developing competitive parcel delivery services for the transport and logistics service sector. This paper aims to conceptualize consumers' most recent delivery service experience using a quantitative research methodology, based on questionnaires, which resulted in a sample of 200 responses. The results of the statistical analyses have demonstrated that consumers' characteristics like age and profession impact on the choice of product type and e-shop origin. Measuring overall customers' satisfaction from e-shopping and delivery services, it was found that the provision of value-added services were the most weak delivery service element. Applying Exploratory Factor Analysis, it was shown that dimensions of satisfaction scale were clustered in two components distinguishing e-shopping elements from delivery service elements.

## 1. INTRODUCTION

The rising effect of e-commerce has changed the way goods are delivered as a result to influence customers' purchase decisions and parcel providers' delivery services. The different options of delivery services and consumers' perceptions towards quality of services are major criteria for e-shoppers which impact on e-retailers' success in the e-business marketplace. From an operational point of view, delivery services include logistics elements, like delivery time, point of delivery, track and trace services which are related with the transport and logistics service industry. E-commerce business has to consider issues such as web-site appearance, product variety and value, payment methods and information systems. However, these two different worlds need to work in parallel, and become fully aligned to respond to the requirements and consumers' demands.

E-shopping in Greece has increased in a considerable rate within the last three years. There are 3.5 million Greeks who purchase online products or services with a total value of approximately 5 billion euros (Eltrun, 2018). They choose to shop online mainly because of finding lower prices or discounts and they can get better product information than in physical stores. The greatest majority of consumers, 85.6 % purchased from domestic e-shops, and 62% of consumers delivered their online order for free. The product category that is most frequently purchased was clothing and footwear at 31%, followed by consumer electronics at 25%. An online order is characterized of low value, almost 40% was up to 25€, of light weight 89% of online orders were weighted up to 2kg and 34% of them could fit in a letterbox (IPC, 2018). A great percentage 70% was asking improvement for free return and 66% simple and reliable return process. E-commerce logistics are providing by three main different types of market players and these are National Post Operators (NPOs), Global Integrators, and Last Mile Specialists. They can be represented as a multi-actor system in the transport and parcel delivery industry who are highly interconnected. The main difference between them lies in the network coverage as a consequence to the logistics services offered to their clients. This growth of e-commerce raises questions about how service interfaces, should be designed to manage the total customer experience. Trevinal and Stenger (2014, p.324) use the term online shopping experience and state that it is 'a complex, holistic and subjective process resulting from interactions between consumers, shopping practices (including tools and routines) and the online environment (e.g. shopping websites, online consumer reviews, and social media)'. The aim of this paper is to conceptualize consumers' most recent e-shopping and delivery service experience and measure overall satisfaction. By measuring customer satisfaction which is the consequence of the customer's experience during the buying process (Kotler, 1997) can provide important knowledge to understand

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[1] Alexia Irakleous: alexia_iracleous@yahoo.gr
[2] Panagiotis Karsiotis:pkarsiotis@elta-net.gr
[3] Seraphim Kapros: skapros@aegean.gr

what directly affects customers' future behavior. Therefore, the research question of this paper is how consumers' delivery service experience can influence on overall satisfaction of e-shopping and delivery service? A research model is proposed to investigate the relationships among consumer delivery service experience and satisfaction in the e-commerce environment.

In the following sections, the theoretical background concerning the concepts of e-shopping, delivery service and satisfaction, is described. Following this, the research model is presented together with the hypotheses that will be tested. A customer satisfaction scale is developed which will be used to measure consumers' delivery service experience. Factor analysis was used to verify reliability and validity of the emerging dimensions. The paper concludes with results discussion. This study can help both scholars and practitioners understand the importance of consumers' e-shopping and delivery service experience within the e-shopping environment across customers in Greece.

## 2. THEORETICAL BACKGROUND

E-shopping experience refers to the cognitive state which is manifested as a subjective response to the e-retailers website, Rose et al. (2012, p. 309). Consumers who choose to proceed with e-shopping instead of in-store shopping, are looking for convenience, product information and product offers and discounts. Delivery service is a key element in the e-shopping experience and has a decisive role for e-shoppers' intention to buy online in the first place as well as for future purchases. Although the provision of delivery service is an issue between the retailer and the transport service provider, the services to be developed need to identify consumers' demandsand especially under what conditions a customer is willing to pay for these services. Consumers expect more choices between different delivery options especially in terms of time and place of delivery.

In consequent, understanding consumers' behavior and identifying the main factors that affect the e-shopping and delivery service is not only important for developing effective retailing strategies, but also for predicting the responsiveness to specific delivery service attributes of heterogenous consumer segments.

Consumers' satisfaction in the e-commerce environment has a critical role as it can be a primary predictor of the Internet retailer's durability and success (Gummerusetal.,2004; Harrisand Goode, 2004; Christodoulides and Michaelidou, 2011). Chen and Dubinsky (2003) define customer satisfaction in two different ways. Firstly, the customer satisfaction is the emotional decision by consumers in response to their most recent experience with a retailer in terms of product, or service aspects. Secondly, over a period of time, the cumulative customer satisfaction results from the customer's overall shopping experience with a specified online retailer. Satisfaction can be reflected by the overall customer attitude towards e-commerce retailers, (Hansemark and Albinson,2004). Oliver (1997) defines satisfaction as "the summary of psychological state resulting when the emotion surrounding disconfirmed expectation is coupled with a consumer's prior feelings about the consumer experience". According to Anderson and Srinivasan (2003),

customer satisfaction is direct related with the performance of e-commerce firms. According to Maslow (1943) motivation theories state that people are driven by the desire to satisfy their needs, whereas satisfaction can be viewed as the end-point in the motivational process.

Different elements can constitute e-shopping customer satisfaction. Szymanski and Hise (2000) concluded that convenience, product offering/information, site design, and financial security are four factors that influence customer satisfaction. McKinney et al. (2002) found that information quality and system quality are two main factors impacting customer satisfaction. Further, in an analysis of service quality in terms of web portals, Gounaris and Dimitriadis (2003) combined SERVQUAL which consisted of transparence, dependence, sympathy, and warranty with the WEBQUAL instruments including function, information and interaction. They concluded that the quality dimensions can be grouped into three main aspects; these are i) customer protection and risk decreasing comprising secure online payment and shipping aspects in terms of time, costs and options, and communication; ii) comprehensive information and its relevance; and iii) interaction consisting of online direction, website characteristics and ease of use. Since then, researchers have concluded that four main elements mostly influence customer satisfaction in the online shopping environment which are i) website design, ii) delivery and refund service, iii) detailing extent with respect to product information provided, and iv) the product variety (Chintagunta et al., 2012; Cao and Li, 2015; Kumar et al., 2009). Jain et al. (2017) conducted an extensive literature review and suggested that availability, timeliness, condition and ease of return, along with e-business quality, product quality, and pricing, are linked to shopping satisfaction and repurchase intention of customers in e-tailing. Although researchers may use different constructs, in essence, they are quite similar to those proposed by Zeithaml et al.,2002. In this research were considered, only those attributes that are relevant with the subject of this research. In particular, customer satisfaction in relation with e-shopping and delivery service.

## 3. RESEARCH METHODOLOGY

In this section the research model and hypotheses that are intended to explain the relationships between overall satisfaction of e-shopping and delivery service, e-shopping characteristics, e-shoppers' characteristics and consumers' delivery service experience in the Greek e-commerce market are presented. The conceptualization of the research model

is depicted in Figure 1. An online survey was conducted to collect data on consumers' most recent e-shopping experience. Questionnaire was developed using Sawtooth Software, and disseminated through internet social networks. The survey took place in the period of May to September 2018 and data were then analyzed using SPSS statistical software package. The total number of valid questionnaires that were collected was from 200 respondents.

**Figure 1** Research Conceptual Model
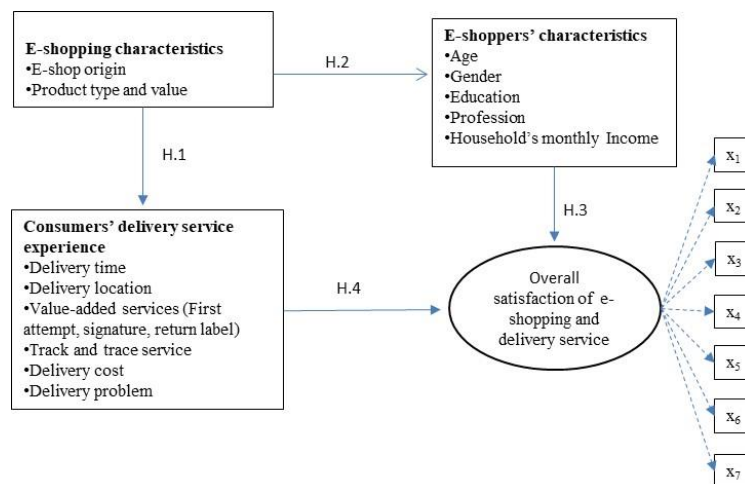


In this model, the effect of each of the variables was examined and four hypotheses for testing the relationships between the variables of the framework were formulated and produced. These are the followings:

H.1    Consumer delivery service experience is dependent on e-shopping characteristics

H.2    E-shoppers' characteristics are dependent on e-shopping characteristics

H.3    Overall satisfaction of e-shopping and delivery services is dependent on e-shoppers'    characteristics

H.4    Overall satisfaction of e-shopping and delivery services is dependent on delivery service  experience

The scale developed to measure consumers' satisfaction for e-shopping and delivery service  is based on the attributes including in Zeithaml et al., 2002 and consists of seven elements as they are described below.

- S.1. Order reliability (on time and at the right place):  Order reliability refers to the ability to perform the promised service dependably and accurately (Stank et al., 1999, 2003). Consumers are satisfied when their parcels are delivered as per request and at the promised time.
- S.2.Frequent electronic notifications for order status: Information is an important resource for online consumers, because they can obtain order status and be aware for the delivery time.
- S.3. Choice of value-added delivery services (e.g. choose specific time-window, return service): In this dimension are included, services that the customer can require them in addition to main service's characteristics and are provided in an additional fee.
- S.4 Lower product price compared with the physical store's price: E-shops can provide offers and discounts more often than physical stores due to the greater product variety they have.
- S.5 Complete and accurate information for the product I wanted to purchase:  Information is an important resource for online consumers, because they can obtain it directly from a Web site rather than having to go through salespeople in an offline store.
- S.6 The website of the e-shop was attractive and user friendly: It is important for consumers to be able to navigate easily in the e-shop environment, so as to minimize their effort for online shopping.
- S.7 I received clear information about the total cost of my electronic purchase prior to check out:
    Inefficient and troublesome procedures when checking out the online order will annoy online     shoppers and could put them off from attempting to get the order through. It will raise the     customer's degree of satisfaction if the checkout stage is straightforward and the transaction can be completed quickly.

The items of the customer satisfaction scale were measured in a seven- point Likert scale, where possible answers ranged from '1' means very dissatisfied and '7' means extremely satisfied whereas '4' means neither satisfied nor dissatisfied.

## 4. DATA ANALYSIS AND RESULTS

### *4.1 Sample Profile*

The descriptive data of the 200 respondents indicated that male and female were almost equally distributed (54.5% Male and 45.5% Female) whereas the majority of the respondents, 62.5% were in the age category of 37-55 years old, 54% were holding an MSc degree and almost 80% of respondents were having a full-time job. The monthly household income was approximately equally distributed within the five income categories approximately at 20% in each category, and only a slight increase at 25% was noticed in the fifth income category of > 2.500 euros. Concerning e-shopping characteristics respondents preferred to shop from domestic e-shops at 64% and less from foreign e-shops. The two most frequent purchased product types were apparel and shoes at 29%, followed by pharmaceutical and cosmetics at 18%. A significant proportion of respondents, almost 16% have chosen 'other' as a product category where they mentioned books or mechanical equipment. Finally, 13% of respondents have chosen to shop electronic devices. Almost half percent 47%, of the product value were in the second value category of 31-80 euros.

### *4.2 Hypothesis testing*

Table 1 presents the results of chi-square test applied to test H1. It was found that, delivery time was statistically significant with e-shop origin and product type. Electronic notifications were statistically significant only with e-shop origin whereas delivery cost was statistically significant with e-shop origin and with product value. Finally, delivery problem was statistically significant with product type. All other variables of delivery service experience had no statistical significance with any of the e-shopping characteristics. It seems that consumers didn't face any problems with the point of delivery service and they didn't request any value-added services.

**Table 1** Consumer delivery service experience vs. e-shopping characteristics

| Consumer delivery service experience | e-shopping characteristics | | |
|---|---|---|---|
| | e-shop origin | product type | product value |
| delivery time | (13,619) 0,034 | (45,363) 0,015 | (3,307) 0,769 |
| point of delivery | (4,253) 0,119 | (7,897) 0,545 | (0,663) 0,718 |
| track and trace | (15,835) 0,045 | (31,353) 0,689 | (9,568) 0,297 |
| delivery cost | (37,943) 0,001 | (21,919) 0,741 | (14,296) 0,026 |
| delivery problem | (12,186) 0,431 | (72,229) 0,049 | (18,857) 0,092 |
| value-added services | (2,394) 0,880 | (32,846) 0,202 | (7,385) 0,287 |

Regarding the second hypothesis, it was found that, only two types of e-shoppers' characteristics were statistically significant with e-shopping characteristics and these were 'age' which was statistical significant with product type ($\chi^2$=32.908 and $p$=0.017) and with product value ($\chi^2$=11.603 and $p$=0.021). Consumers' profession was statistical significant only with e-shop origin ($\chi^2$=16.536 and $p$=0.035). All other e-shoppers' characteristics had no statistical significance with any of the e-shopping characteristics.

The same e-shoppers' characteristics have shown statistical significant results with some of the dimensions of the satisfaction scale. The age of consumers was statistical significant with 'e-shop product information' ($\chi^2$=30.784 and $p$=0.002) and 'e-shop web page user friendly' ($\chi^2$=22.610 and $p$=0.031) whereas the profession of consumers was statistical significant with 'e-shop product information' ($\chi^2$=37.791 and $p$=0.036), with 'e-shop web page user friendly' $\chi^2$=49.180 and $p$=0.002)and with 'e-shop easy check out' $\chi^2$=67.229 and $p$=0.001). All other dimensions of satisfaction scale had no statistical significance with e-shoppers' characteristics. The results so far, notify that consumers' age and profession determine the selection of e-shop origin as well as product type, whereas the elements of e-shopping of the satisfaction scale are also positively related.

The results of the fourth Hypothesis which measured the relation between satisfaction scale and consumers' delivery service experience are presented in Table 2. From the seven-point likert scale only three satisfaction dimensions were statistically significant with more than one attributes of consumers' delivery service experience. In particular, S1.'Reliable delivery' has shown statistical significance with value-added services and with delivery problem, S2. 'Frequent electronic notifications of order status' was statistically significant with track and trace services and with value-added services and the third scale dimension was S5. 'Complete and accurate information for the product I wanted to purchase' which was

statistically significant with delivery problem and value-added services. All other satisfaction dimensions S4. 'Lower product price compared with the physical store's price', and S6. 'The website of the e-shop was attractive and user friendly' was statistically significant with value-added services. Only S3. 'Choice of value-added services' was statistically significant with delivery time. The results showed that consumers' experience was lacking of the provision of value-added services (like signature on delivery, redirect order etc.).

**Table 2** Overall satisfaction from delivery service in relation with consumers' delivery service experience
$*p<0.05, **p<0.01$

| Overall Satisfaction from e-shopping and delivery services | Consumers' delivery service experience | | | | | |
|---|---|---|---|---|---|---|
| | delivery time | point of delivery | track and trace | delivery cost | Delivery problem | Value-added services |
| S1. Order reliability (on time and at the right place) | (28,520) 0,055 | (3,376) 0,760 | (23,142) 0,511 | (15,396) 0,635 | (85,457) 0,001 | (43,033) 0,001 |
| S2. Frequent electronic notifications for order status | (20,090) 0,328 | (3,447) 0,751 | (45,887) 0,005 | (18,897) 0,339 | (38,915) 0,340 | (35,604) 0,008 |
| S3. Choice of value-added services | (30,561) 0,032 | (11,054) 0,087 | (22,501) 0,549 | (13,429) 0,766 | (42,570) 0,209 | (22,513) 0,210 |
| S4. Lower product price compared with the physical store's price | (12,529) 0,819 | (4,474) 0,613 | (21,633) 0,601 | (19,541) 0,359 | (42,855) 0,201 | (56,883) 0,001 |
| S5. Complete and accurate information for the product I wanted to purchase | (18,772) 0,406 | (4,251) 0,643 | (24,890) 0,412 | (15,727) 0,612 | (52,767) 0,035 | (39,202) 0,003 |
| S6. The website of the e-shop was attractive and user friendly | (13,308) 0,773 | (6,187) 0,403 | (26,252) 0,341 | (17,384) 0,497 | (42,132) 0,223 | (31,504) 0,025 |
| S7. I received clear information about the total cost of my electronic purchase prior to check out | (5,780) 0,983 | (1,940) 0,857 | (9,744) 0,973 | (9,134) 0,870 | (26,855) 0,631 | (24,912) 0,051 |

Having proceeded with Hypothesis testing, Figure 2 below presents, the measurement results of the overall customer satisfaction scale. The scale dimension with the highest percentage was S7. 'E-shop easy check-out' in which 63% of consumers replied as extremely satisfied. At the opposite side, is S3. 'Value-added services' which received the lowest rate as 10.5% of respondents replied as dissatisfied. S6. 'E-shop web page user friendly' and S4. 'E-shop product price' were evaluated by consumers almost with the same percentage at 31% as very satisfied. Considering, S1. 'Reliable delivery service', more than half percent of the consumers 72% are quite satisfied with the service they received. It seems that reliable delivery (on time and at the right place) is performed quite well by the transport service providers, thus consumers replied very positively. As far as S2. 'Frequent electronic notifications', is concerned, there seem to be a few issues as a significant percentage 36.5% of consumers, were expressed satisfied or neutral attitude. Finally, S6. 'E-shop user friendly' was rated with a high percentage as only a small percentage of consumers, approximately 10% weren't satisfied from this service.

**Figure 2** Measurement Customer Satisfaction Scale of e-shopping and delivery service



50
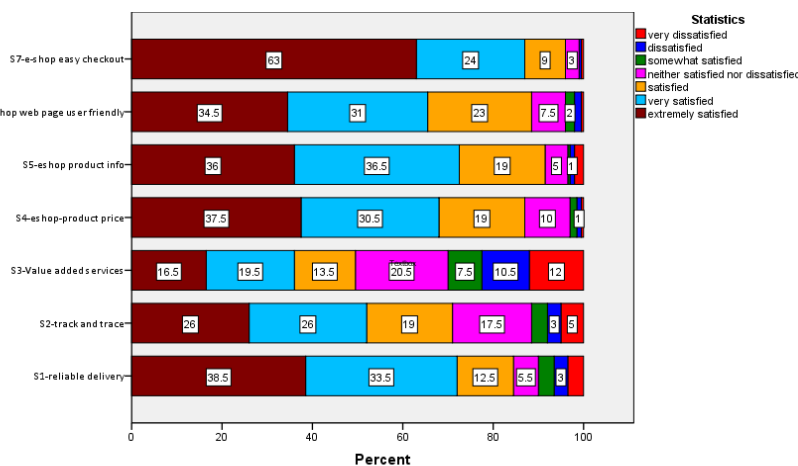
### 4.3 Factor Analysis

Although the dimensions of the satisfaction scale include attributes from both e-shopping and delivery services, consumers' experience is conceptualized considering only delivery service attributes. For this reason, an exploratory factor analysis was applied in order to analyze how consumers' satisfaction varies between these two different types of operational services. Factor analysis (EFA-Principal Components) was applied to identify latent factors within the service quality of e-shopping and delivery service quality scale and to verify reliability and validity of the emerging dimensions. Factor analysis is a means of summating information contained in a large number of variables into a smaller set of new composite factors, with a minimum loss of information (Hair et al., 2010). A principal component analysis (PCA) was conducted on the seven-items satisfaction scale with orthogonal rotation (varimax). The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis, KMO = 0.818>0.60 which was well above the acceptable limit of 0.5 (Field, 2009). Bartlett's test of sphericity $\chi^2$ (481,027), Bartlett's sign<0.001 indicated that correlations between items were sufficiently large for PCA. Therefore, the data were suitable for the application of factor analysis. Customer satisfaction scale included 7 items, but 2 factors were extracted after the exploratory factor analysis. Factor 1 had an eigenvalue of 3.445 and explained 49,22% of variance. This factor referred to S5, S6, S4, S7 which refer to e-shopping characteristics. The second factor had an eigenvalue 1.109 and explained 15.8% of variance and refers to the scale dimensions associated with S2, S1 and S3 which are related with delivery service. Combining these two factors explained 65.053% of the variance. Table 4.4 shows the factor loadings after rotation.

**Table 3** Factor Loadings after rotation

| Satisfaction scale | Component | |
|---|---|---|
| | 1 | 2 |
| S5. Complete and accurate information for the product I wanted to purchase | .839 | |
| S6. The website of the e-shop was attractive and user friendly | .836 | |
| S4. Lower product price compared with the physical store's price | .730 | |
| S7. I received clear information about the total cost of my electronic purchase prior to check out | .724 | |
| S2.  Frequent electronic notifications for order status | | .781 |
| S3. Choice of value-added services | | .781 |
| S1. Order reliability (on time and at the right time) | | .746 |

Kaiser-Meyer-Olkin Measure Sampling Adequacy=0.818
Bartlett's Test of Sphericity: $\chi^2$=481.027, p=0.001

Results have shown that e-shopping characteristics and delivery service characteristics are different groups of service elements therefore consumers have evaluated their quality under a different perspective.

## 5. DISCUSSION AND CONCLUSIONS

The increasing trend of Greek consumers to purchase online, especially from domestic e-shops, requires the development of more efficient and innovative delivery service models. As customer satisfaction refers to the overall customers' evaluation of the product or service after purchase (Choi et al., 2013), e-retailers need to communicate with e-shoppers more often regarding their e-shopping experience.

The purpose of this paper was to conceptualize consumers delivery service experience by measuring overall consumers' satisfaction of e-shopping and delivery service. The research question was to investigate the impact of consumers' delivery service experience on the overall e-shopping and delivery service satisfaction. Having tested the four Hypotheses of the research model, it was found that the most prevalent e-shoppers' characteristics were age and profession which impact on product type and value and e-shop origin. The same e-shoppers' characteristics have played a critical role in overall satisfaction measurement in terms of e-shopping characteristics rather than in delivery service. Concerning e-shopping characteristics, it was found that e-shop origin relates positively with track and trace services as well as delivery cost. Obviously online cross-border requires a higher transport cost and a more frequent order status control to be afforded by consumers. Product type is another e-shopping characteristic that is related positively with delivery problems and delivery

time. Consumers' are relatively satisfied with their experience of delivery service except of not receiving value-added services, like signature on delivery, potential to re-route online order. These types of services are provided with an extra cost from parcel providers to e-retailers in consequence end-consumers need to pay extra for any additional service. The seven-dimensions satisfaction scale was analyzed applying Exploratory Factor Analysis and it was found that e-shopping elements were clustered in the first component and delivery service elements in the second component. These results indicate that e-shopping and delivery services are providing under two different operators, who are e-retailers and delivery service providers respectively. E-shopping cannot exist without delivery service, in consequence these two service dimensions need to be fully aligned.

Consequently, service quality is clearly linked to customer satisfaction and shapes customers' experience. More specifically it has been demonstrated that parcel delivery service providers need to work closer with e-retailers to develop a wide range of e-service quality management practices if they are to get the most from their e-commerce activities. Such observations highlight the fragmented business environment in transport and logistics services in Greece, and how critical is to develop customized services for consumers. In such settings, transport service providers can succeed competitive advantage in such a rapid changing business environment.

The discussion made above indicates that e-shopping and delivery services in Greece constitute a market that is under development and that further cooperation between transport operators and e-retailers need to be attained. Apparently, service quality is clearly linked to customer satisfaction and shapes customers' experience. However, no matter how positive customer attitudes, behaviors and experiences may be, consumers' delivery service experience should be conceptualized, as the degree to realize whether consumers' service needs have been accomplished. If this is not being quantified into tangible and positive business benefits, then it cannot be argued that any e-commerce initiative has been truly successful.

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# MCDA for assessing the impact of digital transformation on hotel performance in Thessaloniki

Dimitrios Mitroulis

*School of Information Sciences, Department of Applied Informatics, University of Macedonia, Thessaloniki, Greece.*

tm1133@uom.edu.gr

Fotis Kitsios

*School of Information Sciences, Department of Applied Informatics, University of Macedonia, Thessaloniki, Greece.*

kitsios@uom.gr

**Abstract**

In a digital economy, customer experience is heavily influencing customers' hotel decision processes. This is the main reason explaining why hotels are looking for how new digital technologies could enable their transformation, stay ahead in competition and improve their organisational performance. Even though existing literature discusses the benefits of digital transformation, measurement of its impact on organisational performance is still vague. Therefore, the aim of this research is to explore the impact of digital transformation on hotels' performance. Data were collected addressing questionnaires to senior hotel and IT executives in Thessaloniki, Greece. The collected data were analyzed using the MUSA (MUlticriteria Satisfaction Analysis) method. The results of this research provide further information related to the impact of digital transformation on hotels' performance. Moreover, it seems that senior hotel and IT executives are somehow satisfied with the organisational performance after enabling digital transformation.

**KEYWORDS**

Digital transformation, strategy, organisational performance, digital innovation, MCDA

## 1. INTRODUCTION

Digital transformation refers to the changes in the organisation`s structure, processes, products or services and business models caused by the adoption of digital technologies in order to radically improve its performance (Hess et al. 2016; Matt et al. 2015). By integrating new digital technologies and organisational processes, many significant improvements in business performance are generated (Angelopoulos et al., 2008). Digital transformation could provide a variety of benefits for an organisation including the improvement of the organisational processes, customer value propositions enhancement, the improvement of quality of customer services, the achievement of customers engagement, the reduction of costs of products or services, the increase of innovation, competitive advantage, customer retention, and the improvement of customers' experience (Chen et al., 2016; Nwankpa and Roumani, 2016; Mitroulis and Kitsios 2019b). These are the advantages which motivate organisations to invest in digital transformation.

Due to the rapid growth of digital transformation, many hotels continuously invest on new digital technologies and digitalisation (Lam and Law, 2019; Mitroulis and Kitsios, 2019b). More specifically, hotels aim to improve customers' experience, which is one of the key enablers for adopting digital transformation (Lam and Law, 2019). Many different organisational capabilities are obtained by digital transformation supporting their customer processes, effective customer engagement, product and service features improvement and provides added value for their customers, enhancing customers' experience (Lam and Law, 2019;Kitsios et al., 2013; Kitsios and Skiadas, 2001; Kitsios and Sindakis, 2014; Mitroulis and Kitsios, 2019b).

Few attempts have been made to develop a comprehensive framework in order to facilitate the implementation of digital transformation and improve business performance in organisations. The purpose of this paper is to develop an MCDA approach of digital transformation in order to evaluate its impact on hotels' performance in Thessaloniki, Greece.

The structure of this paper is as follows. Section 1 includes a brief introduction to previous researches. Section 2 presents the satisfaction criteria and the methodology of the research. Section 3 presents the results which were exported from the implemented methodology. Finally, Section 4 discusses the results and concludes the paper.

## 2. MATERIALS AND METHOD

### 2.1 Satisfaction criteria

Digital technologies such as analytics, big data, cloud computing, social networking, mobile platforms and artificial intelligence enhance innovations by reshaping business models and reinvesting business operations (Berman, 2012;

Bharadwaj et al. 2013; Chanias, 2016; Matt et al. 2015; Mitroulis and Kitsios 2019a). Digital transformation refers to changes and transformations which are enabled and based on new digital technologies. Enterprises are continuously transformed and developed in accordance to the changing business environment. Therefore, digital transformation refer to the changes founded on digital technologies, guiding distinctive transformations in firms' operations, processes and value creation (Chanias et al. 2018; Henriette et al., 2016; Shaughnessy, 2016). It is distinguished from digital upgrade because digital transformation does not only increase efficiency and effectiveness in firm's processes but also provide the basis for radically changing the overall firm's operations, value creation and occasionally offering new digital product or services (Lam and Law, 2019). Organisations are capable of integrating digital technologies in many stages of their operations and are also able to engage customers taking advantage of digital innovations (Bharadwaj et al. 2013; Nadeem et al., 2018). The successful application of digital transformation could lead to superior performance, generating revenue exploiting the existing resources (Chen et al., 2016; Kitsios et al., 2019; Mitroulis and Kitsios, 2019b).

Organisational performance refers to the measurement of firm's ability to meet its aims and objectives in comparison to its competitors (Kamariotou et al., 2018; Mitroulis and Kitsios, 2017). Generally, superior organisational performance is usually characterized by profitability, growth and market value (Mitroulis and Kitsios, 2017).

Considering the effect of digital transformation on organisational performance, firms seem to be more capable of achieving improved customer offerings making use of customization, improved customer satisfaction, and reduced selling costs (Kitsios et al., 2009; Kitsios and Grigoroudis, 2014; 2016; Kitsios et al., 2015). Prior researches on the results of digital technologies suggest that digital transformation could positively influence organisational performance (Chen et al., 2016; Nwankpa and Roumani 2016). Digitally embedded business processes lead to higher performance benefits, which derive from the organisation's IT capabilities (Nadeem et al., 2018). Companies, which leverage digital technologies, attempt to improve performance through the transformation of customer experience and the synchronization of data, information and ideas (Sia et al., 2013). Table 1 presents the criteria which were selected in order to measure the impact of digital transformation on hotels' performance.

Table 1 Satisfaction Criteria

| Criteria | References |
|---|---|
| Customer retention | Chen et al. (2016); Lam & Law (2019); Mitroulis and Kitsios (2019b) |
| Customer satisfaction | Chen et al. (2016); Lam & Law (2019); Mitroulis and Kitsios (2019b) |
| Employees performance | Chen et al. (2016); Mitroulis and Kitsios (2019b) |
| Improvement in products/services | Chanias et al., (2018); Chen et al. (2016); Hess et al., (2016); Matt et al., (2015); Mitroulis and Kitsios (2019b); Nadeem et al., (2018); Nwankpa & Roumani, (2016); Sebastian et al., (2017) |
| Increase of operational efficiency | Chanias et al., (2018); Chen et al. (2016); Hess et al., (2016); Matt et al., (2015); Mitroulis and Kitsios (2019b); Nadeem et al., (2018); Nwankpa & Roumani, (2016); Sebastian et al., (2017) |
| Innovation | Chanias et al., (2018); Chen et al. (2016); Hess et al., (2016); Matt et al., (2015); Mitroulis and Kitsios (2019b); Nadeem et al., (2018); Nwankpa & Roumani, (2016); Sebastian et al., (2017) |
| Increase of ROI | Chen et al. (2016); Mitroulis and Kitsios (2019b); Nwankpa and Roumani (2016) |
| Increase of profitability | Chen et al. (2016); Mitroulis and Kitsios (2019b); Nwankpa and Roumani (2016) |
| Increase of sales revenue | Chen et al. (2016); Mitroulis and Kitsios (2019b); Nwankpa and Roumani (2016) |
| Market share growth | Chen et al. (2016; Mitroulis and Kitsios (2019b); Nwankpa and Roumani (2016) |
| Reduction of expense and cost | Chen et al. (2016); Mitroulis and Kitsios (2019b); Nwankpa and Roumani (2016) |

## 2.2 MUSA method

MUSA method is a multicriteria methodology which focus on measuring and analyzing customer satisfaction. This method is employed for the evaluation of a set of marginal satisfaction functions. The global satisfaction functions derive from the results of the marginal satisfaction functions which are the results of customers' reviews. As a result, the most important objective of the method is the aggregation of individual judgments into a collective value function (Grigoroudis and Siskos 2002).

The MUSA method evaluates global and partial satisfaction functions $Y^*$ and $X_i^*$ respectively, given customers' ordinal judgments $Y$ and $X_i$ (for the i-th criterion). The hypothesis of an added utility model is the basic axis of the method, and it is represented by the following ordinal regression analysis equation:

$$\widetilde{Y}^* = \sum_{i=1}^{n} b_i X_i^* - \sigma^+ + \sigma^-$$

where Ȳ* is the estimation of the global value function Y*, n is the number of criteria, bi is a positive weight of the i-th criterion, σ+ and σ– are the overestimation and the underestimation errors, respectively, and the value functions Y* and Xi*are normalized in the interval [0, 100] (Grigoroudis and Siskos 2002).

According to the survey, each customer is asked to state their personal judgements (i.e. their global satisfaction and their satisfaction considering a certain set of criteria. The main results from the aforementioned preference disaggregation approach are focused on global and partial explanatory analysis. Global explanatory analysis emphasizes on customers' global satisfaction and its primary dimensions, while partial explanatory analysis focuses on each criterion and their relevant parameters separately. Satisfaction analysis results consist of:

- Global satisfaction index: it shows in a range of 0-100% the level of global satisfaction of the customers; it may be considered as the basic average performance indicator for the organisation.
- Global demanding index: it shows in a range of -100%-100% the demanding level of customers according to the following:
  - demanding index 100%: extremely demanding customers
  - demanding index 0%: "normal" customers
  - demanding index -100%: non-demanding customers
- Criteria/sub-criteria satisfaction indexes: they show in a range of 0-100% the level of partial satisfaction of the customers according to the specific criterion/sub-criterion, similarly to the global satisfaction index.
- Weights of criteria/sub-criteria: they show the relative importance within a set of criteria or sub-criteria.
- Demanding indexes: they show in a range of -100%-100% the demanding level of customers according to the specific criterion/sub-criterion, similarly to the global demanding index.

The research was conducted among hotels in Thessaloniki during February and March 2019. The questionnaire included 12 questions and 35 questionnaires were collected. A sample of 35 senior hotel and IT executives took part in the survey. The respondents in the questionnaire were employed in hotels.

## 3.  RESEARCH RESULTS

Taking Table 2 into consideration, "Customer retention", "Increase of operational efficiency", "Increase of ROI" and "Increase of sales revenue" are the most important criteria. The average demanding index is a quantitative measurement for the concept of executives' demanding. It is a measure of the extent of the improvement needed in order to improve satisfaction. The higher the demanding index, the biggest improvement efforts required. Negative values of the demanding indices mean that executives are not very demanding for these criteria, while values close to 0 mean that executives are neutral. Positive values are an indication that executives are demanding (Grigoroudis and Siskos 2002).

Table 2 Criteria Weights and Satisfaction Indices

| Criteria | Weights | Average satisfaction indices | Average demanding indices |
|---|---|---|---|
| Customer retention | 0.1240 | 0.9488 | -0.2789 |
| Customer satisfaction | 0.0957 | 0.9728 | -0.8386 |
| Employees performance | 0.0690 | 0.7325 | -0.2789 |
| Improvement in products/services | 0.0852 | 0.6589 | 0.1282 |
| Increase of operational efficiency | 0.1004 | 0.7325 | -0.3038 |
| Innovation | 0.0903 | 0.8633 | -0.5978 |
| Increase of ROI | 0.1060 | 0.9520 | -0.8000 |
| Increase of profitability | 0.0730 | 0.9334 | -0.7988 |
| Increase of sales revenue | 0.1010 | 0.9400 | -0.8400 |
| Market share growth | 0.0870 | 0.9540 | -0.5980 |
| Reduction of expense and cost | 0.0684 | 0.9500 | -0.8394 |

## 4.  CONCLUSIONS

The main purpose of this research is to explore the impact of digital transformation on business performance for hotels in Thessaloniki, Greece. Limited prior academic papers have highlighted the impact of digital transformation on organisational performance. Questioning senior hotel and IT executives' satisfaction might be considered a reliable way

to measure organisational performance. This kind of surveys could provide useful implications for alike companies and assist decision-makers presenting which satisfaction indices should be improved. The MUSA method unveils the strong and weak criteria of satisfaction. Future research could examine the impact of digital transformation on firm performance in different sectors or industries in Greece and compare these findings with previous ones. Besides, researchers could investigate different aspects of this issue using other multicriteria methods. The limitations of this research is the fact that it is applied to a certain country. Future researchers could expand the sample and assemble data from other countries as well.

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# Information Systems Planning and Business Strategy: Implications for Planning Effectiveness

Maria Kamariotou
*School of Information Sciences, Department of Applied Informatics, University of Macedonia 156 Egnatias st, 54636 Thessaloniki, Greece*

Fotis Kitsios
*School of Information Sciences, Department of Applied Informatics, University of Macedonia 156 Egnatias st, 54636 Thessaloniki, Greece*

**Abstract**

Within the current dynamic, turbulent and digitalized environments, Strategic Information Systems Planning (SISP) is a significant activity for efficient management and strategic use of Information Systems (IS). However, the implementation of SISP process in today's complex environments is difficult because organizations need to consider and take multiple planning perspectives, including managerial, environmental and organizational factors simultaneously, not to deal with only one important perspective. Although, previous researchers have examined the impact of SISP on success, providing recommendations for the implementation of the process based on data collecting from large organizations, they haven't paying attention on Small Medium Enterprises (SMEs). SMEs incline to pay attention on the business's long-term sustainability than perceiving short-term profitability. The current economic crisis has negatively influenced a huge number of activities and the majority of SMEs found themselves in a new complex financial environment where uncertainty prevails and the market characteristics are radically inverted. Except for difficulties in their financial aspect, their relative lack of technological, managerial and human capabilities make them unable to face the crisis and be competitive. Thus, the purpose of this paper is to explore SISP facilitators for success and a competitive advantage. Data were collected using questionnaires to IS executives in Greek SMEs. Data were analyzed using Regression Analysis. The results of this study show that IS executives are not aware of analyzing the external IT environment and evaluating opportunities for IS development. Furthermore, they do not formulate IT strategies and priorities, so they cannot anticipate risks and crises. They only concentrate on Strategy Implementation and as a result the IS projects are ineffective and unsuccessful.

**KEYWORDS**

Strategic Information Systems Planning, IS strategy, Competitive advantage, Success, Small Medium Enterprises.

## 1. INTRODUCTION

As approximately 80% of businesses have been highly influenced by the financial crisis more attention has been paid to Small-Medium Enterprises (SMEs) as to how they deal with it. SMEs constitute 97% of the businesses around the world thus they highly influence world's economy and consequently Greek and European competitive financial growth. It seems that formal processes in SMEs increase firm performance and they concern strategic management and information handling. Thus it is essential that managers should pay attention to business strategies, organizational structures and processes (Bourletidis and Triantafyllopoulos, 2014).

Having been negatively influenced by the financial crisis SMEs try to be innovative and increase their growth by trying to align their business and IT strategy so as to compete in the current uncertain environment. SMEs focus on business's long-term sustainability though there is a lack of strategic planning and formal processes as well as ineffective use of IS as they usually fail to align business and IT strategy (Giannakourou et al., 2015; Rathnam et al., 2004; Siakas et al., 2014; Vassiliadis and Vassiliadis, 2014). Thus, IT investment has been a crucial issue for managers because IT influences business performance and help executives to align business strategy and organizational performance (Kitsios and Kamariotou, 2017; Suh et al., 2013; Ullah and Lai, 2013).

What the results indicate is that if executives wish to be able to apply strategy conception and strategy implementation with greater agility than now they should implement them with greater meticulousness. That means that planners should focus on the analysis of current business systems, organizational systems, Information Systems (IS), business environment as well as external IT environment. If these elements are comprehensible, the results of the planning process can be improved and time and cost needed for the process will be reduced. Executives cannot only determine important IT objectives and opportunities for improvement but they can also evaluate them so as to define high-level IT strategies in conception of their business strategy (Mirchandani and Lederer, 2014; Newkirk and Lederer, 2006; Newkirk et al., 2003; Zubovic et al., 2014).

Thus, the aim of this paper is to examine the phases which contribute to a greater extent of success in order to provide professionals guidelines regarding the implementation of Strategic Information Systems Planning (SISP) process in SMEs.

Data were collected from IS executives in Greek SMEs. Regression Analysis is applied on the detailed items of the SISP process and success constructs.

The structure of this paper is as following: after a brief introduction to this field, the next section includes the theoretical background regarding the SISP process. Section 3 describes the methodology, while Section 4 shows the results of the survey. Finally, Section 5 discusses the results and concludes the paper.

## 2. THEORETICAL BACKGROUND

SISP has been defined as the ability to formulate the strategy of a business with the help of tools, techniques and methodologies which were used to support organizations in identifying potential opportunities to develop IS with greater competitiveness (Peppard and Ward, 2004). Although, the process of Strategic Information Systems Planning (SISP) is significant, its implementation is difficult because organizations need to simultaneously consider multiple planning perspectives, including managerial, environmental, and organizational factors.

SISP is an integrated process which includes specific phases coming from strategic management. These phases are the following five. The first phase is Strategic awareness, which involves the definition of key planning issues, planning objectives, organizing the planning team and the support of top level managers. The second phase is Situation analysis, which includes the analysis of current business systems, current organizational systems, current information systems, the current external business environment, and the current external IT environment. Next, the third phase is Strategy conception, which includes the definition of major IT objectives, opportunities for improvement, alternative scenarios, the evaluation of opportunities for improvement and the definition of high level IT strategies. In terms of strategy formulation, businesses select the most suitable scenario from the previous services, according to new business processes and new IT architectures. Also, in this phase, specific new projects and priorities for new projects are identified. The last phase is Strategy implementation planning, which contains the definition of change management approach, action plan, the evaluation of action plan, and the control of the plan (Brown, 2010; 2004; Kamariotou and Kitsios, 2018; 2017b; 2016; Kitsios and Kamariotou, 2016; Maharaj and Brown, 2015; Mentzas, 1997; Mirchandani and Lederer, 2014; Newkirk and Lederer, 2006; Newkirk et al., 2003).

Findings from previous surveys conclude that managers concentrate more on Strategy Conception and Strategy Implementation and they do not invest time on Strategic Awareness and Situation Analysis and as a result the implemented plans are ineffective and unsuccessful and they do not meet the objectives (Brown, 2010; Kamariotou and Kitsios, 2019a; b; 2017a; Kitsios and Kamariotou, 2018; Mirchandani and Lederer, 2014; Newkirk and Lederer, 2006; Newkirk et al., 2003). Moreover, when managers concentrate on the implementation of the process, they may achieve shorter SISP horizons but the strategic goals cannot be met. Executives do not focus on what strategic objectives really concern and how they can increase value to the business because they invest time on the horizon of the project and on minimizing its cost due to limited IT budget (Brown, 2010).

Based on the analysis of the existing literature, the following hypotheses are defined:

Table 6 Hypotheses

| Hypotheses | References |
| --- | --- |
| H1: Strategic Awareness positively affects SISP success. | Brown, 2010; Mirchandani and Lederer 2014; Newkirk and Lederer, 2006; Newkirk et al., 2003 |
| H2: Situation Analysis positively affects SISP success. | Brown, 2010; Mirchandani and Lederer 2014; Newkirk and Lederer, 2006; Newkirk et al., 2003 |
| H3: Strategy Conception positively affects SISP success. | Brown, 2010; Mirchandani and Lederer 2014; Newkirk and Lederer, 2006; Newkirk et al., 2003 |
| H4: Strategy Formulation positively affects SISP success. | Brown, 2010; Mirchandani and Lederer 2014; Newkirk and Lederer, 2006; Newkirk et al., 2003 |
| H5: Strategy Implementation positively affects SISP success. | Brown, 2010; Mirchandani and Lederer 2014; Newkirk and Lederer, 2006; Newkirk et al., 2003 |

## 3. METHODOLOGY

A questionnaire was based on previous surveys regarding SISP phases and success (Mirchandani and Lederer, 2014; Newkirk and Lederer, 2006; Newkirk et al., 2003). The extent to which the organization conducted the five planning phases and their tasks was measured by SISP process constructs while the success constructs were measures by using four dimensions named alignment, analysis, co-operation and capabilities. Five-point Likert scale was used to operationalize the two constructs mentioned above: SISP phases and success. A sample of IS executives in Greece was selected from the Icap list. SMEs which provided contact details were selected as the appropriate sample of the survey. The questionnaire was sent to 300 IS executives in Thessaloniki and a total of 294 returned the survey. Respondents in this study were employed in a variety of industries, well educated, and experienced. Data analysis was implemented with the use of Regression Analysis.

## 4. RESULTS

Table 2 presents the basic characteristics of dependent and independent variables as explained in the previous sections. Table 3 presents the results of the regression analysis between independent variables (Strategic Awareness, Situation Analysis, Strategy Conception, Strategy Formulation, Strategy Implementation Planning) and dependent variable (Success).

Table 2 Descriptive Statistics

|  | N | Mean | Std. Dev. |
|---|---|---|---|
| Strategic Awareness | 55 | 3.62 | 0.90 |
| Situation Analysis | 55 | 3.83 | 0.85 |
| Strategy Conception | 55 | 3.70 | 0.90 |
| Strategy Formulation | 55 | 3.52 | 0.82 |
| Strategy Implementation Planning | 55 | 3.44 | 0.99 |
| Success | 55 | 3.57 | 0.82 |

Table 3 Regression Results

| Independent variables | β | t | $R^2$ (Adj.) | F |
|---|---|---|---|---|
| Model |  |  | .818 | 49.63 |
| Strategic Awareness | -.01 | -.092 |  |  |
| Situation Analysis | .09 | .772 |  |  |
| Strategy Conception | .09 | .864 |  |  |
| Strategy Formulation | .28 | 2.206 |  |  |
| Strategy Implementation Planning | .50 | 3.987 |  |  |

*Significance at <0.05, **Significance at <0.01, ***Significance at <0.001

The path coefficient between Strategic Awareness and Success was negative and not statistically significant (β= -0.011, p>0.05). Thus, H1 was not supported. Furthermore, there was a positive but not statistically significant relationship between Situation Analysis and success (β= 0.93, p>0.05) and Strategy Conception and Success (β= 0.98, p>0.05). Thus, H2 and H3 were not supported. The path coefficient between Strategy Formulation and Success was positive and statistically significant (β= 0.287, p<0.01), supporting H4. This indicates that a higher level of Strategy Formulation can increase SISP Success. There was also a positive relationship between Strategy Implementation Planning and Success (β= 0.501, p<0.001); thus, H5 was supported. This result indicates that managers' ability to efficiently implement strategic plans plays an important role in SISP success.

Figure 7 Conceptual model
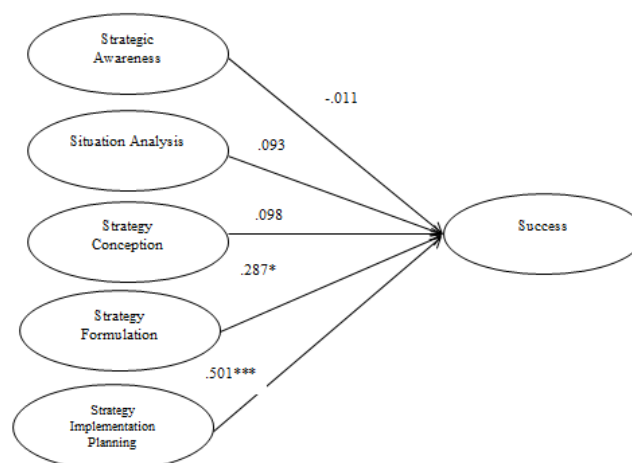


# 5. CONCLUSIONS

The purpose of this paper was to examine the extent to which the phases of SISP process affect IS planning success. Implementation plans are both ineffective and unsuccessful because they do not meet the objectives. While managers focus on Strategy Formulation and Strategy Conception they invest no time on Strategic Awareness and Situation Analysis. Concerning the implementation of the process, managers achieve shorter SISP horizons but they fail to meet the strategic goals. The results clearly show that attention should be paid to the implementation of the Situation Analysis with great meticulousness so that Strategy Conception and Strategy Implementation Planning can be applied with greater agility in the future. By understanding the environment, executives can not only determine important IT objectives and opportunities for improvement but they can also evaluate them so as to define high-level IT strategies regarding their business strategy conception. A limitation of this paper stems from the fact that many hypotheses have not been confirmed. It is therefore proposed for future researchers to analyze why these hypotheses are rejected. It is also recommended for future researchers to increase the sample of respondents and to conduct the same survey in large firms in order to compare the results regarding the SISP process.

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# Investigation and Classification of Risk Factors in Supply Chains:
# A Multi-Criteria Approach

Loukas K. Tsironis
*University of Macedonia,*
*Department of Business*
*Administration,*
*Business Excellence Laboratory (BEL)*
*Egnatia Str. 156, 54636,*
*Thessaloniki, Greece*
loukas@uom.edu.gr

Michael Madas
*University of Macedonia,*
*Department of Applied Informatics*
*Information Systems and e-Business*
*Laboratory (ISeB)*
*Egnatia Str. 156, 54636,*
*Thessaloniki, Greece*
mmadas@uom.edu.gr

Jason Papathanasiou
*University of Macedonia,*
*Department of Business*
*Administration,*
*Egnatia Str. 156, 54636,*
*Thessaloniki, Greece*
jasonp@uom.edu.gr

**Abstract**

The objective of the current paper is the investigation and classification of the risk factors that govern the Distribution Network (DN) Selection. We follow a Multicriteria Decision Analysis approach by applying the Fuzzy TOPSIS methodology. The literature review revealed the risk factors, which create variability in the Supply Chains. Risk factors composed the criteria selection in the multiple criteria model. Furthermore, six alternatives of DN are taken under consideration. A questionnaire survey was conducted in order to capture the field experts' opinions on the evaluation of specific DN according to the predefined criteria. Later on, an analysis of the research is presented. Results show the optimal structure of the DN and they were validated by comparing them with the theory from Chopra & Meindl (2018) and Elmokrini et al. (2015). Finally, we are discussing the results and make suggestion for further research.

**KEYWORDS**

Distribution Network, Supply Chain Risk Management, Multi Criteria Decision Making, Fuzzy-TOPSIS.

## 1. INTRODUCTION

It is widely acknowledged that global supply chains (SCs) and distribution networks (DNs) are the backbone of the global economy, promoting trade and economic growth. In recent years, globalization has become more intense and traditional SCs have become wider, more complex and transformed into multinational networks that are evolving dynamically over time. Modern SCs have evolved into multinational, multilevel networks defined by complex relationships between partners with conflicting interests (Simchi-Levi et al, 2007). Trends such as globalization, outsourcing, inflexible processes and geographical expansion of production have made supply chain (SC) networks more efficient, but they have also changed and increased their risk profile. The emergence of techniques such as Just-In-Time (JIT), reverse logistics, environmental concerns, competition, rising of technological advances, globalization, shorter product life-cycles, depreciation rates and the constantly changing nature of the market and customer demand have transformed the traditional linear flows of the supply chain into vast webs that most often cross the borders of entire continents. As a result, these changes can increase the vulnerability of the SC (Simchi-Levi et al, 2013). Passing through many different countries and cultures, under different working conditions, today's internationalized SCs become more vulnerable than ever to risks. They may be delayed deliveries, supply shortages, poor forecasts, legal issues, regulatory and environmental compliance, security issues or include more rare scenarios such as a hurricane or an earthquake. There is always a risk and therefore increased resistance to various types of risks threatening the viability of an organization is of major importance. Modern Global Supply Chains face multiple and varied risks, come face to face with various disorders and are therefore characterized by increased vulnerability and reduced resilience. Experience and everyday examples from the business world show that disturbances such as supplier mistakes, time delays from strikes in ports or product recalls from contaminated batch detection have a direct impact on the performance of a SC. In today's increased risky environment, any form of disorder, whether deliberately or not, at any point along the SC, can negatively affect the viability of the businesses (Pai et al., 2003). Transport-related risks include increased fuel costs, labor shortages, reduced service reliability, capacity constraints and congestion in ports (Hauer, 2003; LaLonde, 2004; 2005). When logistics activities have to cross international borders, delays (Hauer, 2003) and long queues caused by the toughest security measures (LaLonde, 2005) are also common.

Supply chain risk management (SCRM) is at an early stage of development and when managers try to improve their business performance, they rarely look at all types of risks. Businesses should change their SC structure to adapt to new market demands and challenges such as consumer demands, inventory management and minimization of service time. It is obvious that prescriptions to achieve the ideal performance of a SC do not exist. Nevertheless, the scientific literature provides excellent best practices for various SCRM, which, in combination, can greatly improve things to meet the demand for high customer service level. The ultimate goal of this paper is to highlight which SC network responds better to specific

risks. To meet our goal, we compared the types of distribution networks (DN) with the types of risks that are often disturbing SC operations. Types of DNs are highly attributed to the book of Chopra & Meindl (2018). In order to highlight the types of risks, we critically reviewed the relevant scientific literature. The result of this cross-correlation between risks and DNs and the matching of the appropriate DN that best performs under specific types of risks, investigated with the use of a popular multi-criterion decision making methodology (MCDM), the Fuzzy-TOPSIS. MCDM does not simply link the factors / criteria that will influence the decision but mainly adapts all these criteria to the policy and system of values and preferences of the decision maker. The results have highlighted which criteria are most important in deciding on the choice of distribution network, the optimal selection of the distribution network.

The current paper is organized in sections. In the literature review, section 2, the DN plans and the risk factors were identified. Section 3 and section 4 present some methodology aspects and the results, while section 5 discusses the implications of our work.

## 2. LITERATURE REVIEW

Proper selection of the DN is of a strategic nature and in the international literature it is proposed as the main component for the proper operational and functional performance of SC. The appropriate DN can predict and address risks related to inventories, product availability, responsiveness, coordination and natural, political and legal risks (Chopra, 2003; Elmokrini et al., 2015). Designing a DN is to determine the best way of transferring assets from supply to demand by selecting the structure of the network: the levels, the different types of facilities, their number and location, minimizing total cost (Chopra & Meindl, 2018).

In this article we used the categorization proposed by Chopra & Meindl (2018). They present the next six distinct DN plans:

- *Manufacturer storage with direct shipping*: In this network the product is sent directly to the end customer, bypassing the retailer.
- *Manufacturer storage with direct shipping and in-transit merge*: In this network, the products are shipped from a different manufacturer to a single carrier that merges the two products into one and proceeds to a single delivery to the customer.
- *Distributor storage with carrier delivery*: Under this option, inventory is held not by manufacturers at the factories, but by distributors/ retailers in intermediate warehouses, and package carriers are used to transport products from the intermediate location to the final customer.
- retailers in intermediate warehouses, and package carriers are used to transport products from the.
- *Distributor storage with last-mile delivery*: Last-mile delivery refers to the distributor/retailer delivering the product to the customer's home instead of using a package carrier.
- *Manufacturer/distributor storage with customer pickup*: In this approach, inventory is stored at the manufacturer or distributor warehouse, but customers place their orders online or on the phone and then travel to designated pickup points to collect their merchandise.
- *Retail storage with customer pickup*: In this option, often viewed as the most traditional type of supply chain, inventory is stored locally at retail stores. Customers walk into the retail store or place an order online or by phone and pick it up at the retail store.

Today SCs in order to address issues such as decreasing production costs, proximity to raw materials, responsiveness and increased customer service level are placing their facilities scattered around the globe, resulting in a more complex and complicated DNs. As a result, there is a higher probability of not succeeded the desired SC performance, mainly due to the existence of various risks (Tummala and Schoenherr, 2011). The risk is a multidimensional construct and is directly related to the uncertainty of the results as the potential negative impact that may result from an unfavorable situation (Zsidisin, 2003). The risk may take various forms such as: financial, inventory, demand, information flow, transfer, and supplier (Jüttner et al, 2003).

There are various categorizations of the risk of the supply chain. Some of them simply identified risk types without classification (Chopra & Sodhi, 2004a, Bogotaj & Bogotaj, 2007; Manuj & Mentzer, 2008; Wagner & Bode, 2008; Tang & Musa, 2011). Others ranked them based on probability and their impact (Hallikas et al., 2004). Risks can also be divided into two categories, such as internal and external (Trkman & McCormack, 2009; Olson & Wu, 2010), or business type and disorders type (Sodhi, et al., 2006). In addition, some articles divided the SC risk types into three categories with similar concepts, but they used different terms (Jüttner et al, 2003; Christopher & Peck, 2004). The three categories are organizational risk or internal risk (e.g. the risks of process and control), network-related risks or risks within the SC (e.g. supply and demand risks) and environmental or risk external to the SC (e.g. physical disasters, war). Chopra & Sodhi, (2004b) proposed nine sources of risks (interruptions, delays, system failures, wrong forecasts, intellectual property, supplies, requirements, inventory and capability.

For the purpose of the current work, an exhaustive literature review was performed which revealed 187 types of risks, most of which are presented and analyzed below. Based on their nature and literature findings, we grouped them in the next 15 categories:

*Environmental Risk*: Natural Disasters, War & Terrorism, Fire Accidents, Political instability, political uncertainty, political stability, Political risks, Strikes, Stringent Government Regulations, Government Stability, Economic Downturns / Disruption, Economic Stability, Economic Condition, Economic Crisis, Macroeconomic Uncertainties, Internal Legal issues, External Legal issues, Legal liabilities, Liability uncertainty, Legal Risks

*Demand Risks*: Demand uncertainty, demand variability, sudden shoot-up demand, demand disruptions, inaccurate forecasts, bullwhip effect, order fulfillment errors, variation of demand, sudden market fluctuations.

*Customer Risks*: Customer fragmentation, high level of service required by customers, short lead times, selection of customers, mutual-trust between partners, bad selection of partners, poor cultural fit between client and vendor, different business visions between client and vendor, dependency on single costumer, fluctuations in customer demands, rapid changes in customer expectations, backlogging or shortages in the orders, deficient or missing customer requirements planning policy, number of costumers, financial strength of costumers.

*Market Risks*: Market uncertainty, market changes, market characteristics (size, growth), market price increases, fluctuation of market, decline in market prices, loss of market share, globalization of market, high competition in the marketplace, behaviors of the competitors, competitive uncertainty, competitor moves, competition changes, increasing competition, competitor cost.

*Manufacturing Risks*: Product unavailability, Low in-house production, Product complexity and service ability, Production changes, Product market uncertainty, Rate of product obsolescence, Short life time products, Warehouse and production disruption, Facility unavailability, Loss of production, Production capabilities/capacity, Production flexibility, Product Quality , Quality issues (failure) /poor quality, Product Cost, Delivery of products orders in the quantity and quality demanded, Centralized storage of finished products, Increase of product costs, Inventory holding cost, Cost of capacity, Lack of capacity , Capacity flexibility/ Available capacity, Operating Uncertainty, Operational Risk, Agency Uncertainty, Inventory ownership, Lean inventory, Inventory level set, Inventory shortage, Labor dispute, Labor strikes, Employee accidents, Normal accidents , (system overloads), Abnormal accidents , (deliberate evil intentions), Accident of product operations, Poor employee utilization, Shortage of employment, Internal organization, Loss of organizational competency, Linked phases in manufacturing, Delay in manufacturing, Machine failure, Dissatisfaction with work, Insufficient maintenance, Instable manufacturing process, Loss of motivation, Lack of experience or training, Insufficient breaks, Working conditions, Human errors, Resource breakdown

*Supply Risks*: Supply uncertainty (cost, lead time, capacity), Supplier failure, Supplier bankruptcy, Supplier's service quality, Supplier's dependency, Dependency on single supplier, Supplier solvency / Financial health of suppliers, Supply responsiveness / supplier's reliability, Supplier opportunism, Supply interruptions, Bullwhip effect, Supplier fulfilment errors, Long- versus short-term contracts/ Contractual agreements, High capacity utilization at supply source , Inflexibility of supply source , Monopoly, Small supply base, Narrow number of suppliers, Single source of supply, Lack of integration with suppliers, Lack of suppliers' visibility, Supplier management, Supplier market strength, Selection of the next tier suppliers , Wrong partner selection, Lack of supplier trust & cooperation, Global outsourcing, Outsourcing risks, Globalization of Supply chains.

*Transportation Risks*: Changes in transportation modes, Lack of transport providers' integration, No transport solution alternatives, On-time & On-Budget Delivery, Delivery- Logistics failure, Delay in distribution and transportation process , Selection of ports and carriers, Equipment available and qualified human resources , Accidents in transportation, Damages in transport, Maritime pirate attack , Remote high-way theft, Stress on crew, Lack of training, Long working times, Negligently maintenance, Problems with, transportation vehicle, Global sourcing network, Supply chain complexity, Transportation breakdowns, Port capacity , Port strikes, Higher costs of transportation , Scheduling routes, Determining what to ship with what mode at what time , Transportation failure.

*Information and Information Systems Risks*: Information infrastructure breakdown, Distorted information, E-commerce, Information delays, Information Delivery, Lack of information transparency between logistics and marketing, Internet security, Incompatible information systems, IS breakdown, System integration or extensive systems networking, Network risks, Network security, Computer virus attacks, Lack of compatibility in IT platforms among supply chain partners, Low technical reliability, Technological changes, Technical problems, Old Technology, Deployment of information technology, Technology failure, Outage of IT System.

*Financial Risks*: Exchange rate, Currency risk / fluctuations, Price fluctuations, Stochastic cost, Wage rate shifts, Price discounts, Financial and insurance issues, Financial crises, Loss of contract, Low profit margin, Credit uncertainty, Increasing in raw materials (RM) prices.

*Performance Risks*: Order response time, Product Diversity, Product Availability, Customer experience.

*Supplier Risks*: Chang et al. (2014) pointed out that the reputation and trust SC members is related to the choice of the distribution network.

*Organizational Risks*: The type of business and the business sector (Dey et al, 2016). Company size, company age and R & D activities (Ravindran and Warsing 2013). The size of the company (turnover, number of warehouses etc.) as well as the organizational (Aguezzoul et al, 2006).

*Human Resources Risks*: level of employee training and the fact whether the human resources in a company / country affect the decision-making process (Dey et al 2016). The quality of services, labor costs, specialization of the workforce and the availability of the workforce (Hu, Yaodong et al., 2009).

*Quality Risks*: Quality of service, production quality, quality of transport, production, product quality (Jharkharia & Shankar 2005; Aguezzoul et al, 2006; Ilona & Izdebskib 2017).

*Geographical Risks*: The cost of transport between network facilities, fuel cost, additional costs associated with warehouses such as: local taxes, start-up costs, fixed costs, labor costs, purchase costs of additional land for extension, the distance of warehouses from transportation means (Ilona & Izdebskib 2017).

The reminder sections will consider the issue of the DN which performs best under the impact of the previous risks.

## 3. METHODOLOGY

For the purposes of the research, we developed a questionnaire addressed to upper management executives of the SC departments of various businesses. The firms to which the questionnaire was addressed were Greek companies with internationalized SCs. The risk factors and the corresponding network selection criteria were selected after thorough literature review. The questionnaire was created to capture the personal opinion of the SC executives about the severity of the criteria (represented by the risk factors) and to come up with the best DN alternative. Since risk factors and DN selection criteria are numerous, a grouping of these elements has been followed. Thus, 15 groups of risk factors have been intensified in order to further analyze them.

In addition to demographic data, the questionnaire contains 2 parts. In the first part, the DMs should determine the criteria weights. In the second part DMs are asked to rate the significance of each alternative (represented by DNs) in relation to each criterion.

As far as the classification of the criteria and the optimal choice among alternatives is concerned, the gathered data processed and analyzed with the fuzzy TOPSIS method. This method can accept the specific data volume for processing, as there is no need to collect a further larger volume of data. The fuzzy TOPSIS method, considering both the positive-ideal solution and its counter-diametrically negative solution, is believed to be one of the popular MCDM methods (Boran et al, 2009). Vahdani et al., (2013), after highlighting the advantages of the method, the simplicity of computations and the approach of human logic, argued that the fuzzy TOPSIS yields the weights of the criteria and the classification of the alternatives on the basis of verbal terms given by DMs and do not need to refer to other methods.

## 4. RESULTS

The supply chain/logistics department of 35 companies were responded to the survey. The 35% of them were wholesale and retail, 25.53% industrial and 5.88% services. Furthermore, 53% were companies with up to 50 employees, 30% from 51 to 250 and 12% with over 250 employees. 35% of them are using all types of transportation and distribution, 29% are using land and sea transportation and 24% only land transportation.

Regarding the profile of the people surveyed, 30% were up to 35 years old, 56% to 55 and 14% to 60 years old. The 70% of them were male and the remaining 30% were female. Of these, 76% were senior executives and 24% senior logistics administrators.

Responses rated the criteria as follows: transfer criteria, performance criteria and quality criteria (Score 5.9), Criteria for Customers (5.5), Supplier's Reputation and Trust (5.4), Market Criteria - Human Resources Criteria - Criteria for Information & Information Systems (5,3), Organizational Criteria - Production Criteria - Economic Criteria (5,2), Geographic Criteria (5,0), Supply Risk Criteria (4,9) Criteria - Demand Risk (4,8), Environmental Criteria (4,1), Political Criteria (3,4).

Decision Makers considered the transfer criteria as most important, as they affect the costs of the supply chain. The performance and quality criteria are also very important. Responders considered that the essence of the SC performance lied on the achievement of responsiveness to the customer, which brings high surplus. On the contrary, they considered that the environmental and political criteria are minimal and minor. These criteria include natural disasters, political instability and uncertainty.

As a better alternative, the DN6, or Retail storage with customer pickup with Closeness Coefficient (CC) = 0.520 was rated. In this option, inventory is stored locally at retail stores. Customers either walk into the retail store or place an order online or on the phone, and pick it up at the retail store (Chopra & Meindl, 2018). This network is characterized by high inventory costs and high installation costs compared to other alternatives. On the contrary, it involves low transport costs, as in this form the transport of goods is also done in inexpensive ways. The choice in DN6 means that a responsiveness-oriented network can add value to performance, customer satisfaction and quality of the SC. Transportation cost is much lower than other solutions because inexpensive modes of transport can be used to replenish product at the retail store.

Manufacturer or Distributor Storage with Consumer Pickup, namely DN5, ranked as the last one (CC=0.504). In this approach, inventory is stored at the manufacturer or distributor warehouse but customers place their orders online or on the phone and then come to designate pickup points to collect their orders. Orders are shipped from the storage site to the pickup points as needed. Inventory costs using this approach can be kept low with either manufacturer or distributor

storage to exploit aggregation. Transportation cost is lower than any solution using package carriers because significant aggregation is possible when delivering orders to a pickup site.  This allows the use of truckload or less-than-truckload carriers to transport orders to the pickup site. Facility costs are high if new pickup sites have to be built.

The third and fourth position taken by DN4 (CC = 0,515) and DN3 (CC = 0,513) respectively. Last mile delivery refers to the distributor / retailer delivering the product to the customer's home instead of using a package carrier. Unlike package carrier delivery, last mile delivery requires the distributor warehouse to be much closer to the customer, increasing the number of warehouses required. Distributor storage with last mile delivery requires higher levels of inventory than all options other than retail stores, because it has a lower level of aggregation. Transportation costs are highest using last mile delivery. Response times are faster than the use of package carriers. In carrier Delivery option, inventory is not held by manufacturers at the factories but is held by distributors / retailers in intermediate warehouses and package carriers are used to transport products from the intermediate location to the final customer. Relative to manufacturer storage, distributor storage will require a higher level of inventory because the distributor / retailer warehouse aggregates demand uncertainty to a lower level than the manufacturer. Transportation costs are somewhat lower for distributor storage compared to manufacturer storage because an economic mode of transportation (e.g. truckload) can be employed for inbound shipments to the warehouse, which is closer to the customer. Response time with distributor storage is better than with manufacturer storage because distributor warehouses are, on average, closer to customers and the entire order is aggregated at the warehouse when shipped.

Manufacturer storage with direct shipping or DN1 and manufacturer storage with direct shipping and in-transit merge or DN2 scored the same (CC=0.511). In DN1, the product is shipped directly from the manufacturer to the final consumer, bypassing the retailer. The seller has no inventory and the information is transferred by the customer through the reseller to the final manufacturer and the product is transferred directly to the final customer. This network is characterized by low inventory and plant cost but has a high response time in the market, thus very difficult product responsiveness to the customer market. In addition, it is very difficult to see the stages of order. Response times tend to be large when drop shipping is used because the order has to be transmitted from the retailer to the manufacturer and shipping distances are on average longer from the manufacturer's centralized site. Order tracking, however, becomes harder to implement in a situation of drop shipping because it requires complete integration of information systems at both the retailer as well as the manufacturer. In-transit merge combines pieces of the order coming from different locations so that the customer gets a single delivery. As with drop shipping, the ability to aggregate inventories and postpone product customization is a significant advantage of in-transit merge. In most cases, transportation costs are lower than drop shipping because of the merge that takes place at the carrier hub prior to delivery to the customer. Response times, product variety, and availability are similar to drop shipping. The main advantage of in-transit merge over drop shipping is the somewhat lower transportation cost and improved customer experience.

## 5. DISCUSSION

The purpose of the present paper was to investigate and classify risk factors affecting the supply networks and to compare the types of DNs with the types of risks that are disturbing the SC. To do that we used a very popular MCDM methodology the fuzzy-TOPSIS. This work presents an analysis for choosing the most appropriate DN, among 6 different alternatives proposed by Chopra & Meindl (2018), while the selection of the risk factors, based on exhaustive literature review.

According to the results, the optimal distribution network option was DN6, or retail storage with customer pickup. It is obvious that responsiveness is the most significant feature of the DN, according to the 35 responders. Responsiveness include dimensions such as customer satisfaction, high service level, quick response, decreased lead times and replenishment. As the results have shown, SCs are more effective when they are responsive regardless of the high costs of inventory, transportation and facilities. In addition, they ranked the performance and quality criteria in the first position. However, these results should be interpreted with some caution on the grounds that they are based solely on the particular preferences of the responding decision-makers. According to Chopra & Meindl (2018), most businesses are best served by combining distribution networks. The combination used depends on the product characteristics and the strategic positioning of the company.

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# Measuring the efficiency of Greek regional airports prior to privatization using Data Envelopment Analysis

Miltiadis L. Toskas-Tasios
*Democritus University of Thrace, Department of Civil Engineering MSc Programme in System Engineering & Management University Campus, Faculty of Engineering, 67100, Xanthe, Greece mtoskas@civil.duth.gr*

Loukas K. Tsironis
*University of Macedonia, Department of Business Administration, Business Excellence Laboratory (BEL) Egnatia Str. 156, 54636, Thessaloniki, Greece loukas@uom.edu.gr*

Michael A. Madas
*University of Macedonia, Department of Applied Informatics Information Systems and e-Business Laboratory (ISeB) Egnatia Str. 156, 54636, Thessaloniki, Greece mmadas@uom.gr*

**Abstract**

Air transport plays a fundamental role for local and global economic development. Greek airports in particular constitute an important infrastructure asset for regional development and the promotion of the domestic touristic product. However, many regional airports suffer from economic difficulties due to the lack of high volume of traffic, while others provide poor quality services during the commercially critical summer months. In this paper, we employ Data Envelopment Analysis (DEA) based on a data set obtained by the Hellenic Civil Aviation Authority, in order to benchmark the technical efficiency of the 14 Greek regional airports during 2016, just before their privatization. An output-oriented DEA model is used to assess separately the efficiency of the main infrastructural elements of the airports (i.e., terminal, airside area) on an annual and seasonal basis. The input of the terminal model includes the terminal area, as well as the number of baggage collection belts, gates, and check-in points, while the output deals with the total number of passengers. As far as the airside model is concerned, this uses as input the number and length of runways, the apron size and aircraft parking capacity, with the output being the total number of aircraft movements. The key factors influencing efficiency are investigated in order to suggest necessary improvements or upgrades and compare them with existing investment plans in the currently privatized airports. The results show that a significant lack of efficiency at regional airports can be mainly attributed to the relatively low ability to manage their resources, so as to increase output transport volumes. Finally, most airports are characterized by high scale efficiency and increasing returns to scale (IRS). The latter may provide incentives for investments towards airport capacity on expansion or upgrade projects and a more efficient management of scarce airport resources.

**KEYWORDS**

Airport efficiency, privatization, performance benchmarking, data envelopment analysis.

## 1. INTRODUCTION

Nowadays, air transport is one of the most globalized industries. Air transport connects people, cultures, companies/organizations from different continents and contributes substantially to economic growth by creating jobs and facilitating trade and tourism. Airports are key transport hubs that serve both passenger transport and the global supply chain systems offering flexibility, speed and accessibility.

Greece is a worldwide tourist destination; thus, air transport plays a key role in the country's economy (Fragoudaki and Giokas, 2016). In recent years, the number of visitors has risen significantly, lately surpassing the population of the country, with the number of domestic and foreign passengers amounted at 52.992.396 million movements according to EL.STAT (2017).

On December 14, 2015, Fraport Greece, the Hellenic Republic Asset Development Fund (HRADF) and the Greek State signed a 40-year concession contract for the operation, management, development and maintenance of 14 regional airports in Greece. The concession was completed in April 2017 (HRADF, 2017). The 14 regional airports account for 46.76% of passenger traffic from / to Greek airports (HCAA, 2016) and about half of the passenger traffic in Greece. Three of the fourteen regional airports are in mainland Greece: Aktion (PVK), Thessaloniki (SKG), Kavala (KVA), while the other eleven are in islands, namely Zakynthos (ZTH), Corfu / Kerkyra (CFU), Kefalonia (EFL), Kos (KGS), Mykonos (JMK), Lesbos / Mytilene (MJT), Rhodes (RHO), Samos (SMI), Santorini (JTR), Skiathos (JSI), and Chania / Crete (CHQ). Based on the available data, it is noted that the most busy period (76.01% of passenger traffic) is from May to October, while based on statistics for the period 2007-2016, the summer season traffic appears to be particularly high, due to incoming tourism in Greece (EL.STAT, 2017).

In Greece, airports are a particularly important infrastructure for regional development. However, many regional airports suffer from financial difficulties due to lack of year-round traffic, while others suffer in the summer season from poor service levels due to exceptionally high passenger traffic. In this respect, and with a view to the efficient management of regional airports, it was considered necessary to assess the efficiency of their scarce infrastructure and resources.

Since airports are complex organizations, it is difficult to assess them on the basis of a single criterion. Therefore, the use of the Data Envelopment Analysis (DEA) was considered to be the most suitable because of its ability to consider the effect

of multiple criteria. DEA evaluates and benchmarks decision-making units (DMUs) that operate in a single framework, are comparable, homogeneous and consume the same multiple inputs and produce the same multiple outputs (Khezrimotlagh et al, 2012; Nasseri et al, 2014). Using DEA and based on a data set obtained by the Hellenic Civil Aviation Authority (HCAA), the efficiency of the 14 regional airports is analyzed for the year 2016, the year just before their privatization. This is done both to investigate the factors that affect airport efficiency and to highlight the necessary improvements in airport infrastructure. The herewith presented research can provide useful input for a future assessment of airport efficiency to make it possible to compare the results and draw useful conclusions on the impact of privatization on airport efficiency. The rest of the current paper is divided in four sections. Section 2 provides a brief review of the relevant literature. The purpose of each survey and the models used are presented. Section 3 analyzes the models and data used in this study, as well as the methodology used to derive the results, which are explained in detail in Section 4. Section 5 summarizes the conclusions and possible directions for future research.

## 2. LITERATURE REVIEW

This section outlines a part of the previous airport efficiency survey using DEA. The first extensive research effort is being carried out by Gillen and Lall (1997) who study 21 of the top 30 American airports for the period 1989-1993 by evaluating both terminal and airside operations. In this effort, according to Gillen (1994), operations are performed at constant returns to scale (CRS), while returns to scale are varying (variable returns to scale – VRS) in the case of terminal services. The DEA models used were output oriented for convenience as the orientation was not critical and more suited to the second phase of analysis which included the use of the Tobit model. Later, Sarkis (2000) also studies efficiency at 44 major US airports in 1991-1994, using multiple DEA models to assess parameters that affect efficiency (e.g. if the airport is a hub for a major air carrier or part of a multiple airport system).

In the same period, Parker (1999) made a remarkable longitudinal research effort to study the efficiency of former British Airports Authority (BAA) before and after privatization. This concerns 1979,1980 and1995 to 1996, each year being treated as a separate DMU. In the second part, 22 UK airports (including those of BAA) are compared, but it is limited to 1988, 1989 to 1996, 1997 with each airport per year being a separate DMU. Because there were likely to be scale effects, the two CRS and VRS models were used in both cases. In the second stage of the analysis, however, only the results of the VRS were considered realistic because of the large heterogeneity in the size of the airports. The same, due to the different scales of airports, was also made in the work of Martin & Roman (2001) as well as that of Fernandes & Pacheco (2002). The former investigates the efficiency of all airports in Spain in 1997, the period before the privatization of the Spanish airport system, while the latter examines 35 airports in Brazil with domestic flights for the year 1998. The orientation of the models is based on inputs. This is followed by a comprehensive multi-model DEA (DEA BCC-CCR, DEA Cross-efficiency DEA) work by Barros & Dieke (2007) for assessing economic and operational efficiency. The model is output-oriented and covers 31 Italian airports over a three-year period, 2001-2003. According to the authors, the CCR and BCC models are powerful in identifying inefficient DMUs, but insufficient to distinguish between efficient ones. To overcome this, the 2 other models mentioned above are used. Subsequently, a similar work published by Curri et al. (2011) for 18 Italian airports over the period 2000-2004.

In conclusion, with regard to the case of Greek airports, relevant research efforts are those of Psaraki & Kalakou (2011), Tsekeris (2011) and more recently by Fragoudaki et al. (2016). The first evaluated the efficiency of 27 Greek airports in the period 2004-2007 while the two functional airport areas (i.e. landside, airside) are studied with separate data. The second survey evaluates the total of 39 airports in the year 2007, considering determinants such as the seasonality, location, size and operational characteristics of the airport. In both cases, both BCC and CCR are used. Finally, Fragoudaki et al. (2016) study the efficiency of 38 airports in the early years of the most severe economic crisis, using the BCC model and the Malmquist productivity index. In all three cases, output-oriented models are used, while the scope for airport improvement is highlighted in terms of both the efficient use of their infrastructure and the need to attract more passengers.

## 3. DEA MODELS AND DATA

In this section we present the models, data and methodology used. The required data was collected from the Hellenic Civil Aviation Authority (HCAA), as well as from statistics available by the contractor (Fraport Greece).

## 3.1 Theoretical Background and Data

The DEA principles lead us back to Farrel (1957) and later on a series of debates from Charnes et al. (1978). A detailed introduction to DEA is available from Norman and Stoker (1991), while more detailed and more recent material is provided by Cooper et al. (2000). DEA is a non-parametric method that evaluates and compares the relative efficiency of DMUs. A proposed rule states that the number of DMUs must be at least twice the total number of inputs / outputs (Golany & Roll, 1989) while Banker et al. (1989) consider that the number of DMU's should be at least three times the number of inputs /

outputs. However, such a rule is neither imperative nor has a statistical basis but is often adopted for convenience. The two main models for implementing the method are CCR and BCC. Their name derives from the initials of the researchers who constructed them. The CCR model was developed by Charnes, Cooper, Rhodes (1978) for CRS, and then expanded with the BCC model by Banker, Charnes, Cooper (1984) for VRS. All of them, depending on what they are targeting, are distinguished in output maximization models (output-oriented) and input-minimization (i.e. input-oriented) models. In order to assess the overall technical efficiency, Charnes et al (1978) introduced the CCR model, while in order to convert the overall technical efficiency into pure technical efficiency and scale efficiency, Banker et al (1984) introduced the BCC model.

Based on similar studies, such as those by Gillen & Lall (1997), Pels et al. (2001, 2003), Psaraki & Kalakou (2011), two different models are used to assess the efficiency of regional airports. The choice of the two models is due to the fact that different functions are performed in different areas of the airport. The models therefore concern the two functional areas of the airport, the terminal area (Terminal Model) on which the passengers depart or arriv at the airport and the area of aircraft on which the Airside Model is served. By looking at earlier surveys (e.g. Gillen & Lall, 1997; Parker, 1999; Sarkis, 2000; Martin & Roman, 2001; Pels et al, 2001; Fernandes & Pacheco, 2002; Yoshida & Fujimoto, 2004; Dieke, 2007, Fung et al, 2008, Kocak, 2010, Psaraki & Kalakou, 20011, Tsekeris, 2011, Curi et al, 2011, Chang et al, 2013, Fragoudaki et al. 2016), it is observed that input and output vary substantially. Typical input elements are the number and surface of runways, the terminal surface, the apron area, the number of check-in counters, the number of baggage belts etc. Other types of input elements are related to labor costs, capital, number of employees, hours, etc. On the other hand, the most common output elements are the total number of passengers and flights as well as the freight/cargo volumes transported. In the present study, the Terminal Model uses 4 inputs and 1 output.

Input data: 1. Terminal surface 2. Number of baggage belts 3. Number of gates 4. Number of check-in counters. These data concern the flow of passengers within the airport considering safety standards. These data are often affected by queues and delays.

Output data: 1. Total number of passengers. This number refers to both arrivals and departures to domestic and international passengers intra- and extra-Schengen.

The Airside Model uses 4 inputs and 1 output.

Input data: 1. Number of runways: it affects the number of aircraft movements that can be accommodated by the airport's runway system. 2. Length of the main runway: it determines the size of the aircraft that can effectively use the runway. 3. Apron area surface and . 4. Number of aircraft parking spaces. Data 3 and 4 determine the number of aircraft that can remain parked and served in the apron/ramp area.

Output data: 1. Total number of flights. This figure covers both arrivals and departures for domestic and international flights, both intra- and extra-Schengen.

Input and output elements are selected on the basis of the available data and by studying the planned infrastructural upgrades/improvements at the 14 airports under consideration. It seems that the data selected will be modified in the upcoming years when upgrading airports, which increases the interest and usefulness of this research. Research can therefore be a comparative tool to explore the usefulness or otherwise of the changes that will take place in the next three years at airports.

## 3.2 Methodological rationale

The following assumptions are used to the present work: 1. During the year some items remain unchanged. These are the aircraft area information: the number of runways, the length of the runways, the aircraft parking area and spaces and 2. Items such as gates, baggage belts and check-in counters show some seasonal variations. Thus, airport management per period and occasionally may choose to use only part of these resources.

An important element of the research is the location of the airports, with the majority of the airports under study located in islands. Given the touristic traffic during the summer season, there is a strong seasonal variation. Following the example of corresponding studies for Greek (Psaraki & Kalakou, 2011; Tsekeris, 2011) and Italian airports (Curri et al., 2011), the determinant of seasonality is examined. To take account of seasonal fluctuations in demand, the data are examined at two periods of the year. The split concerns two six-month periods: Summer (May-October) and Winter (November-April). The model adopted in both designs discussed above is output oriented. This suggests that each airport aims to serve as many passengers and aircraft as possible at a given level of input (i.e. resource) utilization.

The approach adopted includes the estimation of both CRS and VRS as it was considered possible to have some scale effects. The results from VRS represent purely technical efficiency (PTE), while those from CRS the total technical efficiency (TE) as a combination of purely technical efficiency and scale efficiency. The TE / PTE rate provides a measure of scale efficiency.

## 4. RESULTS

Regarding DEA implementation, in order to assess the efficiency of airports, the following software was used: DEAP and DEAFrontier. The efficiency for both terminal operations and the airside area is presented in Table 1, as well as Figures 1 and 2.

The average TE is marked on the figures by a horizontal line. Scale efficiency (SE) is given by the TE / PTE fraction and noted on the figures with the sideline. These two lines divide our chart into 4 regions, based on which we can derive useful conclusions. The horizontal axis represents pure technical efficiency (PTE) values, while y represents the total technical efficiency (TE) values. These values range from 0 to 1. Airports are marked with their coded names and indicated as points in the chart. We observe that 4 of the 14 airports lie on point (1.1). This suggests that they operate at the terminal's efficiency barrier. These airports are: Thessaloniki, Rhodes, Santorini, and Chania. These airports are efficient at both CRS and VRS. The airports of Kos and Corfu are in the same area with high PTE and TE. This means that they have exploited their infrastructure well enough while serving a large number of passengers. In the second area, which includes airports with a high PTE and SE below the average, there is no airport. The third area includes airports with low TE and high SE. This area includes the airports of Mykonos, Zakynthos and Aktio which serve several to many passengers but have a limited resource efficiency. The latter region includes airports serving a small number of passengers with low efficiency in terms of terminal infrastructure. Increasing efficiency depends on attracting more passengers. In this category are Mytilene, Kefalonia, Kavala, Samos and Skiathos.

Regarding the chart of the airside traffic area, we notice that 3 of the 14 airports are in point (1, 1). This indicates that they operate at the edge of airside infrastructure efficiency. These airports are: Thessaloniki, Rhodes, Mykonos. These are efficient at both fixed and variable scale yields. The airports of Kos, Chania, Santorini and Skiathos are in the same area with both PTE and TE high. This means that they have exploited their infrastructure well enough while serving a large number of aircraft. Skiathos is highly efficient as it serves a large number of aircrafts in proportion to its limited infrastructure. The second area includes airports with a high PTE and SE lower than average. In our model, this is the airport of Corfu, which has a relatively high SE. The third area includes airports with low TE and high SE. This area includes the airports of Mytilini and Aktio which serve a lot of aircraft, however, having limited efficiency. The latter area includes airports serving a small number of low-cost passengers with regard to the infrastructure of the A / C traffic area. Increasing efficiency depends on attracting more passengers / flights. In this category are the airports of Kavala, Samos, Zakynthos, Kefalonia. These airports have sufficient infrastructure (large parking area and runways) to accommodate much more flights. Particularly Kavala airport has the third largest infrastructure for the apron area, but with a small number of flights.

Table 1. Technical efficiency for Terminal & Airside models

| Airport | TE (CRS) | | PTE (VRS) | | Scale Efficiency | | Position on Frontier | |
|---|---|---|---|---|---|---|---|---|
| | Terminal | Airside | Terminal | Airside | Terminal | Airside | Terminal | Airside |
| tion (PVK) | 0.281 | 0.347 | 0.281 | 0.36 | 1 | 0.964 | - | irs |
| kynthos (ZTH) | 0.498 | 0.547 | 0.506 | 0.602 | 0.984 | 0.908 | irs | irs |
| essaloniki (SKG) | 1 | 1 | 1 | 1 | 1 | 1 | - | - |
| vala (KVA) | 0.24 | 0.095 | 1 | 0.1 | 0.24 | 0.951 | irs | irs |
| rfu / Kerkyra (CFU) | 0.857 | 0.866 | 0.866 | 1 | 0.989 | 0.866 | irs | irs |
| falonia (EFL) | 0.5 | 0.295 | 1 | 0.316 | 0.5 | 0.934 | irs | irs |
| s (KGS) | 0.79 | 0.774 | 0.804 | 0.814 | 0.983 | 0.951 | drs | irs |
| sbos / Mytilene (MJT) | 0.418 | 0.591 | 1 | 0.615 | 0.418 | 0.96 | irs | irs |
| ykonos (JMK) | 0.474 | 1 | 0.484 | 1 | 0.98 | 1 | irs | - |
| odes (RHO) | 0.869 | 1 | 0.869 | 1 | 1 | 1 | - | - |
| mos (SMI) | 0.243 | 0.301 | 0.312 | 0.355 | 0.778 | 0.845 | irs | irs |
| ntorini (JTR) | 1 | 0.928 | 1 | 0.934 | 1 | 0.994 | - | irs |
| iathos (JSI) | 0.367 | 0.988 | 1 | 1 | 0.367 | 0.988 | irs | irs |
| ania / Crete (CHQ) | 1 | 0.867 | 1 | 0.899 | 1 | 0.965 | - | irs |
| **Average** | **0.61** | **0.686** | **0.794** | **0.714** | **0.803** | **0.952** | | |

Figures 1 and 2: Classification of airports in terms of efficiency
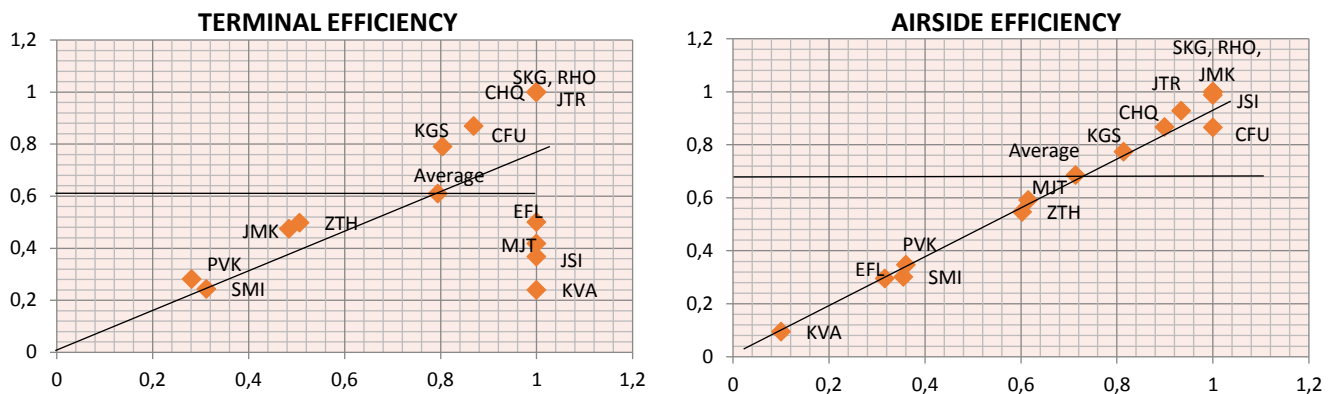


## 4.1 Seasonal Variation

Tables 2 and 3 show the efficiency figures for both models during the winter and summer season. Starting from the Terminal model, it is shown that Thessaloniki's airport is operating at the profitability boundary during the winter season while Santorini Airport and Chania Airport during summer. In the annual Terminal model, the airports operating at the efficiency boundary are Thessaloniki, Santorini and Chania. We notice that 2 of the airports are located on islands while at the same time they represent big tourist attractions. On the contrary, Thessaloniki airport has a smaller increase in traffic during the summer period, which leads to lower efficiency. In the winter, passenger traffic is reduced at all airports. The large decrease in SE in Aktio, Kefalonia, Skiathos is due to the very small number of passengers at these airports in the winter months. In contrast, in the summer there is an increase in traffic at all airports, with the exception of Thessaloniki, which does not show any seasonal fluctuations already reported. With regard to the Airside model, we notice that the airports of Thessaloniki and Mytilene operate at the efficiency frontier during the winter season, while during the summer of Mykonos, Rhodes, Skiathos and Thessaloniki. In the annual Airside model, airports operating at the efficiency frontier are Thessaloniki, Mykonos and Rhodes. We notice that 2 of the airports are on islands. Therefore, seasonal variation also means that these airports have a particularly low efficiency in the winter months, with an exception being Thessaloniki Airport.

Table 2. Airport Seasonal Efficiency [Terminal Model]

| Airport | Winter Season | | | | Summer Season | | | |
|---|---|---|---|---|---|---|---|---|
| | TE(CRS) | PTE(VRS) | Scale Efficiency | Position on Frontier | TE(CRS) | PTE(VRS) | Scale Efficiency | Position on Frontier |
| Aktion (PVK) | 0.007 | 0.015 | 0.448 | irs | 0.328 | 0.328 | 1.000 | - |
| Zakynthos (ZTH) | 0.021 | 0.028 | 0.767 | irs | 0.601 | 0.664 | 0.905 | drs |
| Thessaloniki (SKG) | 1.000 | 1.000 | 1.000 | - | 0.753 | 1.000 | 0.753 | drs |
| Kavala (KVA) | 0.089 | 1.000 | 0.089 | irs | 0.253 | 1.000 | 0.253 | irs |
| Corfu / Kerkyra (CFU) | 0.122 | 0.146 | 0.836 | irs | 0.997 | 1.000 | 0.997 | drs |
| Kefalonia (EFL) | 0.045 | 1.000 | 0.045 | irs | 0.593 | 1.000 | 0.593 | irs |
| Kos (KGS) | 0.134 | 0.145 | 0.924 | irs | 0.900 | 1.000 | 0.900 | drs |
| Lesbos / Mytilene (MJT) | 0.692 | 1.000 | 0.692 | irs | 0.304 | 1.000 | 0.304 | irs |
| Mykonos (JMK) | 0.088 | 0.131 | 0.670 | irs | 0.539 | 0.541 | 0.997 | drs |
| Rhodes (RHO) | 0.206 | 0.206 | 1.000 | - | 0.974 | 1.000 | 0.974 | drs |
| Samos (SMI) | 0.106 | 0.296 | 0.359 | irs | 0.247 | 0.295 | 0.837 | irs |
| Santorini (JTR) | 0.659 | 1.000 | 0.659 | irs | 1.000 | 1.000 | 1.000 | - |
| Skiathos (JSI) | 0.011 | 1.000 | 0.011 | irs | 0.447 | 1.000 | 0.447 | irs |
| Chania / Crete (CHQ) | 0.477 | 0.605 | 0.790 | irs | 1.000 | 1.000 | 1.000 | - |
| **Average** | **0.261** | **0.605** | **0.592** | | **0.638** | **0.845** | **0.783** | |

Table 3. Airport Seasonal Efficiency [Airside Model]

| Airport | Winter Season | | | | Summer Season | | | |
|---|---|---|---|---|---|---|---|---|
| | TE(CRS) | PTE(VRS) | Scale Efficiency | Position on Frontier | TE(CRS) | PTE(VRS) | Scale Efficiency | Position on Frontier |
| Aktion (PVK) | 0.140 | 0.179 | 0.779 | irs | 0.361 | 0.964 | | irs |
| Zakynthos (ZTH) | 0.119 | 0.292 | 0.408 | irs | 0.593 | 0.630 | 0.942 | irs |
| Thessaloniki (SKG) | 1.000 | 1.000 | 1.000 | - | 1.000 | 1.000 | 1.000 | - |
| Kavala (KVA) | 0.079 | 0.178 | 0.443 | irs | 0.083 | 0.087 | 0.961 | irs |
| Corfu / Kerkyra (CFU) | 0.284 | 0.724 | 0.392 | irs | 0.904 | 1.000 | 0.904 | irs |
| Kefalonia (EFL) | 0.102 | 0.203 | 0.506 | irs | 0.305 | 0.321 | 0.949 | irs |
| Kos (KGS) | 0.291 | 0.666 | 0.438 | irs | 0.793 | 0.823 | 0.963 | irs |
| Lesbos / Mytilene (MJT) | 1.000 | 1.000 | 1.000 | - | 0.381 | 0.396 | 0.961 | irs |
| Mykonos (JMK) | 0.356 | 0.733 | 0.486 | irs | 1.000 | 1.000 | 1.000 | - |
| Rhodes (RHO) | 0.522 | 1.000 | 0.522 | irs | 1.000 | 1.000 | 1.000 | - |
| Samos (SMI) | 0.325 | 0.842 | 0.386 | irs | 0.241 | 0.276 | 0.874 | irs |
| Santorini (JTR) | 0.552 | 1.000 | 0.552 | irs | 0.879 | 0.885 | 0.994 | irs |
| Skiathos (JSI) | 0.216 | 1.000 | 0.216 | irs | 1.000 | 1.000 | 1.000 | - |
| Chania / Crete (CHQ) | 0.552 | 1.000 | 0.552 | irs | 0.804 | 0.827 | 0.973 | irs |
| **Average** | **0.396** | **0.701** | **0.549** | | **0.667** | **0.686** | **0.963** | |

## 5. CONCLUSIONS

This research can be a tool for future exploitation to explore the impact of privatization on airport efficiency. Today, the major lack of efficiency in most of the country's regional airports can be attributed mainly to the relatively low ability to manage their resources in order to increase traffic outputs. Most airports, however, are characterized by increasing scale returns, which provides incentives for investments to upgrade and / or expand airports, as well as their proper management, in order to limit the inadequate use of their resources. In addition, the establishment of regional hubs could be examined as a future development plan of the Greek airport system. Furthermore, it is important to develop a plan to improve airport connectivity both with each other and with other airport hubs abroad. This will result in attracting more airlines (some of them low-cost) and thus increasing passenger traffic. Looking at the seasonality factor, unlike the summer season, the winter season leads to a reduced rate of airport efficiency. This phenomenon is more pronounced at regional airports with high tourist traffic (mainly in the islands). This necessitates measures to address the under-utilization of resources at these airports during this period. A key measure is the flexible design of the main terminal area (e.g. changes in the number of check-in, security screening, information portals, etc.) in order to adapt more to the changing needs of airlines. Particularly important for the development of airports with reduced demand in the winter months is the promotion of alternative tourism policies to expand demand during the winter season.

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# Evaluation of alternative sustainable urban mobility scenarios using the PROMETHEE Multi-criteria Decision Making methodology

Dr. Maria Morfoulaki *
*Centre for Research and Technology Hellas*
*Hellenic Institute of Transport **
*6th km. Harilaou-Thermi Rd,*
*Thermi, Thessloniki, Greece*
*marmor@certh.gr **

Dr. Jason Papathanasiou*
*University of Macedonia*
*Dept. of Business Administration  **
*Thessaloniki, Greece*
*jason.papathanasiou@gmail.com **

**Abstract**

The publication of the White and Green European Transport Paper in 2011, highlighted the need of the urban mobility planning to shift, towards sustainable means of transport (public transport, bicycle and pedestrian trips), changing the current travelers' behavior which still remains in favor of the private car, so that the key criterion of the modal choice to become the environmental protection. The new urban sustainable planning framework, aims to give space to the human (citizen) rather than to the car.

This shift towards Sustainable Urban Mobility has resulted in the creation of an 8-step methodology by DG Move and ELTIS, the so called "SuMP Cycle" for developing Sustainable Urban Mobility Plans.  The "SuMP Cycle" after the analyses of the current situation, determines the future vision of each city, the alternative mobility scenarios/strategies that serve this vision and in the end specifies the transport infrastructures, measures and policies that each city should develop in order to become more eco-friendly and green.

One of the most critical steps in this procedure is the determination of the weight of each city's targets for the future and the assessment - with specific criteria - of all the alternative scenarios (measures, policies, infrastructures), which will be optimally combined, in order to fulfill successfully these targets.

The aim of the proposed article is to present the implementation of the PROMETHEE multicriteria decision making methodology in order to examine the impact of each alternative scenario/strategy on the weighted criteria (targets) and then present the final assessment results and measures that were finally selected for implementation in a specific case, through this procedure.  Conclusions for the barriers and strengths of the current methodology in the SuMP Cycle procedure will be also analysed.

## 1. INTRODUCTION

The publication of the White and Green European Transport Paper in 2011, highlighted the need of the urban mobility planning to shift, towards sustainable means of transport (public transport, bicycle and pedestrian trips), changing the current travelers' behavior which still remains in favor of the private car, so that the key criterion of the modal choice to become the environmental protection.  The new urban sustainable planning framework, aims to give space to the human (citizen) rather than to the car.

This shift towards Sustainable Urban Mobility has resulted in the creation of an 8-step methodology by DG Move and ELTIS, the so called "SuMP Cycle" for developing Sustainable Urban Mobility Plans (Figure 1).

Figure 1:  Planning cycle for a sustainable urban mobility plan



*Source: http://www.eltis.org*

According to the "SuMP Cycle", there are seven crucial steps, for identifying the most effective strategies, measures, policies and infrastructures that should be implemented in the study area for achieving sustainable mobility. These steps are:

- Step 3. Analyse the mobility situation and develop scenarios
- Step 4. Develop a common vision
- Step 5. Set priorities and measurable targets
- Step 6. Develop effective package of measures
- Step 7. Agree on clear responsibilities and allocate budget
- Step 8. Build monitoring and evaluation into the plan
- Step 9. Adopt Sustainable Mobility Plan.

The analysis of the mobility situation will give feedback for the current problems and barriers as regards the traffic conditions and the travel patterns of the network users. The answer in the question "how is the mobility situation now and how it will be in 10 years if there will be no action in favor of sustainable mobility?" will highlight the problems, give a clear guide for the future and determine the priorities, vision and the measurable targets.

According to the above, one of the most important steps of the planning procedure, is the determination of the most effective future strategy, that will serve better the vision and the priorities of the city. This strategy will also guide the implementation of the future infrastructures, measures and policies for promoting environmental and low-carbon mobility.

In the next sections, the implementation of the PROMETHEE multicriteria decision-making methodology will be presented, in order to examine the impact of each alternative strategies on the weighted criteria (priorities). Conclusions for the future opportunities of the use of the current methodology in the SuMP Cycle procedure will be also analysed.

## 2. METHODOLOGICAL FRAMEWORK

## 2.1 The PROMETHEE methodology

Multi-Criteria Decision Analysis (MCDA) is one of the very fast-growing areas of Operational Research (OR) over the last two decades. These methodologies usually deal with the ranking of many specific alternatives in a range of best to worst, based on multiple and often conflicting criteria. These methods also deal with theory and methodology that can address complex problems encountered in system management, business, engineering, and other areas of human activity.

The main objective of MCDA is to reach decisions that help to solve complex problems, according to the preferential system and judgment of the decision makers. When there are multiple decision criteria, there can be no unanimity for the optimal (in the traditional sense of optimization), as different goals and priorities naturally lead to the formulation of different proposals.

However, with formal procedures and analytical techniques for structuring a problem or approach and evaluating alternative ways of action, the decision-making process is greatly facilitated. The MCDA intervenes in all phases of the decision-making process, starting from the problem and structuring it up to the implementation of the proposed solutions.

In recent years, various MCDA methods have been proposed to help in selecting the best alternative compromise solutions. The development of MCDA methods is motivated not only to solve real problems that require multiple criteria but also to the desire of professionals to propose improved decision-making techniques using recent developments in mathematical optimization, computer science and computer technology (Wiecek et al., 2008).

The PROMETHEE method (method of ranking preferences for enrichment ratings) is one of the most well-known and widespread MCDA methods. These methods were developed by Brans (1982) and further extended by Vincke and Brans (1985). PROMETHEE is a method of extrovertly addressing a finite set of alternative actions that need to be classified and ranked based on specific criteria, which are often conflicting. PROMETHEE is also a simple method of classification and application compared to other methods for multi-criteria analysis (Brans et al., 1986).

Therefore, the number of professionals using the PROMETHEE method in practical multi-criteria decision-making problems and researchers who are interested in the PROMETHEE sensitivity aspects are increasing every year, as shown by the increasing number of scientific papers and conferences presentations.

The PROMETHEE ranking methodology for the specific pilot case that will be presented, was used to examine the impact of alternative mobility strategies on the priorities and the vision that were determined by transport experts for a specific area.

At the same time, the assessment will also prioritize the importance of all the alternative proposed interventions according to their influence on the weighted priorities.

## 2.2 The evaluation process.

The pilot case examined for the purpose of this work, referred to a group of six transportation and spatial development experts who undertook the responsibility to evaluate three alternative strategies of future mobility development in a city of 400.000 inhabitants. In accordance to the SUMP development procedure, the group of experts, had previously set specific priorities for the implementation of the sustainable mobility planning. For each of the priorities, specific weights had been allocated as it is presented in Table 3.1 below.

Table 8: Criteria and Weights for the Evaluations of Alternative Strategies and Interventions

|   | Priorities | Weight |
|---|---|---|
| 1 | Easy and fast access to the city center using sustainable modes | 13% |
| 2 | Reduction of private vehicle use within the urban center | 11% |
| 3 | Public space for citizens | 11% |
| 4 | Promoting the city as a tourist - cultural destination | 9% |
| 5 | Support and Promotion of Public Transport | 9% |
| 6 | Equal treatment of all network users respecting the specificities of each | 9% |
| 7 | Strengthening sustainable urban intermodal mobility | 8% |
| 8 | Reduction of air pollution and noise pollution by promoting relevant measures and policies | 8% |
| 9 | Increase road safety | 8% |
| 10 | Strengthening the economy of the city through its promotion as a combined transport node | 3% |
| 11 | Strengthening the urban logistic system | 3% |
| 12 | Promotion of new forms of motorized traffic in the city center (electric vehicles, electric vehicle charging stations) | 3% |
| 13 | Introduction and promotion of new technology systems to improve the mobility of the citizens | 3% |
| 14 | Promote e-services that reduce citizens' trips (e-services for the citizen) | 3% |

The three alternative strategies of sustainable mobility development (shown in Table 3.2) in the study area has been evaluated by the experts according to their influence in the above-mentioned priorities (where 1: no influence, 2: minimum influence, 3: low influence, 4: medium influence, 5: enough influence, 6: big influence and 7: high influence).

Table 9: Alternative Strategies

|   | **Alternative Strategies** |
|---|---|
| 1 | Equal treatment of private vehicle as an alternative mode for covering urban trips/ Traffic management solutions for minimizing the environmental effects |
| 2 | Development of multimodal public transport system as the base for a sustainable modal shift. |
| 3 | Restriction of the road space available in the private vehicle with extended pedestrianizations of road axis and development of bikeways. |

It must be mentioned here, that the choice of the strategy was very crucial for the next steps of the SuMP development as each of the strategy is linked with different infrastructures, policies and measures that are going to give specific characteristics in the future development of the city. The results of the evaluation procedure are analytically presented in the next sections.

## 2.3 Results of the Multi-criteria Analysis.

The data was recorded in the Visual PROMETHEE software and analyzed by selecting "normal" as a preference function. This is a simple function, which in fact corresponds to the optimization explained by "the higher the price, the better". It does not include thresholds and according to the bibliography is the right choice for evaluation criteria with a great range of ratings, that is, mainly for qualitative criteria such as those used in the case of this assessment.

From the overall results of the preferences flows, for all strategies and criteria, there is a clear preference of the experts for the third strategy, namely the "Restriction of the road space available in the private vehicle with extended pedestrianizations of road axis and development of bikeways". Their second choice is the "development of multimodal public transport system as the base for a sustainable modal shift" while their last choice is the "equal treatment of the private vehicle".

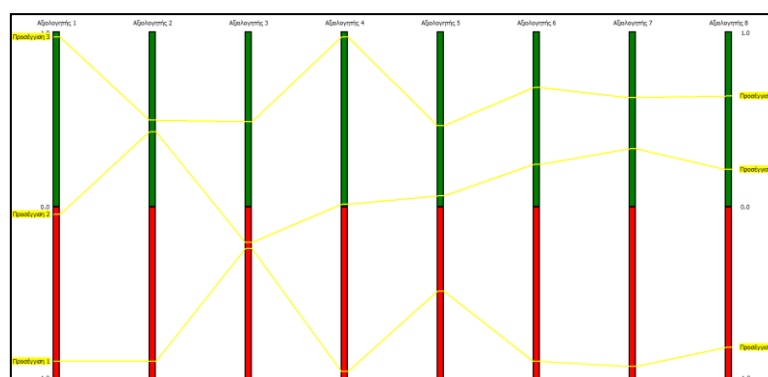Figure 2: Preference Flows for the Ranking of Alternative Strategies



Table 10: Ranking Results of Alternative Strategies

|   | Alternative Strategies | Phi | Phi+ | Phi- |
|---|---|---|---|---|
| 1 | Equal treatment of private vehicle as an alternative mode for covering urban trips/ Traffic management solutions for minimizing the environmental effects | 0,6287 | 0,6881 | 0,0594 |
| 2 | Development of multimodal public transport system as the base for a sustainable modal shift. | 0,2030 | 0,4604 | 0,2574 |
| 3 | Restriction of the road space available in the private vehicle with extended pedestrianizations of road axis and development of bikeways. | -0,8317 | 0,0297 | 0,8614 |

The sensitivity analysis made on each criterion, to see if a change in their weight would change the final choice of the strategy, has made clear that this can happen only in case of doubling the weight of criterion 11 for urban logistics. This is perfectly reasonable, since a possible pedestrianization of the city center and of main axes would cause difficulties in the logistic services of these areas.

## 3. CONCLUSIONS

The new concept of the Sustainable Mobility Planning in urban areas and the methodological framework that should be followed according to the European Specification and the SuMP cycle, give the opportunity to exploit the use of Multi-criteria Analysis in decision-making.

The analysis of a pilot case where PROMETHEE method has been used in order to select the strategy that answers better the priorities set by the community and the experts, as regards the mobility future of the city, resulted to the following conclusions:

- It is very important to set independent priorities covering not only the transportation and the mobility development but also the spatial, economic and cultural planning of the area.
- The weights that will be assigned to these priorities are going to influence each step of the Sustainable Mobility planning and for this reason; specific experts must set them.
- In order to achieve reliable results, a sensitivity analysis on each criterion should take place in order to see if a change in their weight is able to modify the final ranking (choice of the strategy, measure etc).
- According to the results of the pilot case evaluation, it has been made clear, that there should be at least doubling of a weight in one or more of the criteria in order to modify the final selection.

A very important step for continuing and upgrade the above presented methodology will be to include more criteria in the current methodology and analysis. The use of the PROMETHEE for selecting alternative strategies, infrastructures, measures or policies can be enriched with the introduction of more weighted criteria (additional to the priorities) as regards the comparative costs, the ease of implementation or even the necessary institutional framework that must take place for the implementation of any of these alternatives.

## ACKNOWLEDGEMENT

of Public Transport Quality Measures. In 2010 she acquired her MSc diploma on Systems' Simulation from the University of Thessaly. She is currently post-doc candidate in the Department of Business Administration of the University of Macedonia. Her professional experience covers a wide range of studies and research programs with subjects related to urban mobility issues, traffic management, transportation master plans, transportation planning using simulation analysis and transportation systems' management emphasizing on the quality, the safety and the reduction of environmental impacts.

**Jason Papathanasiou** is an Associate Professor at the Department of Business Administration, University of Macedonia, Greece. He holds a PhD in Operational Research and a degree in Physics from the Aristotle University of Thessaloniki. He has worked for a number of years at various institutes and has organized and participated in a number of international scientific conferences and workshops. He has published papers in international scientific peer referred journals like the Environmental Monitoring and Assessment, Regional Studies, European Journal of Operational Research, PNAS, Fuzzy sets and Systems and has edited or authored a number of books. He has participated and coordinated many research projects in FP6, FP7, Horizon 2020, Erasmus+, Interreg and COST; he was also a member of the TDP Panel of COST. His research interests include Decision Support Systems, Operational Research and Multicriteria Decision Making.

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# Constrained Nonlinear Optimisation Using Resilient Backpropagation as Search Method

Apostolos Kotsialos
*Generation Planning and*
*Performance Department*
*Generation Business Unit*
*Public Power Company Greece*
*Chalkokondyli 22, T.K. 10432, Athens*
*a.kotsialos@dei.com.gr*

**Abstract**

This paper builds on the earlier work of Kotsialos (2013, 2014), where the Resilient BackPROPagation (RPROP) algorithm is recast as a search direction and step selection method for solving smooth and non-smooth, unconstrained and simply-bounded nonlinear optimisation problems. Although RPROP was originally proposed as a learning algorithm for neural networks training, it has been shown that it is competitive and sometimes can outperform highly sophisticated algorithms, especially for solving non-smooth problems. The simplicity of implementation, the relatively low computation effort, as only one function and one gradient evaluation are required per iteration, and the good convergence properties make RPROP a highly efficient algorithm for large scale problems. RPROP can tolerate errors in the gradient evaluation, since it is based on the partial derivatives' sign rather than their values, allowing its application to non-smooth Lipschitz continuous objective functions. The constrained optimisation problems considered here are transformed to unconstrained problems by use of exact ℓ1 as well as quadratic penalty functions and combinations thereof. RPROP is applied to the unconstrained problems within a simple multi-start framework for improving convergence. Penalty-barrier as well as augmented Lagrangian methods may be considered in this setting as well. A set of benchmark academic problems available from the literature are used for demonstrating and evaluating the overall algorithm's performance. Detailed computational results and the impact of the main RPROP parameters, the directional step increase rate and the restart frequency, are reported. Hence, this paper extents the investigations reported in Kotsialos (2013, 2014) for nonlinear constrained problems.

**KEYWORDS:**
Constrained nonlinear optimization, resilient backpropagation, penalty methods.

## 1. INTRODUCTION

In Kotsialos (2013, 2014) the Resilient Backpropagation (RPROP) algorithm proposed in (Riedmiller and Braun, 1993) was recast as a search direction and step finding procedure. Originally RPROP was designed as a learning algorithm for solving the neural network training problem. However, work in applied numerical optimal control of motorway traffic flow problems, described in a series of publications, see e.g. (Kotsialos and Papageorgiou, 2004) provided strong evidence that RPROP is highly efficient and competitive to classical line search algorithms. This lead to the formulation of a more coherent and generic description of RPROP as a nonlinear numerical optimisation algorithm for simply bounded non-smooth (Kotsialos, 2013) and smooth unconstrained (Kotsialos, 2014) problems. In this framework, a convergence analysis was given in (Bailey, 2015). RPROP showed excellent convergence properties, scaling with the problem dimension and in some cases, particularly for the non-smooth problems, it outperformed far more sophisticated algorithms. This was further supported in the work related to the problem of parameter identification of large scale models of motorway network traffic flow by Poole and Kotsialos (2016, 2018).

Both problems of motorway traffic optimal control and model parameter identification are dynamic in nature and are reduced to static large scale simply bounded nonlinear optimisation problems. For the optimal control problem, the calculation of the gradient vector is based on the forward integration of the dynamic state equation and the backwards integration of the adjoint. This double integration scheme allows the explicit consideration of the problem's equality constraints without having to resort to penalty or barrier functions. These are used only for expressing special requirements of the particular application, e.g. allowing a maximum queue to be built at specific on-ramps of the motorway network. The approach used for the parameter identification problem was more straightforward in the sense that only a forward integration was performed, but this was done in conjunction with the automatic differentiation package ADOL-C (Walther and Griewank, 2009). The gradient vector is calculated in this case by following the sequence of numerical operations in the overall calculation of the objective function. In the numerical investigations for both problems RPROP proved a highly successful choice for solving the resulting nonlinear optimisation problem.

Having these properties in mind, this paper reports the application of RPROP to constrained nonlinear problems. The constraints are all more general and don't have the structure of a discrete dynamic system. Instead, they are equalities and inequalities that need explicit consideration as such. Exact and quadratic penalty functions are used for transforming the constrained problems into simply bounded ones. Depending on the type of penalty function used, the resulting problems are smooth and non-smooth.

In section 2, a simple description of the basic principle of RPROP as a directional search and step algorithm is discussed. Section 3 outlines the algorithm and section 4 introduces the test problems. Section 5 presents the investigation's results and section 6 concludes this paper.

## 2. SEARCH DIRECTION AND STEPS

Let us consider the nonlinear unconstrained optmisation problem of finding x* = argmin$_\mathbf{x}$ $f(\mathbf{x})$, with $\mathbf{x} \in \mathbb{R}^n$ and $f$ a continuous function of $\mathbf{x}$. The two main methods for solving iteratively this problem is line search and trust region methods. Let us assume that at iteration $k$ the algorithm is at point $\mathbf{x}^{(k)} \in \mathbb{R}^n$ and the value $f(\mathbf{x}^{(k)})$ has been calculated as well as the gradient vector $\mathbf{g}^{(k)} = \nabla f(\mathbf{x}^{(k)}) \in \mathbb{R}^n$. Line search methods require first the determination of search direction $\mathbf{s}^{(k)} \in \mathbb{R}^n$ along which a step $\alpha^{(k)}$ is taken for reaching the next iteration's point given by the update rule $\mathbf{x}^{(k+1)} = \mathbf{x}^{(k)} + \alpha^{(k)}\mathbf{s}^{(k)}$. $\mathbf{s}^{(k)}$ is calculated by following a specific rule tailored to the problem's needs. The most common is to follow the steepest descent direction $\mathbf{s}^{(k)} = -\mathbf{g}^{(k)}$. $\alpha^{(k)}$ is decided by a one-dimensional optimization procedure that ends up with an optimal step size that satisfies a pre-specified set of conditions, such as the Wolfe, strong Wolfe or Armijo conditions (Nocedal and Wright, 1999). Trust region methods follow the opposite sequence of calculations. First, the step is decided, in the sense that a quadratic approximation of $f$ around $\mathbf{x}^{(k)}$ with radius $\alpha^{(k)}$ is trusted to be sufficiently accurate. Subsequently a quadratic programming problem is solved for deciding along which direction $\mathbf{s}^{(k)}$ to move within the bounds of the trust region and apply the update rule of $\mathbf{x}$.

RPROP follows a strategy that falls in between. Both the step and the search direction are determined concurrently, since a different step is calculated for each dimension of $\mathbf{x}^{(k)}$. Applying the algorithm's reasoning to each dimension $i=1,...,n$, the directional step $\alpha_i^{(k)}$ is calculated explicitly. Setting $\alpha^{(k)} = |\Pi_i \alpha_i^{(k)}|$, where the multiplication takes place only for $\alpha_i^{(k)} \neq 0$, the RPROP search direction vector becomes $\mathbf{s}_{\text{RPROP}}^{(k)} = [\alpha_1^{(k)}/\alpha^{(k)} \dots \alpha_n^{(k)}/\alpha^{(k)}]^T$. $\mathbf{s}_{\text{RPROP}}^{(k)}$ can be used for updating $\mathbf{x}$ according to the rule that explicitly includes $\alpha^{(k)}$. A simpler but equivalent update is $\mathbf{x}^{(k+1)} = \mathbf{x}^{(k)} + \mathbf{s}_{\mathbf{R}}^{(k)}$, where $\mathbf{s}_{\mathbf{R}}^{(k)} = [\alpha_1^{(k)} \dots \alpha_n^{(k)}]^T$. Clearly, the dimensional steps determine both the search direction and the step along it. The calculation of the individual $\alpha_i^{(k)}$ is performed by the RPROP rule as detailed in (Kotsialos, 2014).

## 3. CONSTRAINED NONLINEAR PROBLEMS AND PENALTY FUNCTIONS

Let us consider the constrained nonlinear optimisation problem

$$\min_{\mathbf{x} \in \mathbb{R}^n} F(\mathbf{x}) \tag{1}$$

P1      subject to

$$h_p(\mathbf{x}) = 0 \qquad p = 1,...,N_1 \tag{2}$$
$$u_q(\mathbf{x}) \geq 0 \qquad q = 1,...,N_2 \tag{3}$$
$$\mathbf{b}_1 \leq \mathbf{x} \leq \mathbf{b}_2 \tag{4}$$

where $F$, $h_p$ and $u_q$ are continuous nonlinear functions.

Using exact $\ell_1$ penalty functions for both (2) and (3) transforms P1 to the following problem.

$$\min_{\mathbf{x} \in \mathbb{R}^n} f(\mathbf{x};k) = F(\mathbf{x}) + \mu(k) \sum_{p=1}^{N_1} |h_p(\mathbf{x})| + \mu(k) \sum_{q=1}^{N_2} \max\{0,-u_q(\mathbf{x})\} \tag{5}$$

P2($k$)      subject to (4)

where $\mu(k) > 0$ a large penalty weight updated within an external iteration with index $k$. Using quadratic penalty functions, the transformed problem becomes

$$\min_{\mathbf{x} \in \mathbb{R}^n} f(\mathbf{x};k) = F(\mathbf{x}) + \mu(k) \sum_{p=1}^{N_1} h_p(\mathbf{x})^2 + \mu(k) \sum_{q=1}^{N_2} \left\{\max\{0,-u_q(\mathbf{x})\}\right\}^2 \tag{6}$$

P3($k$)      subject to (4).

P2($k$) and P3($k$) are simply bounded nonlinear problems where the RPROP algorithm detailed in (Kotsialos, 2014) is applied. The partial derivatives of $f$ with respect to $\mathbf{x}$ are computed analytically. Although (5) and (6) contain the non-smooth absolute value function and the max operator, the partial derivatives' calculation is performed according to the method followed in (Kotsialos, 2013), where simply bounded non-smooth problems were successfully solved with explicit definition of the partial derivative function. The box constraints are retained in the transformed problems P2($k$) and P3($k$), since a projection operator is used for the gradient vector, (Kotsialos, 2013).

P2($k$) and P3($k$) are solved within an iterative scheme with increasing weight $\mu(k)$, i.e. $\mu(k) \leq \mu(k+1) \leq \mu_{\max}$. Typically, at external iteration $k$ RPROP converges to the optimal solution $\mathbf{x}*(k)$, which acts as initial point for iteration $(k+1)$, i.e. $\mathbf{x}_0(k+1) = \mathbf{x}*(k)$. However, within the multistart framework used here, RPROP is initialised from $R$ different start points and at the end of iteration $k$ there are $R$ optimal points $\mathbf{x}*(k,r)$, $r=1,...,R$. Let $r*(k) = \arg \min_{r=1,...,R} \{f(\mathbf{x}*(k,r);k)\}$. The first start point is then $\mathbf{x}*(k,r)$, i.e. $\mathbf{x}_0(k+1,1) = \mathbf{x}*(k,r*(k))$ and $\mathbf{x}_0(k+1,r) = \mathbf{x}*(k,r*(k)) + 0.5\, s_1\, s_2\, (\mathbf{b}_2-\mathbf{b}_1)$ for $r = 2,...,R$, where $s_1$ is a random sign variable and $s_2$ a random variable following the $U(0,1)$ distribution. The calculated $\mathbf{x}_0(k+1,r)$ are subsequently bounded by $\mathbf{b}_1$ and $\mathbf{b}_2$. In other words, the starting points for $r = 2,...,R$ are simple perturbations of the current best point, which by default is assigned as initial point for $r = 1$.

## 4. TEST PROBLEMS

The test problems used in this preliminary investigation are small to medium scale problems available from the literature. For the sake of brevity in Table 1 each is assigned a number, a reference and an indication pointing to it inside that reference.

Table 11 Test problems and references

| Problem | Reference | Comment | Number of variables | Number of inequality constraints excluding box constraints | Number of equality constraints |
|---|---|---|---|---|---|
| 1 | Parsopoulos and Vrahatis (2002) | Test problem 2 | 2 | 2 | 0 |
| 2 | Parsopoulos and Vrahatis (2002) | Test problem 3 | 7 | 4 | 0 |
| 3 | Parsopoulos and Vrahatis (2002) | Test problem 1 | 2 | 1 | 1 |
| 4 | Parsopoulos and Vrahatis (2002) | Test problem 4 | 5 | 6 | 0 |
| 5 | Parsopoulos and Vrahatis (2002) | Test problem 5 | 5 | 6 | 6 |
| 6 | Dolan and Munson (2004) | Distributions of electrons on a sphere | $3 \times$ number of electrons. | 0 | Equal to the number of electrons |
| 7 | Dolan and Munson (2004) | Shape optimization of a cam | Equals to the number $n$ of points on the cam surface. | $3n$-1 | 0 |
| 8 | Liang *et al.* (2006) | Problem g01 | 13 | 9 | 0 |
| 9 | Liang *et al.* (2006) | Problem g21 | 7 | 1 | 5 |
| 10 | Liang *et al.* (2006) | Problem g13 | 5 | 0 | 3 |

## 5. NUMERICAL RESULTS

Table 2 Results from solving P2($k$) and P3($k$)

| Problem | Best known $F^*$ | P2($k$) $F^*$ P3($k$) $F^*$ | Constraint violation | RPROP maximum iterations | $\eta^+$ | Nr of iterations to restart | Nr of external iterations | Nr of starting points |
|---|---|---|---|---|---|---|---|---|
| 1 | -6961.81381 | -6961.81087 | 1E-9 | 700 | 1.4 | no restart | 1 | 1 |
| | | -6981.81091 | 2.1E-8 | 700 | 1.4 | no restart | 1 | 1 |
| 2 | 680.630057 | 680.8688 | 0.0 | 400 | 2.8 | 20 | 25 | 1 |
| | | 680.8347 | 0.0 | 400 | 2.8 | no restart | 150 | 2 |
| 3 | 1.3934651 | 1.3950648 | 4.5E-11 | 2000 | 2.8 | 20 | 50 | 6 |
| | | 1.3934692 | 8.7E-10 | 1000 | 2.8 | 20 | 120 | 1 |
| 4 | -30665.538 | -30661.361 | 0.0 | 2000 | 4.8 | 200 | 100 | 3 |
| | | -30665.520 | 3.9E-6 | 1500 | 4.8 | 200 | 100 | 2 |
| 5 | -31544.054§ | -31026.403 | 0.0 | 400 | 4.8 | no restart | 80 | 1 |
| | | -31026.414 | 0.0 | 1500 | 4.8 | no restart | 100 | 1 |
| 6 | 1055.18(50), 4448.47(100), 18438.9(200)† | 1056.951, 4464.74545, 18483.1126, 42251.208‡ | 1E-10 | 1200 | 1.2 | no restart | 80 | 6 |
| | | 1055.182, 4448.410, 18439.246, 42131.626‡ | 1.8E-8, 3.9E-8, 8.1E-8, 1.2E-7 | 1200 | 1.2 | no restart | 100 | 1 |
| 7 | 4.27427 | fail | – | – | – | – | – | – |
| | | fail | – | – | – | – | – | – |
| 8 | -15 | -15 | 0.0 | 200 | 2.8 | no restart | 20 | 1 |
| | | -15 | 0.0 | 400 | 2.8 | no restart | 80 | 1 |
| 9 | 193.7245101 | fail | – | – | – | – | – | – |
| | | fail | – | – | – | – | – | – |
| 10 | 0.053941514 | 0.058464171 | 4E-11 | 20 | 1.2 | no restart | 20 | 1 |
| | | 0.054049352 | 1.3E-10 | 400 | 1.2 | no restart | 200 | 1 |

§ known solution with large constraint violations; †number of electrons in parenthesis; ‡300 electrons.

The computational results are summarised in Table 2. For each function, the value of the unpenalised function $F$ at the convergence point of the solution of problems P2($k$) and P3($k$) is given together with: the maximum constraint violation,

the maximum number of RPROP iterations, the RPROP parameter $\eta^+$ and the number of iterations for a restart (as discussed in Kotsialos (2013, 2014) these two are critical parameters for RPROP's convergence), along with the number of external iterations updating the penalty weight $\mu(k)$ and the number of different starting points.

## 6. CONCLUSIONS

The initial results shown in Table 2 show that RPROP has the potential of addressing constrained optimization problems using exact and quadratic penalty functions. It is worth noting that the multistart option was necessary only in five out of the twenty P2 and P3 problems, showing that RPROP is highly efficient as a stand alone search method that can lead to global minima. Nonetheless, a globalization scheme further improves convergence. Furthermore, the non-smooth nature of the penalized unconstrained objective function does not cause significant problems. A more judicious and detailed process of parameter selection would most likely yield better results. Thus, one of the main directions of future work is concerned with improved automatic methods for parameter selection. The most likely direction to be taken is that of hyperheuristic schemes for automatic tuning the RPROP parameters. This should result to an algorithmic scheme requiring minimum manual tuning and more sophisticated termination conditions. The use of automatic differentiation software should also make software development easier at the expense of course of computation time. The problems to which the algorithm failed to deliver a result require more attention, although for problem 7 this could be because of some error in coding or mismatch of the parameters used with respect to the results reported in the literature. In future work, more detailed statistics will be presented and problems with larger dimensions will be considered.

## ACKNOWLEDGEMENT

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# Digital Intelligence: The Impact of Digital Technologies on Human Thinking

Emmanouil Stiakakis
*University of Macedonia*
*156 Egnatia Str., 546 36, Thessaloniki, Greece*

Yiorgos Liapis
*University of Macedonia*
*156 Egnatia Str., 546 36, Thessaloniki, Greece*

**Abstract**

It is a fact that digital technologies strongly influence every aspect of our lives, even the way we react to the stimuli of our environment, understand messages, solve problems, communicate, and generally all the ways we think. This paper presents evidence from the literature that several cognitive abilities are very different in the digital and the physical (tangible) environment. For example, people's reading behaviour is quite different in the digital environment, since less time is devoted on in-depth reading and sustained attention on an electronic document has decreased, mainly due to hyperlinks which distract people from continuous and concentrated reading. For the purpose of this study, an online survey was conducted among under- and post- graduate students of two universities and a technological educational institute of the city of Thessaloniki, Greece, with a sample size of 2,345 individuals. The findings of the survey show statistically significant differences about how specific cognitive activities are performed in the digital and the tangible environment. More specifically, six activities, i.e. reading, playing a game, information seeking, communication, learning to do things, and multitasking were investigated in the two environments. The survey respondents with an advanced usage of digital devices perceive that their own abilities for those activities are better in the digital environment. On the other hand, those who were classified as novice users cannot perceive different abilities between the two environments. The findings of this study reveal signs of digital intelligence, a new way of thinking that is emerging as people are trying to adapt to the radically changing and highly demanding digital environment. The existence of digital intelligence and the results of its future investigation will have serious implications on what children should learn and how they could learn better in the digital age.

## 1. INTRODUCTION

Digital technologies and media have a strong impact on how people live, work, even on how they think nowadays. A lot of questions arise and need answers, as for instance, whether people and particularly youth have started to develop a new type of intelligence in the digital environment. In the context of addressing that issue, a survey was conducted in this study with the aim to confirm whether there are differences in cognitive abilities, between the digital and the physical (tangible) environment. By cognitive abilities, it is meant all the intellectual abilities through which information is acquired, transformed, memorized, recovered, and used (Scheiner et al., 2015).

A successful distinction emphasizing on how digital technology affects our lives was proposed by Prensky (2001), distinguishing people into 'digital natives' and 'digital immigrants'. Whoever belongs to the first category thinks and process information fundamentally differently from the others. A digital immigrant also uses digital technologies but most of the times 'footprints' of not so good usage are left. Tapscott (2008) named the people who grew up and were educated at about the time of the Internet's advent, the 'Net Generation' (they are also called Generation Y) and the children who were born afterwards, the 'Generation Next' (also called Generation Z). According to Tapscott, people of the Net Generation and the Generation Next show signs of learning differently. He also said that it is the first time in history that children are more knowledgeable and literate than their parents. Additionally, Carr (2008, 2010) pointed out that we are not thinking nowadays the way we used to think. In the same vein, Nicholas et al. (2004) noted that the Internet has given birth to a new cognitive model of obtaining knowledge.

## 2. INTELLIGENCE IN THE DIGITAL ENVIRONMENT

Digital technologies surround us in every aspect of our lives, like being a part of our lives. It can be said that the digital environment is so ubiquitous that it has become invisible, particularly for younger people. For example, if someone showed a nice photo on his/her new technology smartphone to a middle-aged man and his son, a possible reaction would be that the father would be amazed by the phone, but his son would only be amazed by the photo, as the technology were invisible for him. A short list of strong indications, found in the literature, about the differences of cognitive abilities in the physical and the digital environment is presented in Table 1. These differences indicate the significant impact of digital technologies and media upon a lot of ways of thinking and cognitive activities of a human being nowadays.

Table 12 Cognitive abilities in the physical and the digital environment

| Physical environment | Digital environment | Reference |
|---|---|---|
| In depth reading | One-time reading, selective reading | Carr (2008); Liu (2005) |
| It is possible to pay sustained attention on reading | Possible distraction of attention on reading | Carr (2010, 2008); Liu (2005) |
| Serial access to information of a text | Random access through hypertext links and browser functions | Kress (2003); Prensky (2001) |
|  | Multimodality of electronic documents (image, audio, video, text) changes the way that readers perceive and understand such a document | Kress (2003) |
| Reading via print media, along with audio media, improve critical thinking and imagination |  | Greenfield (2009) |
|  | Video games improve visual-spatial skills | Greenfield (2009) |
|  | Video games improve many cognitive abilities, such as reasoning, receptive vocabulary, visual short-term memory, and processing speed | Gnambs and Appel (2017); Dobrowolski et al. (2015) |
|  | Real-time thinking, in sense of processing a large number of simultaneous stimuli of different kinds (e.g. sound, text, images) | Eshet (2012) |
|  | "Knowing together": children want to seek information in groups and they like to share it with others | Dresang (2005) |
| In face to face communication, the participants respond immediately and spontaneously | In instant messaging and other digital media (e.g. email, blogs, fora), the users have the time to compose and revise their responses, thus getting more control over their communication | Bowman et al. (2010) |
| Usually performing one task at a time | Usually multitasking (doing different things simultaneously, as for instance, during a video game) | Wolf and Barzillai (2009); Greenfield (2009) |
|  | It is possible for the user of digital media to externalize an algorithmic way of thinking | Williamson Shaffer and Clinton (2006) |
|  | New ways of learning to do things (e.g. via computer games, simulation) | Prensky (2001); Tapscott (2008) |

Based on Table 1, the main research question of this study is whether there are 'signs' of a new way of thinking in the digital environment. In our analysis, the main focus will be on the following cognitive abilities: (i) reading, (ii) playing a game, (iii) information seeking, (iv) communication, (v) learning to do things, and (vi) multitasking. For all of these, there are serious indications that they are performed differently in the physical and the digital environment and need to be further investigated. The null hypotheses are stated below:

$H_1$     There is no difference in how reading is performed in the physical and the digital environment.
$H_2$     There is no difference in how playing a game is performed in the physical and the digital environment.
$H_3$     There is no difference in how information seeking is performed in the physical and the digital environment.
$H_4$     There is no difference in how communication is performed in the physical and the digital environment.
$H_5$     There is no difference in how learning to do things is performed in the physical and the digital environment.
$H_6$     There is no difference in how multitasking is performed in the physical and the digital environment.

## 3. METHODOLOGY AND RESULTS

To test the hypotheses, an online survey was conducted in the context of a postgraduate university course. The students who attended that course were asked to distribute the online form of a questionnaire, which was created via Google Forms, to mailing lists. The target group of the survey comprised the under- and post- graduate students of two universities and a technological educational institute of the city of Thessaloniki – Greece, during the period October-December 2018. The sample size was 2,345 students with a response rate of about 16.3%. The respondents to the survey were classified into five categories according to three variables: (a) the digital devices that they use, (b) the frequencies of use, and (c) the reasons of use. The five categories are: (i) beginners, (ii) developing users, (iii) average users, (iv) advanced users, and (v) experts. At the end of the classification process, 1,989 users of digital devices were classified into the five suggested categories out of 2,345 respondents to the survey. The rest 356 respondents were not classified because according to their answers they had not used most of the digital devices at all (also including all the questionnaires that were not filled in correctly). The results from the classification process are as follows: 144 beginners, 288 developing users, 417 average users, 733 advanced users, and 407 experts.

As earlier mentioned, the following cognitive abilities were chosen to be investigated whether they are performed differently in the digital and the physical environment: (i) reading, (ii) playing a game, (iii) information seeking, (iv) communication, (v) learning to do things, and (vi) multitasking.

The survey respondents were asked whether they perceive their own abilities to be better or worse in the two environments. More specifically, the possible choices were: 'much better in the digital environment', 'better in the digital environment', 'the same in the digital and the physical environment', 'better in the physical environment', and 'much better in the physical environment'; there was also the choice of non-opinion. The purpose was to see whether the respondents with an advanced usage of digital devices have different cognitive abilities (of those examined in the research) in the digital and the physical environment. Since it was needed to consider the relationship between an ordinal variable (user category, getting the values of 'beginner', 'developing user', 'average user', 'advanced user', and 'expert') and a nominal variable (digital vs. physical environment, getting the values mentioned above), correspondence analysis was selected for the visual representation of that relationship. It should be mentioned that correspondence analysis is a non-parametric exploratory statistical technique, which can be used to graphically display the relationship between the variables in a multidimensional space; however, it is a descriptive method and does not allow testing statistical hypotheses. That is the reason for that chi-square testing was also used. The diagrams arising from correspondence analysis are illustrated in Figure 1, where:

- user category (expert, advanced user, average user, developing user, and beginner)
- digital vs. physical environment {mb DIGITAL (much better in the digital environment), b DIGITAL (better in the digital environment), the same (the same in the digital and the physical environment), b PHYSICAL (better in the physical environment), and mb PHYSICAL (much better in the physical environment)}.

Analyzing the diagrams of Figure 1, it should be pointed out that two dimensions were extracted in all the cases, accounting for a very high percentage of the total 'inertia', i.e. the total variance of the analysis (the lowest percentage was 92% and the highest 98.4%). In all the diagrams, it can be seen that the user who is considered as 'expert' is very close to 'mb DIGITAL', implying that the category of experts has a close relationship with the category of much better in the digital environment. Correspondingly, the advanced user is related to the perception of cognitive abilities as better in the digital environment (while in the case of playing a game they are related to much better in the digital environment). In three of the cases, i.e. playing a game, information seeking, and communication, the average user is related to better or much better in the digital environment. There were no relationships of the 'weak' user categories (developing user and beginner) with high perceptions of cognitive abilities in the digital environment or the physical environment, as it was anticipated. More specifically, beginners cannot perceive different abilities between the two environments simply because they do not use the digital devices.

According to the results of chi-square testing, all the tests were statistically significant implying the rejection of the null hypotheses about the independence of the two variables. It can be concluded that there is a significant relationship between the user category and the perception of the examined abilities in the digital and the physical environment. Since the strength of the relationship cannot be indicated by the coefficient of chi-square, Cramér's V was used. The values of Cramér's V for all the cognitive abilities showed a weak to moderate relationship of the variables: (0.182 for reading, 0.174 for playing a game, 0.192 for information seeking, 0.195 for communication, 0.172 for learning to do things, and 0.18 for multitasking).

Figure 1 Diagrams of correspondence analysis
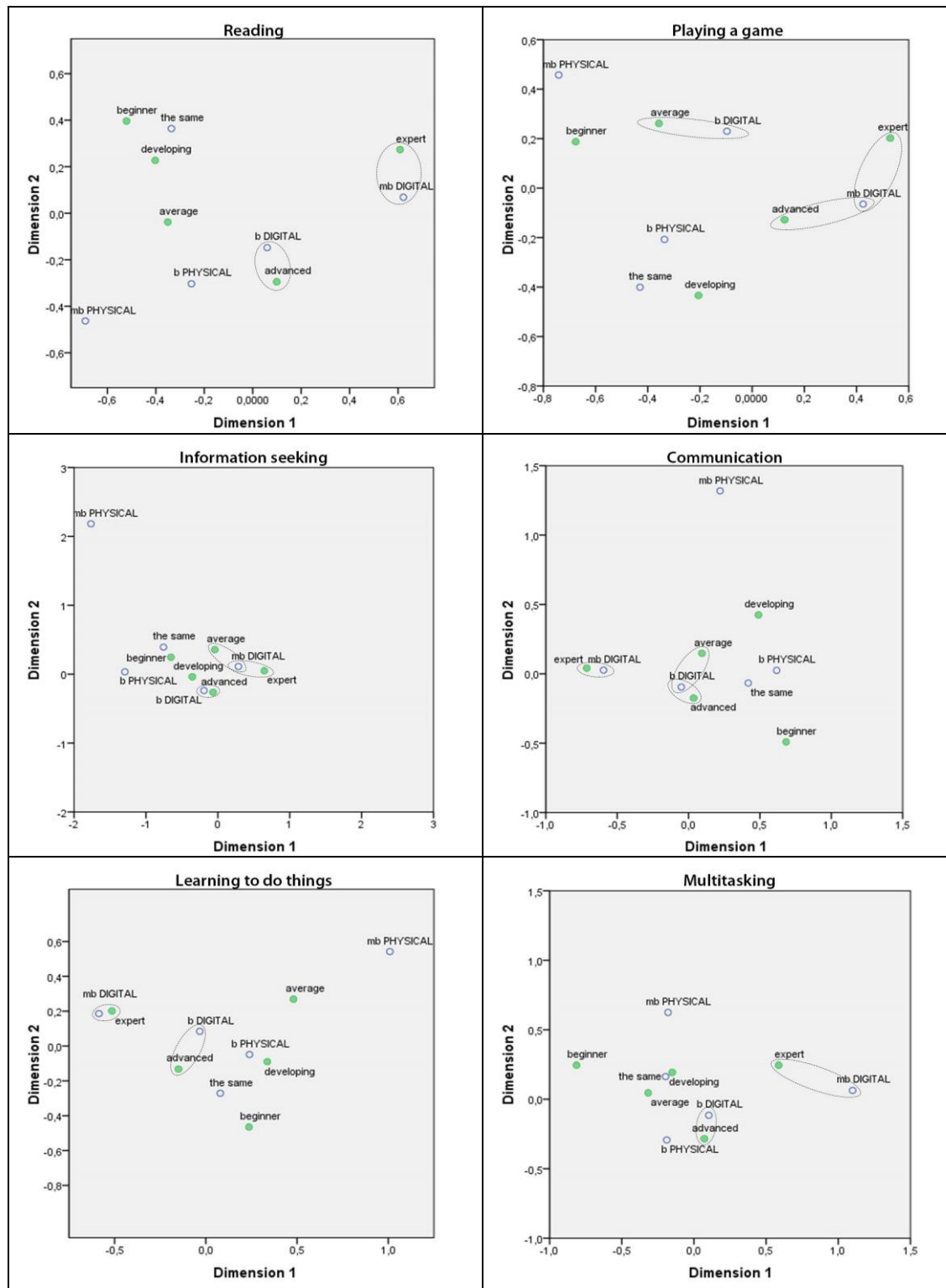


## 4. CONCLUSIONS

The findings of this study indicate a different way of thinking between the physical and the digital environment, so it can be concluded that there are 'signs' of a new way of thinking in the digital environment, that could be named 'digital intelligence' (not well-known and accepted in the literature yet). This way of thinking will be increasingly developing as, in essence, it is the outcome of people's efforts and their willingness to adapt to the new and continuously expanding digital

environment. And, as more complex digital technologies will emerge in the near future, digital intelligence is more likely to be the most necessary type of intelligence for survival and success in the digital age.

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# A Robust Model for Pollution Routing Problem Considering Noise and Greenhouse Gas Emission

Hani Shahmoradi-Moghadam *
*Boysen-TU Dresden-Research Training Group (Cluster B) ***
*Chair of Transport Services and Logistics, Technical University of Dresden, Germany ***

Omid Samani *
*Boysen-TU Dresden-Research Training Group (Cluster D) ***
*Chair of Acoustics and Haptics, Technical University of Dresden, Germany ***

Jörn Schönberger *
*Institute of Transport and Economics ***
*Chair of Transport Services and Logistics, Technical University of Dresden, Germany ***

**Abstract**

One of the most important goals of green logistics is to reduce the destructive side effects of freight transportation which can lead to several types of health risks. The pollution routing problem (PRP) is an extension of the vehicle routing problem (VRP) which considers greenhouse gas emission in addition to the travel time, cost, and delivery constraints. Another environmental impact of vehicles, especially in urban areas is noise emission which is ignored in optimization PRP researches. This form of pollution endangers physical well-being by causing annoyance, hearing loss, heart disease, mental issues for children, and sleep disorders. In this paper, using noise emission mathematical equations, we aim to reduce noise and exhaust gas emission in VRP with respect to delivery and time window constraints. Our model presents a scenario-based robust optimization model for PRP, considering noise and greenhouse emissions as well as inherent demand uncertainty. In order to model the uncertainty of the problem, we adopted a scenario-based robust optimization approach which considers uncertain scenarios with a determined occurrence probability. Furthermore, based on the noise effecting factors such as speed and acceleration of vehicle. This model suggests a range of solutions that can be selected according to decision maker conservatism level and preferences. To examine the performance of the model, a real-world data sets from PRPLIB instances which are randomly selected from the cities in United Kingdom. The results approve the possibility of finding a sustainable solution for VRP which takes into account various parameters including cost, social, and environmental aspects of freight transportation for a vehicle fleet.

## 1. INTRODUCTION

The pernicious effects of transportation on the environment and human should not be ignored under the shadow of ease that it brings to the life. The negative effects such as noise and greenhouse gas emission, resource depletion, acidification, and toxic effects on ecosystems are all caused by transportation (Knörr, 2009). Since introducing the Vehicle Routing Problem (VRP) Dantzig and Ramser (1959), many researches have been conducted to minimize the destructive effects of transportation by selecting between different vehicle routes based on customer demands. In the VRP an attempt is made to minimize the total travelled distance by all vehicles. More sophisticated models were introduced based on VRP, taking into account fuel consumption (Bektas and Laporte, 2011). Green Vehicle Routing Problem was also used by (Bektas and Laporte, 2011) and leads to an improvement called Pollution Routing Problem (PRP) in which a time window is used for VRP (VRPTW). Considering the deleterious effects of noise pollution on the environment and human mental and physical well-being, it is absolutely vital to include it to the Pollution Routing Problem. In this paper a new PRP-based model is introduced, in which, for the first time the effect of noise is taken into account. This model is called NPRP. Including noise emission factor in optimization process leads to more comprehensive and reliable results which work as a preventive factor improving the health related quality of life by elimination of the detrimental effects of noise exposure such as annoyance, hearing loss, cardiovascular disease, sleep disturbance, nervousness, etc.

## 2. LITERATURE REVIEW

The existing literatures on PRP are shortly reviewed in this section. The mathematical models are introduced as well as traffic modeling model used in this project.

### 2.1 Green Vehicles Routing Problem(Gvrp)

Green vehicle routing problem is an extension to VRP by taking into account $CO_2e$ emission (Demir et al.,2014). PRP is based on GVRP which introduced by (Bektas and Laporte, 2011). PRP is a time windowed VRP aiming at minimizing fuel consumption, greenhouse gas emission, and cost in a multi destinations routing service for customers (Eshtehadi et al.,2017).

## 2.2 Traffic Noise Models

There are many noise emission models which work mostly based on the same concept. Depending on the model the impact of various parameters including spectrum, acceleration, and speed will be investigated. Moreover, there are some compensation factor depending on the category type of vehicle, road conditions etc. A comprehensive review of different noise emission models can be found in (Can, Aumond, 2018). In this paper Harmonoise model is used. Two main noise emitting sources of a vehicle are tyres and engine. Generated noise by tyres and engine are called respectively Rolling and propulsion noise (Jonasson et al., 2004). At the end the sound pressure level of each sources will have a weighted contribution to the emitted noise by vehicle. The Harmonise model predicts the noise emission in a function of frequency, speed and acceleration. The effect of the speed is investigated in the range of 10 to 130 km/h for five category of vehicles (Watts, 2005).

## 2.3 Research gap

Many researches have been carried out in PRP field and tremendous improvements have been achieved. Although the effect of noise pollution as a serious problem is ignored. In this project the attempt is to consider the noise emission as an unwanted parameter that must be minimized in Pollution Routing Problems.

## 3. MODEL FORMULATION

Firstly, we describe our adoptive robust optimization for better understanding of our robust noise and air pollution routing problem (NPRP). Then the proposed Robust NPRP model is formulated according this scenario-based robust optimization method which includes demand uncertainty in the model.

## 3.1 Robust optimization methodology

According to (Mulvey et al., 1995) method, constraints and variables are divided to two major categories: (1) *structural*, that is fixed and remained unchanged while any probable scenario occurs. (2) *control*, which may take different values in each individual scenario and is subjected to adjustment whenever uncertain parameter realized. Consider following uncertain model:

$$Min:\ c^T x + d^T y \tag{1}$$

$$Subject\ to:$$

$$Ax = b, \tag{2}$$

$$Bx + Cy = e, \tag{3}$$

$$x, y \geq 0, \tag{4}$$

Where $x$ and $y$ are structural and control variables and (3) is controlling constraint respectively. In order to rewrite robust counterpart of the model, a set of scenarios $S = \{1,2,3,\dots,S\}$ is defined and the probability of the scenario $p_s$ ($\sum_{s=1}^{S} p_s = 1$) is associated. Furthermore, $\{\delta_1, \delta_2, \dots, \delta_s\}$ is the set of error vectors. (Mulvey et al., 1995) approach extended by Yu and Li (2000). Their robust counterpart is as follow:

$$Min\ Z = \sum_{s\epsilon\Omega} p_s \xi_s + \lambda \sum_{s\epsilon S} p_s \left[ (\xi_s - \sum_{s'\epsilon S} p_{s'}\xi) + 2\theta_s \right] + \omega \sum_{s\epsilon S} p_s \delta_s \tag{5}$$

$$s.t.$$

$$\xi_s - \sum_{s\epsilon S} p_s \xi_s + \theta_s \geq 0 \tag{6}$$

$$Ax = b \tag{7}$$

$$B_s x + C_s y_s + \delta_s = e_s \qquad \forall s\epsilon S \tag{8}$$

$$x \geq 0, y_s \geq 0 \ \theta_s \geq 0 \ \forall s \in S \tag{9}$$

## 3.2. Mathematical Formulation for the Robust NPRP

We now present a robust formulation for pollution routing problem which considers both noise and air pollution simultaneously. A generic vehicle routing problem is considered in a way that demands of customers are uncertain and can be described as optimistic, realistic, and pessimistic values.

Regarding air pollution, the PRP first time introduced by (Bektas and Laporte, 2011), and extended by (Demir et al., 2012). They proposed the following formulation for calculating fuel consumption with high accuracy:

$$F(v) = \frac{\lambda(kNV + w\gamma\alpha v + \gamma\alpha f v + \beta\gamma v^3)d}{v} \tag{10}$$

Where $v$, $d$, and $w$ denote vehicle speed, travel distance, and curb weight of an empty vehicle. Furthermore, the description and typical values of the other parameters related to road and vehicle specification can be found in (Demir et al., 2012). From this formulation, it is obvious that fuel consumption strongly depends on payload and travel speed.

A noise prediction model called Harmonoise model was developed to be used by European Union members for noise mapping (Watts, 2005). The equations for this models are presented below:

$$L_{WR}(f) = a_R(f) + b_R(f) \log\left(\frac{v}{v_{ref}}\right), \qquad L_{WP}(f) = a_P(f) + b_P(f)\left(\frac{v - v_{ref}}{v_{ref}}\right) \tag{11}$$

In this formulation, $L_{WR}(f)$ and $L_{WP}(f)$ are function of frequency that denotes rolling and propulsion noises emission respectively. Accordingly, $v_{ref}$ is considered 70 km/h, and $a_R(f), b_R(f), a_R(f),$ and $b_R(f)$ are compensation factors for frequency. More information about this model can be found in (Jonasson, 2007). In order to take into account the environmental factors such as road condition, a random parameter namely ($GE_{ij}$) between 0.5 and 1.2 is considered.

The model is described as a complete direct graph $G = (N, A)$ with $N = \{0, 1, 2, \ldots, n\}$ as the set of nodes and node 0 assumed as a depot. $d_{ij}$ denotes distance matrix between nodes $i$ and $j$; moreover, $q_i^s$ is a non-negative and uncertain parameter that shows the demand of customers in scenario $s$ and $Q$ is equal to the capacity of each vehicle which cannot exceed $m$. In this problem, all customers have their own time window; therefore, the earliest and latest are $a_i$, $b_i$ simultaneously.

We also adopt $v^h$ ($h = 1, 2, 3, \ldots H$) as a discrete parameter for the range of speed; consequently, the assumption is that the vehicle speed has a constant value during traveling between nodes and binary variable $z_{ij}^{h,s}$ determines speed level for traveling between node $i$ to $j$ in scenario $s$. Our suggested robust NPRP model based on (Bektas and Laporte, 2011) is as follow:

$$Min\ Z = \sum_{s \in \Omega} p_s \xi_s + \lambda \sum_{s \in S} p_s [(\xi_s - \sum_{s' \in S} p_{s'} \xi) + 2\theta_s] + \omega \sum_{s \in S} p_s \delta_s \tag{12}$$

**Subject to:**

$$\xi_s = Z_s^A + Z_s^R + Z_s^P \qquad \forall s \in S \tag{13}$$

$$Z_s^A = \sum_{i=0}^n \sum_{j=0}^n \sum_{h=1}^H \frac{kNV\lambda d_{ij}\, z_{ij}^h}{v^h} + \sum_{i=0}^n \sum_{j=0}^n w\gamma\lambda\alpha_{ij}\, d_{ij}\, x_{ijs} + + \sum_{i=0}^n \sum_{j=0}^n \gamma\lambda\alpha_{ij}\, d_{ij}\, f_{ij} + \tag{14}$$

$$\sum_{i=0}^n \sum_{j=0}^n \beta\gamma\lambda d_{ij}\, z_{ij}^{h,s}(v^h)^2 \qquad \forall s \in S$$

$$Z_s^R = \sum_{i,j}^n HN_{i,j,s}{}^R \qquad \forall (i,j) \in A, s \in S \tag{15}$$

$$Z_s^P = \sum_{i,j}^n HN_{i,j,s}{}^p \qquad \forall (i,j) \in A, s \in S \tag{16}$$

$$L_{i,j}{}^R = GE_{ij}\left(a_R(f) + \sum_{h=1}^H b_R(f)\log\left(\frac{v^h}{v_{ref}}\right) z_{ij}^{h,s}\right) \qquad \forall (i,j) \in A \tag{17}$$

$$L_{i,j}{}^P = GE_{ij}\left(a_P(f) + \sum_{h=1}^H b_P(f)\left(\frac{v^h - v_{ref}}{v_{ref}}\right) z_{ij}^{h,s}\right) \qquad \forall (i,j) \in A \tag{18}$$

$$L_{i,j,s}{}^R - l^R \le HN_{i,j,s}^R \qquad \forall (i,j) \in A, s \in S \tag{19}$$

$$L_{i,j,s}{}^p - l^p \le HN_{i,j,s}^p \qquad \forall (i,j) \in A, s \in S \tag{20}$$

$$\sum_{i=0}^n x_{ijs} = 1, \qquad j = 1, 2, \ldots, n, \forall s \in S \tag{21}$$

$$\sum_{j=0}^n x_{ijs} = 1, \qquad i = 1, 2, \ldots, n \qquad \forall s \in S \tag{22}$$

$$\sum_{i=1}^n x_{0js} = VEC_s \qquad \forall s \in S \tag{23}$$

$$\sum_{i=1}^n x_{0js} \le m + \delta_s \qquad \forall s \in S \tag{24}$$

$$\sum_{j=0, j \ne i}^n f_{ji}{}^s - \sum_{j=0, j \ne i}^n f_{ij}{}^s = q_i{}^s, \qquad i = 1, 2, \ldots, n, s \in S \tag{25}$$

$$q_i{}^s x_{ijs} \le f_{ij}{}^s \le (Q - q_i{}^s) x_{ijs}, \qquad \forall (i,j) \in A, s \in S \tag{26}$$

$$y_i - y_j + t_i + \sum_{r \in R} d_{ij} z_{ij}^{h,s} \Big/ v^h \le O_{ij}(1 - x_{ijs}) \qquad \forall i \in N, j \in N, i \ne j, s \in S \tag{27}$$

$$a_i \le y_i \le b_i \qquad \forall i \in N \tag{28}$$

$$y_i - s_j + t_i + \sum_{r \in R} d_{ij} z_{ij}^{r,s} \Big/ v^h \le M(1 - x_{ijs}) \qquad \forall i \in N, j \in N, i \ne j, s \in S \tag{29}$$

$$\sum_{h=1}^H z_{ij}^{h,s} = x_{ijs} \qquad \forall (i,j) \in A, s \in S \tag{30}$$

$$x_{ijs} \in \{0,1\}, \ P_{i,j,s}^p, P_{i,j,s}^R, f_{ij,s} \ge 0 \ , \ z_{ij}^{r,s} \in \{0,1\}, \quad \forall (i,j) \in A, \ h \in H. \tag{30}$$

The objective function (12), minimize hazardous noise and total fuel consumption and constraint (13) expresses the normalized objective function of each scenario based on three main objective functions (14), (16). Constraints (17) and (18), give us the rolling and propulsion noise emissions respectively while noise levels exceeding the threshold ($l^R, l^p$) are calculated in constraints (19) and (20). Constraints (21) and (22), enforce that each customer should be visited once and constraint (23) and (24) state amounts of hired vehicles which should not exceed from $m$; otherwise, company should rent from a third party ($\delta_s$) with additional cost of $\omega$. Constraints (25) and (26), ensure flow balance in each scenario and constraints (27), (29) enforce the time window limitations. Finally, speed level for each arc is determined in constraint (30).

## 4. COMPUTATIONAL EXPERIMENTS

In this section, in order to examine the performance of our suggested NPRP model, a well-known data set (PRPLIB) is used which can be downloaded from the following website: http://www.apollo.management.soton.ac.uk/prplib. It should be noted that $GE_{ij}$ generated randomly between 0.5 and 1.2 for each arc and $l^R$, $and\ l^P$ are considered 71 dB each. Furthermore, optimistic and pessimistic scenarios are defined as 50% and 150% of the average demand respectively. We also set 0.2, 0.45, and 0.35 as scenario probabilities ($p_s$). The proposed NPRP model completed using CPLEX solver embedded in GAMS 26.1 on a laptop with Intel Core i5 82050U CPU and 8 GB RAM. For this purpose, we developed and adopt 4 data sets with 10 and 20 nodes.

In Table 1, to demonstrate the effectiveness of NPRP model on noise reduction, we compare our results for over threshold noise (dB) with the PRP model which does not take into account the noise pollution. As can be seen, when noise equations are included in the PRP model, a significant drop in overall noise level from 139 and 76 dB to 0 for the both types of noise will happen.

**Table 1.** Comparison between PRP and NPRP

| Vehicle | PRP | | | | NPRP | | | |
|---|---|---|---|---|---|---|---|---|
| | Route | $Z^A$ (L) | $Z^P(dB)$ | $Z^R(dB)$ | Route | $Z^A$ (L) | $Z^P(dB)$ | $Z^R(dB)$ |
| 1 | 1-2-11-4-1 | | | | 1-2-7-10-1 | | | |
| 2 | 1-6-3-9-1 | 53 | 139 | 76 | 1-3-5-8-6-1 | 63 | 0 | 0 |
| 3 | 1-8-10-7-5-1 | | | | 1-9-11-4-1 | | | |

Table 2 and 3 present the results for three main objective functions as well as penalty variable for data sets 10- 20-nodes respectively. As it can be seen in the tables, in terms of noise emission higher number of options gives the driver the possibility to choose between better condition routes in order to meet time window limitation. It is not necessary to increase their speed level and this is why by increasing penalty coefficient (ω) value of $Z^P$ increases from 38,38,91 dB to 95,95,91 dB in the first data set for the engine noise. Moreover, by increasing the amount of demands in scenario 3, fuel consumption rises significantly. As can be seen in 20-nodes data set, fuel consumption raised 57 liters in scenario 3 respect to scenario 1. In addition, it is clear that by increasing the penalty value, the model tends to use fewer vehicles; therefore, fuel consumption shows an indirect relationship in the case of vehicle amounts.

**Table 2.** model results for 10-nodes instance ($m = 3$)

| $N$ | $\omega$ | $Z_s^A$(L) | | | $Z_s^R$ (dB) | | | $Z_s^P$ (dB) | | | $\delta_s$ | | | CPU |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S1 | S2 | S3 | S1 | S2 | S3 | S1 | S2 | S3 | S1 | S2 | S3 | Time(s) |
| | 0 | 86 | 87 | 110 | 9 | 9 | 15 | 38 | 38 | 91 | - | - | - | 3 |
| | 1 | 86 | 87 | 110 | 9 | 9 | 15 | 38 | 38 | 91 | 2 | 2 | 3 | 6 |
| | 10 | 79 | 81 | 110 | 9 | 9 | 20 | 38 | 38 | 91 | 1 | 1 | 2 | 8 |
| 10 | 30 | 79 | 81 | 110 | 9 | 9 | 20 | 38 | 38 | 91 | 1 | 1 | 2 | 10 |
| | 60 | 79 | 81 | 110 | 9 | 9 | 20 | 38 | 38 | 91 | 1 | 1 | 2 | 8 |
| | 90 | 77 | 79 | 110 | 31 | 31 | 20 | 95 | 95 | 91 | 0 | 0 | 3 | 41 |

**Table 3.** model results for 20-nodes instance ($m = 4$)

| $N$ | $\omega$ | $Z_s^A$(L) S1 | S2 | S3 | $Z_s^R(dB)$ S1 | S2 | S3 | $Z_s^P(dB)$ S1 | S2 | S3 | $\delta_s$ S1 | S2 | S3 | CPU Time(s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|    | 0 | 90 | 123 | 147 | 0 | 0 | 0 | 5 | 0 | 1 | 3 | 5 | 6 | 799 |
|    | 10 | 91 | 118 | 147 | 0 | 0 | 0 | 2 | 0 | 1 | 3 | 5 | 6 | 5213 |
|    | 30 | 93 | 113 | 147 | 0 | 0 | 0 | 13 | 9 | 1 | 4 | 4 | 6 | 4244 |
|    | 50 | 104 | 114 | 147 | 0 | 0 | 0 | 0 | 7 | 1 | 4 | 4 | 6 | 3834 |
| 20 | 80 | 105 | 114 | 147 | 0 | 0 | 0 | 0 | 8 | 1 | 4 | 4 | 6 | 14706 |
|    | 90 | 103 | 120 | 147 | 0 | 0 | 0 | 0 | 8 | 1 | 4 | 4 | 6 | 14852 |
|    | 120 | 102 | 115 | 147 | 0 | 0 | 0 | 0 | 10 | 1 | 4 | 4 | 6 | 23358 |
|    | 200 | 98 | 117 | 147 | 0 | 0 | 0 | 0 | 15 | 1 | 4 | 4 | 6 | 5388 |

## 5. CONCLUSION

In this paper, we developed a mixed integer programing model for robust noise and air pollution routing problem considering demand uncertainty. We adopt a real-world data sets in order to evaluate proposed model and analyze the noise emission effects on vehicle routing problem. Final results approve that including noise pollution in PRP models is relevant and suggested NPRP model can reduce noise emission significantly. For future researches, solution algorithms for solving large scale problems and also considering vehicle reliability is recommended.

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# Optimal order quantity for an inventory system with defective items

Georgios Karakatsoulis

*Department of Mathematics*
*University of Ioannina,*
*45110 Ioannina Greece*
*Email: g.karakatsoulis@gmail.com*

Konstantina Skouri

*Department of Mathematics*
*University of Ioannina,*
*45110 Ioannina Greece*
*Email: kskouri@uoi.gr*

**Abstract**

A continuous review inventory system with deterministic demand and defective items (low quality items) is considered. The fraction of defective items is a random variable. The order quantity is subjected to a 100% screening process with a fixed screening rate. The defective items are sold as a single batch at the end of the process in a lower price. Due to defective items, stockouts can occur and they are complete backlogged. Perfect and low quality items have different holding costs per unit per unit time. The replenishment policy that minimizes the total cost of the system is derived. The proposed model integrates and extends previous existing models.

## 1. INTRODUCTION

The production of imperfect items in the several stages of a supply chain directly impacts its efficacy. For example, in the production of the curved glass for the display of a new cell phone series from Samsung, the imperfect quality items are on average more than 50% (Sonntag and Kiesmüller, 2018). So, in order to incorporate this issue many extensions and modifications of the Economic Order Quantity (EOQ) model was proposed, in an attempt to approach the reality. Silver (1976) has shown numerically that the total cost of the system, where the quantity received does not necessarily match the quantity requisitioned, can be increased more than 120% if the simple EOQ is used. Salameh and Jaber (2000) proposed a model in which each lot contains a random percentage of imperfect quality items that are inspected with a finite screening rate. Wahab and Jaber (2010) modified the model proposed by Salameh and Jaber (2000) and the model proposed by Maddah and Jaber (2008) assuming that the holding cost of the perfect quality items is different for the holding cost of the imperfect. Khan et al. (2011) reviewed the literature that has extended the Salameh and Jaber (2000) EOQ model for imperfect items. Vörös (2013) modified the model proposed by Maddah and Jaber (2008) allowing the percentage of the imperfect quality items to be large enough so the system will not be able to satisfy the demand.

In this study a model is proposed that unifies the model of Vörös (2013) and Wahab and Jaber (2010) while relations with other, simpler models, are shown.

The paper is organized as follows. Section 2 provides the notations and assumptions used in the model. Section 3 shows the mathematical formulation of the total cost per unit time and also provides the main result regarding the optimal solution of the underlying optimization proplem. Special cases that follow from this model presented in Section 4. Finally conclusions and directions for further research are given in Section 5.

## 2. PRELIMINARIES

The assumptions underlying the model and the notation used have as follows:

### 2.1 Assumptions

1. The planning horizon is infinite.
2. The demand rate is known and constant.
3. The lead time is zero.
4. An order is placed once the inventory level drops to zero. The time between two consecutive orders is defined as cycle.
5. Each lot contains a random percentage of imperfect quality items with a known probability density function.
6. Each lot is subjected to 100% inspection process at a finite rate.
7. The inspection process is supposed to be error-free.
8. The inspection rate is bigger than the demand rate.

9. The imperfect quality items are sold as a single batch at a lower price at the end of the screening process
10. Due to randomness of the percentage of the imperfect quality items, stockouts can occur and they are complete backlogged at the end of the inspection process, by ordering from a second, reliable but more expensive supplier.
11. The holding cost of the perfect quality items is different from the holding cost of the imperfect.

## 2.2 Notation

| | | | |
|---|---|---|---|
| $Q$ | Order Quantity (in units) [decision variable] | $c_b$ | Backlogging cost (per unit, per unit time) |
| $D$ | Demand rate (in units, per unit time) | $p$ | Percentage of defective items |
| $K$ | Fixed ordering cost (per order) | $f(p)$ | Probability density function of $p$ |
| $h_g$ | Holding cost of perfect quality items (per unit, per unit time) | $x$ | Screening rate (in units per unit time) |
| $h_d$ | Holding cost of imperfect quality items (per unit, per unit time) | $T$ | Length of a cycle |

## 3. MATHEMATICAL MODEL AND OPTIMAL ORDER QUANTITY

Using the above assumptions the total cost per time unit will be derived. To this end, the following two cases are considered: $p < 1 - \frac{D}{x}$, this implies that the demand can be satisfied by non defective items during a cycle (Figure 1, second cycle) and $p \geq 1 - \frac{D}{x}$, this implies that the demand cannot be satisfied during a cycle by non defective items (Figure 1, first cycle).
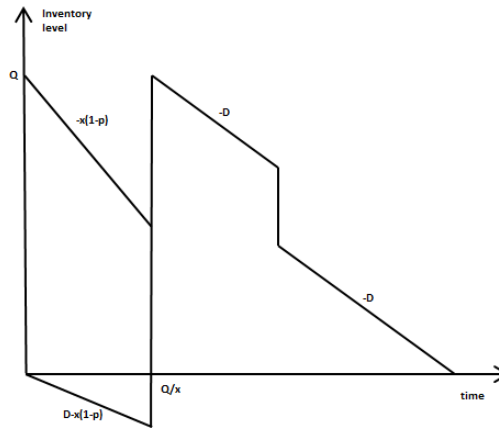


Figure 13 The two possiple cases for inventory cycle: $p \geq 1 - \frac{D}{x}$ (first cycle) and $p < 1 - \frac{D}{x}$ (second cycle)

For the holding cost of perfect quality items per cycle, two cases are considered.
When $p < 1 - \frac{D}{x}$, the inventory level of the perfect quality (non defective) items at time $t$ is:

$$I_g(t) = \begin{cases} Q - (D + px)t, & 0 \leq t \leq \frac{Q}{x} \\ (1-p)Q - Dt, & \frac{Q}{x} \leq t \leq \frac{(1-p)Q}{D} \end{cases}$$

Therefore, if $z = \frac{D}{x}$, the holding cost of the perfect quality items is

$$h_g \left[ \int_0^{\frac{Q}{x}} [Q - (D + px)t]dt + \int_{\frac{Q}{x}}^{\frac{(1-p)Q}{D}} [(1-p)Q - Dt]dt \right] = h_g \left[ \frac{pQ^2 z}{2D} + \frac{(1-p)^2 Q^2}{2D} \right]$$

When $p \geq 1 - \frac{D}{x}$ the inventory level of the perfect quality items it time $t$ is:

$$I_g(t) = Q - xt, \ \ 0 \leq t \leq \frac{Q}{x}$$

Therefore, the holding cost is:

$$h_g \int_0^{\frac{Q}{x}} (Q - xt) dt = h_g \frac{Q^2 z}{2D}$$

In each case, the inventory level of the imperfect quality items is:

$$I_d(t) = pxt, \qquad 0 \le t \le \frac{Q}{x}$$

Hence, the holding cost of imperfect quality items is

$$h_d \int_0^{\frac{Q}{x}} pxt \, dt = h_d \frac{pQ^2 z}{2D}$$

Finally, the expected total holding cost per cycle is

$$\int_0^{1-z} \left[ h_g \left[ \frac{pQ^2 z}{2D} + \frac{(1-p)^2 Q^2}{2D} \right] + h_d \frac{pQ^2 z}{2D} \right] f(p) dp + \int_1^{1-z} \left[ h_g \frac{Q^2 z}{2D} + h_d \frac{pQ^2 z}{2D} \right] f(p) dp$$

Next, the backlogging cost is derived. Notice that stockouts occur only when $p \ge 1 - \frac{D}{x}$. In this case, inventory level is described by:

$$I(t) = [D - x(1-p)]t, \qquad 0 \le t \le \frac{Q}{x}$$

Therefore, the backlogging cost is:

$$c_b \int_0^{\frac{Q}{x}} [D - x(1-p)]t \, dt = c_b \frac{Q^2 [z^2 - z(1-p)]}{2D}$$

Taking into account that in each cycle one order is placed with a fixed cost of $K$, then the expected total cost of the system per cycle is:

$$ETC_c(Q) = K + \frac{Q^2}{2D} E(I)$$

where

$$E(I) = \int_0^{1-z} \left[ h_g [pz + (1-p)^2] + h_d pz \right] f(p) dp + z \int_{1-z}^1 \left[ h_g + h_d p + c_b(z - 1 + p) \right] f(p) dp$$

Then, the average length of the cycle is derived taking into account the two possible realizations of inventory cycle. When $p < 1 - \frac{D}{x}$:

$$T = \frac{Q}{x} + \frac{Q(1 - p - \frac{D}{x})}{D} = \frac{Q(1-p)}{D}$$

Where the first term corresponds to inspection time and the second term is the remaining cycle time until the inventory level to reach zero.

When $p \ge 1 - \frac{D}{x}$:

$$T = \frac{Q}{x}$$

Hence, the average length of cycle is:

$$ET = \int_0^{1-z} \frac{Q(1-p)}{D} f(p) dp + \int_{1-z}^1 \frac{Q}{x} f(p) dp = \frac{Q}{D} E(L)$$

where

$$E(L) = \int_0^{1-z} (1-p) f(p) dp + z \int_{1-z}^1 f(p) dp$$

Using the Renewal Reward Theorem, the total cost per unit time is:

$$TC_{ut}(Q) = \frac{D}{QE(L)} \left[ K + \frac{Q^2}{2D} E(I) \right]$$

The objective is to determine the optimal order quantity that minimizes the total cost per unit time, $TC_{ut}(Q)$.

The next theorem, the proof of which is omitted due to limited space, shows the main property of the $TC_{ut}(Q)$ and provides the optimal order quantity and cost in closed form.

**Theorem:** The function $TC_{ut}$ is convex in $Q \ge 0$. The optimal order quantity is:

$$Q^* = \sqrt{\frac{2KD}{E(I)}}$$

and the optimal cost is:

$$TC_{ut}(Q^*) = \frac{\sqrt{2KD}}{E(L)} \sqrt{E(I)}$$

**Remark 1**

If $c$ is the unit purchase cost, $s$ the unit revenue of the non defective items and $v$ the unit revenue of the defective items, then the profit per unit time is:

$$TP_{ut}(Q) = \frac{[s(1 - E(p)) + vE(p) - c]D}{E(L)} - \frac{D}{QE(L)}\left[K + \frac{Q^2}{2D}E(I)\right]$$

So, the order quantity that maximizes $TP_{ut}(Q)$ is also $Q^*$.

**Remark 2**

For the optimal order quantity and cost the following properties hold:

a) The optimal order quantity is a decreasing function of $h_d$:

$$\frac{\partial Q^*}{\partial h_d} = -\frac{1}{2}zE(p)\sqrt{\frac{2KD}{(E(I))^3}} < 0$$

Since $h_d < h_g$, this result shows that the optimal order quantity is always larger than the order quantity proposed by Vörös (2013).

b) The optimal total cost is an increasing function of $h_d$:

$$\frac{\partial TC_{ut}(Q^*)}{\partial h_d} = \frac{\sqrt{2KD}}{E(L)}\frac{zE(p)}{2\sqrt{E(I)}} > 0$$

Since $h_d < h_g$ this result shows that the objective function of the model proposed by Vörös (2013) overestimates the objective function of this model.

c) The optimal order quantity is a decreasing function of $c_b$:

$$\frac{\partial Q^*}{\partial c_b} = -\frac{1}{2}z\int_{1-z}^{1}[(z - 1 + p)]f(p)dp\sqrt{\frac{2KD}{(E(I))^3}} < 0$$

So, the optimal order quantity is smaller than the order quantity proposed by Wahab and Jaber (2010).

d) The optimal total cost is an increasing function of $c_b$:

$$\frac{\partial TC_{ut}(Q^*)}{\partial c_b} = \frac{\sqrt{2KD}}{E(L)}\frac{z}{2\sqrt{E(I)}}\int_{1-z}^{1}[(z - 1 + p)]f(p)dp > 0$$

So, the objective function of the model proposed by Wahab and Jaber (2010) underestimates the objective function of this model.

## 4. SPECIAL CASES

In this section special cases of the total cost per unit time, $TC_{ut}(Q)$, which correspond to the following special models, are derived:

1. If $h_g = h_d = h$, the model proposed by Vörös (2013) is obtained.
2. If $P\left(p \geq 1 - \frac{D}{x}\right) = 0$, the model of Wahab and Jaber (2010) follows.
3. If $P\left(p \geq 1 - \frac{D}{x}\right) = 0$ and $h_g = h_d = h$, the above proposed model is the same as the one in Maddah and Jaber (2008).
4. If $P\left(p \geq 1 - \frac{D}{x}\right) = 0$, $h_g = h_d = h$ and $c_b \to \infty$, $x \to \infty$ and $\sigma = \sigma_1 Q$, the model of Silver (1976) follows.
5. If $P(p = 0) = 1$, $h_g = h_d = h$ and $c_b \to \infty$ and $x \to \infty$, the EOQ model follows.

## 5. CONCLUSIONS

In this paper the model proposed by Vörös (2013) is modified assuming that the holding cost of the imperfect quality items is different from the holding cost of the perfect, since as usually the perfect and imperfect items are hold in different

warehouses. From the present model other models, existing in the literature, follow as special cases. This model can be extented assuming that the imperfect quality items can be reworked instead of  sold as a single batch at the end of the screening process, while sustainability issues can be also taken into account.

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# Implications on marketing mix decisions when Agro-tourism enterprises decide to act internationally with the use of Internet: Ranking of importance of the main factors towards standardization and adaptation

Theodore Tarnanidis, PhD,
*Researcher, University of Macedonia, Thessaloniki*

Jason Papathanasiou, PhD,
*Associate Professor, University of Macedonia, Thessaloniki*

Vasilis Kostoglou, PhD,
*Professor, Alexander Technological Institute of Thessaloniki*

**Abstract**

The scope of this article is to assess and leverage the standardization and/or adaptation process of marketing mix elements for enterprises who act in different markets in the agro-tourism industry. In general it is argued that the use of internet through technological advancements can be characterized with success as the powerful force that drives and leads the world toward a converging commonality. Similarly, the common trade liberalization with bilateral and free trade areas and agreements among different countries, have converged to the existence to a more homogenous consumers and markets that build the first steps for the globalization and the evolution of global standardized marketing strategies, over the last decades. The main findings of the literature suggest that the similarities between countries are substantial more than the exist differences. On the other hand, the perceived differences among countries cannot be eliminated and treated as a single one and therefore successful companies in order to achieve profit maximization they need to tailor their marketing strategy to local marketing environment. In doing so, we have collected data from Greek Agro-tourism entrepreneurs, where they ranked and assessed the relative importance of the main factors towards of a more Stand/Adapt marketing strategy, with relevance to the marketing mix elements by formulating a more favorable strategy `according to the perceived preferences of information`. Finally, a thorough discussion and conclusions are given to different research practitioners and policy makers.

**KEYWORDS***:*

 International marketing mix, internet marketing, intelligent systems in marketing, multicriteria analysis, PROMETHEE, Greece.

## 1. INTRODUCTION

Among the main challenges agro-tourism is to face, the analysis of strengths, weaknesses and medium-term needs of this sector has underlined the decreasing share of the international agro-tourism and tourism market, with demand shifting towards on finding innovative mechanisms for growth potentials. To that extent, technology can be characterized with success as the powerful force that drives and leads the world toward a converging commonality (Levitt, 1983). It has bridged the gap between different people and places all over the world, with the contribution of the growing forces of communications, transport and travel. Similarly, the frontiers of new technologies build the first steps for the globalisation and the evolution of global marketing strategies. Having that in mind, many MSMEs (Micro, -Small and Medium Enterprises), industry associations and other businesses in the Greek context are trying to offer research and innovation in the area of food and agriculture research (societal challenge, food safety, sustainable agriculture and culinary vacations, tours, cooking holidays and alternative tourism options focused on gastronomy) for the promotion of the rural areas. Therefore, the role of marketing is shaped towards on implementing a movement of agricultural products from production to consumption. Marketing strategies according to Kotler et al. (2008) involve the manipulation of the marketing mix variables, like to what the company is selling (product), where the products and services are made available to customers (place, or distribution), how products and services are priced and paid for (price), and where and how the products and services are made known to people and they are motivated to purchase them (promotion). To that extend when agro-tourism firms want to act international with the use of internet they face the challenge of two alternative options. The first one is the standardization of the marketing mix elements in all the company's international markets (Armstrong and Kotler, 2008). Whereas, the second strategy one is by adopting the marketing mix variable according to the needs of each international target market. Based on this discussion, this paper aims to compare those two strategies in the agro-tourism production sector in Greece.

## 2. LITERATURE REVIEW

Speaking about international marketing strategies in the agro-tourism, companies operate in a variety of countries, in which its products and services must be adjusted according to the unique customs and habits of each culture separately (high relatively costs). Similarly, Cateora and Graham (1999) argue that the standardization of the marketing mix elements perceives the world as one market and is based on identifying and targeting cross-cultural similarities. In contrast, different researchers (Jain, 1989; Dahringer and Muhlbacher, 1991) possess that successful organization should not ignore the

cultural differences among markets. For example, the use of advertising is translated into different languages for different national markets and therefore different distribution strategies are developed for areas with different distribution structures. So, the diversity in language is taken into consideration by a company dealing with international marketing oriented perspective, since it is one of the main differences that each country has from another. Hence, most standardized programmes can be placed between two and three common elements in the marketing mix, while it is very extreme to find a company that uses the same product, promotion, price, and distribution mix to all of its markets (Mesdag, 2000; Akhter,1995).

Additionally, the differences of culture that exist in consumer tourist markets such as differences in customer response patterns, language, lifestyles, patterns of livings, and purchasing behaviour, determine the need for some degree of adaptation (Clark, 1990; Czinkota and Ronkainen,1998; Douglas and Craig, 1995; Jain, 1989; Whitelock, 1987). According to Dahringer and Muhlbacher (1991) one important factor that agro-tourism companies should take under consideration, before piloting standardized marketing strategies, is the life cycle of the product and the market as well. Finally, those products that are targeted for urban markets in less developed countries needed few changes from products sold to urban markets in developed countries (Cateora and Graham, 1999).

The most powerful argument according to Cateora and Graham (1999) that favours global marketing orientation and standardization of the marketing mix is the unique ability of the company to reach economies of scale in production and marketing. The principles of economies of scale states that whenever the production or sales volume of a product increases, the total cost per unit fall, including production, marketing, administrative costs (Dahringer and Muhlbacher, 1991). The author's indicate economies of scale are more favourable in large businesses because they are able to operate at a lower cost per unit than their smaller competitors. Meaning that, it is easy to assume that when a company can use the same marketing mix in several different countries, with only few changes resulting from the different languages and cultures, it can save more money (inventories, logistics, advertising, promotion campaigns). One other great benefit of using common marketing mix worldwide is the increased effectiveness due to transfer of experience and know-how across countries, through the coordination and integration of the marketing activities (Cateora and Graham, 1999; Dahringer and Muhlbacher, 1991; Wiechmann, 1975). Moreover, the control and coordination of the same marketing mix strategy is another benefit of using the same quality standards, promotional campaigns, product and spare inventories (Cateora and Graham (1999).

From another point of view, it's too difficult for an agro-firm to use a total standardized marketing mix and is rarely feasible or desirable. The advocates of multi-domestic strategies assert that because of the fact that only few markets are exactly alike, the need of some adaptation is essential in order to ensure that customers' needs are satisfied effectively and efficiently (Szymanski et al, 1993; Dahringer and Muhlbacher, 1991). Moreover, Mesdag (2000) believes that the differences varying in language, distribution facilities, retail structure climate, and even great to the regulations that govern marketing and cultural features such as colour, taboos, history, and religion, among countries exert considerable influence that pure standardization of marketing mixes is not feasible. According to Douglas and Craig (1995) there are numerous barriers for using and adopting a common marketing mix, ranging from different regulations and different consumers preferences. Similarly, the government can have an impact to the price policy by setting upper or lower charge limits and forcing a firm to distribute its products in places where it may not be so profitable. Moreover, the government can oblige the firm to use local advertising agency to develop its promotional campaigns. Furthermore, one other limitation of a standardized marketing mix is that it is useless to a specific type of products. Jain (1989) asserts that the use of a standardized marketing mix can be used more effectively in the category of industrial goods. For example, consumers' durables offer great opportunity for standardization than non-durables, because they appeal to habits and customs, which are unique to every society. Some successful examples are the industrial and high technology products such as computer hardware, airliners, automobiles, and heavy equipment. Additionally, toiletries, clothing, food, and household cleaners are being considered as much less appropriate (Whitelock, 1987; Dahringer and Muhlbacher, 1991).

## 3. METHODOLOGY

The methodology that has been adapted is a qualitative research. The information were collected with a combination by desk research from the current literature on marketing strategies (e.g. secondary sources) and by making additional interviews with seven (7) decision-makers in the agro-tourism sectors, like farmers, agricultural and tourism organizations. The random sampling technique was employed. Data analysis was made with the use of multicriteria decision-aid analysis and the software of PROMETHEE II (Visual PROMETHEE, 2019).

## 4. DATA ANALYSIS AND RESULTS

The results of the PROMETHEE analysis for the implementation of the two alternative strategies (i.e. standardization and adaptation) are presented in the following figures.

Standardization Strategy

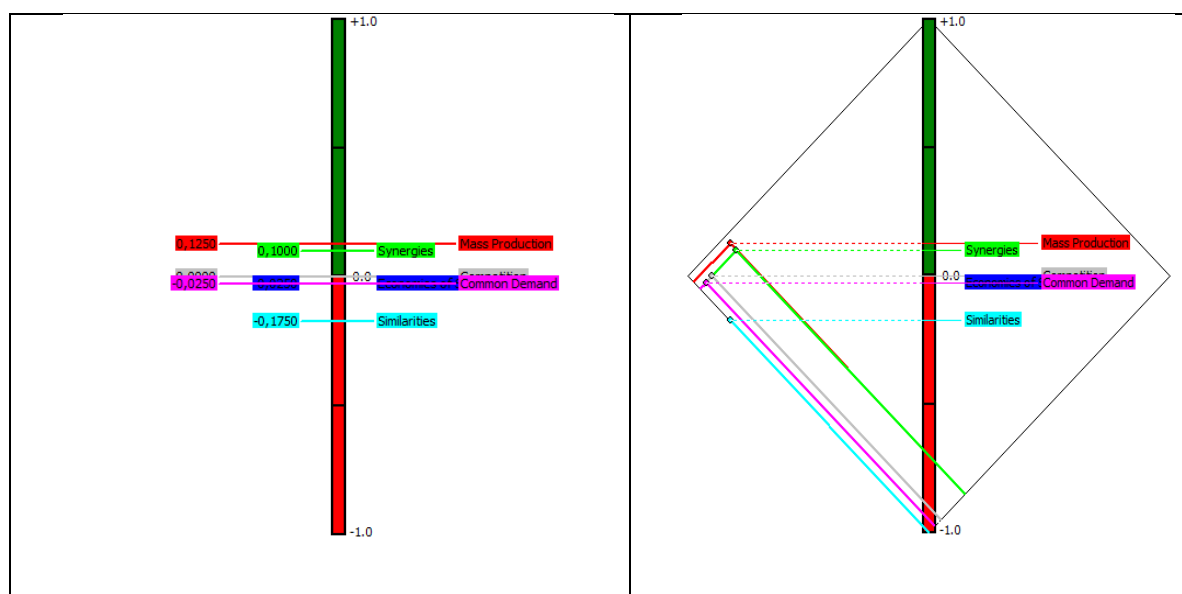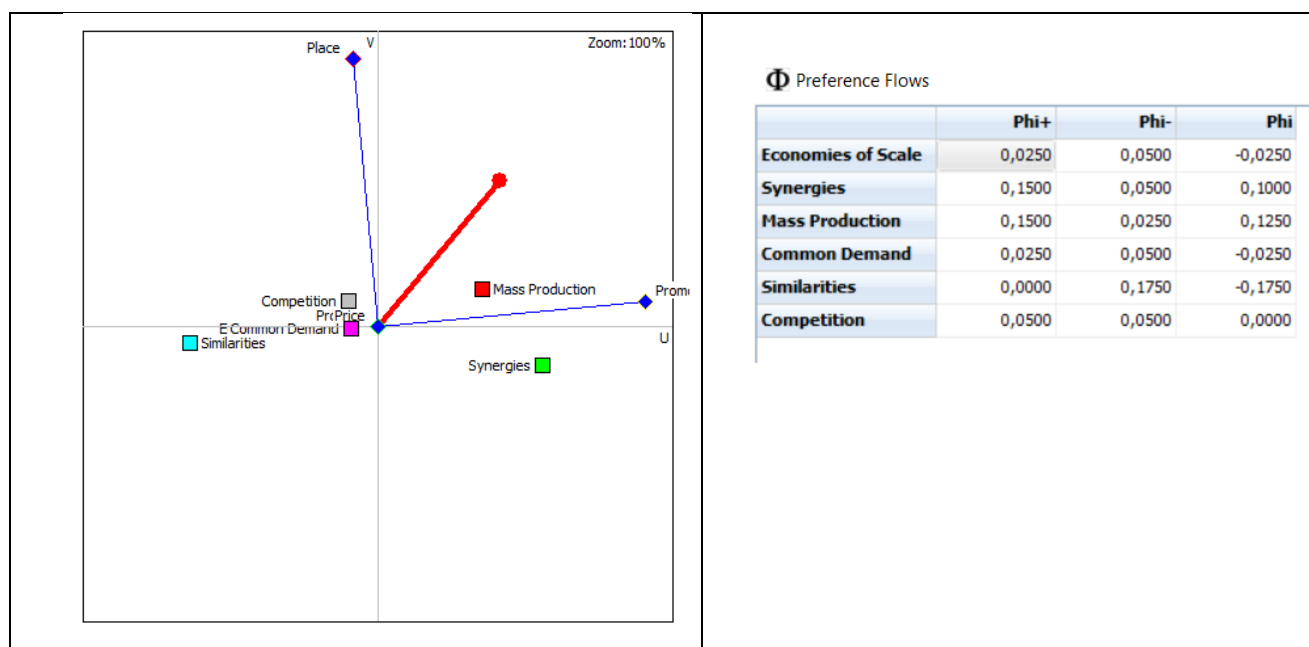**Figure 1: Complete ranking of alternatives and PROMETHEE Diamond Model**



Figure 1, depicts the complete rankings of the six alternative actions. We can see on the left figure the PROMETHEE II complete ranking analysis of the actions according to Phi+ preference flows. The Phi scores show the incomparability between actions which determines the decision-makers to focus on these variables. Based on our results we can see that the factors that influence decision-makers to promote a standardized marketing mix are: mass production and synergies, as the specific indicators are preferred to all other actions. On the right side of the figure we can see the PROMETHEE diamond, where the vertical dimension gives the Phi net flow identified in the complete ranking process.

**Figure 2: PROMETHEE Gaia Plane and preference flows**



Preference Flows

|  | Phi+ | Phi- | Phi |
|---|---|---|---|
| **Economies of Scale** | 0,0250 | 0,0500 | -0,0250 |
| **Synergies** | 0,1500 | 0,0500 | 0,1000 |
| **Mass Production** | 0,1500 | 0,0250 | 0,1250 |
| **Common Demand** | 0,0250 | 0,0500 | -0,0250 |
| **Similarities** | 0,0000 | 0,1750 | -0,1750 |
| **Competition** | 0,0500 | 0,0500 | 0,0000 |

The Gaia plane in figure 2 depicts that the indicators of Competitions, Common demand and Similarities are close to each other, they have similar actions, whereas the areas of Mass Production and Synergies, are in the opposite directions and therefore, it can be concluded that they are different from the other actions. Additionally, on the right side of the figure the preference flows are displayed.

Adaptation Strategy

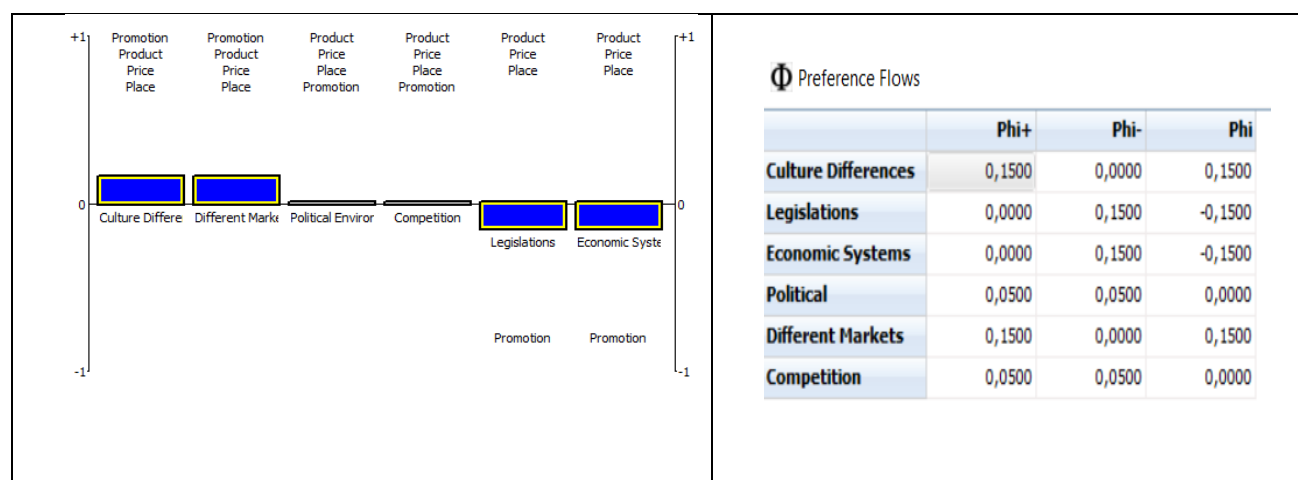**Figure 3: Partial ranking of alternatives and PROMETHEE Diamond Model**
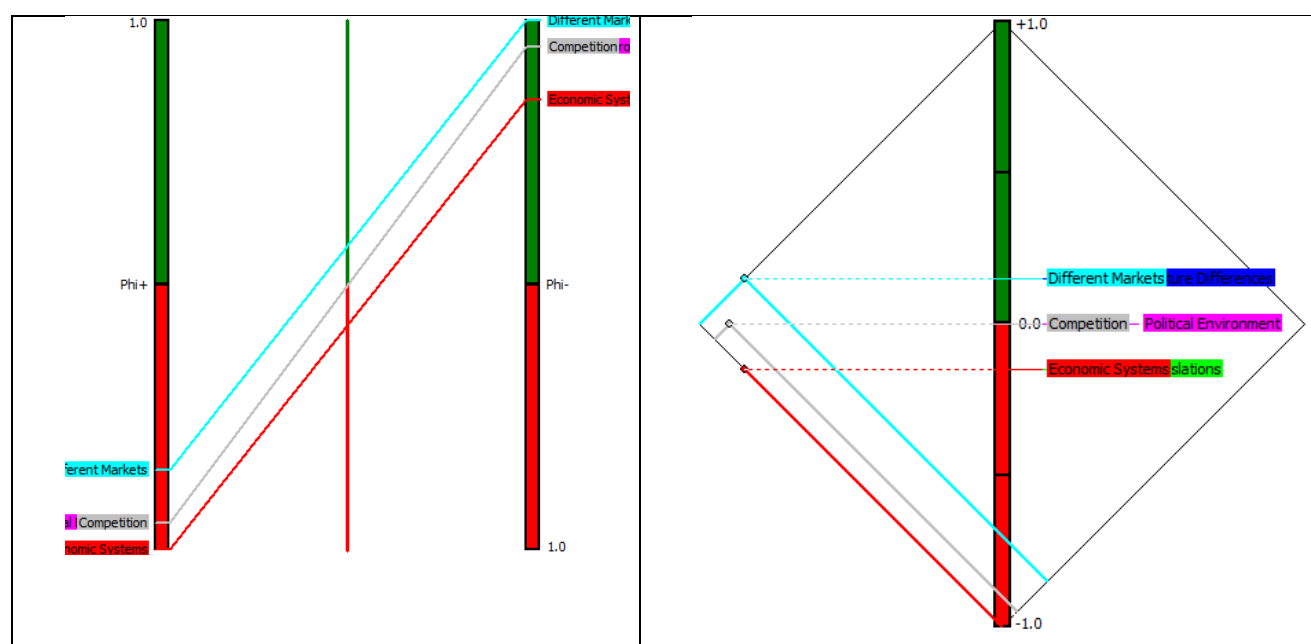


Figure 3, depicts the partial rankings and the PROMETHEE Diamond model of the six alternative actions

**Figure 4: PROMETHEE Rainbow and Preference flows**



| Φ Preference Flows | Phi+ | Phi- | Phi |
|---|---|---|---|
| **Culture Differences** | 0,1500 | 0,0000 | 0,1500 |
| **Legislations** | 0,0000 | 0,1500 | -0,1500 |
| **Economic Systems** | 0,0000 | 0,1500 | -0,1500 |
| **Political** | 0,0500 | 0,0500 | 0,0000 |
| **Different Markets** | 0,1500 | 0,0000 | 0,1500 |
| **Competition** | 0,0500 | 0,0500 | 0,0000 |

We can see on the left that all the actions draw on a horizontal line by representing their position inside the phi flow scores ranging from +1 to -1. The first two criteria contribute positively to their net flow scores.

## 5. CONCLUSIONS

PROMETHEE II method was used to assess the marketing mix criteria and to suggest ranking of six evaluations that was underpinned through a combination of a desk and qualitative research interviews with agro-tourism entrepreneurs. In the context of this study the main factors. The evaluations for the relative importance of the main factors towards of a more Stand/Adapt marketing strategy were ranked. The applied methodology is a useful planning and management tool for the crafting of more successful marketing strategies for businesses in general.

Based on our findings entrepreneurs seek to pursue standardized marketing strategies in order to increase the available production margins by satisfying the needs of a common demand in the markets that want to attract through their on-line presence. However, they face many difficulties when trying to assess the potential similarities of the market. Also, we could say that standardization in several foreign markets fails due to the fact that intents to ignore the relationship

between marketing technology and the social marketing functions of the markets in which the firms operate, i.e., the cultural situational environment. Similarly companies following standardized marketing strategies tend to ignore the marketing concept and adopt a production oriented approach for their overseas marketing activities, this is more evident to the food and gastronomy sector. On the other, the adaptation marketing strategy offers many flexibilities and unique potentials to attract distinct target groups on different markets. The most important factor that influences the adaptation level of the marketing international efforts is by reaching different markets and by fighting the potential competition. To conclude, international agro-tourism organizations, in order to distinguish whether to standardize or differentiate their marketing strategies with the use of internet, they must develop some mechanisms for a systematic analysis, including the market incentives as well as the current and future conditions in different countries.

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Visual PROMETHEE - Academic edition (2019) available at: http://www.promethee-gaia.net, Visited date 21 January 2019.

# A sustainable inventory policy for two substitutable products

Iris-Pandora Krommyda
*Department of Mathematics,*
*University of Ioannina*
*45110 Ioannina - Greece*

Vasileios A. Tatsis
*Department of Computer Science*
*Engineering, University of Ioannina*
*45110 Ioannina - Greece*

Konstantina Skouri
*Department of Mathematics,*
*University of Ioannina*
*45110 Ioannina - Greece*

**Abstract**

We study an inventory problem considering two products with a fixed shelf life. The products are ordered simultaneously from the same supplier. We assume that their demand is freshness dependent, so in order to increase sales the retailer offers a single markdown near their expiration date. We also assume that the products are substitutable, so in case of a stock-out for one of the products, a known fraction of its demand can be satisfied by using the stock of the other product. In this context, our model can be applied to the management of foodstuffs. Hence, in accordance with EU guidelines for food waste reduction, we assume that unsold items at the end of the replenishment cycle can be donated to non-profit organizations or be sold at a salvage price to a secondary market. Due to space limitations, only numerical examples under different parametric scenarios are presented in order to illustrate the optimal policy that maximizes the retailer's profit.

**KEYWORDS**

Inventory management; Substitution; Perishability; Food waste;

## 1. INTRODUCTION

Products with a fixed shelf life constitute a large part of retail inventories. Previous studies usually assume that the demand for such products is dependent on the time remaining to their expiration date, i.e. freshness level ([1], [2]), including sometimes also price dependency ([3],[4],[5]) and/or stock dependency ([6],[7]).In the model, presented in this study, freshness dependent demand is also assumed. However, in order to be in accordance with the common practice of many retail stores, we assume that a single price markdown is offered when a product is close to its expiration date, in order to boost sales. This is also noted by [8], in their study of the effect of expiration dates on the purchasing behavior for grocery store perishables, that an effective mean of selling aging inventory is to offer a price discount near the expiration date of the product. Relevant papers include [9], [10] and [11].

In addition, we assume that the products are ordered simultaneously from the same supplier. This implies that the products are similar and therefore substitutable, such as different types of yogurt, milk, etc. So in case of a stock-out for one of the products, a known fraction of its demand can be satisfied by using the stock of the other product (see [12], [13]).

Furthermore, in accordance with EU guidelines for food waste reduction, we assume that unsold items at the end of the replenishment cycle can be donated to non-profit organizations or be sold at a salvage price to a secondary market. The only work we found regarding food donations in an EOQ context is the one by [14], who study a supply chain composed by a retailer and potential recipients of food recovery. They assume that the retailer deals with k products and maximize the joint profit of the supply chain by assuming that the demand of each product is linearly dependent on the time remaining to its expiration date and tax deductions are granted to the retailer due to the donation of surplus food.

The model presented in this work incorporates the above mentioned assumptions describing a situation confronted by many retailers. Our goal is to derive the optimal solution that maximizes the retailer's profit and at the same time reduces food waste. The rest of the paper is organized as follows. First, the notations and basic assumptions of the model are provided. Then the model formulation, for the different cases that arise, is presented. Due to space restrictions, the optimization procedure is omitted. However, numerical examples under different parametric scenarios are conducted, in order to illustrate the optimal solution to the problem.

## 2. NOTATIONS AND ASSUMPTION

To develop the mathematical model, the following notations and assumptions are used:
**Notations (i=1,2):**

$D_i$    demand for product $i$, per time unit

$h_i$    inventory holding cost for product $i$, per unit, per time unit, including capital cost

$c_i$    purchase cost for product $i$, per unit

$p_i$    selling price for product $i$, per unit

$\beta$    discount percentage on selling price ($0 \leq \beta \leq 1$)

$p_i^{'}$    discounted selling price for product $i$, per unit $p_i^{'} = (1-\beta)p_i$

$A$    joint ordering cost, per order

$\gamma_1$    opportunity gain due to the donation of food to non-profit organizations, per unit donated

$\gamma_2$    selling price per unit of expired product to livestock market

$l_i$    lost sales cost for product $i$, per unit

$\delta_{ij}$    the percentage of demand that can be satisfied by product $j$ in case of a stock out of product $i$

$W$    total storage capacity for both products

$e_i$    fixed shelf life of product $i$

$T$    length of the replenishment cycle-reorder interval (decision variable)

$t_i$    the time at which a price markdown is offered for product $i$ (decision variable)

$q_i$    the inventory level of product $i$ at time $T$ (decision variable)

$Q_i$    order quantity for product $i$

**Assumptions:**

1. The retailer deals with two products that have a fixed Shelf Life (SL), i.e. the products remain safe and suitable for human consumption until the reaching of the SL.
2. The planning horizon and replenishment rate are infinite.
3. The products are ordered simultaneously from the same supplier with a joint ordering cost.
4. The retailer's total storage capacity for both products is constant and equal to $W$. Obviously the order quantity cannot exceed capacity, i.e. $Q_1 + Q_2 \leq W$.
5. Initially, the demand of each product is constant and equal to $D_i$. At time $t_i$ the retailer offers a price markdown $p_i^{'} = (1-\beta)p_i$, because product $i$ is close to its expiration date. This increases the demand to $\alpha D_i, \alpha > 1$. However, at the same time, the customer becomes aware of the expiration date of the product and the demand becomes a decreasing function with respect to the time remaining before the expiration date. Hence, the demand of each product is defined as:

$$D_i(t) = \begin{cases} D_i, & 0 \leq t < t_i \\ \alpha \left( \frac{e_i - t}{e_i} \right) D_i, & t_i \leq t \leq e_i \end{cases}.$$

6. At time $T$, the retailer withdraws the remaining products from the shelf and a new order arrives. We distinguish the following cases:
   - When $T < e_i$, the withdrawn items for product $i$ are donated to a non-profit organization, this works as advertisement and creates a gain of goodwill towards the retailer from the customers which is quantified as a profit per unit of product donated $(\gamma_1)$.
   - When $T = e_i$, the withdrawn items for product $i$ are sold to a secondary market at a salvage price $(\gamma_2)$.
   - When $T > e_i$, then during time period $e_i - T$ shortages occur for product $i$.
7. The products are substitutable, so the demand of product $i$ during stock out can be satisfied by the other product at a known percentage $0 < \delta_{ij} \leq 1$. The unsatisfied demand is completely lost.
8. It is realistic to assume that $p_i > p_i^{'} > c_i$ and $\gamma_2 < c_i$.

## 3. MODEL FORMULATION

Without loss of generality, $e_1 < e_2$ is assumed. At time 0 a new order of $Q_1 + Q_2$ units arrives. During time period $[0, T]$ the inventory level of each product depletes due to demand $D_i(t)$, as defined in the assumptions. At time $T$, the retailer withdraws the remaining products from the shelf and a new order arrives. In order to formulate the mathematical model we distinguish the following cases depending on the order of the variables $t_1, t_2, T$ and the parameters $e_1, e_2$:

$0 \leq t_i \leq T \leq e_1 < e_2, i = 1,2$ (Case A),

$0 \leq t_i \leq e_1 \leq T \leq e_2$ $i = 1,2$ (Case B),

$0 \leq t_1 \leq e_1 \leq t_2 \leq T \leq e_2$ (Case C).

**Case A**

The differential equations that describe the depletion of the inventory level for both products ($i$=1,2), for Case A, are as follows:

$$\frac{dI_i(t)}{dt} = -D_i, \ 0 \le t < t_i,$$

$$\frac{dI_i(t)}{dt} = -\alpha D_i \left(\frac{e_i - t}{e_i}\right), \ t_i \le t \le T,$$

$$I_i[T] = q_i, \ I_i[t_i^+] = I_i[t_i^-]$$

The retailer's profit per time unit, for this case, can generally be expressed as:

$$\Pi_A(T, t_1, t_2, q_1, q_2) = \begin{cases} \frac{1}{T}\{\overline{\pi}_A(T, t_1, t_2, q_1, q_2) + \gamma_1 q_1 + \gamma_1 q_2\}, \ 0 \le t_i \le T < e_1 < e_2, \ i = 1,2 \\ \frac{1}{T}\{\overline{\pi}_A(T, t_1, t_2, q_1, q_2) + \gamma_2 q_1 + \gamma_1 q_2\}, \ T = e_1, \ 0 \le t_i \le e_1 < e_2, \ i = 1,2 \end{cases},$$

where

$$\overline{\pi}_A(T, t_1, t_2, q_1, q_2) = p_1 D_1 t_1 + p_1' \int_{t_1}^{T} \alpha D_1 \left(\frac{e_1 - t}{e_1}\right) dt - c_1 Q_1 - h_1 \int_0^{t_1} I_1(t)dt - h_1 \int_{t_1}^{T} I_1(t)dt$$

$$+ p_2 D_2 t_2 + p_2' \int_{t_2}^{T} \alpha D_2 \left(\frac{e_2 - t}{e_2}\right) dt - c_2 Q_2 - h_2 \int_0^{t_2} I_2(t)dt - h_2 \int_{t_2}^{T} I_2(t)dt - A.$$

The terms appearing in $\overline{\pi}_A(T, t_1, t_2, q_1, q_2)$ correspond to the sales revenue during the time each product has its original price, the sales revenue after the discount is offered, the purchasing cost and the holding cost for both products, as well as the joint ordering cost. The term $\gamma_1 q_i$ corresponds to the profit generated by the donation of the surplus quantity of product $i$, while the term $\gamma_2 q_i$ by selling the leftover products of product $i$ to the secondary market.

The problem to be solved is:

$$\max \Pi_A(T, t_1, t_2, q_1, q_2)$$
$$\text{s.t. } 0 \le t_i \le T \le e_1 < e_2$$
$$q_i \ge 0, \ i = 1,2$$
$$Q_1 + Q_2 \le W$$

**Note:** Since the two products are independent, the order of $t_1, t_2$ will be derived by the optimal solution.

**Case B**

The differential equations that describe the depletion of the inventory level for both products ($i$=1,2), for Case B, are as follows:

$$\frac{dI_1(t)}{dt} = -D_1, \ 0 \le t < t_1, \qquad\qquad \frac{dI_2(t)}{dt} = -D_2, \ 0 \le t < t_2,$$

$$\frac{dI_1(t)}{dt} = -\alpha D_1 \left(\frac{e_1 - t}{e_1}\right), \ t_1 \le t \le e_1, \qquad \frac{dI_2(t)}{dt} = -\alpha D_2 \left(\frac{e_2 - t}{e_2}\right), \ t_2 \le t \le e_1,$$

$$\frac{dI_1(t)}{dt} = -(1 - \delta_{12})D_1, \ e_1 \le t < T, \qquad \frac{dI_2(t)}{dt} = -\alpha D_2 \left(\frac{e_2 - t}{e_2}\right) - \delta_{12}D_1, \ e_1 \le t \le T,$$

$$I_1[e_1] = 0, \ I_1[t_1^+] = I_1[t_1^-], \ I_1[e_1^+] \qquad I_2[T] = q_2, \ I_2[t_2^+] = I_2[t_2^-], \ I_2[e_1^+] = I_2[e_1^-]$$
$$= I_1[e_1^-]$$

**Note:** Since we have assumed that $\gamma_2 < c_1$, there is obviously no point in having leftover quantity at the time of the expiration date of product 1 (the holding cost of keeping the extra inventory is greater than the gain of selling it to the livestock market). Hence, we set $I_1[e_1] = 0$.

The retailer's profit per time unit, for Case B, can generally be expressed as:

$$\Pi_B(T, t_1, t_2, q_2)$$

$$= \begin{cases} \frac{1}{T}\{\overline{\pi}_B(T, t_1, t_2, q_2) - l_1(1 - \delta_{12})D_1(T - e_1) + \gamma_1 q_2\}, 0 \le t_i \le e_1 \le T < e_2, \ i = 1,2 \\ \frac{1}{T}\{\overline{\pi}_B(T, t_1, t_2, q_2) - l_1(1 - \delta_{12})D_1(T - e_1) + \gamma_2 q_2\}, T = e_2, \ 0 \le t_i \le e_1, \ i = 1,2 \end{cases},$$

where

$$\overline{\pi}_B(T, t_1, t_2, q_2) = p_1 D_1 t_1 + p_1' \int_{t_1}^{e_1} \alpha D_1 \left(\frac{e_1 - t}{e_1}\right) dt - c_1 Q_1 - h_1 \int_0^{t_1} I_1(t)dt - h_1 \int_{t_1}^{e_1} I_1(t)dt + p_2 D_2 t_2$$

$$+ p_2' \int_{t_2}^{T} \alpha D_2 \left(\frac{e_2 - t}{e_2}\right) dt + p_2' \delta_{12} D_1(T - e_1) - c_2 Q_2 - h_2 \int_0^{t_2} I_2(t)dt - h_2 \int_{t_2}^{e_1} I_2(t)dt - h_2 \int_{e_1}^{T} I_2(t)dt - A.$$

Obviously, the term $l_1(1 - \delta_{12})D_1(T - e_1)$ corresponds to the lost sales cost due to unsatisfied demand for product 1 during time period $T - e_1$.

The problem to be solved is:

$$max\, \Pi_B(T, t_1, t_2, q_2)$$
$$s.t.\, 0 \leq t_i \leq e_1 \leq T \leq e_2$$
$$q_2 \geq 0,\ Q_1 + Q_2 \leq W$$

**Case C**

The differential equations that describe the depletion of the inventory level, for Case C, are as follows:

For product 1 see case B.

For product 2:

$$\frac{dI_2(t)}{dt} = -D_2,\ 0 \leq t < e_1,$$

$$\frac{dI_2(t)}{dt} = -D_2 - \delta_{12} D_1,\ e_1 \leq t < t_2,$$

$$\frac{dI_2(t)}{dt} = -\alpha D_2 \left(\frac{e_2 - t}{e_2}\right) - \delta_{12}\, D_1,\ t_2 \leq t \leq T,$$

$$I_2[T] = q_2,\ I_2[t_2^+] = I_2[t_2^-],\ I_2[e_1^+] = I_2[e_1^-]$$

The retailer's profit per time unit, for Case C, can generally be expressed as:

$$\Pi_C\big(T, t_1, t_2, q_2\big) =$$

$$\begin{cases} \frac{1}{T}\{\overline{\pi}_C\big(T, t_1, t_2, q_2\big) - l_1(1 - \delta_{12})D_1(T - e_1) + \gamma_1 q_2\}, & 0 \leq t_1 \leq e_1 \leq t_2 \leq T < e_2 \\ \frac{1}{T}\{\overline{\pi}_C\big(T, t_1, t_2, q_2\big) - l_1(1 - \delta_{12})D_1(T - e_1) + \gamma_2 q_2\}, & T = e_2, 0 \leq t_1 \leq e_1 \leq t_2 \leq e_2 \end{cases},$$

where

$$\Pi_C\big(T,\ t_1,\ t_2,\ q_2\big)=$$

$$p_1 D_1 t_1 + p_1' \int_{t_1}^{e_1} \alpha\, D_1 \left(\frac{e_1 - t}{e_1}\right) dt - c_1 Q_1 - h_1 \int_0^{t_1} I_1(t)dt - h_1 \int_{t_1}^{e_1} I_1(t)dt + p_2 \delta_{12} D_1(t_2 - e_1) + p_2 D_2 t_2$$

$$+p_2' \delta_{12} D_1(T - t_2) + p_2' \int_{t_2}^{T} \alpha D_2 \left(\frac{e_2 - t}{e_2}\right) dt - c_2 Q_2 - h_2 \int_0^{e_1} I_2(t)dt - h_2 \int_{e_1}^{t_2} I_2(t)dt - h_2 \int_{t_2}^{T} I_2(t)dt - A.$$

The problem to be solved is:

$$max\, \Pi_C(T, t_1, t_2, q_2)$$
$$s.t.\, 0 \leq t_1 \leq e_1 \leq t_2 \leq T \leq e_2$$
$$q_2 \geq 0,\ Q_1 + Q_2 \leq W$$

## 4. NUMERICAL EXAMPLES

In *order* to illustrate the optimal solution to the problem, numerical examples are presented under four different scenarios. The following parametric values are used: $D_1$=60, $D_2$=40, $h_1$=0.8, $h_2$=1.2, $p_1$=4, $p_2$=6, $β$=0.3, $c_1$=2, $c_2$=3, $A$=250, $γ_1$=2.5, $γ_2$=1, $e_1$=4, $e_2$=6, $α$=1.5, $W$=500, $l_1$=0.5, $\delta_{12}$=0.3.

**Scenario 1:** Using the above default values of the parameters, the optimal solution to the problem is obtained by the first branch of profit function $\Pi_A$, i.e. $t_1$=$t_2$=$T$=2.28, $q_1$=$q_2$=0, $Q_1$=136.93, $Q_2$=91.29, with corresponding optimal profit $\Pi_A$=20.9. This solution indicates that for these specific parametric values it is not optimal to markdown the products during the replenishment cycle, or to keep leftover quantity at the end. The optimal cycle length is derived by the EOQ formula.

**Scenario 2:** We now lower the shelf life of product 1, to $e_1$=2. In this case the optimal solution is $t_1$=$t_2$=$T$=2, $q_1$=$q_2$=0, $Q_1$=120, $Q_2$=80, $\Pi_A$=19. This solution is obtained by the second branch of profit function $\Pi_A$, which indicates that the replenishment cycle of the retailer should coincide with the shelf life of product 1, no markdown should be offered and no leftover quantity should remain at the end of the cycle.

**Scenario 3:** As a third scenario, we assume a very high ordering cost, i.e. $A$=100 and a very low holding cost, as well as purchasing cost for the second product, i.e. $h_2$=0.1, $c_2$=1. The optimal solution, derived by the second branch of profit function $\Pi_C$, is $t_1$=3.17, $t_2$=$T$=6, $q_2$=0, $Q_1$=197.95, $Q_2$=276, $\Pi_C$=78.68. In this case, it is optimal for the retailer to coincide his replenishment cycle with the shelf life of the second product and to allow shortages for product 1. Also, a markdown should be offered for product 1 near its expiration date. Keeping leftover quantity of product 2 at the end of the cycle is not in the best interest of the retailer.

**Scenario 4:** Finally, in the fourth scenario, we assume a smaller ordering cost, i.e. $A$=100. In this case, the optimal solution derived is $t_1$=$t_2$=$T$=0.1, $q_1$=490, $q_2$=0, $Q_1$=496, $Q_2$=4, with corresponding optimal profit $\Pi_A$=1293.2. For this case, we observe that it is optimal to make the cycle length as small as possible (in order to be realistic, we assume that there exists a minimum reorder interval $T_{min}$=0.1) and to donate as much quantity as possible of product 1. The storage capacity is therefore fully utilized.

From the results presented above, that coincide with our theoretical analysis, we observe that the standard optimal policy of the retailer, confronted with the problem described in this work, is the EOQ for two products with deterministic demand, as long as the necessary conditions are satisfied (expiration date, storage capacity). In this case, markdowns and food donations are not essential for the retailer's profit maximization. However, if the optimal replenishment cycle is restricted by the shelf life of the products, then it is usually optimal to set the cycle length equal to the shelf life of one of the products and in this case markdowns may be required in order to obtain maximum profit. Regarding food donations, we have proven that it is optimal either not to donate any product or to donate as much as possible, i.e. adopt a minimum replenishment cycle and take advantage of full storage capacity for donating products. This, evidently rare case, occurs when the profit derived from food donations exceeds the ordering cost.

## ACKNOWLEDGEMENT

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# Optimizing collateral allocation: A comparative study

Konstantinos Papalamprou
*Aristotle University of Thessaloniki*
*Department of Electrical and*
*Computer Engineering*

Efthymios P. Pournaras
*National and Kapodistrian*
*University of Athens*
*Department of Economics*

## Abstract

The collateral allocation strategy followed by a financial institution is considered as one of the crucial factors determining its available liquidity to conduct business. Moreover, given the scarcity of the external liquidity sources observed in the last decade for particular banking systems (Greek included), the optimization of the procedure allocating the available collaterals to the associated loans/credits seems to be one of the top priorities for the financial institutions. Different approaches have been developed in order to handle the aforementioned allocation problem that can be found in the relevant literature. Recently, Papalamprou et.al. have modelled this problem by the means of a bipartite graph and a mathematic programming formulation has also been provided viewing the whole setting as a variant of the well-known transportation problem. In this work, empirical results produced by the proposed model are compared with those produced by other models/methodologies developed for the same problem. In particular, parameters of the associated formulations are being stressed in order to examine the behavior of these different models under different scenarios. Finally, we comment on the results and the underlying assumptions of each modelling methodology as well as on the possible extensions of the proposed methodology.

**KEYWORDS**

Collateral allocation, transportation problem, credit risk.

## 1. INTRODUCTION

Following regulatory guidelines, financial institutions should hold capital in order to be covered by expected and potential unexpected losses. This amount of capital is put aside to ensure that these institutions do not take on excess leverage and become insolvent. The total losses that are actually experienced by a financial institution depend mainly on the credit quality of the obligors as well as on the size and type of the collaterals used as security over a portfolio of loans. In the vast majority of cases, there is no one-to-one relationship between a given set of loans and the set of collaterals. Thus, given a set of loans associated with the same set of collaterals, it is of critical importance for a financial institution to allocate in an optimal way the collateral in order to minimize the regulatory capital (RC). In that way, more capital will be available for the institution to run business (e.g. issue loans).

In this work, three different approaches are being examined: (i) a simple method based on a rule of proportional allocation, (ii) an integer linear programming formulation suggested by a researcher affiliated with a major investment bank (iii) a method developed by the authors of this work which is based on a variant of the well-known transportation problem. In the context of our approach, the overall framework is modelled by the means of a bipartite graph where each collateral corresponds to a vertex of the one set of the vertex bipartition of the aforementioned graph while the loans correspond to vertices to the other set of the bipartition. Whenever a collateral is eligible to secure a loan then an edge between the corresponding vertices does exist in the bipartite graph. This modelling approach helps us to reduce the problem in a series of subproblems; specifically, for each connected component of the aforementioned graph we employ each of the three approaches. Next, the level of capital that should be held for regulatory purposes is estimated using the well-known formulas for such computations (see e.g. [1]). Synthetic datasets are being used where the total portfolio coverage ratio is changed in different levels in order to observe/compare the behavior of the three methodologies. In the next section we provide a short description of the three methodologies (which are also described in [6]) while in the last section the description of the datasets along with the results are presented. The overall conclusion is that the approach based on the variant of the transportation problem is the most efficient for allocating collaterals to loans leading to the minimum level of RC requirements.

## 2. MODELLING THE PROBLEM

As mentioned, the minimization of the RC requirements for a financial institution would serve as a competitive advantage. In the current work we examine three different methodologies for allocating collaterals to loans. In what follows, we shall assume that the realized values of the collaterals are available. Specifically, we assume that the appropriate haircuts have been applied to the values of the collaterals in order to consider all types of collaterals as cash collaterals. Let us denote the exposure associated with loan $i$ by $L_i$, $i \in \{1, \dots, n\}$, and the value of collateral loan $j$ by $L_j$, $j \in \{1, \dots, m\}$. The percentage of (the value of) collateral j allocated to cover the exposure associated with loan $i$, denoted by $d_{ji}$, for all pairs of loans and collaterals form the set of variables in all three approaches. It is evident that, using the bipartite graph scheme

proposed in the previous section, that the allocation process can be performed in each connected component of the graph independently and then add up the impact associated with each component. Given a bipartite graph, there are various methods to extract the connected components; in our approach, we have an adaptation of the Hoshen-Kopelman algorithm [5]) is being utilized. The connected components obtained from this preprocessing step will be called clusters of loans and collaterals. Since each allocation methodology

can be applied to each cluster independently, in what follows we work on a single cluster.

The three methodologies, presented in [6] as well, are the following:

**Proportional allocation method:** Under this approach, each $d_{ji}$ is determined by the ratio of $L_i$ to the total amount of loans that can be covered by the collateral j, denoted by $L(j)$, i.e.: $d_{ji} = \frac{L_i}{L(j)}$.

**CS method (or Cutaia method):** A methodology for optimal collateral allocation has been proposed by M. Cutaia in [3] (affiliated with Credit Suisse investment banking company in 2011). The overall approach has been based on setting two optimality criteria: (1) the coverage ratio of every loan of a cluster to be as close as possible to the coverage ratio of the whole cluster, i.e. for each loan i (in a cluster), minimize the $\left|\Sigma_j \frac{d_{ji}C_j}{L_i} - a_0\right|$, where $a_0 = \frac{\Sigma_j C_j}{\Sigma_i L_i}$ is the average cluster coverage ratio; and (2) the percentage allocation of each collateral j to the associated loans should be as close to $d_{j0} = \frac{1}{N_j}$, where $N_j$ is the number of loans associated with collateral $j$. The exact mathematical formulation of the optimization problem goes as follows:

$$min \sum_{i=1}^{n} \left| \sum_{j=1}^{m} \frac{d_{ji}C_j}{L_i} - a_0 \right| + \sum_{i=1}^{n}\sum_{j=1}^{m} |d_{ji} - d_{j0}|$$

subject to:

$$\sum_{i=1}^{n} d_{ji} = 1 \qquad \text{for each } j \in \{1, \dots, m\}$$
$$d_{ji} \geq 0 \quad \text{for each } j \in \{1, \dots, m\} \text{ and } i \in \{1, \dots, n\}$$
$$d_{ji} = 0 \quad \text{for each } j \in \{1, \dots, m\} \text{ and } i \in \{1, \dots, n\}, \text{ if } j \text{ is not connected to } i$$

The aforementioned problem can be easily linearized (i.e. express it using a linear programming formulation) as shown in [3] and, therefore, efficient methods for solving linear programming problems can be employed.

**Transportation Method:** In the formulation proposed in [6], the rationale and notation of the well-known transportation problem is utilized. The set of collaterals correspond to the source nodes that distribute part of their value to the connected loans (in the same cluster) which correspond to destination nodes (see e.g. Chapter 8 in [4]). Let $x_{ji}$ be the amount of collateral $j$ which is assigned to loan $i$ and $y_i$ be the amount of the exposure of loan $i$ being uncovered. Regarding the coefficients of the variables in the objective function, it is evident that the $c_{ji}$ applied to $x_{ji}$ should be less than the $e_i$ applied to $y_i$. In our case we have set the value 1 to all $c_{ji}$ while each $e_i$ has been set equal to 1.5. As discussed in [6], the aforementioned coefficients can correspond to the risk weight factors proposed in the relevant guidelines [1,2]. In other words, in our analysis we make the assumption that all pairs of loans and collaterals have the same risk weight factor. The proposed formulation goes as follows:

$$\min \sum_{i=1}^{n}\sum_{j=1}^{m} c_{ji}x_{ji} + \sum_{i=1}^{n} e_i y_i$$

subject to:

$$\sum_{j=1}^{m} x_{ji} + y_i = L_i \text{ for each } i \in \{1, \dots, n\}$$
$$\sum_{i=1}^{n} x_{ji} \leq C_j \text{ for each } j \in \{1, \dots, m\}$$
$$x_{ji} = 0 \quad \text{for each } j \in \{1, \dots, m\} \text{ and } i \in \{1, \dots, n\}, \text{ if } j \text{ is not connected to } i$$
$$x_{ji} \geq 0 \quad \text{and } y_i \geq 0 \text{ for each } j \in \{1, \dots, m\} \text{ and } i \in \{1, \dots, n\}$$

## 3. RESEARCH SCOPE ANALYSIS AND RESULTS

The proposed methodological approach to achieve the optimal solution, regarding the allocation of collaterals, can be divided into two major study components which are presented hereinafter:
1. The robustness of the proposed transportation method.
2. The impact of portfolio specificities.

The first component is characterized as static, since it does never change among the execution of iterative – usually monthly - calculations for the estimation of the RC. It is also independent of portfolio individual characteristics, meaning that it can be utilized 'as is' for all banking institutions and loan-collateral connections' pattern. The performance of the static component was assessed in [6] by utilizing real and synthetic datasets. The proposed methodology was found to be more efficient - against alternatives - concerning the allocation capacity in both datasets, hence proving that the methodology's core component is adequately robust. However, the algorithm's robustness can be hindered by impediments arising by idiosyncratic characteristics of the portfolio, recognized in the above list as the portfolio specificities. These characteristics include but not limited to the type of loans and collaterals, with the latter being

characterized by a higher diversity. The banks usually utilize land property and savings deposits, which are considered as collaterals of low risk that demand basic managerial skills. Nonetheless, stocks, bonds and sophisticated securities have also been employed by institutions with in-depth expertise in the effective management of financial instruments using advanced techniques. The nature of collaterals and the complications arising from the possible complexity of the relative evaluation algorithms, is directly connected with the estimated portfolio Total Coverage Ratio (TCR). The latter is recognized as a factor of crucial importance for the result of the allocation methodology, because it provides the theoretical upper threshold of accounts' coverage. Main aim of the current analysis is to place the abovementioned portfolio specificity under scrutiny by performing an impact assessment of its variation in the final model outcome. The synthetic dataset employed consists of a portfolio with 68 loans and a set of 65 available collaterals. For the generation of the loan exposures, collateral amounts and loan-collateral connections, the SAS "RAND" function (see [7]) was utilized (where the input "seed" was set equal to zero, so that the stream of generated numbers is initialized by the computer clock). A connection between a collateral and a loan was also randomly chosen (based on a Bernoulli trial with a probability p = 0.05 of establishing a connection). The collaterals' in the initial (baseline) sample were required to have value no greater than the 50% of the total exposure of its associated loans, resulting in a total coverage ratio equal to 89.90%. The characteristics of the dataset so-obtained are provided in Table 1:

**Table 1.** Results regarding the synthetic dataset

| # Accounts (=N) | # Collaterals (=M) | Portfolio Total Exposure | Total Collaterals Value |
|---|---|---|---|
| 68 | 65 | 2,035,600.00 € | 1,828,000.00 € |
| # min Account Connections | # max Account Connections | # min Collateral Connections | # max Collateral Connections |
| 2 | 5 | 2 | 12 |

The rescaling of the portfolio TCR by dividing the collaterals' values by a cumulative factor - with a step of 0.1 - consecutively, led to a set of values depicted in the following chart:

**Chart 1.** Portfolio TCR (%) = f (Collaterals' values scaling factor)
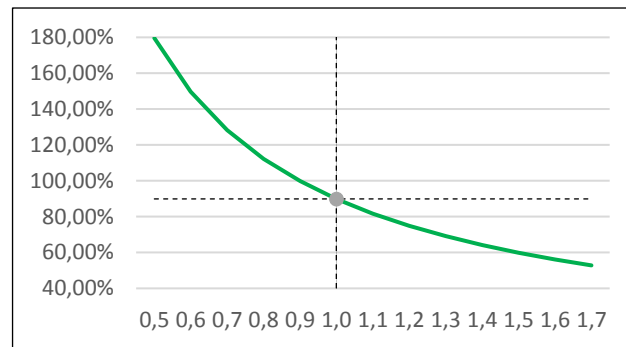


The baseline dataset (represented by the point (1.0, 89.90%) of Chart 1) as well as all other datasets resulting from the TCR rescaling process and only, were used as an input to all three methodologies presented in Section 2. The relative results are presented hereinafter.

**Chart 2.** Portfolio TCR (Ref. Line) vs. Methodologies' achieved coverage ratios
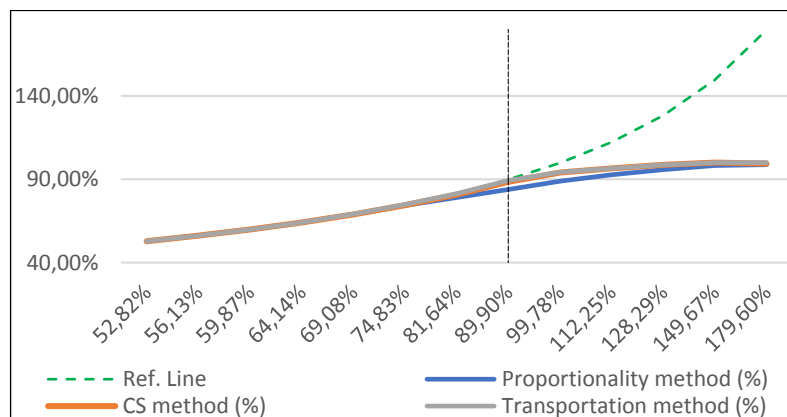
All three methodologies do cap the TCR to 100% and provide similar response in extreme macro-economic conditions, when the collateral values start collapsing significantly. However, the Transportation method achieves a slightly better TCR than CS method does and a noticeably better than the simple Proportionality method does in regular conditions.
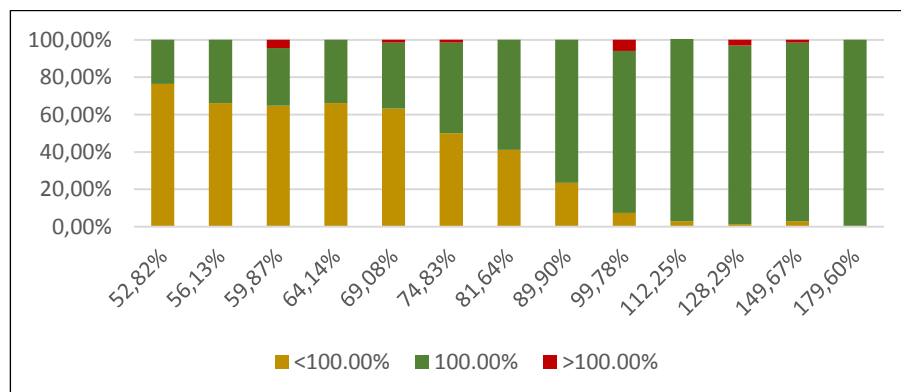
**Chart 3.** Pct. of accounts' coverage achieved by Prop. method with respect to TCR
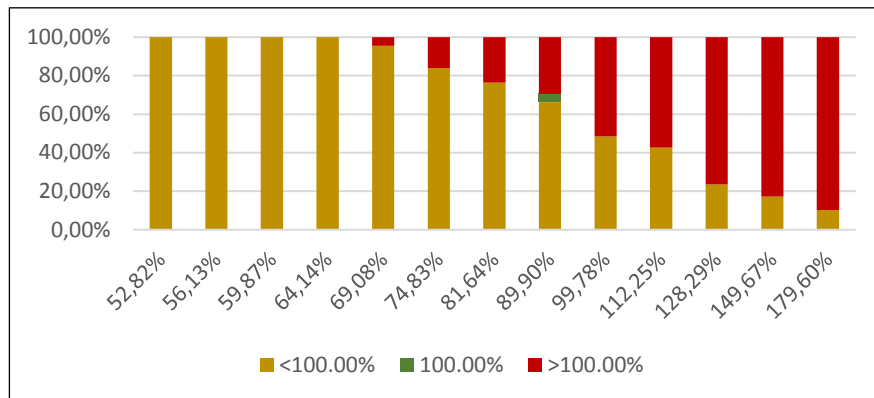


**Chart 4.** Pct. of accounts' coverage achieved by CS method with respect to TCR
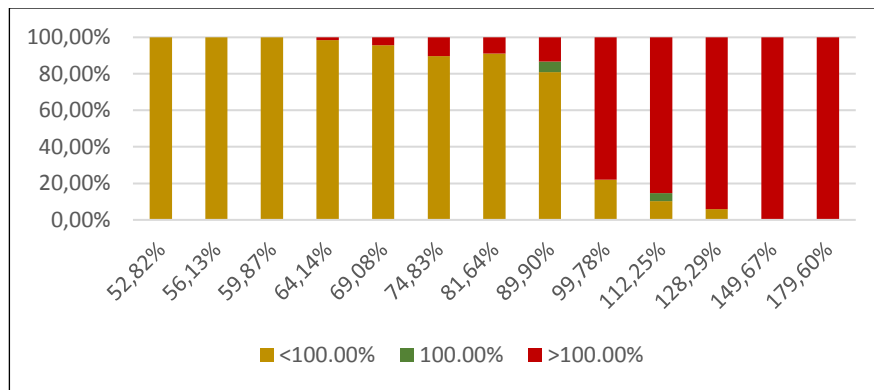


**Chart 5.** Pct. of accounts' coverage achieved by Transportation method with respect to TCR



In Charts 3, 4 and 5 it is obvious that all three methodologies respond as expected, with the coverage below 100% becoming dominant in macro-economic downturn conditions and the coverage above 100% in relevant upturns. However, the Transportation method presents a way more efficient overall result by achieving the vast majority of 100% coverages throughout the TCR scale and insignificant percentages above 100%.

**Chart 6.** Regulatory Capital with respect to portfolio TCR
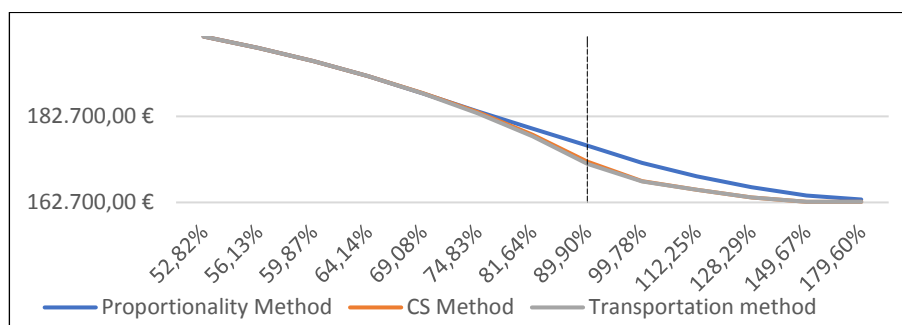
The methodologies' evaluation - in terms of final Regulatory Capital estimation - is depicted in Chart 6. The Transportation method is once again proved to be the most robust approach, managing to achieve the lowest levels of RC.  In order to foster the more efficient implementation of the proposed methodology, a thorough ("deep dive") assessment of the Hoshen-Kopelman algorithm's information entropy manipulation power, regarding the connections pattern among accounts and collaterals (contained in the relevant Bernoulli table), is planned to be carried out. Removal of identified undue negative influences as well as further fine-tuning adjustments, which will enhance the process in terms of calculation time and data management capacity will be duly performed.

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# Innovation Management and New Service Development Strategy: A Case Study in Cultural Heritage Institutions

Eleni Champipi
*Department of Communication & Media Studies, National and Kapodistrian University of Athens Athens, Greece*

Fotis Kitsios
*School of Information Sciences, Department of Applied Informatics, University of Macedonia 156 Egnatias st, 54636 Thessaloniki, Greece*

Maria Kamariotou
*School of Information Sciences, Department of Applied Informatics, University of Macedonia 156 Egnatias st, 54636 Thessaloniki, Greece*

### Abstract

During the last decades the industry of art has changed significantly. Museums are significant pillars of economic growth and competitiveness. They try to meet visitors' expectations operating in a highly competitive leisure market. As cultural industries have been facing many transformations in the last decade due to the development of emerging technologies and the increase of visitors' expectations to receive additional services to improve their experience, museum managers try to find out processes that increase value proposition. To be able to develop innovative services that comprehend the underlying business logic of service provision, managers should shift to a new strategic planning, a new organizational structure, and market launch process. Despite the increased recognition of researchers to New Service Development process, academics have given less attention to development activities for the innovation of new process and services in cultural institutions. The emerging field of transformation in cultural industries provides a new perspective to approach service innovation and has encouraged many museums to invest in the improvement of the visitor's experience. Thus, the purpose of this paper is to investigate the factors that affect the process of service development in cultural industries. This paper presents a conceptual framework which is based on the existing literature regarding the New Service Development and success factors of innovative services. The findings of this paper denote the attention paid by museum managers to improve the process of New Service Development and increase visitors' experience. Furthermore, this paper is useful to practitioners in order to design more successful services and consider closely these factors in service systems design.

## 1. INTRODUCTION

Cultural industry contributes to economic growth of each country. As museums are significant pillars of economic growth and competitiveness they need to gain revenues in order to survive. Therefore, they have similarities with organizations whose main goal is profit. It is required for them to adopt marketing techniques and develop innovative services that distingue them from their competitors (Kitsios et al., 2016; 2015). As cultural industries have been facing many transformations in the last decade due to the development of emerging technologies and the increase of visitors' expectations to receive additional services to improve their experience, museum managers try to find out processes that increase value proposition. To be able to develop innovative services that comprehend the underlying business logic of service provision, managers should shift to a new strategic planning, a new organizational structure, and market launch process (Evrard and Krebs, 2018; Kim, 2018).

In this framework, researchers have investigated the effect of the development of new services on financial performance at museums (financial results, revenues from funding and sponsorships) and the relationship among organizational size, novelties, their business management, technology, value creation and social performance (Barczak et al., 2006; Camarero and Garrido, 2012; 2008; Garrido and Camameo, 2010). Despite the increased recognition of researchers to New Service Development process, academics have given less attention to development activities for the innovation of new process and services in cultural institutions. Thus, the purpose of this paper is to investigate the factors that affect the process of service development in cultural organizations. This paper presents a conceptual framework which is based on the existing literature regarding the New Service Development and success factors of innovative services.

The structure of this paper is as following: after a brief introduction to the field of New Service Development and innovation management in museums, next section includes the theoretical background which was analyzed in order to highlight the issues which are discussed in this paper. Then, a theoretical framework is developed based on the literature review whereas the final section concludes the paper.

## 2. THEORETICAL BACKGROUND

Services are important pillars of the economy of each country and key drivers of competitiveness and profitability. However, there are significant differences between products and services that distinguish New Product Development

(NPD) from New Service Development: lack of tangibility, simultaneous production and purchase, variability and corruptibility Thus, the academic community has focused on the process of New Service Development and especially on factors that can predict the success of new services (Kitsios and Grigoroudis, 2014; Kitsios and Sindakis, 2014; Kitsios et al., 2013; 2009). Researchers have examined the critical success factors in many sectors. These factors are related to the alignment of business strategy with new service strategy, employees' and customers' participation in idea generation process, communication with customers, organizational structure and innovation climate.

As managers aim to develop services that meet customers' expectations, it is important to align business strategy with new service strategy. Benefits of alignment include the strategic selecting of the markets to enter, the strategically planned projects which enable the business to take advantage of the synergy between similar innovation projects and the support of learning (Baradarani and Kilic, 2017; Kitsios and Kamariotou, 2016a). An open, informal organizational climate which supports innovation positively affects this effort. Furthermore, flexible organizational structures, high levels of formalization, a high level of involvement in decision making process, management style, learning processes and management support are significant factors that significantly influence new service success (Eveleens, 2010; Kitsios and Kamariotou, 2019; Lievens and Moenaert, 2000).

Specifically, the creation of conditions that facilitate the informal exchange of information not only among different departments and teams but also between the organization and customers strongly and positively affects the internal innovation climate. Employees' involvement in idea generation is significant because they interact with customers and suggest features for the new service according to customers' needs. Additionally, their participation is valuable during the launch stage because they can improve customer perceptions of new service quality, ease of use, brand name and increase sales performance. Organizations train frontline employees to interact with customers, learn about their expectations, their behavior and their needs and provide important information about them. Thus, they can affect the reactions and behavior of customers for the new service and they are able to suggest new ideas that will satisfy customers' needs (Avlonitis et al., 2001; Baradarani and Kilic, 2017; Kitsios and Kamariotou, 2016b; Melton and Hartline, 2010; Ottenbacher and Harrington, 2010).

On the other hand, customers' involvement in New Service Development process increases the understanding of their needs and preferences, they are willing to pay in order to purchase the new service because it offers added value for them and they will more possibly repeat their purchase in the future. Grissemann et al., (2013) conclude that customers' participation is more effective in the development stage because they can redefine their needs and give feedback to service organizations.

Previous researchers have examined critical success factors in many industries such as financial institutions, tourism industry, healthcare organizations, telecommunication and e-government. However, studies that measure the relationship between critical success factors and success or failure of new service in museums are limited. Museums invest in the improvement of the visitor's experience because many people are not visiting them because of their image as boring and they try to serve visitors better. Museum managers use focus on marketing strategies in order to increase the quality of the services offered as well as experiences and activities to visitors (Evrard and Krebs, 2018). Harrison and Shaw (2004) examined visitors' experience, satisfaction and loyalty in museums. They concluded that, even if visitors are satisfied with the initial experience, most of them who visited a museum might not repeat their visit immediately. Therefore, understanding visitor motivation and visitor behaviors are important factors of communication between museum and visitors because managers engage them to the process of service development, they provide information regarding their expectations in order to help managers to offer them services that will improve their experience (Kim, 2018).

## 3. METHODOLOGY

Based on the analysis of the existing literature review, a set of variable is identified in order to identify the critical success factors that influence New Service Development in Cultural Heritage Institutions. These factors are the following: Business/Financial Analysis, Resource Allocation, Launch Effectiveness, Detailed Market Study, Organization – Internal Consequence, Project Focus Strategy, Preliminary Market Assessment, Market Synergy, Business Analysis prior to Launch, Human Resources Management, Continuous Evaluation, Idea Generation, Formalization Development Procedures and Market potential. Financial analysis, Business analysis prior to launch and market potential describe analysis which is implemented before the launch of new services to the market (e.g. analysis of competitors, forecasting of sales, ROI analysis, DCF analysis and promotion plans). Resource allocation refers to resources that are available for new service development. Launch effectiveness includes activities that are related to communication, promotion and marketing activities. Detailed market study and preliminary market assessment include variables such as primary market research, evaluation of marketing plan and resources. Organization – internal consequence refers to management support and information that are available for the new service. Project focus strategy identifies objectives and strategic plans of action for the development of new service. Market synergy refers to the analysis of customer's behavior. Human resources management refers to employees that are responsible for new service development and market launch. During continuous evaluation managers assess each stage of New Service Development process. Idea generation includes formal processes to collect ideas from internal and external sources and formalization development procedures refer to activities that are

implemented for new service development (De Brentani 2001; Edvardsson et al., 2013; Kitsios and Grigoroudis, 2016; Kitsios et al., 2016; 2015; 2009; Ottenbacher and Harrington, 2010; Voss et al., 2006).

The following hypotheses are defined in order to measure the relationship between critical success factors and success or failure of new service:

H1: There is a positive effect between Business/Financial Analysis and success of new services.

H2: There is a positive effect between Resource Allocation and success of new services.

H3: There is a positive effect between Launch Effectiveness and success of new services.

H4: There is a positive effect between Detailed Market Study and success of new services.

H5: There is a positive effect between Organization – Internal Consequence and success of new services.

H6: There is a positive effect between Project Focus Strategy and success of new services.

H7: There is a positive effect between Preliminary Market Assessment and success of new services.

H8: There is a positive effect between Market Synergy and success of new services.

H9: There is a positive effect between Business Analysis prior to launch and success of new services.

H10: There is a positive effect between Continuous Evaluation and success of new services.

H11: There is a positive effect between Idea Generation and success of new services.

H12: There is a positive effect between Continuous Evaluation and success of new services.

H13: There is a positive effect between Formalization Development Procedures and success of new services.

H14: There is a positive effect between Market potential and success of new services.

A questionnaire including 126 variables in order to measure these factors was developed for Museum managers in Greece. The questionnaire was based on previous similar studies (De Brentani 2001; Edvardsson et al., 2013; Kitsios and Grigoroudis, 2016; Kitsios et al., 2016; 2015; 2009; Ottenbacher and Harrington, 2010; Voss et al., 2006). In the first part of the questionnaire respondents are asked to select and refer to one new service. Then, they are asked to indicate the extent to which the events that are described in these 126 variables have been implemented during the New Service Development process. 5 point likert scale ranging from "percentage of 0 %—not done" and "100 %—completely done" was employed. Success and failure was defined by each respondent in terms of their own organization's interpretation of whether or not the new service met their success criteria. A five-point Liker-type scale was adopted for measuring the dependent variable that refers to the new service success or failure. Figure 1 presents the conceptual model of the survey. Given the classification of the projects as successful or failures, the objective of the analysis was to examine the critical factors that influence new service success or failure. Thus, the development of a reliable success identification/prediction model which aggregates all the relevant information as described by the selected variables is analyzed using Regression Analysis in order to test hypotheses.

Figure 14 Conceptual model
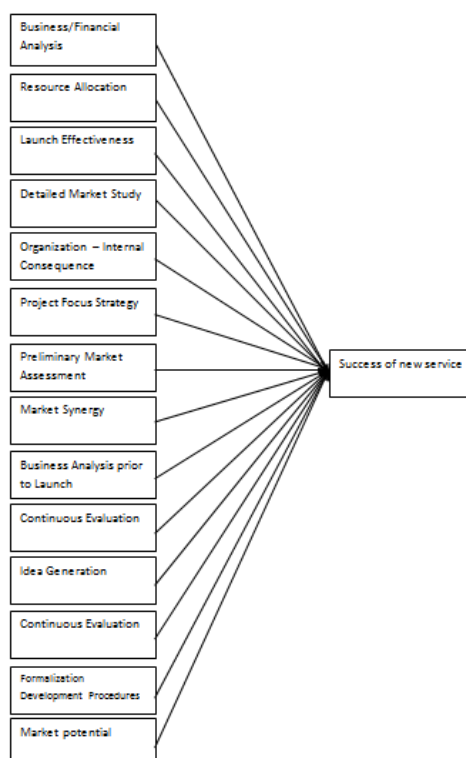
## 4. CONCLUSIONS

Within the rapidly changing business environment managers have payed attention to the role of innovation in gaining competitive advantage. Managers realize that they have to satisfy customers' and increase service quality, as well as the degree of innovation in service design in order to survive and compete in the current increasingly demanding environment. Thus, the purpose of this paper was to investigate the factors that affect the process of service development in cultural organizations. This paper presented a conceptual framework which is based on the existing literature regarding the New Service Development and success factors of innovative services. This paper is useful to practitioners in order to design more successful services and consider closely these factors in service systems design. It is anticipated that New Service Development process will be transformed in next years as a result of rapid developments in new technologies and changing customer needs or expectations. This paper is useful for researchers who are interested in studying to expand knowledge in this filed. Furthermore, the findings of this paper denote the attention paid by museum managers to improve the process of New Service Development and increase visitors' experience. Museums face challenges in their environment due to changes in customers' needs and expectations and the development of new technologies. Thus, cultural institutions should take into account the factors that affect new service success in order to change their mission and operations.

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# Developing a risk-based policy portfolio analysis framework for scaling-up participatory innovation in Greece

| Apostolos Arsenopoulos[a] | Nikolaos Mastromichalakis[a] | Vangelis Marinakis[b] | Haris Doukas[a] | John Psarras[a] |

[a]*School of Electrical and Computer Engineering, Decision Support Systems Laboratory (EPU-NTUA), National Technical University of Athens, 9, Iroon Polytechniou str., Athens, 15780, Greece*

[b]*Holistic S.A., 507, Mesogeion Ave., Agia Paraskevi, Athens, 15343, Greece*

### Abstract

Policy portfolio configuration feature high complexity due to the numerous possible combinations of actions. The latter, imply a great deal of difficulties when it comes to defining and implementing them, mainly because of the underlying uncertainty as to their impact on the beneficiaries.

The aim of this paper is to develop a methodological framework that enables the integration of participatory innovation into decision-making processes at local level. The proposed actions are assessed both by the citizens and experts against major socio-economic risks (e.g. bureaucracy, social acceptance, etc.), through customised questionnaires. These actions constitute the alternatives of a Multicriteria Analysis problem, where the citizens' individual assessments are eventually grouped into a collective one, resulting to a final score (risk) for each action. The methodology also includes a bi-objective linear programming model, for eliciting the optimal policy portfolios, which comprise of sustainable actions, as well as the optimal budget allocation to each of them. To summarise, the proposed methodology responds to the following problem: developing an optimal portfolio of policy measures that meets the energy saving or $CO_2$ reduction target, for a given budget, in the context of minimizing the total cost and risk involved. An online platform, integrating the said methodology, will also be developed to facilitate the whole initiative.

The proposed methodology will provide significant added-value to the decision-making processes at local level and to the well-being of the society in general, allowing both stakeholders and decision-makers to design and jointly select the most effective courses of actions towards reaching sustainability, in the context of facilitating the Sustainable Energy and Climate Action Plans (SECAP) implementation.

**Keywords:**
*Participatory innovation; sustainability; portfolio analysis; optimisation; platform; decision-making.*

## 1. INTRODUCTION

The European Union (EU) faces unprecedented challenges stemming from the increased dependence on energy imports and insufficient energy resources, as well as from the need to reduce climate change and tackle economic crisis (COM (2011) 370 final). Increasing energy efficiency and reducing $CO_2$ emissions are the keys to addressing these future challenges (Directive 2012/27/EU), with the main axis of the European energy policy being a firm commitment to these needs. Drawing from its respective national commitments as well as from the need to respond to the European and global efforts in the climate change front, Greece has recently been striving to design and implement an effective and sustainable course of actions.

To this end, local municipalities are envisaged to bear the burden for the transition to a low-carbon climateresilient economy, taking into consideration that their fundamental role is not limited to the provision of public services (Bressers et al., 1998), but they must also serve as political, social and developmental institutions. As a result, several municipalities across Europe have expressed their intention to adopt and implement a series of actions in order to address the urgent need of growing energy demand and its consequent increase in greenhouse gases, in the context of facilitating the implementation of Sustainable Energy and Climate Action Plans (SECAP) through strategic policy-making.

The strategic policy-making process often includes several "beneficiaries" (e.g. citizens, customers, workers, businesses, etc.) and a smaller number of "decision-makers" (managers of public and private organisations, etc.). The major defect with regard to the said process lies in the potentially large number of policy combinations and their ambivalent impact on the beneficiaries, given the limited input provided by the latter in the composition of the final policy portfolio.

In this respect, the current paper intends to present an innovative methodology, for the facilitation of the "co-creation" of interventions by all stakeholders involved, at local level, using crowd-sourcing techniques, modelling/simulation of complex systems and open data sources. The said methodology includes a modelbased Multi-criteria Analysis on the mix of measures that the Municipalities are considering to implement, in order to elicit a total score (risk) for each action, as well as a Portfolio Analysis (PA) to allow for the optimal assessment of measures that contribute to significant reduction in the energy sources consumed and the resulting emissions. On top of that, it is crucial that the experts' evaluations over the exposure of the proposed measures to key socio-economic risks (e.g. bureaucracy, social acceptance, etc.) are effectively integrated into the analysis, with a view to identifying a portfolio of measures that achieves the optimal resource allocation. The proposed methodology will be integrated into a web-based platform in order to facilitate the engagement process.

The paper is organised as follows: the following section contains a brief description of the employed models and methods; the third section presents a numerical example of the proposed approach; and finally, some conclusions are elicited.

# 2. METHODS AND TOOLS

Deriving from the aforementioned discussion, the current analysis is conducted based on a) customised questionnaires for incorporating the public opinion into the decision-making procedure; b) an integrated Multi-Criteria Decision Support System (MCDSS) which allows both normative judgement and technical expertise in the assessment process; c) a Policy Portfolio Analysis framework for eliciting the optimal policy measures to be implemented and d) a Robustness analysis method for extracting the most robust policy portfolio measures, given the underlying uncertainty of the problem's parameters. Its main focus lies in a quantitative evaluation of several Energy Efficiency and CO2 reduction measures towards a thoroughgoing reform of the local municipalities, in the context of facilitating the implementation of SECAP.

Under the scope of prioritization, the proposal's main multidisciplinary objective is summarised as follows: developing a joint optimal portfolio of policy measures that meets the energy saving or $CO_2$ reduction target, for a given budget, in the context of minimizing the total cost and risk involved. The said methodology is broken down into the following technical components:

*Consolidating the citizens' assessments using Multi-criteria analysis*

The citizens' estimates over the exposure of each policy measure to each of the identified socio-economic risks (e.g. bureaucracy, social acceptance, etc.) are captured through customised questionnaires, where each citizen is kindly asked to assess the extent to which he/she considers that the selected risks threatens the unobstructed implementation of each alternative, using a five-step linguistic scale (0: Very little effect, 1: Little effect, 2: Moderate effect, 3: High effect, 4: Catastrophic effect). In order to aggregate the said estimates to be utilized in the Multi-criteria Analysis model, the gathered assessments are transformed into numerical values. The engaged citizens are also provided with the capability to suggest new actions to be integrated into the whole analysis, based on their needs and priorities.

For the purpose of this analysis, the risk assessment is carried out using the Multi-criteria decision support method TOPSIS or Technique for Order of Preference by Similarity to Ideal Solution (Hwang and Yoon, 1981), which was developed as an alternative to the ELECTRE family of methods. TOPSIS is a compensatory aggregation method, based on the assumption that the action selected should have the minimum and maximum geometric distance from the ideal and the non-ideal solution respectively.

*Eliciting the optimal portfolios using the "AUGMECON-2" method*

The augmented e-constraint method (AUGMECON & AUGMECON2) is a multi-criteria optimisation technique mainly applied to mixed-integer variable problems, such as Portfolio Analysis (PA) (Mavrotas et al., 2013). It aims at facilitating the analysis of multi-objective problems, by optimising one of the objectives and converting the remaining ones into constraints. The algorithm used, leads to a rapid identification of the optimal solution.

*Introducing uncertainty using the "Monte Carlo" method*

The inherent uncertainty in the parameters of the problem is of stochastic nature, that is, quantified under probability distributions, which in turn are modeled with the Monte Carlo simulation (Vose, 1996), according to the following algorithm:

- Selecting the formula and the respective parameters of the probability distribution function to incorporate the uncertain parameters.
- Using the Monte Carlo method multiple times in order to sample coefficients of the objective functions and eliciting the respective Pareto fronts with the "AUGMECON-2" method (Mavrotas and Florios, 2013), as described in Paragraph 2.2.
- Selecting a Pareto front as the most representative one and calculating the distance of each separate Pareto solution from the respective Pareto optimal solution of the representative Pareto front. The smaller the distances, the more robust the portfolio turns out.

*Robustness analysis and final evaluation from the citizens*

The robustness analysis is carried out using the Iterative Trichotomic Approach (ITA) (Mavrotas and Pechak, 2013). ITA provides information about the degree of certainty for the inclusion or rejection of a specific action in the final portfolio. The version of ITA used in the current paper provides information about the degree of certainty for inclusion of a specific portfolio in the final Pareto set, expanding thus its application area from action level to portfolio level. This kind of

information is essential for the decision-makers to be more confident to select policy portfolios that feature high degree of certainty regarding their Pareto optimality. These final portfolios are eventually presented to the citizens for one last evaluation, in order to jointly select the participatory portfolio that best serves the local community.

The proposed methodology is presented in Figure 1.

**Figure 1** Proposed methodology
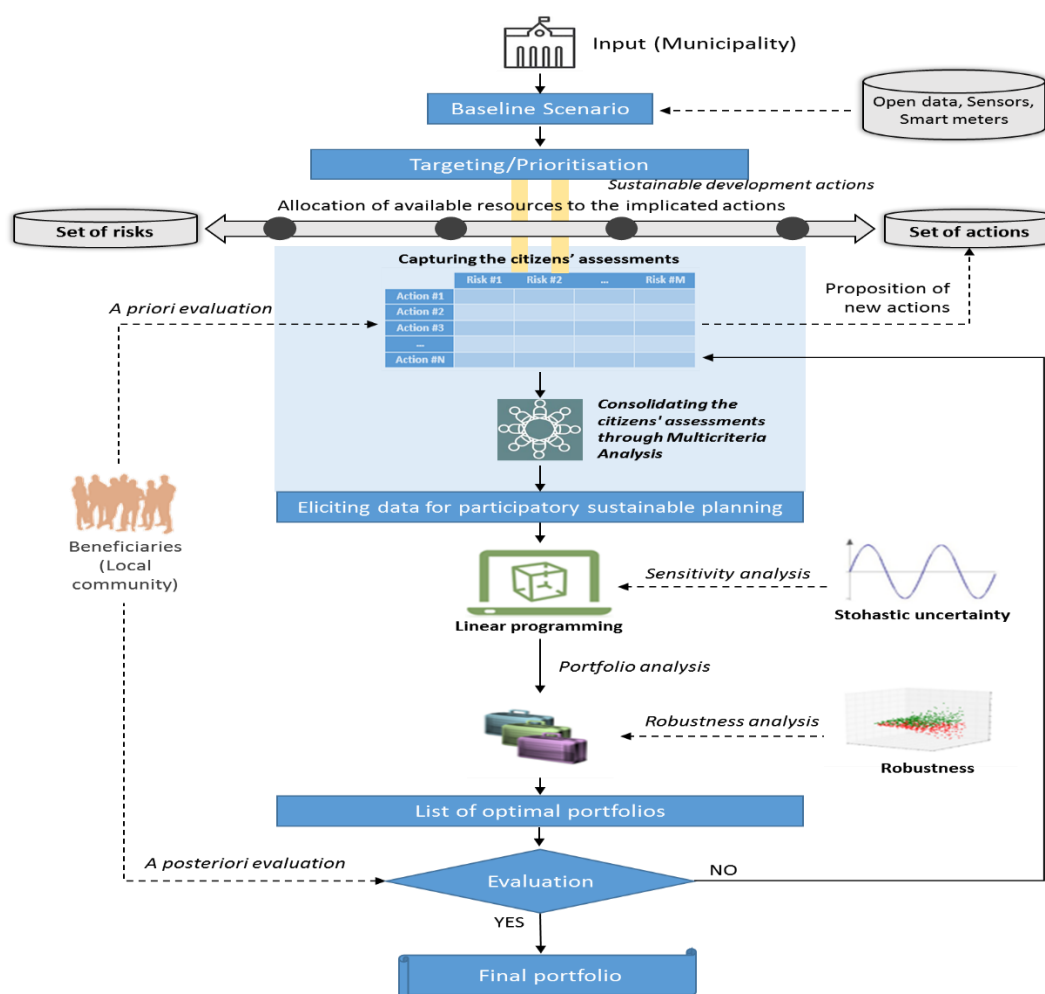


# 3. NUMERICAL EXAMPLE

## 3.1 Problem specification

The proposed methodology is applied in a numerical example, in order to showcase its functionality. The aim of the methodology application lies in the identification of the optimal policy portfolio measures among a set of 58 actions, evaluated against the objectives of minimising both costs and associated risks of the resulting policy framework at local level, in the context of facilitating the SECAP implementation. Within this framework, the proposed actions are considered to be $CO_2$ reduction measures from a wide range of actions in different sectors, the implementation of which, will significantly contribute to the achievement of the $CO_2$ reduction target set by the local municipality.

As described above, in order to solve the problem, TOPSIS and augmented ε-constraint (AUGMECON-2) approach were extensively used, followed by the respective robustness analysis. The application of TOPSIS was based on the citizens' engagement, which stems from the exploitation of the relevant questionnaires where each citizen was asked to evaluate the alternatives against a set of 5 consistent criteria-risks (Makropoulos and Butler, 2006), namely a) bureaucracy; b) installation cost; c) social acceptance; d) experienced personnel and e) market conditions. The total scores extracted from TOPSIS were associated with each action, representing a level of risk for their effective implementation, in the following Portfolio Analysis. Stochastic uncertainty was also integrated into the PA process, regarding the parameters of specific actions that exceeded a predefined level of risk. PA was solved in the General Algebraic Modelling System (GAMS) environment using the CPLEX solver. Eventually, the optimal policy portfolios elicited from the PA, were stress-tested in terms of robustness, in order to obtain the most robust one to be extensively analysed.

## 3.2 Results and discussion

Figure 2 represents an indicative Pareto front that was elicited from the PA process, featuring minimal uncertainty, thus incorporating the most robust policy portfolios. However, the optimal policy portfolio extracted from the application of ITA, in terms of robustness (enters the final green set of ITA sooner than the rest), is depicted in a red spot (Figure 2). The technical characteristics of the selected joint portfolio, which meets the $CO_2$ reduction target, are presented in Table 1.

**Table 1** Optimal actions elicited from the application of the proposed methodology

| Action | Sector | Fuel | $CO_2$ reduction (tn) | Cost (mill. €) | Penetration (%) |
|---|---|---|---|---|---|
| GPS installation on tractors | Agriculture | Diesel | 846.16 | 1.439 | 10 |
| Drip irrigation | Agriculture | Electricity | 309.82 | 0.574 | 5 |
| Lighting system automations | Municipal buildings | Electricity | 28.541 | 0.002 | 2 |
| Lighting management system | Municipal public lighting | Electricity | 188.573 | 0.038 | 14 |
| Solar water heater | Residential | Electricity | 67933.08 | 37.227 | 90 |
| LED lighting | Residential | Electricity | 9661.594 | 5.063 | 96 |
| Air-conditions upgrading | Residential | Electricity | 19373.508 | 25.399 | 70 |
| Application of cold colours | Residential | Electricity | 7850.045 | 10.48 | 52 |
| Installation of tents in apartments | Residential | Electricity | 1107.058 | 0.568 | 22 |
| Installation of PV under net metering | Residential | Electricity | 29675.892 | 51.161 | 12 |
| Behavioural change | Residential | Electricity | 12580.2 | 0 | 100 |
| | | Heating oil | 15106.3 | 0 | 100 |
| Campaign to commit enterprises towards reducing their energy consumption by 10% | Tertiary | Electricity | 1617.63 | 0 | 20 |
| | | Heating oil | 644.45 | 0 | 20 |
| LED lighting | Tertiary | Electricity | 24264.45 | 16.427 | 100 |
| Lighting system automations | Tertiary | Electricity | 258.821 | 0.023 | 2 |
| Exterior shading | Tertiary | Electricity | 291.173 | 0.164 | 6 |
| Application of cold colours | Tertiary | Electricity | 1455.867 | 2.114 | 10 |
| Frequent maintenance of vehicles | Public transport | Diesel | 213.228 | 0.302 | 30 |
| Eco-Driving seminars | Private transport | Petrol | 70451.37 | 9.863 | 64 |
| | | Diesel | 36142.242 | 5.096 | 28 |

By delving into the results, it is clear that the proposed methodology provide with the capability to calculate the total cost required on behalf of the municipality as well as of the citizens for the effective implementation of the elicited optimal actions, the budget allocation per activity sector, and last but not least the social acceptance of each proposed action, namely the penetration level of each action to the engaged stakeholders.

**Figure 2** Pareto front elicited from the application of the proposed methodology
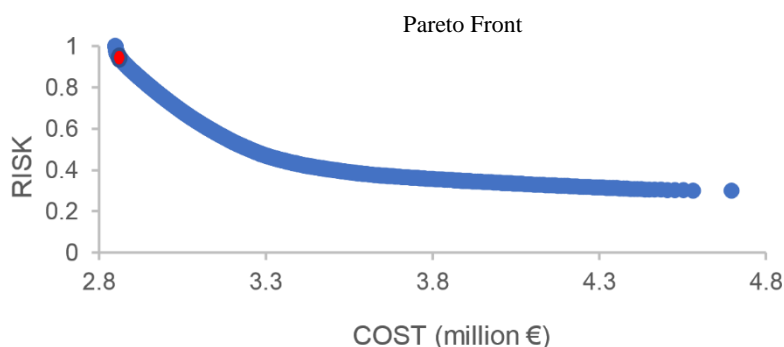


## 4. CONCLUSIONS

This brief paper intends to showcase the link between three models (TOPSIS, AUGMECON and ITA) used to explore participatory strategies of climate change mitigation and energy planning at local level. The numerical example particularly focuses on the evaluation of sustainable actions for reducing $CO_2$ emissions or energy consumption, in the context of facilitating the SECAP implementation. The analysis properly integrates the SECAP data into a portfolio generation model, while also treating exogenous uncertainty stochastically. The results provide an indication on how financial resources among the implicated sustainable actions should be allocated. The outcome of the proposed approach is a set of optimal sustainable actions portfolios, among which the most robust is selected.

Finally it should be noted that the proposed methodological framework is in the context of supporting participatory policymaking at local level that pinpoints the need to reduce or effectively integrate uncertainty (Doukas et al., 2018) into the said analysis, by providing information on the level of certainty associated with resulting policy options thereby maximising the robustness of the elicited results (Doukas and Nikas, 2019).

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# An Advanced Routing and Scheduling System for Dangerous Goods Transportation

Evripidis Kechagias
*eurikechagias@mail.ntua.gr*

Sotiris P. Gayialis
*sotga@central.ntua.gr*

Grigorios D. Konstantakopoulos
*gkonpoulos@mail.ntua.gr*

Georgios A. Papadopoulos
*gpapado@mail.ntua.gr*

*National Technical University of Athens, School of Mechanical Engineering, Sector of Industrial Management and Operational Research, Zografos Campus, 15780, Athens, Greece*

**Abstract**

The transportation of dangerous goods is usually a process involving risks for both the staff implicated in this process and potentially the entire population in the event of an accident. In order to limit these embarrassing situations, a set of rules need to be established, which should be considered as binding and inevitable. Critical factors affecting the efficiency of the transportation of such goods include on-time delivery (especially for goods with short usable time), compliance with safety rules, right packaging, observance of the measures to protect those who come into contact with these materials and avoidance of possible risks. In recent years, vehicle routing systems have rapidly developed, but are mainly used to facilitate vehicle routing from the perspective of reaching destinations on-time or with the minimum cost, without considering the safety of the transport. Of course, when a vehicle transports dangerous goods, safety must be a priority, as such an accident will cause incalculable disasters. At the same time, many of these dangerous goods have a limited lifetime and therefore need to be delivered just in time. Otherwise, the impact (economic, environmental, social) will be significant. The scope of this paper is to describe the conceptual design and the methodological approach for the development of such a routing and scheduling system. This system will be specialized in the transportation of dangerous goods, taking into consideration the aforementioned factors affecting the efficiency of such deliveries and therefore provide safe and accurate routes for the vehicles.

## 1. INTRODUCTION

Dangerous goods are defined as goods, materials and cargoes which may pose a danger to the community, the life and health of humans, animals, and public order and safety (Johan Lundin, 2018). This danger may be due to the nature, properties and condition of these goods, as well as to any accidents that may arise during their transport (A. Romanovich, A. Yudin, 2016). The transportation of dangerous goods can lead to a particularly severe accident even if transported in small quantities. The need to transport these goods requires their transportation in a public space, such as the road, the harbor or even the airport, away from the controlled environment of an industrial establishment (Liu, Li, & Li, 2017). Therefore, during their transportation, many dangers may arise, and it becomes clear that when dealing with transportations of dangerous goods the number one priority should not be speed or fuel consumption savings but the safest possible transportation of the goods in order to minimize the possibility of an accident (Hristova, 2017).
In many cases, such as (Forigua & Lyons, 2016) and (Ren, Zhou, Hu, He, & Wang, 2019), the occurrence of an accident is not due to omissions that involve strictly the cargo carried but mostly due to the usual traffic risks associated generally with freight transportation. Several times people who are involved in transporting dangerous goods are not adequately trained and do not know their peculiarities and the risks involved (Ebrahimi & Milos, 2018). Dangerous goods, therefore, can damage things, installations (e.g. ramps) or their means of transport (e.g. lorries) and, more generally, cause damage to humans and/or the environment. Several of these materials are well known to us, such as solvents, acids, fuels and others.

## 2. TRANSPORTATION OF DANGEROUS GOODS

Transportation of dangerous goods is a significant problem in modern industrialized societies (Wang, Zhang, & Huang, 2018). In fact, due to the wide use of these materials, life without dangerous goods is unthinkable (Molero, Santarremigia, Aragonés-Beltrán, & Pastor-Ferrando, 2017). Unfortunately, most of the dangerous goods cannot be useful at their production sources, so they need to be transported over long distances (Assadipour, Ke, & Verma, 2015). For example, it is estimated that 250,000 to 500,000 dangerous transports occur in the United States per day, summing up to an annual transport volume of between 1.5 and 4.0 billion tons of dangerous goods. To put this figure in perspective, according to

the US Department of Commerce, roughly every 5th truck on America's motorways carries dangerous materials (Health Canada, 2018).

The source of hazardous materials can be industrial and chemical factories, oil refineries, as well as medical stations such as hospitals and clinics (Jacyna, Semenov, & Trojanowski, 2015). Some potential accidents/hazards that may entail danger to humans may be an explosion in storage facilities or processes, leakage of hazardous cargo into containers directly into the atmosphere, explosion or leakage due to a traffic accident involving the transport of dangerous materials (Landucci et al., 2017). Consequently, such accidents could have devastating consequences and therefore transportation of such materials should be done with particular care.

What differentiates the transportation of dangerous goods from those of normal goods are the risks of accidents associated with them during transport. Dangerous goods may become extremely hazardous to the nature and the health of humans, since exposure to these goods can lead to injury or death of living beings (Hsu, Huang, & Tseng, 2016). These risks are considered by the society, and in many cases, rigorous laws govern such transfers (Kinateder et al., 2015). In general, dangerous goods transportation needs to take all necessary actions in order to prevent accidents (Huo et al., 2017). Nevertheless, and despite being rare, accidents occur during this type of transport. For example, in Canada, Ontario, Canada, a chlorine leak resulted in the evacuation of an area of 200,000 inhabitants (Lane & Thomson, 1981). Also, in a particularly horrible crash in an Afghan tunnel in 1982, 2,700 deaths were recorded by a gasoline burst (Burgherr, Eckle, & Hirschberg, 2012). Due to the nature of the products being transported, minimizing the risk of accidents needs to be the main priority. For this reason, this problem has complex and potentially conflicting objects, and the priority of the performance measures should be different between the prospects for a solution.

## 3. THE NEED FOR A TRANSPORTATION SYSTEM

Nowadays due to the globalization of the transportation of goods, the issue of the transportation of dangerous goods is no longer regarded exclusively as a matter of sending goods from one place to another but extends to the relationships and consequences of the existence and the functioning of the right transport system in the wider social and natural environment of all regions, ranging from production to the delivery of various dangerous goods (Verma & Verter, 2010). The transportation of dangerous goods, as with all goods, in order to avoid unpleasant consequences, must be done not only within the framework of modern technological possibilities at a reasonable cost, but at the same time must promise to safeguard to a satisfactory degree organic and inorganic nature, free from dangers and pollution (Orso, Bratta, Gandini, & Studer, 2012).

In general, the transportation system should distinguish (Weigkricht & Fedra, 1995):
- the means of transporting the goods;
- the networks, roads or corridors where the means of transport are moving;
- the terminal facilities (parking, refueling, loading and unloading); and
- maintenance facilities serving the means of transport.

In recent years, exciting developments have taken place in vehicle routing and scheduling systems, but are mostly used to facilitate the logistics activities aiming for minimizing costs and routing times without considering the safety of transport. Of course, when a vehicle transports dangerous goods, safety must be a priority, as such an accident will cause incalculable disasters (Dzemydienė & Dzindzalieta, 2011). At the same time, many of these dangerous goods have a limited lifetime, and therefore they need to be delivered on-time (JIT), otherwise the impact (economic, environmental, social, etc.) will be significant (Planas, Pastor, Presutto, & Tixier, 2008).

All of the above clearly show that a system that will allow the transportation of Dangerous Goods in a way that minimizes the possibility of accidents and that will ensure that the goods arrive on-time, is needed. In particular, the actors involved (such as dangerous goods producers, logistics companies, truck drivers, etc.), no matter their efforts, do not have a systematic and comprehensive policy to ensure on-time and safe delivery of goods (Laarabi, Roncoli, Sacile, Boulmakoul, & Garbolino, 2013). Consequently, the measures implemented are limited. For example, a major motorway or tunnel operator may aim to protect other infrastructure users and the infrastructure itself, by sending the dangerous goods vehicles on mountainous ring roads, which may, in turn, cross residential areas and thus setting residents, unjustifiably, at high risk (Roncoli, Bersani, & Sacile, 2013).

## 4. THE PROPOSED SYSTEM

The proposed system shall take into consideration various dangerous goods transportation characteristics. An advanced vehicle routing system will be developed that minimizes the dangers faced when transporting dangerous goods while also assuring the on-time delivery of these goods. In addition to routing, the system can also support dynamic tracking and rerouting (in case of need), using real-time data as well as historical data.

More specifically (Figure 1):

(1) The telecommunication system can provide real-time traffic, road and environmental data as well as road blocks and unexpected road events.
(2) Logistics companies can provide real-time data concerning their activities (including driver, vehicle register, load according to hospital demand, plant capacity, etc) through a specialized online environment.
(3) The Decision Support System can utilize the above data providing accurate and real-time routing services to Logistics companies in a dedicated cloud environment.
(4) The system can display the best solutions, inform the stakeholders and the drivers of the vehicles will be aided to follow the aforementioned optimal solutions, and their routes will be continuously monitored through advanced tracking methods.

Eventually, the required quantities will be delivered to the hospitals safely and on-time (JIT) in case of short life-cycle products, like radioactive materials or medicines.
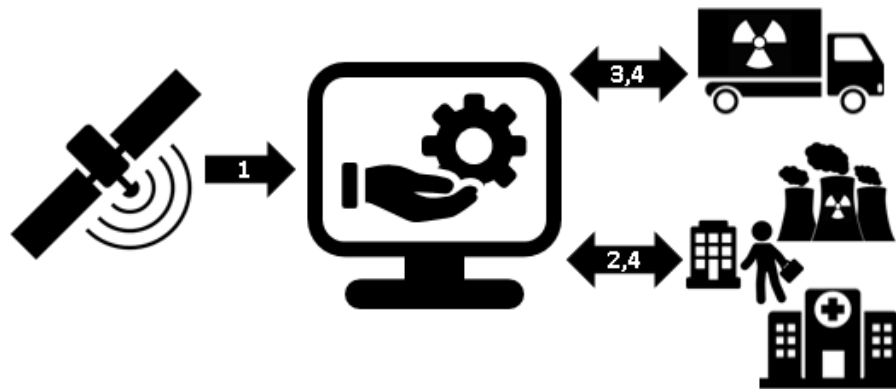


Figure 1: DGTrans System

In order for the system to work effectively, the following actions will also be carried out:

- Analysis of accidents and needs of freight forwarders, carriers, drivers, dangerous goods, customers, transport network, stakeholders, etc., utilizing the best practices, followed up today in order to define the basis of the Advanced Routing and Scheduling System for Dangerous Goods Transportation.
- Development of an effective and robust framework that will categorise and associate dangerous goods, trucks and road network elements to effectively enable the routing and or re-routing of vehicles transporting dangerous goods through the road network (i.e. roads, tunnels, large bridges, etc.).
- Development of a cloud platform capable of collecting and processing real-time vehicle, supply, demand and environment data as an input for the Advanced Vehicle Routing and Scheduling System for the Dangerous Goods Transportation.
- Development of the routing system to ensure the safe and on-time delivery of dangerous goods capable of routing and rerouting dangerous goods vehicles, considering the risk, cost and time (based on cloud platform-based dynamic data).
- The system will maintain a database for vehicle routing problems by analyzing cases and methods and will analyze and categorize each problem encountered as well as an adaptive selection of the best methods.
- Development of a system for automatic retrieval, storage and management using various techniques and onboard data, to track basic parameters of dangerous goods vehicles (e.g. actual versus planned route, speed, weight per axle, etc.)
- Development of user friendly and user centered interfaces for all parties interacting with the system, providing them with all necessary information without increasing their workload and avoiding needless behavioral adaptation.
- Integration of all operations into original transport vehicles and pilot testing to assess the reliability, usability and efficiency of the system as well as the benefits to stakeholders and society in general.

## 5. CONCLUSIONS

To sum up, the main objective of the Advanced Routing and Scheduling System for Dangerous Goods Transportation is to reduce the risk created by the transport of these goods. Consequently, the main elements of this system are the assessment of transportation dangers, providing routing with this crucial factor and, of course, on-time delivery especially in cases that the products have short life-cycle. The establishment of an integrated system for the transportation of dangerous goods requires the implementation and exploitation of advanced technologies and regulations in order to meet

the additional requirements created by the parallel operation of the various sections of these transports. A further aim of the system is to achieve the harmonious operation of the subsystems as mentioned above and the ability to penetrate new users in the future.

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# User Satisfaction and Acceptance of the e-justice system in Greece

Fotis Kitsios
*School of Information Sciences, Department of Applied Informatics, University of Macedonia 156 Egnatias st, 54636 Thessaloniki, Greece*

Anastasia Tsotoulidou
*School of Information Sciences, Department of Applied Informatics, University of Macedonia 156 Egnatias st, 54636 Thessaloniki, Greece*

Maria Kamariotou
*School of Information Sciences, Department of Applied Informatics, University of Macedonia 156 Egnatias st, 54636 Thessaloniki, Greece*

**Abstract**

During the last decades information and communication technologies (ICTs) in e-government have been increased. The implementation of ICTs in the public sector and especially in courts offers new possibilities for citizens, users and more effective services. E-justice systems enhance interaction and communication among different actors and support court administrative staff and judges in streamlining their daily work activities. E-justice systems have encouraged the development of new working practices and organizational procedures improving the court's performance. Despite the fact that this field has attracted the interest of several court management scholars and practitioners, and the money that have been spent to improve court staff's performance and court output, studies that examine the acceptance and user satisfaction of e-justice systems are limited. Thus, the purpose of this paper is to investigate the factors that affect user acceptance and satisfaction of e-justice systems. This paper presents a conceptual framework which is based on the existing literature regarding the success factors and measurements of e-justice acceptance. Also, it analyzes the factors that affect the satisfaction of internal users. The findings of this paper denote the attention paid by court staff to improve the quality and output of e-justice systems. Furthermore, this paper is useful to justice authorities and practitioners in order to design more effective these systems and consider closely these variables in court systems design and usage.

**KEYWORDS**

E-justice system; E-court success; Information Systems; User satisfaction; User acceptance.


## 1. INTRODUCTION

With the rapid growth in Information Technology (IT) and Information Systems (IS) many applications have emerged. These technological developments have affected many sectors as well as e-government. IT and IS applications provide easy and efficient access to all public services for citizens, firms, and public organizations from a single point. The implementation of IS applications in public sector is part of a wider transformation process which aims to improve government in order to offer better, more efficient and effective services to citizens, organizations and businesses (Agrifoglio et al., 2016; Angelopoulos et al., 2010; Kitsios et al., 2009; Oktal et al., 2016; Sachan et al., 2018; Stefanovic et al., 2016; Wang and Liao, 2008). As in other parts of public sector, e-justice systems that are part of e-government have been developed to ensure a fast, reliable, efficient, and accurate judicial system. The main goal of these systems is to improve the efficiency and effectiveness of services as well as the interaction among different actors (Agrifoglio et al., 2016; Oktal et al., 2016; Sachan et al., 2018; Stefanovic et al., 2016; Wang and Liao, 2008).

Within the e-justice, IT solutions have been developed to support layers and staff to conduct their daily work activities. These court-management applications improve the job performance of administrative staff because they have encouraged the development of new working practices. In e-justice systems the information is recorded in the central electronic environment in order to be available to all users. Authorized users are layers, judges, solicitors, and all judicial staff. E-justice systems provide quick and easy access to this information. Furthermore, e-justice systems allow users to perform all types of information and document transfers in an electronic environment. The main goal of an e-justice system is to establish a faster, more reliable information, document, and workflow of judicial services in compliance with IT developments (Agrifoglio et al., 2016; Oktal et al., 2016).

User groups use e-justice systems during business processes. Therefore, factors that affect an internal user's evaluation of IS success and satisfaction are examined in this study. Previous researchers have used existing theories and models related to IT/IS adoption in order to help businesses implement successful IS. Examples of these theories and research models are the Technology Acceptance Model (TAM) which was suggested by Davis, (1989), the Theory of Planned Behavior (TPB) which was studied by Ajzen, (1991), and the unified theory of acceptance and use of technology which was used by Venkatesh et al., (2003). Factors that influence IS and user behavior are crucial because they affect the successful implementation of IS. Thus, evaluation models have been implemented to understand user needs and to examine the factors that influence user acceptance and satisfaction during the development of IS (Kamariotou and Kitsios, 2019; 2017; 2016).

Existing studies in the e-government field have examined the satisfaction of the public as the end users. There are limited studies that have been conducted on internal user acceptance and satisfaction. Furthermore, current models regarding to

IS evaluation focus on system-centered evaluation or organizational structure. Researchers have not explored user-centered evaluation concerning e-justice systems yet. It is important to achieve a performance level that primarily satisfies the majority of internal users in order to develop a successful e-justice system (Agrifoglio et al., 2016; Oktal et al., 2016; Stefanovic et al., 2016). Therefore, the purpose of this paper is to investigate the factors that affect user acceptance and satisfaction of e-justice systems. This paper presents a conceptual framework which is based on the existing literature regarding the success factors and measurements of e-justice acceptance. Also, it analyzes the factors that affect the satisfaction of internal users.

The structure of this paper is as following: after a brief introduction to the field of e-justice systems and success, next section includes the description and the implementation of the literature review methodology which was followed in order to highlight the issues which are discussed in this paper. Next section, suggests a conceptual framework, whereas the final section concludes the paper.

## 2. THEORETICAL BACKGROUND

The literature review methodology was adopted by Webster and Watson (2002). In the first step of the methodology a research of previous literature review studies was done. According to the subject of IS success/adoption and user satisfaction, four literature reviews were used, which describe the keywords that were used in searching articles as well as databases they searched into.

Scopus was the database for the research. The keywords were the following: "e-justice" and "satisfaction", "E-government" and "satisfaction", "information systems" and "justice" and "satisfaction", "information systems" and "justice" and "satisfaction", "Judicial Information Systems". Articles were only in English. Papers were published journals and conference proceedings in the field of business management. From the initial pool of 600 articles, only 59 fulfilled the above criteria. The final sample of 59 articles was classified to the following categories according to their main subject; employee's satisfaction and acceptance of the e-justice systems or e-government systems.

Existing literature indicates that benefits of e-government systems are not reaching users due to which many e-government applications are termed as a failure or partially successful. Factors that affect the adoption behavior of e-government systems should be studied more carefully as it remains a popular topic of information system research (Angelopoulos et al., 2009; Kitsios and Skiadas, 2001; Kitsios et al., 2008; Sachan et al., 2018). TAM is a useful model that can be used to measure user acceptance of new technology. Two variables can predict user's behavior in this model; perceived usefulness and ease of use. The first one indicates to what extent a user believes that the system which uses can increase her/his job performance. The second one indicates to what extent a user believes that the system which uses will be free from effort (Davis, 1989). System and service quality affect perceived usefulness and ease of use. They are critical factor in e-government adoption. If systems have user-friendly interfaces users might have to give more effort adopting them. When users find using e-government systems convenient, time efficient and cost saving, they are satisfied with the general effectiveness and efficiency of the system (Sachan et al., 2018).

Wang and Liao (2008) based on the DeLone and McLean (2003) IS success model, examined the impact of information quality, service quality, system quality and use on user's satisfaction for e-government applications. Their findings show that e-government authorities should develop IS for the public sector that will provide precise and useful information and a user-friendly system in order to be accepted by users. Furthermore, their survey indicated that information quality has greater effect on user's satisfaction and perceived net benefit than service and system quality. Thus, authorities should focus on providing up-to-date and sufficient information. Other researchers examined the impact of information quality, service quality, system quality and use on employees' satisfaction that used e-government systems in municipalities. The results of their survey indicated that service quality and technical quality increase employees' satisfaction. Therefore, employees are willing to use systems that have a high level of usability, user-friendliness, and ease of use. User satisfaction is a driving force in obtaining benefits such as higher productivity, job performance and efficiency of municipal government employees (Sachan et al., 2018; Stefanovic et al., 2016).

Specifically in the justice sector, researchers have measures user's satisfaction adapting three dimensions: information quality, service quality and system quality. The first dimension measures the content of IS including determinants such as accuracy, precision, currency, output timeliness, reliability, completeness, conciseness, convenience and sufficiency. Service quality supports administrative staff to perform daily work activities. Thus, determinants such as the output of information, the user-friendly interface, availability of the system and the skills of technical staff to support users are crucial. The third dimension refers to the quality of IS output. Service quality includes determinants such as information completeness, accuracy, format, currency, relevance, timeliness, precision, reliability, accessibility, and conciseness in order to measure the effect of this dimension to user's satisfaction. Internal users of justice systems indicated that system and service quality have directly but not highly and positively effect on user satisfaction. Their expectations concentrate on information quality, perceived ease of use and system's interface because they aim to perform their work better. Users need timely information through real-time access to data; accurate information, fewer incorrect data entries and more consistent data entry across users and over time. If the process steps related to juridical services are complex, the speed of the system is low and technical staff cannot provide the required support, then users are not willing to use the e-justice

system. Court administrative staff indicated that the more that a system is used and employees are satisfied with it, the higher the impact it will have on job performance. Thus, findings from surveys in courts show that information quality has a greater influence on user satisfaction than system quality and use (Agrifoglio et al., 2016; Oktal et al., 2016).

## 3. METHODOLOGY

The overall research framework of this survey is presented in Figure 1. In the first phase a structured literature review was conducted in order to identify factors/criteria that affect user's satisfaction. These criteria are based on studies that examine employee's satisfaction and acceptance of the e-justice systems or e-government systems and they are presented in the previous section. system in Greek courts.

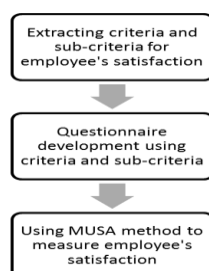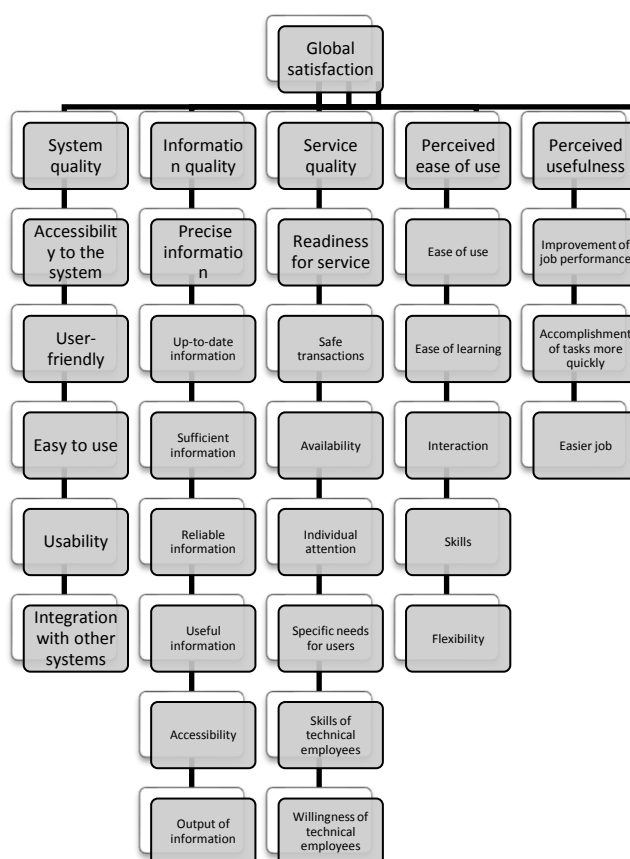Figure 15 Overall research framework



Figure 2 Criteria and sub-criteria



Criteria are related to system quality, information quality, service quality, perceived usefulness and perceived ease of use. System quality measures the satisfaction that a user gains when use the e-justice system. Information quality refers to dimensions that are used to measure the quality of information that are provided by the e-justice system (e.g. accessibility, reliability, usefulness, output). Service quality indicates the satisfaction from the service which is provided by the e-justice system. This criterion measures the availability of the system, the readiness and specific needs of users, skills and experience of technical staff to support users and the safety of transactions that are conducted through the system. Perceived ease of use refers to the ease of use, ease of learning, flexibility of the e-justice system, users' skills and user interaction with the system. Finally, perceived usefulness includes dimensions such as the improvement of job

performance and the improvement of quality of user's job using the e-justice system (Agrifoglio et al., 2016; Delone and McLean, 2003; Kitsios et al., 2019; Oktal et al., 2016; Rai et al., 2002; Sachan et al., 2018; Stefanovic et al., 2016; 2011; Wang and Liao, 2008). Each of the 5 criteria above is divided into sub-criteria, which appear in Figure 2. In the second phase a questionnaire was drawn up in order to measure employee's satisfaction and acceptance of e-justice The questionnaire was distributed to lawyers and employees who use e-justice system in courts in Thessaloniki. Criteria and sub-criteria that appeared in Figure 2 were used to measure employee's satisfaction. In the third phase the Multicriteria Satisfaction Analysis (MUSA) is used in order to measure employee's satisfaction in this study as proposed by Grigoroudis and Siskos (2002).

# 4. CONCLUSIONS

The purpose of this paper was to investigate the factors that affect user acceptance and satisfaction of e-justice systems. This paper presented a conceptual framework which is based on the existing literature regarding the success factors and measurements of e-justice acceptance. Also, it analyzed the factors that affect the satisfaction of internal users. This paper presented an evaluation model for e-justice system in Greece. The proposed model includes constructs from both internal user satisfaction and technology acceptance. Furthermore, this study presented an evaluation model of an e-justice system from an internal user perspective. This study used variables that were used by previous researchers to measure user satisfaction and acceptance of IS. Aspects of IS success based on different models could be analyzed and used. Moreover, behavioral models of IS use could be used in order to explain IS use in different settings (such as operational, tactical and strategic level) where IS use can be assessed by time spent to the system. The findings of this paper denote the attention paid by court staff to improve the quality and output of e-justice systems encouraging authorities and court application vendors to take into consideration these factors in court systems design and usage. Furthermore, this paper is useful to justice authorities and practitioners in order to design more effective these systems and consider closely these variables in court systems design and usage. Due to the growing use of IT to deliver public services, a greater understanding of these constructs is important in order to increase users' acceptance. Also, it may be crucial for agencies that provide e-justice services.

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# Half-integral optimal solutions in real-life applications

Konstantinos Papalamprou

*School of Electrical and Computer Engineering*

*Aristotle University of Thessaloniki*

*54124 Thessaloniki, Greece*

Leonidas S. Pitsoulis

*School of Electrical and Computer Engineering*

*Aristotle University of Thessaloniki*

*54124 Thessaloniki, Greece*

Eleni-Maria E. Vretta

*School of Electrical and Computer Engineering*

*Aristotle University of Thessaloniki*

*54124 Thessaloniki, Greece*

**Abstract**

Certain classes of matrices have been proven to be of significant importance in combinatorial optimization. One such well-studied class is that of totally unimodular matrices, i.e. matrices whose each square submatrix has determinant in {0, 1, -1}. It is well-known that total unimodularity is strongly associated with a class of optimization problems which can be solved in polynomial time. In particular, integer programming problems with totally unimodular constraint matrices and integral right-hand side vectors can be solved efficiently by relaxing the integrality constraints and then applying well-known algorithms devised for linear programming problems (e.g. Simplex). Another special class of matrices is that of k-regular matrices (k∈N*) which furnish a natural generalization of totally unimodular matrices. Generally speaking, as total unimodularity guarantees integrality of the optimal solution, k-regularity guarantees 1/k-integrality. In this work, we focus on the case of k=2 and present formulations of real-life problems with constraint matrices being 2-regular. Moreover, it is known that 2-regularity yields integral optimal solutions for optimization problems with right-hand sides having as elements multiples of 2. Based on that, we shall present formulations of instances of real-life optimization problems yielding integer solutions when the parameters of these problems satisfy certain conditions. Finally, we comment on the generalization of the aforementioned observations and findings when the constraint matrix of such problems is k-regular with k>2.

**KEYWORDS**

half-integrality, k-regular matrices, total unimodularity

## 1. INTRODUCTION

The class of totally unimodular matrices plays a central role in combinatorial optimization since it defines a class of optimization problems that can be solved in polynomial time. More precisely, it has been proved that integer programs with totally unimodular constraint matrices have integral optimal solutions. This result was derived from the famous theorem of Hoffman and Kruskal [5] which states that for an integral matrix $A$, the polyhedron $P(A, b) = \{x | Ax \leq b, x \geq 0\}$ is integral for all integral right-hand side vectors $b$, if and only if the matrix $A$ is totally unimodular. Consequently, the problems of this class can be solved efficiently. Two well-known examples of totally unimodular matrices are network matrices and node-edge incidence matrices of directed graphs. The node-edge incidence matrix of a simple undirected graph is a matrix with elements in $\{0, +1, -1\}$ with exactly two 1's in each column while a directed graph is represented by a matrix with elements in $\{0, +1, -1\}$ in which each column has one $+1$ and one $-1$. Network matrices derive from directed graphs as follows. If $A = [R|S]$ is a full row rank incidence matrix of a directed graph, where $R$ is a basis of the matrix $A$ then the matrix $N = R^{-1}S$ is called a network matrix.

Totally unimodular matrices have two important properties which derive from their definition. They are integral and any of its non-singular square submatrices has an integral inverse. Generalizing total unimodularity by requiring the inverses of subdeterminants to be scalable to integral, Appa et.al. defined k-regularity in [1,2]. Specifically, for any positive scalar $k$, a rational matrix is called k-regular if for each of its non-singular square submatrices $R$ of $A$ the matrix $kR^{-1}$ is integral. Thereby k-regularity is a natural generalization of total unimodularity. There is a polyhedral characterization for k-regular matrices presented in [2,6] which states that a rational matrix $A$ is k-regular if and only if the polyhedron $\{x | Ax \leq b, x \geq 0\}$ is integral for each integral vector $b$. The latter result generalizes the abovementioned result of Hoffman and Kruskal, as it extends the connection between totally unimodular matrices and integral poyhedra to rational matrices and the associated polyhedra.

In this work we focus on k-regularity with $k = 2$. It is known that 2-regularity yields integral optimal solutions for optimization problems with right-hand sides having as elements multiples of 2. Therefore, if we ignore the integrality constraints of a formulation with a 2-regular constraint matrix and a right-hand side having as elements integer multiples of 2, then the associated problem can be solved by efficient methods developed for linear programming problems. To highlight the applicability of the aforementioned theoretical framework, we study two real-life optimization problems. Finally, we comment on the generalization of the aforementioned observations and findings when the constraint matrix of such problems is k-regular with $k > 2$.

## 2. K-REGULARITY

Vectors and matrices whose elements are integers are called integral vectors and integral matrices, respectively; similarly, vectors and matrices whose elements are rational numbers are called rational. Moreover, vectors and matrices having elements that are integer multiples of ½ are called half-integral. If $A$ is a matrix, then $kA$ denotes the matrix obtained by multiplying all elements by $k$. Therefore, $A$ is a half-integral matrix if and only if $2A$ is integral. A matrix is of full-row rank, if its rank equals the number of its rows. A matrix is called totally unimodular, if each of its square submatrices has determinant in $\{0, +1, -1\}$.

The notion of k-regularity generalizes total unimodularity because it permits rational values in the inverses of submatrices. In [2] it was proved that k-regular matrices are the rational matrices for which the polyhedron $\{x|Ax \leq b, x \geq 0\}$ with a right-hand side vector that is an integer multiple of k has integral vertices. Hence as total unimodularity guarantees integrality of the optimal solution, k-regularity guarantees 1/k-integrality. In this work, we focus on the 2-regular case (i.e. when $k = 2$). As defined in [2], a rational matrix is 2-regular if the inverse of each of its non-singular square submatrices is half-integral. Therefore, it is evident that if the constraint matrix of a linear program is 2-regular and the right-hand side vector is integral, then there is always a half-integral optimal solution for any objective vector for which the optimum is finite.

Two examples of 2-regular matrices are formed by the classes of totally unimodular matrices and binet matrices. Binet matrices were introduced in [1] and constitute a natural generalization of network matrices as they arise from the node-edge incidence matrices of bidirected graphs in the same way as the network matrices do from directed graphs (see [2,3] for a detailed exposition).

## 3. APPLICATIONS OF 2-REGULARITY

In this section we present two simple optimization problems whose constraint matrix is 2-regular. It is evident that these problems can be generalized in various ways and, as a consequence, large-scale optimization problems are found to be associated with k-regular constraint matrices (see e.g. [6,7,8], for such applications).

**Application 1**: Suppose that we must design the production of six products: 1, 2, 3, 4, 5 and 6 whose production demands five different raw materials: A, B, C, D, E and F. The raw materials which are needed for the production of each of the six products as well as the corresponding quantities in kg (kilograms) are given in the following matrix.

|   | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **A** | 1 | 0 | 1 | 0 | 0 | 0 |
| **B** | 1 | 1 | 1 | 1 | 0 | 0 |
| **C** | 1 | 0 | 1 | 1 | 1 | 0 |
| **D** | 1 | 0 | 0 | 1 | 1 | 1 |
| **E** | 1 | 0 | 0 | 0 | 1 | 0 |

Table 1 The quantities in kg of the raw materials needed for the production of each product.

The profit from the sale of each of the six products per kg is $c_1$ for the product 1, $c_2$ for 2, $c_3$ for 3, $c_4$ for 4, $c_5$ for 5 and $c_6$ for 6. The total monthly production in kg of all six products should not exceed $d_G$. Moreover, the (monthly) availability in kg of the raw material A, B, C, D and E is $d_A, d_B, d_C, d_D$ and $d_E$, respectively. We would like to determine the distribution of the five raw materials for the production of the six products so that the total profit of the sales of the six products is maximized subject to the demand constraints and the constraints regarding the availability of the five raw materials.

We denote by $x_i$ (i =1,2,3,4,5,6) the monthly production in kg of each of the six products and we assume that $x_i \geq 0$. Our objective is to find the values of $x_1, x_2, x_3, x_4, x_5$ and $x_6$ which will maximize the following function:

$$z = c_1 x_1 + c_2 x_2 + c_3 x_3 + c_4 x_4 + c_5 x_5 + c_6 x_6$$

There is a demand constraint of the market concerning the production of the six products which must be satisfied:

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 \leq d_G$$

Furthermore, the following constraints concerning the availability of the five raw materials must be also satisfied:

$$x_1 + x_3 \leq d_A$$
$$x_1 + x_2 + x_3 + x_4 \leq d_B$$
$$x_1 + x_3 + x_4 + x_5 \leq d_C$$

$$x_1 + x_4 + x_5 + x_6 \leq d_D$$
$$x_1 + x_5 \leq d_E$$

The constraint matrix given by the above constraints is the following:

$$\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 & 1 & 0 \\ 1 & 0 & 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}$$

The above matrix is 2-regular as proved in [6] and a minimally non-totally unimodular matrix which was presented in [4]. Therefore, if the right-hand side vector of the linear problem consists of elements being multiples of 2, then the optimal solution of the aforementioned problem is integral.

**Application 2**: A big firm intends to invest an amount of money equal to $d_1$ to shares of oil industries and steel industries. A stockbroker hired by the company suggested two oil industries and two steel industries which are presented in Table 2 below along with their expected annual returns.

| Investment | Expected annual retu (%) |
|---|---|
| IRON oil | $c_1$ |
| TITAN oil | $c_2$ |
| ZEUS steel | $c_3$ |
| ARIS steel | $c_4$ |

Table 2 The suggested investments and their expected annual return (%)

The senior management of the company decided to invest the amount of money according to the following rules:
1. Two times the total amount invested to oil companies must be equal to $d_2$.
2. The sum of the amount of money invested at ARIS steel and two times the amount of money invested at ZEUS steel and must be less than or equal to $d_3$.
3. The amount of money invested at steel companies must be at least $d_4$.
4. Two times the money invested at IRON oil must be at least $d_5$, where $d_5 \geq 0$.

The firm is interested in finding the amount of money which should be invested in each of the four available options so that the total annual profit of the investment is maximized. Therefore, let $x_1$ be the amount of money invested at IRON oil, $x_2$ be the amount invested at TITAN oil, $x_3$ at ZEUS steel and $x_4$ at ARIS steel. The invested amounts cannot be negative, therefore $x_i \geq 0$ (i =1,2,3,4). Let $z$ denote the total expected annual profit. Our objective is to find the values of $x_1$, $x_2$, $x_3$ and $x_4$ which will maximize the following function:

$$z = c_1 x_1 + c_2 x_2 + c_3 x_3 + c_4 x_4$$

The constraints which derive from the decisions of the senior management are:

$$2x_1 + 2x_2 = d_2$$
$$2x_3 + x_4 \leq d_3$$
$$x_3 + x_4 \geq d_4$$
$$2x_1 \geq d_5$$

Finally, the total amount which will be invested must be equal to $d_1$:

$$x_1 + x_2 + x_3 + x_4 = d_1$$

The constraint matrix given by the above constraints is the following:

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 2 & 2 & 0 & 0 \\ 0 & 0 & 2 & 1 \\ 0 & 0 & 1 & 1 \\ 2 & 0 & 0 & 0 \end{bmatrix}$$

The above matrix is 2-regular since for every non-singular square submatrix $R$, the matrix $2R^{-1}$ is integral. Thus, the above optimization problem has a 2-regular constraint matrix and therefore, if the the right-hand side vector is integral, then the problem has a half-integral optimal solution (if there exists an optimal solution).

## 4. CONCLUSIONS

The notion of k-regularity furnishes a generalization of total unimodularity having similar consequences on the integrality of polyhedra as total unimodularity has. The class of 2-regular matrices has attracted significant scientific interest since the well-studied classes of totally unimodular matrices and binet matrices belong to that class. In this work, we tried to exploit the impact that the aforementioned theoretical results may have in real-life applications. Finally, given that a constraint matrix has a k-regular structure with k>2, then it might be the case that the parameters of the associated problem can be selected appropriately ensuring integral optimal solutions; such a case is presented in [8], where the planning period, regarding a scheduling and production planning problem, was determined by taking into account the k-regularity of the associated constraint matrix.

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# A value case approach for improving the quality of rail freight services: control tower concept

Miloš Milenković[1,2]

[1]Zaragoza Logistics Center, Zaragoza, Spain
[2]Division for Management in Railway, Rolling stock and Traction, The Faculty of Transport and Traffic Engineering, University of Belgrade, Vojvode Stepe 305, 11000 Belgrade, Serbia

Nebojša Bojović[1]

[1]Division for Management in Railway, Rolling stock and Traction, The Faculty of Transport and Traffic Engineering, University of Belgrade, Vojvode Stepe 305, 11000 Belgrade, Serbia

Susana Val[1]

Zaragoza Logistics Center, Zaragoza, Spain
Avenida Ranillas, 5 - Edificio A bajo
50018 Zaragoza, SPAIN

**Abstract**

Despite a number of initiatives targeted at modal shift from road to rail the share of rail freight in intra-EU transport has been constantly decreasing over recent decades. Solution for modifying shipper's mode choice could be more efficient targeting the factors affecting the competitiveness of rail freight. Among these factors the most important are: reliability, visibility, lead time, cost and flexibility. Improvement of these factors could be achieved by a higher level of coordination between all railway and non-railway related stakeholders in transport chain. Rail enabled control tower concept may substantially improve communication and information sharing between these stakeholders. It represents an innovation that requires the support of multiple stakeholders in order to be implemented successfully. In this paper, Value Case Methodology is used for assessment the feasibility of control tower implementation in order to make a collectively accepted solution and value alignment of all involved actors. Stakeholder's preferences are quantified by applying the Analytic Hierarchy Process. It is concluded that the stakeholders as well as the experts consider the whole concept as a necessity and therefore, it was not so hard to make the agreement about this collective action.

## 1. INTRODUCTION

European rail freight market is a complex system that involves multiple stakeholders with different perceptions, objectives and resources. A part of these stakeholders is jointly involved (directly or indirectly) in the operation of running a train. Another part of the chain is however, the logistics part (shippers or their logistics service providers) whose needs and service requirements are different. Meeting these service aspects would reinforce the rail sector leading to additional rail demand flows.

One of the innovative ways to improve rail freight service and to meet requested service criteria from a shipper's perspective is to design a rail enabled Control Tower (CT) or in other words, an information sharing platform that will support planners in supply chain optimization and fulfill the shipper's requirements for real-time visibility in whole transport chain (Smart-Rail, 2016). Some larger logistic service providers have CT. However, they have the difficulties to monitor the shipments during their travelling on a railway legs due to non-availability of data and they tend to minimize railway legs.

In order to develop an extension of the CT, by means of a specific rail freight service add-on it is needed to improve the data availability for rail transport. For fulfilling this objective multiple stakeholder collaboration is required. With a full collaboration among the stakeholders, smart interfaces between multiple stakeholders' data sources may be created to increase quality of today's rail freight service and supply chain in general, making it more efficient, effective and sustainable.

Each of involved stakeholders has its own role, interest and value added in the whole stakeholder network.

However, interests of stakeholders are not fully aligned because their "environments" are not identical. Further, for such a complex innovation like the rail-enabled CT concept is, it is important that all decision makers adopt the innovation. This adoption is known as collective action and it can be obtained when the value of innovation created for each stakeholder, or potential losses of values from innovation are balanced.

In this paper, Value Case Methodology (VCM) as a multi value multi stakeholder approach is applied in order to make a collectively accepted solution and value alignment of all involved actors in rail enabled CT innovation (Dittrich et al., 2015). Unlike the business analysis focused only on financial effects of an investment, the VCM takes into account both financial as well as non-financial values. Within the VCM, there is a need to quantify all these values expected by the stakeholders.

For that purpose, Analytic Hierarchy Process (AHP) (Satty and Vargas, 2012) is chosen. With the AHP, stakeholders together with experts involved in rail-enabled CT design assign weights to effects. With this input, AHP provides an overview of how different effects combine to a positive or negative outcome for the stakeholders. The quantitative analysis of the obtained data showed that the rail-enabled CT concept will be beneficial for all stakeholders. It will create a solid basis for mutual cooperation and it will contain a potential for further growth.

The remainder of this paper is organized as follows. After the introduction, in Section 2 VCM is applied for multi stakeholder value network analysis of rail enabled CT innovation. All related actors, their motives and barriers are stressed. Quantification of all effects identified by the stakeholders and point sensitivity analysis are performed. In the value alignment phase, overall compromised outcome about stakeholder's value distribution was obtained. Section 4 contains concluding remarks as well as future research directions.

## 2. RAIL ENABLED CT DESIGN: VALUE CASE METHODOLOGY FOR MULTI STAKEHOLDER NETWORK ANALYSIS

In order to analyze the effects of an innovation, it is needed to take into account financial as well as nonfinancial values in complex multi stakeholder environments. As a consequence of considering only financial effects, many innovations have not been realized or did not fulfill their desired impact and objectives. That was the motive for developing a Value Case Methodology which takes into account all financial and nonfinancial values in decision making process of large innovation projects (Dittrich and Van Dijk, 2013). In order to apply VCM for rail enabled CT innovation there is a need to iteratively pass through the set of following steps:

- Value identification: In this step all network participants that influence the value the rail enabled CT concept delivers to its end customers are identified. In other words, all actors that exist in transport chain and that have a direct influence on, or they are affected by its value propositions toward customers.
- Value quantification: In this step quantification of qualitative effects is performed. Among a number of quantification methods Analytic Hierarchy Process (AHP) is selected in this case. This step also provides the input for value sensitivity step.
- Value sensitivity: In this step analysis and visualization of point sensitivity of stakeholders in terms of acceptance the rail enabled CT concept.
- Value alignment: This step consists of a structured process aimed at obtaining an overall acceptable solution for rail enabled CT investment.

## 2.1 Value Identification

Value network analysis (VNA) enables a visual interpretation of all business activities and sets of relationships from a dynamic system perspective. The general objective is to provide a description of where value lies in a network and how the value is created.

VNA is applied in VCM in order to provide a comprehensive analysis of relationships between potential stakeholders involved in rail-enabled CT innovation. Namely, implementation, or better, expanding the existing CT by rail freight module will provide numerous effects to all involved actors in this value network. CT concept has a platform character, it is complex in nature, and it will involve multiple stakeholders with different roles, backgrounds and values. A clear picture about the value network in rail enabled CT concept, all stakeholders involved and their interrelationships, was made based on a number of consultations with experts and stakeholders. It is concluded that extended rail-enabled CT platform has to include following actors: Shippers/manufacturers; Logistic Service Providers; Terminal operators; Wagon keepers; Shunting operators; Railway operators; Infrastructure managers.

Besides these directly involved stakeholders, there is a number of private and public actors which facilitate the transport service provision and related investments (for example ministries and regulatory agencies). CT concept provides substantial benefits for final customers through lower transport costs, higher performances of transportation services and greener supply chain, however they are not included into the analysis because they do not have the influence to initiate this innovation. Roles, interests and values delivered of some of the involved stakeholders are presented in following table (full table omitted due to the space limitations).

As the output from the value network analysis, the value network map that represents relationships among value chain actors has been designed. Together with these relationships, VNA enables displaying resources that actors exchange or pool as part of their operations (information, mobile capacities, infrastructure and financial assets). Information on exchange resources among actors is qualitative – the map illustrates that two actors exchange money and information but not the exact quantity of those two. However, these key resources are of strategic type and they are considered as underlying valuable resources achieved from the relationship among the stakeholders within the rail enabled CT solution

(Figure 1). Financial exchanges are implicitly included through service provisions between stakeholders. It can be noticed that the presented network represents a very complex value chain, considering that stakeholders in it may feed into a number of different value chains (Kaplinsky and Morris, 2000).Types of influences on Figure 1 are: I = Information flow; TS = Train service; SS= Shunting service; P = Train paths provision; TC = Traffic control service.

**Table 1** Drivers and barriers of stakeholders for participating in rail enabled CT concept

| Stakeholder | Change in business | Drivers | Barriers |
|---|---|---|---|
| **Shipper** | No change in business | Decreased running capital costs Improved carbon footprint. Better predictability of business process. Cost savings due to more transportation performed via rail. | No barriers. |
| **LSP** | Better service provision due to higher visibility | Extended portfolio – upgrade to 4PL. Better dynamical process because more information is available. | Higher cost for collecting the information. |
| **Railway operator** | Business process redesign due to more demanding communication and more visible planning of operations | Processes optimized. Resource utilization improved. | Unwillingness for information sharing. Costly improvements of information sharing infrastructure. Need for shifting in modality – from single modality to multi-modality. |

**Figure 1** Value network analysis map
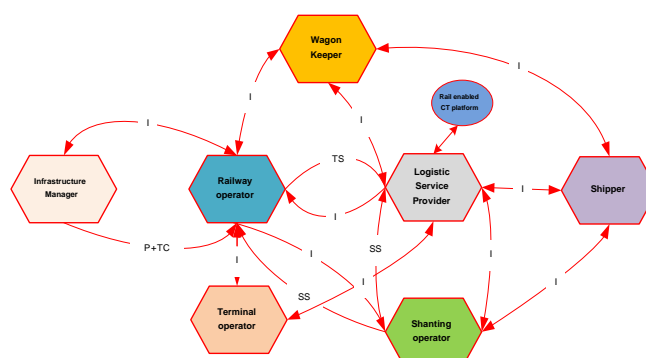


## 2.2 VALUE quantification

Stakeholder's expectations are qualitatively expressed in Table 1 and in order to be analyzed these effects have to be quantified. In the literature, among many other techniques, multi-criteria analysis (MCA) and conjoint analysis (CA) are the most frequently used quantification techniques (School, 2005). For purpose of value quantification analysis in the context of rail-enabled CT innovation MCA is chosen as the more appropriate method. The goal is to evaluate the effects each stakeholder expects from participating in a new CT concept which also incorporates the railway transport mode. Based on these preferences – preferred conjoint features of an innovation (CT concept in this case) it is possible to offer a concept which will satisfy interests of all stakeholders. Based on the previous step of VCM we can summarize the set of all values that stakeholders and experts associate with CT innovation: Profit, capacity utilization, reliability of service, flexibility of service, visibility of service; cost of participation in rail-enabled CT innovation, cost of service provision; mental shift, lead time.

Stakeholders and experts filled seven comparison matrices which comprise preferences of each of the seven stakeholders involved in the transportation planning process of rail-enabled CT solution. However, it is also needed to know the relative impact (considering their role and impact in the transport chain) of every stakeholder in the value network (Figure 2). This is important when the relative contribution of every effect to the rail enabled CT concept is analyzed. Levels of attributes

for some of the stakeholders and their meaning are presented in Table 2. Explicit financial representations of some attributes (cost related attributes and profit) in table are not available, however they are estimated from an economic point of view.

**Figure 2** Relative rank of stakeholders in rail-enabled CT concept according to value they deliver to it



**Table 2** Levels of attributes

| Attribute | Attribute level | | |
|---|---|---|---|
| | **Low** | **Medium** | **High** |
| **Railway operator** | | | |
| Profit | = < production cost | = break even | = > break even |
| Capacity | = < production cost | = covering production cost, break even | = > break even |
| Cost of participation | zero, without charge | 0.1% of expected turnover | 0.5% of expected turnover |
| Mental Shift | no willingness to share data | only upon request according to contracted process | actively contributing |
| **Shipper** | | | |
| Lead time | delay >= 24 hours | delay <= 24 hours | on time |
| Profit | loss | break even | = > break even |
| Visibility | no visibility | visibility only partial or only per demand | full visibility automatically |
| Reliability | no flexibility, changes/modifications not possible (measurement for elasticity) | not fully conforming to required modification | fully conforming to required modification |
| Flexibility | no flexibility, changes/modifications not possible (measurement for elasticity) | not fully conforming to required modification | fully conforming to required modification |

Remaining part of the section considers relative priorities of effects from the aspect of stakeholders. These are quantitative expressions or part worth utilities related to stakeholder's value perceptions given in previous section. In case of rail-enabled CT concept (according to the Table 1 and also the insights from stakeholders' analysis) the main value for shippers are better business results due to decreased service costs, and also more visible service (Figure 3). The shippers also want to be fully reliable with the transport in terms of perfect conditions of security, without errors. Certain level of flexibility in terms of possibility to change schedules, lengths, freight, wagons is also desirable for shippers. The same analysis of relative priorities is conducted for all other stakeholders (results are omitted due to space limitations).

Now, after evaluating the hierarchy it is possible to determine the absolute utilities of all effects or attributes which are expected by the stakeholders. These utilities are calculated by multiplying all relative weights along the path from the top level objective to the level of attribute (Figure 4). As it can be seen, the overall aim of the concept is contribution to better business results. Visibility also represents one of the utilities that most of stakeholders expect. Cost of participation play also a large share at some stakeholders, due to their unwillingness to cooperate in this more intensive information sharing

concept, and also due to high investments in IT infrastructure that will enable the participation of some actors in the concept.

**Figure 3** Expectations and their level for shipper
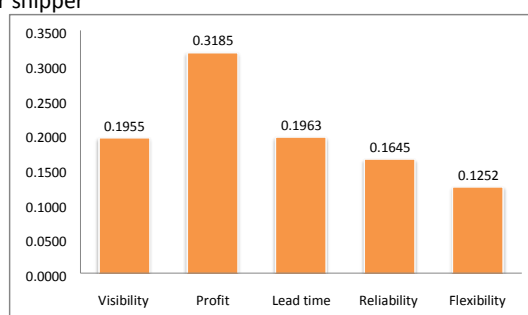


**Figure 4** Absolute utilities of all effects or attributes expected by the stakeholders
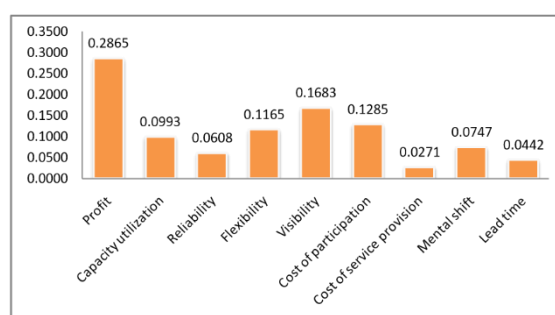


However, considering that the focus is to find preferred conjoint features of rail enabled CT concept (or in other words, the best combination of features) it is needed to focus on partial utilities of all attribute levels in order to be able to evaluate rail enabled CT concept with different pre specified levels of key attributes. Part worth utilities are computed by multiplying the absolute utility of an attribute and a relative utility value of certain level belonging to that attribute. This is done for every decision maker (stakeholder) individually. In case of shipper part worth utilities are presented in Figure 5.

**Figure 5** Part worth utilities per stakeholder



## 2.3 Value sensitivity

The aim of this section is to evaluate point sensitivity of each stakeholder (Dittrich et al., 2015). By generating various versions of rail enabled CT concept (by varying the attribute levels) and by their quantification it is possible to realize the incremental effect of each attribute level upon the rail enabled CT concept choice. In other words, the idea is to present how much should stakeholder's utility perception change when the

proposal changes. Stakeholder's utility in case of rail enabled CT solution can be viewed as the willingness to participate in the solution. It is also useful to define the threshold value known as the attribute value which will still generate some utility

acceptable to the stakeholder. Every level of attribute which is lower by utility than a threshold value will be rejected by the stakeholder.

According to Table 2. it is reasonable to assume that the threshold value for each stakeholder corresponds to medium level of an attribute value. Therefore, it is needed to demonstrate sensitivity of stakeholder to a change as compared to an attribute value of the idea behind rail enabled CT concept. This idea is based on providing a concept which will enable shippers a service with more degrees of freedom by incorporating the fully visible rail transport legs.

Therefore, shipper will expect substantial improvement of some key attributes, higher profit due to lower expenses by including railway legs and due to shorter lead time (high level of attribute "lead time" represents faster delivery service) and full visibility of railway related parts of the transport chain. In case of the last attribute, shipper will be very restrictive, considering his bad experience from the past and present practice. Shippers also insist on higher reliability and flexibility attributes which are not very bright feature of railway transport. Figure 6 shows the results of sensitivity analysis for shipper. With increasing the attribute value the perception of shipper's utility increases. Yellow colored points with associated utility values represent assumed thresholds for accepting the innovation by the stakeholder.

**Figure 6** Results of sensitivity analysis – shipper
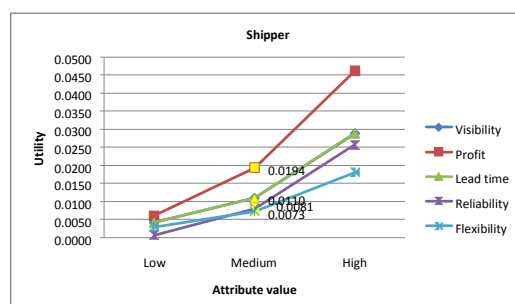


## 2.4 Value alignment

Sensitivity analysis provides insight in the attributes which may serve for value compensation among stakeholders. Compensation must be with minimal costs and maximal effect. In order to expand previous analysis in this section we analyze graphs on the level of attributes. It is the most important to see which values have a collective effect and which values have only individual effect.

For example, only shipper will benefit from lead time, whereas an alignment on the value like "cost of participation" is likely to affect most of the stakeholders in rail enabled CT concept. Therefore, in this case, we select the collective effects for alignment analysis. These effects and stakeholders that benefit from them are:

- Profit – infrastructure manager, railway operator, shipper, shunting operator, wagon keeper;
- Capacity utilization – infrastructure manager, railway operator, terminal operator, wagon keeper;
- Cost of participation – infrastructure manager, logistic service provider, railway operator, shunting operator, terminal operator;
- Mental shift – infrastructure manager, railway operator, shunting operator, wagon keeper;
- Visibility – logistic service provider, shipper, shunting operator.

Graphs from previous section (analysis by stakeholder) as well as the graphs presented here may give an insight which attribute has a large effect on the acceptance of stakeholders. Therefore, it is needed to realize how much compensation – alignment is needed. Alignment represents necessary level of increase or decrease of an attribute value which is offered by the initial design of proposed innovation, rail enabled CT concept in this case, in order to reach collective acceptance by all stakeholders to participate in realizing the innovation. Here, there is a need to make a distinction between stakeholders with utility below and above a threshold value for a given attribute value. The former need compensation and the latter can compensate if that is needed. From graphs before and below, we may see which stakeholders will accept proposed CT concept and which stakeholders need to be compensated. In this case there are no blockers (stakeholders with opposite direction of point elasticity than other) so it will be easy to propose redistribution of values in case of possible misalignments identified. Analyzing the attribute "Profit" we can see that all stakeholders show positive point elasticity and their threshold utility values are assumed to correspond to medium level of attribute value offered by the CT concept (Figure 7). This is reasonable assumption since it is expected that the rail enabled CT innovation will contribute to significant increase of traffic intensity on rail lines. Infrastructure managers will probably gain more than only to cover infrastructure and maintenance cost and other stakeholders will operate on a level higher than break even due to

decreased operational costs or increased revenues from higher volume of work. Therefore, the medium level of attribute "Profit" is a minimum level which will be provided by the concept.

**Figure 7** Point sensitivity curve for attribute "Profit"
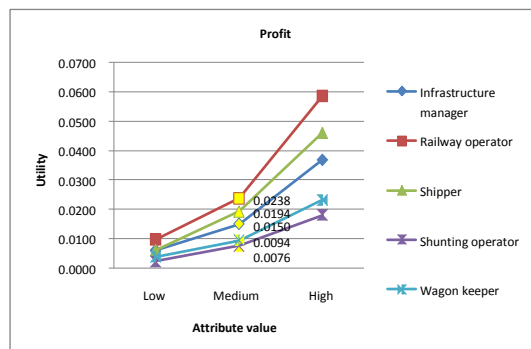


## 3. CONCLUSIONS

At this moment one of the most urgent objectives of the European Union for the transport sector is to substantially decrease emissions of greenhouse gases. Modal shift from road transport to the currently more environmental friendly rail transport is targeted to contribute to the
fulfilling of these objectives. However, shippers choose modes of transport on the basis of business criteria not on the basis of EU policy priorities. These business criteria include reliability, visibility, lead time, cost and flexibility. In order to realize the desired improvements of these service aspects an important prerequisite is improved information sharing and communication between all related actors in transport chain. Rail enabled control tower could provide real-time information on the status of the shipments along the rail freight corridors, synchronization of transport activities and proactive decision making process in case of disturbances. However, in this multi-value multi-stakeholder investment it is needed to make a collectively accepted solution and value alignment of all involved parties. In this paper, Value Case Methodology was applied for analysis of all facilitators and barriers and assessment of potential for reaching a value aligned solution of all related actors. Quantitative analysis made using the Analytic Hierarchy Process showed that the rail enabled CT concept could be beneficial for all stakeholders. Potential misalignments were identified and possible ways of compensation proposed. It is clear that the stakeholders as well as the experts consider the whole concept as a necessity and therefore, it was not so hard to make the agreement about this collective action.

## ACKNOWLEDGEMENT

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# Desires and perceptions of primary school teachers about Leadership

Panagiotis Mitropoulos
TEI of Western Greece
Patras, Greece
pmitro@upatras.gr

Vasiliki Kourkouta
TEI of Western Greece
Patras, Greece
vasilikikourkouta@gmail.com

Konstantinos Christopoulos
TEI of Western Greece
Patras, Greece
k_christ@otenet.gr

**Abstract**

Leadership is a very important factor in the proper function of a school organization, has been studied by many researchers and is considered to be one of the key elements of an effective school. Educational leaders are faced with new and multiple challenges as the larger social, political and economic environments become more complex. Transformational leadership is increasingly seen as the most appropriate and desirable form of leadership for the success of an educational organization. However, the heavily centralized and bureaucratic Greek education system does not allow the leader to develop transformative practices to a great extent. The purpose of this paper was to investigate the degree of three leadership styles (transformational, transactional and avoidant) in primary school managers in the prefecture of Achaia, according to teachers' perceptions, as well as to explore their desired leadership style. The questionnaire used is weighted and consists of two parts: A) The demographic characteristics and B) The Multifactor Leadership Questionnaire (MLQ) with 36 questions about what the teachers perceive and the same 34 questions about what teachers desire.

**KEYWORDS**

Primary Education, Leadership Style, Transformational, Transactional, Passive- Avoidant Leadership

## 1. INTRODUCTION

Leadership concerns the scientific community and is at the center of many modern educational systems. School leadership is at the center of educational reform, as education staff can lead to improved learning outcomes (Harris,2005,p.73). The character of educational institutions is determined by the personal leadership style adopted by the leader-headmaster. Particular importance has been given to transformational politics in recent years as it is seen by many as the best practice in schools (Hallinger, 2003). The Transformational Leader seeks to adopt and implement innovative ideas to promote the organization and to strengthen and encourage the educational team, which contributes positively to schools effectiveness Bass and Avolio (1990). In addition, it is of particular importance to examine how teachers perceive different leadership styles.

Bass and Avolio (1990) argue that the transformational leadership style leads to an increased productivity of the organization. In addition, it is of particular importance to examine how teachers perceive different leadership styles.

## 2. EDUCATIONAL LEADERSHIP

According to Leithwood & Riehl (2003), great importance is attached to the educational leadership and there is a strong interest in how educational leaders can influence these results. There are many types of educational leadership, however, emphasis will be placed on transformational, transactional and passive – avoidant leadership, as they are the leadership styles that are being explored in this paper.

Transformational Leadership holds a vision, personal commitment, collaborative culture, participatory decision-making and problem solving, as well as the creation of good interpersonal relationships (Hopkins, Ainscow & West, 1994). According to Bass (1990) the characteristics of the transformational leader are: Idealized influence, 2) Inspiration, 3) Intellectual stimulation and 4) Individual Consideration.

Transactional Leadership is based on a relationship between the Leader and his followers. The characteristics of the trade leadership are: 1) contingent reward leadership, which refers to leaders giving followers things they want in exchange for things leaders want and 2) Exceptional leadership - Active, which refers to leaders actively monitoring performance and taking corrective action as problems become apparent (Bass,1990). Passive or avoidant leadership refers to the lack of leadership and is considered to be the most ineffective leadership style (Antonakis et al., 2003). The factors of passive leadership are: 1) Exceptional leadership - passive where the leader avoids making decisions and takes action and does not clarify the aspirations and objectives of the school organization (Avolio & Bass, 2004). 2) Laissez-Faire leadership where the leader is absent and does not assume his responsibilities (Avolio & Bass, 2004).

## 3. METHODOLOGY

The purpose of this paper was to investigate the degree of three leadership styles (transformative, transactional and avoidant) in primary school managers in the prefecture of Achaia, according to teachers' perceptions, as well as to explore their desired leadership style.

The research questions are:
   • Which leadership style prevails in primary schools in the prefecture of Achaia, according to teachers' perceptions?
   • What leadership style do the teachers of Achaia desire?
   • Does the leadership style that teachers perceive is different from what they desire?
   • What dimensions of leadership style are most often found in elementary schools?
   • What dimensions do teachers desire? Is there a difference between them?

MLQ Form - 5x was used to collect the survey data from its latest Avolio and Bass version in 1995. Multifactor Leadership Questionnaire includes 45 statements, 36 of which measure the 9 dimensions of the three leadership styles (transformational, transactional and passive) with 4 proposals for each dimension.

The sample of the survey consists of 123 subjects, 33 men (26.8%) and 90 women (73.2%). In order to test the credibility of the leadership style for what is applied and what teachers want to apply, a correlation analysis was made by calculating the Cronbach coefficient and their high internal cohesion was established.

## 4. RESULTS

Figure 1: teacher's perceptions and desires about the leadership style prevails in primary schools of Achaia region
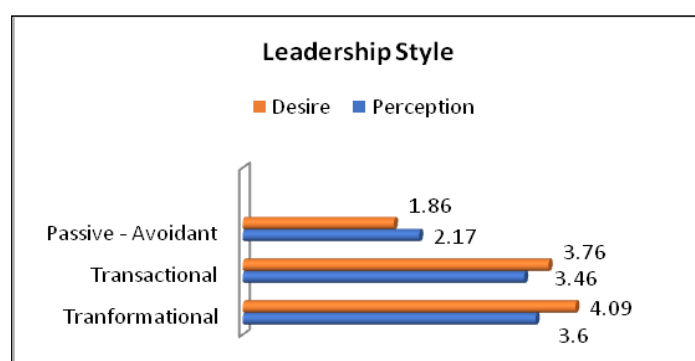


According to teacher's perceptions, transformational leadership prevailed marginally on transactional leadership (Figure 1), with means 3.6 and 3.46 respectively, with a statistically significant difference (p = 0.000 <0.05). Passive - Avoidant Leadership followed with a significantly lower mean (2.17) and a statistically significant difference (p = 0.000) between the two above-mentioned leadership styles (Tables 1, 2, 3).

Teacher's desires indicate that they prefer a transformational leader more than an transactional (average values 4.09 and 3.76 respectively), a statistically significant difference of p = 0.000 (Table 1) and that passive - avoidant leadership is the most inappropriate for the school unit (Mean 1.86), with statistically significant differences between transactional (Table 3) and transformational (Table 2) leadership (p = 0.000 and p = 0.000, respectively).

Table 1: Differences between transformational and transactional leadership style

| Leadership Style | Perception | | | T- Test | Desire | | | T- Test * |
|---|---|---|---|---|---|---|---|---|
| | Cronbach's Alpha | Mean | St.D. | | Cronbach's Alpha | Mean | St.D. | |
| Transformational | .948 | 3.6 | .811 | .000 | .911 | 4.09 | .589 | .000 |
| Transactional | .790 | 3.46 | .746 | | .750 | 3.76 | .649 | |

Table 2: Differences between transactional and avoidant leadership style

| Leadership Style | Perception | | | T- Test | Desire | | | T- Test * |
|---|---|---|---|---|---|---|---|---|
| | Cronbach's Alpha | Mean | St.D. | | Cronbach's Alpha | Mean | St.D. | |
| Transformational | .948 | 3.6 | .811 | .000 | .911 | 4.09 | .589 | .000 |
| Avoidant | .800 | 2.17 | .742 | | .773 | 1.86 | .674 | |

Table 3: Differences between avoidant and transactional leadership style

| Leadership Style | Perception | | | T-Test | Desire | | | T- Test * |
|---|---|---|---|---|---|---|---|---|
| | Cronbach's Alpha | Mean | St.D. | | Cronbach's Alpha | Mean | St.D. | |
| Transactional | .790 | 3.46 | .746 | .000 | .750 | 3.76 | .649 | .000 |
| Avoidant | .800 | 2.17 | .742 | | .773 | 1.86 | .674 | |

## 4.1 Transformational Leadership

Teachers desire their manager to apply more transformational practices than he already does with a statistically significant difference (p = 0.000). The greatest mean for what teachers perceive and desire (3.84 and 4.4 respectively) is observed in the dimension "Idealized influence - Characteristics". This suggests that the evaluated leaders show a sense of strength and confidence, put the team's good above their personal interest and earn the respect of teachers to a high degree, which teachers desire even more (p = 0.000) . Similar mean values also appear in the dimensions of "Inspiration ", "Cognitive Skills Activation" and "Idealized Influence - Behavior," showing that headmasters are talking optimistic about the future and are convinced that the goals will be achieved, in a more than moderate degree (Table 4), something that teachers want even more with a statistically significant difference. The lowest mean (3.48) is concentrated in the dimension of "Individual Consideration" but it is also higher than average, suggesting that managers most often treat teachers as individuals with particular abilities and ambitions. Teachers desire this behavior to a greater extent (3.97, p = 0.000).

Table 4: Analysis of the four behavioral components of transformational leadership

| Dimensions of Transformational Leadership | Perception | | | Desire | | | Wilcoxon Test |
|---|---|---|---|---|---|---|---|
| | Mean 3.6 | St.D. | Cronbach's Alpha | Mean 4.09 | St.D. | Cronbach's Alpha | .000 |
| Idealized influence - Characteristics | 3.84 | 1.01 | .876 | 4.4 | 0.64 | .792 | **.000** |
| Idealized Influence - Behavior | 3.53 | .785 | .713 | 3.8 | .714 | .710 | **.000** |
| Inspiration | 3.6 | .933 | .872 | 4.09 | .730 | .818 | **.000** |
| Cognitive Skills Activation | 3.56 | .933 | .884 | 4.19 | .730 | .717 | **.000** |
| Individual Consideration | 3.48 | 1.1 | .840 | 3.97 | .777 | .701 | **.000** |

## 4.2 Transactional Leadership

We observe a larger deviation between means of transactional leadership's dimensions (Table 5). Mean of "Contingent Reward Leadership " (3.76) shows that teachers perceive that headmasters help them when they see them trying and expressing their satisfaction when they have the desired results in a degree higher than the moderate. The corresponding mean that expresses their desire (4.21) shows that teachers want this behavior of their managers to an even greater extent. Also, from the "Exceptional Leadership - Active" dimension, we understand that managers sometimes monitor any mistakes, and draw attention to teachers when they do not respond to the standard (Men. 3.17), something teachers want to do more (Mean 3.3). Differences between what is true and what teachers want is also statistically significant (p = 0.000, Table 5).

Table 5: Analysis of the two behavioral components of transactional leadership

| Dimensions of Transactional Leadership | Perception | | | Desire | | | Wilcoxon Test* |
|---|---|---|---|---|---|---|---|
| | Mean 3.46 | St.D. | Cronbach's Alpha | Mean 3.76 | St.D. | Cronbach's Alpha | .000 |
| **Contingent Reward Leadership** | 3.76 | .923 | .701 | 4.21 | .796 | .712 | **.000** |
| **Exceptional Leadership - Active** | 3.17 | .923 | .710 | 3.3 | .626 | .739 | **.000** |

## 4.3 Passive - Avoidant Leadership

As far as the dimensions of the leadership are concerned (Table 6), headmasters rarely seem to not take action when problems appear, since the "Exceptional Leadership - Passive" dimension the low mean of 2.41. The Leadership Laissez-Faire dimension has even lower mean (1.92), suggesting that primary school managers rarely not get involved when serious issues arise, are absent when they need it, avoid making decisions. This is something that teachers seem to want even more strongly (p = 0.000), as these are the lowest average values (2.19 and 1.53 respectively).

Table 6: Analysis of the two behavioral components of passive - avoidant leadership

| Dimensions of Passive – Avoidant Leadership | Perception | | | Desire | | | Wilcoxon Test* |
|---|---|---|---|---|---|---|---|
| | Mean 2.17 | St.D. | Cronbach's Alpha | Mean 1.86 | St.D. | Cronbach's Alpha | .000 |
| Exceptional Leadership - Passive | 2.41 | .706 | .840 | 2.19 | .626 | .701 | **.000** |
| Laissez – Faire Leadership | 1.92 | .980 | .859 | 1.53 | .932 | .748 | **.000** |

## 5. CONCLUSIONS

Accordingly, with the research results, the leadership style prevailing in public primary schools in the prefecture of Achaia is the transformational one, which received little more than moderate scores in its five dimensions. Then follows the transactional leadership with a moderate rating, followed by the passive - avoidant leadership with a low score. Teachers seem to want to a large extent a transformational leader, to a moderate extent a transactional leader and to a very small extent a passive leader who basically does not exercise leadership.

In addition, all dimensions of the transformational leadership were rated with higher than moderate score. The dimension "Idealized Influence - Characteristics" gathered the highest score. The lowest score was concentrated on the dimension " Individual Consideration", but it also appears to be in a satisfying level.

In transactional leadership, the "Contingent Reward Leadership" dimension rated with higher than moderate score. The corresponding mean that expresses teachers' desire shows that they want this behavior of their managers to an even greater extent. From the "Exceptional Leadership - Active" dimension, managers seem to focus on teacher mistakes to a moderate degree, while they want to do it even more.

The Laissez - Faire dimension scored the lowest score relative to all dimensions of the multifactor questionnaire. However, teachers want their managers to exhibit such behaviors to a lesser extent. To summarize, teachers desire their manager to apply more transformational and transactional practices than he/she already does, while they want elements of passive - avoidant leadership to a lesser degree than exist.

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# Assessing the educational task as a job satisfaction factor amongst secondary teachers

Maria Kalavrouzioti

*Technological Educational Institute of Western Greece*
*Megalou Alexandrou 1, Patra, 26334*

**Abstract**

Teacher evaluation provides the capacity for professional development; enhances accountability; contributes to improving the quality, efficiency and effectiveness of the educational system in general. Whilst its acceptance is critical, it does not appear to have occurred in Greece with the introduction of teacher evaluation legislation that was finally abolished due to intense teacher reactions.

Our investigation of the evaluation's effectiveness as a job satisfaction factor initially reviewed the Greek and international literature and then conducted a quantitative investigation with a closed-ended questionnaire amongst 30 secondary teachers at two Patras schools on: 1) the educational evaluation's contribution to professional development and enhanced accountability; 2) whether teachers should be evaluated; 3) evaluation contributing to job satisfaction; and 4) evaluation system features and types significantly contributing to job satisfaction.

Results indicate that evaluation significantly contributes to job satisfaction; evaluations do not have the same positive effect on job satisfaction; the most effective professional development systems contribute to job satisfaction as opposed to those designed for enhancing accountability. Our findings coincide with previous investigations where the potential for professional development is a significant factor for forecasting job satisfaction amongst Greek teachers. Factors that may reduce job satisfaction levels are evaluation systems designed to enhance accountability, which are likely to make teachers feel less independent or that more control is exercised by educational authorities. Given recent national developments, our results are useful in formulating Greek educational policy and designing evaluation systems acceptable to teachers. The results are significant but cannot be generalised due to the restrictive small population sample exclusively drawn from Patras schools. Future investigations need to investigate larger populations that will export more credible results that can be better used by policymakers.

## 1. INTRODUCTION

Human resources in educational are the most significant means for achieving targets and their effectiveness determines the final results of the process and effective delivery of education to students. Job satisfaction and motivation are amongst the significant factors influencing teacher efficiency and effectiveness. Job satisfaction is defined as a pleasant or positive emotional state resulting from an assessment of the work experience with respect to the individual's attainment of professional and personal goals.

Given the significance that job satisfaction has currently acquired amongst teachers for improving educational results amongst students, the currently literature significantly concentrates upon factors influencing job satisfaction amongst teachers. The significant factors influencing job satisfaction include work conditions, remuneration, workplace relations, management and professional development potentials. The evaluation of teachers and evaluation practices has not been widely examined to date in relation to the manner that they influence workplace satisfaction.

The objective is to investigate the evaluation in terms of the job satisfaction factor amongst secondary teachers. Within the Greek framework, the investigation of teacher evaluation is exceptionally interesting due to developments in recent years with the introduction and eventual abolition of the relevant legislation. This resulted due to intense reactions by teaching communities that considered the manner of the legislation's implementation would lead to dismissals and salary cuts.

## 2. TEACHER PERFORMANCE EVALUATION

Teacher performance evaluation relates to formal processes observed at an educational institution to evaluate and review the teaching process. The teacher evaluation processes focus upon the main teaching activity, which often covers areas such as planning and preparation, the class environment and teaching itself (OECD).

Teacher evaluation serves two main purposes: professional development of teachers and accountability. A system is employed in both cases to evaluate and provides information on employee performance, which includes measures to

improve or redirect activities. The most significant stages in the evaluation process are to identify the weakest skills and abilities and create a plan for improvement (OECD).

The evaluation objective for professional development and growth measures performance standards enabling teachers to move up or into different positions; accountability is primarily intended to enhance responsibility amongst teachers towards education management, which can relate to a single institution or the system in general. Both evaluation objectives must not be independent of one another and an evaluation system must be designed in a manner that covers both objectives, to serve the ultimate purpose, namely improving teaching and learning.

Different evaluation systems may include a range of performance indicators based upon learning results; classroom observations; self-reporting; defining and reviewing individual objectives; etc.

Regardless of the evaluation system, evaluation is implemented and indicators are used, which contribute to improving teacher and teaching performance and effectiveness, by further improving the quality of the institution or the system. It is very important that evaluation systems receive teacher acceptance.

A significant application of evaluation in organisations is performance related remuneration, which is frequently employed for aligning employee goals with enterprise goals to motivate and reward employees. These goals provide employees with more specific understanding of what is expected and facilitates in directing employee activities towards those goals. Various investigations have been conducted outside the education sector and indicate that feedback received and clear objectives are positively linked to job satisfaction.

There are other evaluation factors such as the relation between the person evaluated and evaluator, support by the supervisory body, confidence, accuracy of evaluation, reliability of evaluation methods, justice and transparency of the system, and even types of evaluation, which are associated with job satisfaction. Brown and others analysed the relation between evaluation system quality (i.e. clarity, communication, confidence and impartiality of the evaluation process) and job satisfaction in a sample of civil servants and found employees who reported that the system had a lower quality (lower levels of confidence in the supervisory body, poor communication, absence of clarity regarding expectations, perception of a less equitable evaluation process) also reported lower levels of job satisfaction.

The M.O. of these systems may influence job satisfaction. Evaluation requiring continuous monitoring of employees may restrict employees in how they organise and perform their work, which impact negatively on job satisfaction.

A system evaluating teachers attributing greater emphasis to accountability rather than professional development, may in lead teachers to feeling insecure or afraid, which reduces the system's acceptance. It was found in Greece that teachers believe that cost-oriented evaluation systems reduce levels of flexibility and impact negatively on the school environment. Anastasiou examined opinions of Greek teachers on their evaluation and found they had lower levels of confidence in evaluation system and its implementation method, despite teachers generally formulating a positive attitude towards supportive and formative evaluation providing feedback and promoting professional development.

The reduced acceptance of the evaluation reduced teacher flexibility; the school environment deteriorates and there is an absence of confidence in the processes, which may lead to low levels of job satisfaction; the potential for professional development may however enhance job satisfaction levels. The "Teaching and Learning International Survey" (TALIS) that was carried out by the OECD in 2013 amongst teachers in 24 Member States to investigate the manner in which evaluation systems and feedback also affect job satisfaction, found that teachers generally had a positive opinion about the evaluation process; they considered it just and useful; that it contributed to their professional development by increasing overall job satisfaction, even though there were differences between countries.

A similar investigation by Koedel and others examined the impact of evaluation introduced amongst public school teachers at Tennessee in the USA. This system was designed in manner that enhanced the rigour of the evaluations, which better differentiated teachers based on performance. The results indicated that teachers scoring higher on performance also had higher job satisfaction levels, since performances contributed to professional development.

Dowing examined the evaluation reforms affecting job satisfaction amongst Ohio teachers. The evaluation system also considered student results as a key indicator of performance, where these changes were not found to have negatively affected job satisfaction, despite being specifically geared towards enhancing teacher accountability.

The above findings demonstrate that evaluation of the educational task is linked to and positively influences job satisfaction, regardless of its purposes (accountability and vocational training). Research in this area is very limited. A relevant investigation has not been specifically identified in Greece.

## 2.1 RESEARCH METHODOLOGY

A quantitative investigation was conducted on formal, objective and systematic process; it collected quantitative data on the impact of performance evaluation in teacher satisfaction. A Questionnaire was designed comprising 12 questions divided into two sections. Section 1 comprising 4 questions collected demographic features about the participants (gender, age, service and education). Section 2 comprising 8 questions collected data for answering research questions. Some of the questions were based on the OECD survey. The survey population comprised 30 teachers from secondary schools in Achaia prefecture; specifically 3 Patras schools (Patras 1st General Lyceum, Patras 6th G.L. & Patras 9th G.L.). The questionnaires were personally handed out; the investigation was explained to every participant and clarifications were

provided. It was completed on-site during recess periods and then collected. Participation in the investigation was voluntary and anonymous. Results were collated and analysed in Microsoft Excel (2007 version).

## 2.1.1 Presentation of results

I.  **Demographic Data**. Questions:
1.  Gender: 63 % of the population is female and 37 % is male (19 females and 11 males);
2.  Age: 23.3 % are 25-34 years; 40 % are 35-44 years; 30 % are 45-54 years; and 6.7 % are over 55 years old;
3.  Service: 6.7 % have 1 – 5 years; 20 % have 6 – 10 years; 26.6 % have 11 – 15 years; 30 % have 16 – 20 years; and 16.7 % have in excess of 20 prior; and
4.  Specialisation: 64 % have a Bachelor degree; 33 % - Master's degree; and 3 % - PhD degree in education.
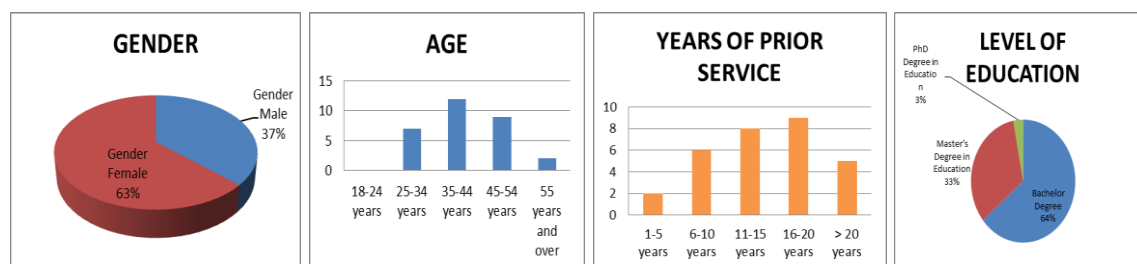


Diagram 1

II.  **Educational Evaluation and Job Satisfaction**

In questions 5, 6 and 7, teachers were questioned whether they believe that evaluation contributes to professional development, enhances accountability and respectively reduces autonomy. Teachers were asked in question 8 whether they believe that they should be evaluated.
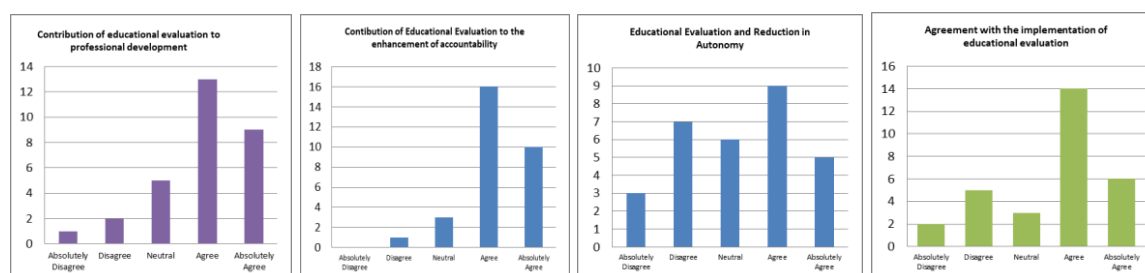


Diagram 2

The majority of teachers (73.3 %) absolutely agree that evaluation contributes to their professional development.

The agreement percentage is higher in question 6, where 86.6 % of the teachers stated that they agree or absolutely agree that educational evaluation contributes to enhancing accountability in the educational system.

Responses are more scattered in the responses to question 7. 46.6 % agree or absolutely agree that evaluation reduces autonomy; 30 % stated disagree or absolutely disagree; and 20 % were neutral.

In question 8, 66.6 % believe in evaluation, whilst 23.3 % do not believe in evaluation.

Question 9 asked whether they believe that evaluation contributes to job satisfaction; at question 10 they nominated the type of evaluation best contributing to job satisfaction (internal evaluation, external evaluation, self-evaluation and a combination thereof). Question 11 relates to the type of evaluation (based upon its purpose) they believe best contributes to job satisfaction. Question 12 relates to the level of job satisfaction.
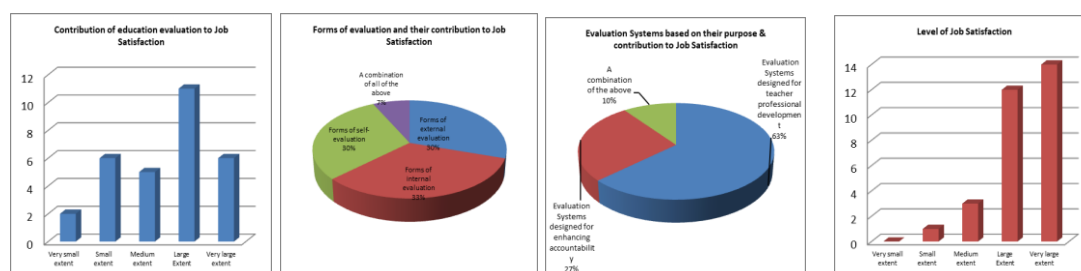


Diagram 3

The majority of teachers (56.6 %) believe that evaluation greatly or significantly contributes to job satisfaction, whilst 26.6 % believe that it contributes to a small or very small extent. The forms of internal evaluation that best contribute to job satisfaction were stated by 33.3 %, with similar percentages for self-evaluation (30 %) and the combination of internal and external evaluation (30 %). Just 7 % believe that external evaluation contributes to job satisfaction.

On the evaluation system (based on its purpose) that best contributes to job satisfaction, 63 % mention the evaluation systems designed for teacher professional development and 27 % mention evaluation systems designed in combination for professional development and enhancing accountability to the education system. Only 10 % believe the systems designed for enhancing accountability better contribute to job satisfaction with respect to the other evaluation systems. Finally, the overwhelming majority, namely 86.6 % feels satisfied with its work to a large or very large extent and only 3 % feels that it is minimally satisfied by its work.

The questionnaire's reliability in research is a significant factor for ensuring the validity of the results. This control occurs through the Cronbach alpha coefficient of reliability that measures an instrument's internal reliability. The values received by the coefficient fluctuate between 0 and 1. Coefficient values greater than 0.700 indicate that there is good internal cohesion and reliability by the questions (Cohen et al, 2008); the examination of the reliability for the specific tool indicated that $\alpha = 0.590$ for the questionnaire, which is potentially justified by the small size of the sample population and by the small number of questions that are included in the questionnaire.

## 3. CONCLUSIONS

We investigated the extent to which the teacher evaluation contributes to job satisfaction. The empirical investigation was conducted amongst 30 teachers at the 3 Patras secondary colleges; it recorded their views, which indicate that the evaluation of the educational task contributes to a large or very large extent to job satisfaction. All the forms of evaluation systems were not however evaluated equally positively regarding their contribution to job satisfaction. We have seen that evaluation systems exclusively designed for the teacher professional development are those that greatly contribute to job satisfaction; it is believed that those systems that have been designed for enhancing accountability have a lesser contribution to job satisfaction. These findings are reasonable since the potential for professional development in the workplace has been found to be a significant factor for job satisfaction by previous investigations in respect of Greek primary and secondary teachers. Accordingly, evaluation systems that provide teachers with the potential for development may enhance job satisfaction.

We have moreover seen that not all the systems and forms of evaluation contribute to job satisfaction in the same manner. Fewer teachers stated that systems designed to enhance accountability contribute to job satisfaction. During the implementation of these systems, teachers potentially feel less independence and autonomy in relation to their task or that greater control is exercised by educational authorities, which are factors that may reduce the levels of job satisfaction. Grammatikou found that even though primary teachers derive job satisfaction in Greece, they were sceptical or dissatisfied with work conditions, especially in the areas of evaluation and potentials for development provided to them. Self-evaluation (implemented and abolished in Greece) was only indicated by a small percentage of the population sample as a form of evaluation that better contributes to job satisfaction.

Our findings are to a certain extent in overall agreement with findings by previous investigations that also found that evaluation contributes to job satisfaction amongst teachers in Europe, as well as research that found that systems based upon teacher professional development increase job satisfaction, especially amongst teachers that score well in their performances. The investigation conducted amongst teachers in the USA found that even systems directed at enhancing accountability amongst teachers do not negatively influence job satisfaction and that teachers feel equally satisfied with their work through those evaluation systems or the systems that are better oriented to job satisfaction. These differences may be attributed to the fact that there may be a potential difference in the evaluation culture between the educational systems in Greece and the USA; Dowing arrived at these conclusions by correlating the results of teacher evaluations with results of a questionnaire on job satisfaction.

We may conclude that the systems amongst secondary teachers contributing to their professional growth and development are those that best contribute to job satisfaction. These results are useful to agencies formulating educational policies in Greece; to design evaluation systems that are also acceptable amongst Greek teachers.

The results cannot however be generalised, primarily because of the small population sample. Future investigations must be conducted amongst larger population samples of secondary teachers, as well as population samples drawn from teachers widely dispersed throughout Greece, in order to reflect a more comprehensive picture about which evaluation contributes to job satisfaction and the types and form of evaluation systems contributing to a larger or smaller degree of job satisfaction. The results would potentially be more effective if they could be implemented amongst teachers that are already being evaluated.

## ACKNOWLEDGEMENT

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# Programming in education: Developing collaborative teaching practices

Maria Pavlochristou

*Technological Educational Institute of Western Greece*
*Megalou Alexandrou 1, Patra, 26334*

**ABSTRACT**

The key importance of programming has emerged in a large number of cases of the application of new methods and innovative actions in education. It is a precondition for the development of the school unit and an important mechanism for its empowerment. However, there is a limitation in its application due to the nature of the Greek education system.

The aim of this paper is to demonstrate the value of programming in education and to present a proposal for its implementation in the development of cooperative teaching practices in public primary schools.

From the present research it becomes clear that programming is apt to apply in the field of cooperation development among primary school teachers in the country. In particular, it is possible to solve a number of problems related to the use of teaching material already developed or to be developed by the teachers and to the dissemination of the good teaching practices applied by them.

**KEYWORDS:**
programming, education, public schools, collaborative teaching

## 1. INTRODUCTION

Programming is a requirement of the modern, rapidly changing environment and applies to all educational organizations as it contributes decisively to their effective operation (Katsaros, 2007)

Its lack tends to disorientate the educational organization from its priorities, leads to inefficient use of resources, human and material, and makes it inadequate to predict and eventually exploit future opportunities or optimally address problems that may arise (Schermerthorn, 2011).

Although its advantages are numerous, there is a difficulty in its implementation, especially in public schools, due to the centralized nature of the Greek educational system (Saitis, 2008)

In other countries, and in particular in France, the 1989 Framework Educational Law strengthened the pedagogical autonomy of educational institutions by assigning to colleges and universities responsibility for the design and implementation of national education programs. Also in England, Wales and Northern Ireland, schools enjoy a high degree of autonomy, as from 2008 an emphasis is placed on the annual cycle of programming by schools to improve their quality (IEP).

This paper attempts to highlight the value and necessity of programming in educational units. Also, a series of actions for a significant part of the educational project is presented; the development and implementation of cooperative teaching practices, following the steps of the programming process according to the Koutouzis model (1999).

## 2. THE VALUE OF PROGRAMMING-PLANNING IN EDUCATION

A key advantage of educational programming is that it sets clear and comprehensible goals for all members of the school organization, thus avoiding misunderstandings and making them able to set the right conditions for achieving the goals. It organizes and coordinates the necessary actions, avoiding omissions, overlaps and unnecessary moves. It manages rightly and financially the time as well as the human and material resources. It also sets the standards for process monitoring, control and evaluation of the results (Katsaros, 2007).

The value of school-level programming also lies in the fact that it uses the knowledge from the evaluated educational project to plan actions for improving its quality. It is a mechanism for strengthening the school as it offers the possibility of recognizing and managing the necessary changes to improve the practices of the school. It is also a lively, dynamic and flexible process. Taking into consideration the evaluation of the actions of previous years and of the new aspects of school life, it modifies the planned actions whenever necessary. Thus, it is better adapted to the needs of pupils and teachers, but also to the particular conditions of the school (Papachristos, 2012)

However, the Greek system of public administration, influenced by centralized European systems of the first half of the 19th century, presents the image of a powerful state with the government defining politics in all areas. Consequently, the Greek educational system is characterized by centralized structure and is subject to central control by the Ministry of Education. The Ministry decides and the intermediate powers simply execute without taking initiatives (Andreou & Papakonstantinou, 1994).

The centralization and bureaucracy that characterize our educational system (Giannakopoulos, 2002) is the main cause of the pathogenesis of Greek education. School-level scheduling is fragmentary and is limited to organizing school life and sharing work. As Lainas (2000) says, the management of Greek schools is based on rules rather than goals.

The lack of programming results in various problems and makes it difficult for the school to function. In particular it leads to a lack of coordination. The different people who make up the educational organization are doing different things at the same time. When their efforts and plans are not coordinated and complementary, they cannot promote the performance of the school.

Without scheduling, the focus of the school is lost. A school organization with no focus does not know its abilities, it does not know its needs, it does not understand where it is and where it wants to reach. Also, without the flexibility of programming, the school does not have the capacity to change and adapt to the new conditions and to exploit the growing opportunities.

Moreover it makes control very difficult, as there are no goals and standards. Unless the goals of a good planning are set out from the outset, it is not possible to measure the results and take action to improve things where and when necessary (Schermerthorn, 2011).

In Europe, contrast to Greece, there exist different levels of autonomy in school unit management with the Finnish model being the pioneer in administrative reforms and student performance. The Finnish educational system is decentralized and the programming is done at school level by the teachers themselves, who have autonomy to develop their self-sufficiency, responsibility, professionalism and collectivity (Katsaros, 2007). The same seems to be true in other central European countries, where a graduated scale of autonomy of the educational units is presented.

## 3. PROGRAMMING CASE: DEVELOPMENT OF COLLABORATIVE TEACHING PRACTICES

One of the many cases where programming is necessary is in the field of developing co-operation between teachers of the same or other school units to exchange experiences, knowledge and material. This is operational planning, with short-term goals and limited activities. It is mainly done by the director and less by the teachers of the school and it concerns the organization of school life and the division of work (Saitis & Saitis, 2012). It involves educational action coordinators, all teachers who teach the same classes or the same subject, the pupils, their parents and the local community. The programming of this case follows six steps, according to Koutouzis (1999) model.

### *Step One; Goal setting*

The director investigates the field and finds a lack of cooperation, trust and mutual support among teachers. He also notes that there is no exchange of information, experience, practice and teaching material.

Based on the above finding, the aim of the programming is the development of collaborative teaching practices by the teachers who teach the same subject.

Other objectives are the implementation of teaching practices as a product of teachers' cooperation, the development and utilization of teaching material (lesson plans, worksheets, evaluation sheets, software) and the creation of a digital library.

### *Step two; Development of alternatives*

At this point a series of actions should be planned

Teachers should be officially informed and educated about the action by the director and the coordinators. It follows the formation of working groups and a schedule of regular teacher meetings to exchange information, experiences and practices as well as mutual visits to classes and meetings for feedback. Tools should be developed for monitoring the action (student observation plan, worksheets, teacher and pupil questionnaires).

The next step should be the production and use of teaching material for each lesson, such as worksheets and lesson plans, along with the use of existing material available to teachers and the use of educational software to which all teachers should be trained.

All teaching material should be registered on a computer of the school, which will be the digital bank of the school, and posted on the school's website for use by all partner teachers.

A parents briefing about the implementation of the action is also important to be planned.

### *Step 3; SWOT analysis*

A SWOT analysis will be carried out to investigate the internal and external environment of educational organizations with a view to identifying actions.

Table 1. SWOT analysis

| STENGTHS | WEAKNESSES |
|---|---|
| teachers with long-term service and teaching experience | Time problems for visiting colleagues. |
| | Lack of observing material |
| Previous teacher experience in collaborative practices (health and environmental education programs). | Difficulties in organizing and coordinating working groups. |
| Support by school coordinators. Director that cultivates a spirit of collectivity. | Possible training costs. |
| | Involvement of students. |
| OPPORTUNITIES | THREATS |
| | Perception of the privacy of the classroom Reaction of old teachers due to labor exhaustion, conservatism and complacency. |
| Exploitation of the capabilities of human resources. | |
| | Unwillingness to create material due to workload. |
| Implementation of educational programs and innovations. | Increasing teaching time and difficulty in covering the curriculum. |
| Improvement of teachers relationships | |
| Improvement of students progress | No school website |

## *Step 4; Assessment of alternatives*

Each alternative for each target is evaluated on the basis of certain criteria, such as its applicability, its benefits and its potential cost. The timing of its implementation, the extent of its acceptance and the degree of its moral correctness in terms of acceptable social criteria, are also very important.

## *Step 5; Selection of the best solution*

The option does not arise automatically because it is impossible to precisely determine the results of each alternative. However, on the basis of the detailed assessment of each proposal, it is possible to reject those who are disadvantaged and to choose those who have the most advantages.

At this specific step it is precisely and clearly defined how each action will be taken, by what materials, in what place, by whom and at what time. At this point a Gantt chart is used.

Table 2. Gantt chart

| ACTIONS | S | O | N | D | J | F | M | A | M | J |
|---|---|---|---|---|---|---|---|---|---|---|
| Meeting with the teachers | ■ | | | | | | | | | |
| In-school training | ■ | | | | | | | | | |
| Formation of workgroups | ■ | | | | | | | | | |
| Development of control tools | ■ | | | | | | | | | |
| Parents briefing | | ■ | | | | | | | | |
| Exchanges of class visits | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Feedback | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Production of collaborative material | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Recording of material | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |

## *Step 6; Project implementation*

Quick and smooth implementation of resolved solutions requires the involvement of appropriate people in decision-making, as they build the commitments that are necessary for their implementation.

The Director takes care of the formation of the teams and ensures that all the potential of the human resources is exploited. He also makes available all the supporting material of the action (stationery, computers). He organizes feedback meetings and communicates the information. In general, the director works as an organizer, an inspirer, a promoter and a helper in the implementation of the project.

## 4. CONCLUSIONS

Programming is an essential tool for executives, as it presents many positive elements stemming from clear targeting, coordination of actions and the utilization of human and material resources (Saitis, 2008)
The structure of the Greek education system allows minimal administrative activities to the school unit, which thus assumes the role of executor of central education policy (Mavroyogoros, 2008). However, the school unit has a degree of autonomy, mainly in programming for operational issues.
Finally, in the present study it was found that school planning can benefit the entire organization. It can play a decisive role in shaping the particular character, culture and climate of each school. It can be applied to develop a climate of co-operation, trust and mutual support among teachers.

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# Adult Education Policies: Basic Dimensions according to the International discourse

Dr Karanikola Zoe
*Technological Educational Institute of Western Greece*
*Megalou Alexandrou 1, Patra, 26334*

Dr Panagiotopoulos Georgios
*Technological Educational Institute of Western Greece*
*Megalou Alexandrou 1, Patra, 26334\**

Dr Mitropoulos Ioannis
*Technological Educational Institute of Western Greece*
*Megalou Alexandrou 1, Patra, 26334*

## Abstract

The development of policies aimed at educating and developing citizens is of crucial importance as a result of the particular contemporary societal characteristics, the global demographic changes, the intense rhythm of immigration, the rapid development of technology and the increase in the unemployment rate. This research, through the analysis of the text "Third World Report on Adult Learning and Adult Education (UNESCO, GRALE III, 2016), comes to explore the key dimensions of adult education policies. The methodology used to investigate the material is the qualitative analysis and in particular the methodological tool of thematic analysis with the contribution of thematic networks. The analysis of the text shows that policies supporting adult education should be universal, holistic, inclusive and without exclusions. A second dimension concerns the need for the Member States to modernize their policies, to control and evaluate their implementation. The proportion of public funding in the field of adult education constitutes a challenge, since it remains fairly low in the government's investment priorities, which seem to give priority to other areas, such as health, infrastructure and social welfare. Moreover, it appears that all countries do not interpret international policies in the same way. Thus, policies are sometimes used as a general frame of reference and sometimes as well-established practices. These practices could be implemented by governmental organizations, research institutes, civil society organizations, trade unions and other agents. Finally, governments, in cooperation with regional and local authorities and services are called to broaden their policies and strengthen adult learning and education. Towards this direction, the development of the mobility and participation of trainees in programs such as ARION, Comenius, Grundtvig, Erasmus and Erasmus plus is absolutely of major importance (UNESCO, 2016).

**KEYWORDS:**

Adult education, policies, international organizations, UNESCO

## 1. INTRODUCTION

The rapid development of technology has led to major changes in the workplace, resulting in a change in wages, productivity, working conditions and relationships, types of occupations and organizational models (UN Human Development Report, 2015). This pace of change is expected to continue in the coming decades, causing workers to feel uncertain, complex and volatile. In addition, strong demographic changes and increased life expectancy have the natural consequence of increasing work life limits. These particular conditions provoke the increase of groups that are vulnerable socially, economically and professionally. These groups are obliged to redefine their work profile and strengthen it with skills that will allow them to respond to the mental, physical and emotional demands of the new labor market (Panagiotopoulos & Karanikola, 2017).

In such a context, training and educating potential professionals becomes a matter of major importance and a reference point for the policies of international organizations, given that education can act both as a growth mechanism and a "luxury ancillary factor", while it can also relieve the citizens from the unfavorable conditions under which they live (World Economic Forum, 2016). Thus, the UN with the Sustainable Development Goals program, adopted in September 2015, establishes seventeen key objectives for sustainable development. As it is stated in the preamble of its official text, it is "an action plan for people, the planet and prosperity", with its main axes being economy, society and the environment (paragraphs 7, 19, 25). In addition, it aims to ensure equal access for all women and men to affordable and high-quality technical and vocational education, and calls on governments to equip adults with skills that will ensure decent work for everyone, increase productivity, promote and defend of their labor rights. In an effort to align with UN objectives, UNESCO has drafted texts which aim, through the adoption of common cohesion and synergy policies, to help achieve the goals of the 2030 Agenda.

UNESCO's "Third World Report on Adult Learning and Adult Education" presents the results of an international survey involving 139 UNESCO member countries, on the impact of Learning and Adult Education in Health, Prosperity, Employment and the Labor Market, Social, Political and Community Life.

## 2. ADULT EDUCATION CONTEXT

Adult education is a focal point in continuing lifelong learning, covers every activity (formal, non-formal, informal) following the initial education and interacts with all types of education (primary, secondary, vocational education and tertiary education) (European Commission, 2015:2).

According to the latest UNESCO definition (2015), adult education equips people with the skills needed to exercise and realize their rights, promotes personal and professional development, supports active participation in society, community, and environment, while it also contributes to sustainable and inclusive economic growth  (Panagiotopoulos & Karanikola, 2018).

In addition, adult education is considered to be one of the main ways of assimilating global socio-economic and cultural changes and makes a substantial contribution to the specialization and upgrading of human resources. Its benefits include ensuring a decent standard of living, increasing opportunities for finding, maintaining or changing work, improving self-confidence, changing attitudes and perceptions, enhancing social cohesion and involving citizens in social and political life (UNESCO, 2016).

Over the last decades, adult education's aim is to ensure that the knowledge and skills of adults are adapted to the contemporary work environment (Osterhammel & Petersson, 2013). This event is of crucial importance given that formal educational institutions find it difficult to respond to modern challenges, a situation that can be resolved through the flexibility of the adult education field (Day, 2003).

## 2.1 International Organizations and adult education

The interest of international organizations in adult education started early. In particular, UNESCO has designed educational policies that place the adult at the core of development and promote the full development of human personality in a climate of respect for fundamental freedoms (Beech, 2009).

As early as the 1930s, UNESCO pointed out (www.ibe.unesco.org, 1935) that the education system should contribute to further professional development. In the Recommendation on Adult Status (UNESCO, 1966) and subsequent statements, the organization analyzes the adult's professional profile, highlights the academic freedom and the need for specific knowledge and skills, while stressing the need to create an extensive system training (UNESCO, 2003/2004; Robertson, 2012).

At the Dakar Forum in 2000, the need to improve the status of adults is repeated, while adults should be respected by the state, by taking part in the decisions affecting their professional career (Tsaousis, 2007).

Subsequently, UNESCO participated in the "Education for All (2012-2015)" program, whereby national governments are called upon to strengthen the moral and professional status of adults by allowing their active participation in training networks and actions (UNESCO, 2012 / 2015a).

Then, in the Strategy developed for the current period 2014-2021, the organization is deeply concerned about the serious qualitative shortcomings of the human resources education and their work, highlighting the use of new technologies as a means of improving the evaluation of adult education and the dissemination of good practices (UNESCO, 2015b; Panagiotopoulos, Pertesi & karanikola, 2018).

Finally, it composes official texts on the basis of international research data, interprets political strategies, develops evaluation and control mechanisms for forthcoming programs and actions (European Commission, 2016).

## 3. RESEARCH METHODOLOGY

This study comes to explore key dimensions of adult education policies through the qualitative analysis of the UNESCO text, GRALE III (2016). In particular, the methodological tool of thematic analysis was applied. Qualitative research through thematic analysis constitutes a methodical and systematic analysis of the material under investigation, facilitates the organization of analysis and allows extensive exploration of the superficial and deeper structures of the text (Boyatzis, 1998).

The development of qualitative methods constitutes a form of quality data coding (Clarke, Braun & Hayfield, 2015). In particular, the thematic networks method is distinguished by flexibility, large-scale data, interpretation of themes and finally the formation of categories derived from them (Braun & Clarke, 2006; Gibbs, 2007).

## 3.1. Presentation of results

The analysis of the UNESCO text (2016a: 32) shows that policies supporting adult education are universal, comprehensive, inclusive and integrated. In particular, the universal approach lies in the fact that adult education is originally an integral part of lifelong learning. In addition, the impact and diagnostic assessment of national adult education policies is highlighted as a long-term approach to both labor market and personal and social needs.

Regarding comprehensive policies, governmental structures and institutions should address learning in a wide range of spheres, including the economic, political, social, cultural, technological and environmental. As far as the inclusive policies

are concerned, they should provide equitable access to learning opportunities and strategies without discrimination (UNESCO, 2016b:8-9). Thus, adult education can contribute to the protection of fundamental human rights (respect for diversity, empowerment of all vulnerable social groups, solidarity and social justice, citizenship), but also to the management of modern social issues related to employability, poverty, unemployment, lack of appropriate and right skills, labor market, cohesion and social exclusion, environmental protection (UNESCO, 2016a).

A second dimension concerns the need to modernize Member States' policies, to control and evaluate their implementation. Educational policy makers are called upon to modernize their policies according to the requirements of the economic, political, social, cultural and technological environment, and to evaluate the implementation of the applied training methods and techniques.

The proportion of public funding in the field of adult education constitutes a challenge, since it remains fairly low in the government's investment priorities, which seem to give priority to other areas, such as health, infrastructure and social welfare. In particular, the proportion of public budget (around 2.2%) spent on adult education in 2009 (GRALE II, 2009) has gradually risen, according to the next UNESCO survey (GRALE III, 2016). 57% of countries in total and 90% of low-income countries are planning to increase public spending on adult education (Panagiotopoulos & Karanikola, 2017). However, 42% of countries spend less than 1% of the public education budget for adult education and only 23% spend more than 4% (GRALE III, 2016: 48).

However, the efficient allocation of government expenditures as well as the initiatives of the competent agents is still a major problem. To this end, it is necessary for the countries to use specific indicators to measure the resources invested in the education system and the corresponding results (UNESCO, 2016: 45).

Moreover, it appears that all countries do not interpret international policies in the same way. Thus, policies are sometimes used as a general frame of reference and sometimes as well-established practices. These practices could be implemented by governmental organizations, research institutes, civil society organizations, trade unions and other agents. Additionally, governments, in cooperation with regional and local authorities and services are called to broaden their policies and strengthen adult learning and education. Towards this direction, the development of the mobility and participation of trainees in programs such as ARION, Comenius, GRUNDTVIG, Erasmus and Erasmus plus is absolutely of major importance (UNESCO, 2016a).

The exchange of ideas and practices is beneficial not only between states at a global level but also between local and regional authorities at a national level. Besides, the quality of the educational framework is judged by the diffusion of ideas and the transfer of competences, especially from lower to upper educational levels (UNESCO, 2016a).


## 4. CONCLUSION

According to the findings of the qualitative analysis of this text, a basic dimension of adult education is the formulation and implementation of universal policies which, however, should be in harmony with the requirements and peculiarities of each state (ideology, culture, historical payments) (OECD, 2013; European Commission, 2011; Reder, 2012). This dimension is also reflected in the policies of the European Commission (2016), as emphasis is placed on policies that are characterized by the coherence and synergy of many actors and partners (Panagiotopoulos & Karanikola 2018).

Adults engaged in lifelong learning are more likely to be working, and to be economically, socially and politically active (Bosche & Brady, 2013), as they have the required skills. Right skills are a fundamental factor of economic and social success, helping adults to develop their work and adapt to changing needs (OECD, 2017: 32). Dissemination of good practices is also an effective education policy, as effective learning methods can be transferred and implemented through learner mobility (Robertson, 2012; European Commission, 2013). A similar finding is supported in a research emerging from the analysis of EU policies (European Commission, 2016; Panagiotopoulos & Karanikola, 2017).

However, it should not be overlooked that adult education is a multidimensional and complex policy field that interacts and contributes to other areas of political action. Therefore, there is often a lack of coordination and different approaches. This contributes to the fragmentation and inefficiency of adult education (Panagiotopoulos, Pertesi & Karanikola, 2018). Additionally, some questions arise regarding the transfer of policies into the field of application. How easy is it to achieve the objectives of international policies?

In any case the best adult policies and programs are evidence-based. By investing more in long-term research on what works in a particular context, countries can make their policies more efficient and effective (European Commission, 2015).


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# Quality of Education and Economic Development in the EU

Karampelas Panagiotis

TEI of Western Greece, MSc program in Education Management

**Abstract**

In this research, a methodological approach is made to the relationship between education and development of a country. A person's earnings depend on the total education he has received all years of formal and non-formal education and working experience according to the Mincer (1974) equation, but also by other factors. The relationship between education and development grew when economists began to give importance to the human capital factor as a factor in the developmental functions.

From the development of human capital theory to integration into developmental functions and transformation, global education, skills throughout the educational and work path gained play a key role in shaping a country's growth rate. Please note that there are functions that incorporate other quantitative training features, other qualities, and others. The research question is whether quality education and the factors influencing it positively affect a country's GDP. But the study expands its research into the European Union. In the paper, answers are given on the relation of qualitative characteristics in the countries of the European Union with the least squares' method in the form of panel data. The paper deals with an econometric model of Barro J. (1999) which has been transformed for EU data. Data are from databases such as World Bank and OECD in the period 1990-2013.

The results of the study follow the basic economic development principles and the variables that are statistically significant confirm the initial assumptions that education and economic development go hand in hand.

**KEY WORDS:**

Education, Development, Human Capital.

## 1. INTRODUCTION

The way in which human capital theory plays a role in the economy is examined through the microeconomic and macroeconomic environment. In the first case, human capital reserves affect the growth and change of incomes on a personal level, while in the second case the social stock is examined and how it affects the economic development of the whole. Human capital as a development factor includes education, health and aspects of "social capital". The main objective of the research is to examine education as a key factor in how it influences the overall development of a country. Investment categories, in human capital can be described on a life-cycle basis, starting from pre-school age, following formal school education expenditure. Expenditure can be considered as all related to the continuing vocational training of workers as well as investments for labor market mobility. First Adam Smith (1776) recognized the importance of investment in education. Employers give higher salaries to more educated employees because their skills and productivity are greater. The steady increase in demand for more educated workers increases the rate of return on education, also increasing sustainable growth.

The ability of an economy is strongly linked to the quality of the education provided. Skills and intellectual capital play an increasingly important role in a modern economy and schools play a central role in developing valuable skills.

A big part, of the initial empirical studies on human capital indicate that years of study are factors that affect it. The amount of education can be measured and focused given that more years of education are associated with higher individual earnings and growth rates accordingly.

But the amount of education is a slow measure to achieve the quality of students' skills. What students know, what knowledge and skills they have in the labor market, are important in economic development debates. Can a more educated society lead to higher patents? Making everyone more productive, introducing faster new technologies and leading to growth the economy; Basic questions that I aim to examine and analyze in my research.

## 2. EDUCATION AND DEVELOPMENT

Nations all around the world are trying to improve their schools in order to enhance the skills of their young people. Schools and education systems generate economic growth over the long term. The schooling factor and investment in human capital is strong and in harmony with economic growth. The relationship between improving school and cognitive skills translates into economic outcomes as a dynamic in the nature of human capital for growth.

The communication channel between education and development has been studied over the last 50 years. Barro (1991), Barro and Xavier Sala-i-Martin (1995), Xavier Sala-i-Martin (1997) found that school education is correlated with a positive GDP growth per capita. Quantitative the 1% increase in documents in education implies 30% faster annual growth. In In other words, the rates of change of a country's human resources, also give also and rates of change of the growth. The

development of human resources through systematic certification gives the dynamic relationship between education and development.

## 3. BIBLIOGRAPHIC REVIEW OF STUDIES

The bibliographic references and studies presented in this paragraph clearly show the great controversy and anxiety of scholars to bring education to a country's economic development. Studies were developed between education and earnings, quantitative education and quality education with percentage change in GDP. Studies that once either of these parameters have them either together or separately, each of which has its own results.

### 3.1 Experimental developmental analyzes using as a fact human resource
The macroeconomic literature focuses on the differences between the economic development of countries related to the level of studies or the years of school education. The initial analyzes were based on the student population, Barro (1991), Mankiw, Romer and Weil (1992), Levine and Renelt (1992), as it is a first sample of human capital. The data for enrollment and school years are, according to Barro (1993, 2001), internationally, statistics that can relate the amount of education to growth.

### 3.2 Experimental developmental analyzes by examining cognitive skills
Hanushek and Kimko (2000) have used the results of various cognitive tests that show a statistically and economically significant positive impact of these tests on economic growth. These estimates show that if a country has a higher return on such a test it will yield about one percentage point higher annual GDP growth.

## 4. EMPIRICAL MODEL

As we have already mentioned, the transformation of the models that link development to education, from its link to its quantitative characteristics, has now been linked to qualitative characteristics. The philosophy that new models want to introduce is that skills wherever they are acquired (home, school, work) are the ones that are integrated and analyzed in development models. This research has been based on a study and an econometric model developed by Barro in 1999, and I use data from 28 countries of the European Union for the period from 1990 to 2013.

## 5. QUANTITATIVE ANALYSIS OF THE DATA

The compendious presentation, of the independent variables we used:
**Initial level of per capita GDP**. Derivatives in an economy allow it to produce economic goods. **Government Expenditure**. The percentage of Government Expenditure in relation to GDP. **State of justice**. Many institutional analysts believe that the shielding of individual property rights and a stable justice system are key factors for investment and economic activity. **Democracy.** Another aspect of research into the role of the institutions in the impact of development. **Inflation**. The economy in essence detracts from the value of money and investment, examining whether it affects public and private investment in education has a lot of interest. **Education.** Typically, as we know, the state's biggest investment factor is education. **Fertility rates**. Fertility rates and the choice of this variable in a developmental function have to do with the logic that the more children are born, the more they will get into education.

## 6. RESULTS OF EMPIRICAL STUDY

The results are shown in Table 2 (see Annex), where the estimation of the panel - data regression to determine the GDP growth rate. The effect of the initial level of per capita GDP is shown in the estimated coefficients of the independent variables log (GDP) and log (GDP) in the square. The econometric model I used at the research and based on the $R^2$ determination coefficient (0.91) shows that the data I used approximated 91% of the regression line.
The estimated result using the least squares method for the 28 countries of the European Union is:
GDP_GROWTH = -8163.6 + 608.5*LOG(GDP_IN_USD) - 11.7*LOG(GDP_IN_USD)^2 - 0.31*GOVERMENT_CONSUPTION + 0.04*RULE_OF_LAW + 10.2*DEMOCRACY - 0.1*DEMOCRACY^2 - 0.02*INFL + 1.1*Y_SCH - 7.6*LOG(FERTILITY_RATE) + 0.6*INVESTMENT_RATIO + 0.02*TERMS_OF_TRADE

The results of working with the least squares method in the panel data are:

| Variable | Correlation Positive / Negative | statistical significance |
|---|---|---|
| log (GDP) | POSITIVE | YES |
| log (GDP) ^ 2 | NEGATIVE | YES |
| State expenses | NEGATIVE | YES |
| State of justice | POSITIVE | YES |
| Democracy | POSITIVE | YES |
| Inflation | NEGATIVE | NO |
| Human resource | POSITIVE | YES |
| Fertility rate | NEGATIVE | YES |
| new Investments | POSITIVE | YES |
| Terms of Trade | POSITIVE | NO |

## 7. CONCLUSIONS

As it is obvious from the conclusions of the analyzes and the research, the interest in the benefits of a society from the quality of education and the specific skills offered by education has shifted. These special or otherwise the above features that an employee may have are those that make the salary different. This explains the diversity of each worker and the diversity at the macro level for each country. Because, a society can develop from another when its human recourses,are more educated. The basic dilemma is if we want to have simple schools or good schools.

Empirical results show good and bad news to the anticipate future growth. The good news is that most countries, in co-operation with each other, are pursuing policies that seek to lead to higher growth rates. As is already known, countries that are initially low have the potential to grow at a faster rate. The bad news is that rich countries and countries with already high growth rates do not expect to see increased rates of growth. Developed countries, in order to be able to continue to grow, should invest in new products, new ways of production and investing in new technologies.

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## Annex

Table 1. Econometric Model of Labor, based on Barro (1999).

| Dependent variable | Independent variables |
|---|---|
| Percentage change in GDP | DUE (per capita GDP) |
| | Log (GDP per capita) ^ 2 |
| | Proportion of Public Expenditure / GDP |
| | State Law Index |
| | Republic Index Level |
| | Level Indicator Republic ^ 2 |
| | Inflation |
| | Years of schooling |
| | Log (fertility rates) |
| | Ratio investment / GDP |
| | Terms of trade |
| | residues |

Table 2 Estimation Model 28 countries.

Dependent Variable: GDP growth rate
Method: cross-sections - Least Squares.
Sample: 1990 - 2013
Period: 24 years
Countries: 28
TotalObservations: 672

| independent Variables | rated Coefficient | Typical error | t-statistic | Chance |
|---|---|---|---|---|
| C | -8163.661 | 663.3517 | -12.30669 | 0.0000 |
| DUE (GDP) | 608.5370 | 51.52028 | 11.81160 | 0.0000 |
| Log (GDP) ^ 2 | -11.72923 | 0.995001 | -11.78816 | 0.0000 |
| GOVERNMENT EXPENDITURE | -0.317014 | 0.058594 | -5.410382 | 0.0000 |
| state of justice | 0.043188 | 0.026109 | 1.654162 | .0986 |
| LEVEL REPUBLIC | 10.24575 | 0.868899 | 11.79164 | 0.0000 |
| LEVEL REPUBLIC ^ 2 | -0.102501 | 0.008840 | -11.59497 | 0.0000 |
| INFLATION | -0.020121 | 0.028020 | -0.718073 | .4730 |
| SCHOOL YEARS | 1.112681 | 0.369861 | 3.008380 | 0.0027 |
| Log (RATES OF FERTILITY) | -7.654649 | 3.349979 | -2.284984 | .0226 |
| STATE INVESTMENT RATIO | 0.634742 | 0.028821 | 22.02360 | 0.0000 |
| CONDITIONS OF INTERNATIONAL TRADE | 0.027192 | 0.007851 | 3.463358 | 0.0006 |

| | |
|---|---|
| R2 | 0.911321 |
| ADJUSTED R2 | 0.902289 |

# Legislative Reforms in Experimental Schools and their Reversals

*Anastasios Drongitis, MSc "Education Management"*
*Technological Education Institute of Western Greece*
*Department of Business Administration, Patras*
*adrogitis@sch.gr*

**Abstract**

A debate has been going on in recent years about the role of Experimental Schools. Several scientific and political arguments have been raised, concerning the goals of Experimental Schools. However it is frequently expressed that these goals are not met. With a "model of analysis" the scientific position that educational reforms are not independent from the socio-economic, cultural and political factors of the historical moment that are happening and with tools the Historical Comparative Analysis, attempts to approach the legislative reforms concerning the Experimental Schools and of their reversals.

The aim of this study is to describe and compare the two main reforms concerning the Experimental Schools in Greece: one in 1929 (Venizelou Government) and one in 2011 (Papandreou Government) regarding the context in which their gradual reversals took place, with the individual legislative changes that took place as the social, economic and political environment changed. It is noted that following the implementation of a comprehensive legislative reform of the Experimental School legislation and changes in the overall environment, changes are gradually taking place in individual but important points that eventually lead to the total dysfunctionality of the overall original philosophy of legislation.

The comparative review of the Experimental Schools legislation, in conjunction with the factors that formed it, leads to a deeper supervisory board)r understanding of how the Experimental Schools operate and is a useful tool for making alternative proposals and criticizing the proposed legislative changes.

**Keywords**:
Experimental Schools, Educational Legislation, Educational Reform, Excellence, Innovation

## 1. INTRODUCTION

The educational reforms follow political, social and economic changes. The factors that determine the educational reforms, through their interaction and have been defined as "fields of power" are: politics, economy, ideological and cultural context and the educational framework (Μπουζάκης, 2002). On this basis, it is possible to detect and analyze the evolution of the legislation concerning Experimental Schools over time.

As a methodological tool of comparative pedagogy and analysis, Historical Comparative Analysis (HCA) combines social science with history, with emphasis on the causal relationship between conditions and social phenomena. The HCA deals with interpretation and not with the prediction of educational events and phenomena (Καζαμίας, as cited in Δίπλαρη, 2011, pp. 159).

Regarding the interpretation of the texts, each political text and consequently every educational political text, especially in the case of educational reform, is formed by processes of interaction and compromise. It is likely that the focus will be largely lost in the practical implementation of the policy. The political text describes planning and strategy, but implementation is an independent, multifactorial process. For the study of a law it is necessary to carefully investigate and identify formalities that conceal latent meanings in order to interpret political action. Two levels of analysis are proposed in the interpretation of the political texts. (Ουδατζής, 2003, p. 124). The first level refers to the legal text and its purposes, the second level in social reality and the objectives of the text that serve it (Ουδατζής, as cited Δίπλαρη, 2011, p.164).

## 2. THE EVOLUTION OF THE LEGISLATION OF EXPERIMENTAL SCHOOLS

## 2.1 The reform of 1929-1930 and its overthrow

The establishment of Experimental Schools in 1929 occurs at a time when the Venizelos government policy is geared towards urban integration and modernization of society and the economy with the aim of reconstructing the productive structure, supporting the internal market and changing behavior and the attitude of the citizens (Vergopoulos, 1978). The literary and spiritual process of the period contributes to the gradual maturation of society and to the creation of the necessary conditions for the deterioration of the archaic ideal (Δελμούζος 1950, p.15).

However, conservative forces were powerful at the political level, supported the restoration of the monarchy and at the educational level they were opposed to the reforms and insisted on the classical and "Greek-Christian" content of education. But also from the left, criticism is strong. Glinos speaks of "the mockery of the people by his chosen ones" (Καραφύλλης, 2002), calling for generalization of Primary School and technical-vocational education (Μπουζάκης, 2002). In this context, the Experimental Schools of Athens and Thessaloniki are established under Laws 4376/1929 and 4600/1930. Their creation as a laboratory of Experimental Pedagogy was a demand for both progressive pedagogues since the founding of the Educational Group and for a conservative pedagogue such as N. Exarchopoulos (Σκληράκη, 1994). The Framework and Legislation for PCs 1929-1930 is presented in Table 1 below:

Table 1, The Venizelos reform (1929-1932)

| | |
|---|---|
| Law 4376/1929 (Government Gazette A 300 / 21-8-1929) "On the establishment of experimental schools at the University of Athens and Thessaloniki" <br> Law 4600/1930 (Government Gazette A 149 / 19-5-1930) "Amending and supplementing Law 4276" | |
| The social and political context | Prime Minister El. Venizelos. Action program for the modernization of society, the economy and the reconstruction of the productive structure. <br> Reflective problem <br> International economic crisis <br> Dissemination of the communist party's program- "ghost of communism" - is concerned with the bourgeoisie |
| The educational policy | Educational Democracy <br> Modernist Pedagogical-Didactic Framework- School of Labor <br> Technical and Professional Education |
| Purpose of Experimental Schools | Pedagogical training of future teachers. <br> "Therapy of Pedagogical Science" |
| Administration Institutions | **Supervisor :** Regular Professor of Pedagogy with the role of linking with the University and supervising the School **-** Exact jurisdiction by Presidential Decree **-** Role in the formulation of legislation <br> **Director :** Uniform Directorate **-** Duties of Inspector General and Inspector of Primary Education <br> College of teachers : Changing the timetable - curriculum - provision of *"experimentation"* |
| Teaching staff | Special employment status (wage, working hours, sabbaticals, transfers) <br> Selected by Supervisor and Manager |
| Students of Experimental Schools | Preferential number of students per class (30) <br> Primary: twenty boys and ten girls per class <br> Gymnasium: Only Boys <br> Selection of students: Elementary- psychological tests - Gymnasium - oral and written examinations |

While political developments in 1933 lead to a change in political affairs, there are actions that one might see as complementing the reform of the '29 and at the same time promote the neutralization of the reform and the return to the old spirit (Δημαράς, 1986 pp.39(2) ). The Royal Decree 550/1935, which comes to complement Laws 4376/1929 and 4600/1930, reveals the conservative shift and control of every progressive voice in education.

Table 2, Supplements - amendments to Law 4376/1929

| | |
|---|---|
| **The Royal Decree (Government Gazette 550/1935 (4) / 14-11-1935)** <br> "On the implementation of Laws 4376, 4600 on the Establishment of Experiments. Schools in the University.... and 6379 ... on the administration of education ... " | |
| Social and political context | Bankruptcy of the economy. Resignation of Venizelos <br> Continuous coups <br> Kondylis overthrows the Tsaldari government <br> Reconstruction of the Monarchy |
| The educational policy | Neutralization of the reform and return to the old spirit <br> Bureaucratic perception and centralization |

| Administration Institutions | The Supervisor's authority is limited to purely pedagogical issues-a reduced role<br>Administrative omnipotence of the Director<br>College of teachers: an executive body, strictly supervised and continuously evaluated and judged. |
|---|---|
| Practical exercises | Obligation to attend the graduates of the Faculty of Philosophy and Theology and the Faculty of Physics and Mathematics who will work as teachers<br>The ban on appointing a teacher without the pedagogical degree is lifted<br>Obtain a pedagogical degree and after appointment with educational leave |

## 2.2 The laws of 1977-1981 and Law 1566/1985

It will be over forty years since no remarkable change will occur in the legislation of the Experimental Schools, except for the establishment of the Experimental School of the University of Patras in 1972.

After the 1974 uprising, the need for legislative intervention was created because of the increasing pressure from parents who, in search of better education, are requesting the enrolment of their children in the Experimental Schools. Thus, Presidential Decrees 483 & 484/1977 were adopted, later amended by Presidential Decrees 497 & 498/1981. In the framework of the general educational reform of the period, the "opening" of the Experimental Schools are being taken, giving the opportunity to access the "rising social intermediary" (Μπουζάκης, 2002, pp.54(2) ). Thus the region of the Experimental Schools was abolished and the draw was introduced as the only way of introducing them.

The 1976 reform was not later cancelled with a counter-regulation. Law 1566/85 did not repeal the fundamental provisions of Law 309/1976 (9-year compulsory education, municipal language etc). For the first time, Experimental Schools are operating, not linked to the Universities and do not follow the Law 4376 / 1929 and the Law 4600/1930, alongside the University Experimental Schools. Experimental Schools operate at the headquarters of each Regional Training Center (RTC). However, there is a clear separation between these Experimental Schools of RTC. And the Experimental Schools of the Universities.

The Standard Secondary Education Schools are also converted into Experimental Schools of ΠΕΚ, while the Standard Schools of the Pedagogical Academies and the Kindergarten Schools are renamed Experimental and with Ministerial Decision Φ27 / 148 / C1 / 160 -14/2/1995 joined the Pedagogical Departments

## 2.3 The 2011 reform and its overthrow

The multiplicity of types of Experimental Schools, the non-issuance of a Presidential Decree for the University Experimental Schools, the stagnation of any research and experimentation effort, and their discrediting, led to the formulation of the request for modernization of the legal framework of Experimental Schools. Papandreou's government (Ministry of Education, D. Diamantopoulou) promoted Law 3966/2011, aiming at reforming the Experimental and Template Schools in "Cells of Excellence and Implementation of Experimental Education Policies" to become "Pilots of Knowledge" (Briefing Note on Issues in the Council of Ministers, 29/12/2010). For the first time an evaluation of the Experimental Schools was carried out with a specific framework and measurable criteria for the selection of the new Experimental School Templates. Model experimental schools have been standardized with Experiments. The term " Model experimental schools " are mainly high schools, which are differentiated for historical reasons and are distinguished for their pursuit of high performance and their selective character as the introduction of students is always done with examinations.

Table 3, the 2011 educational reform

| Law 3966/2011 *" Institutional framework of the Experimental Schools, Establishment of the Institute for Educational Policy, Organization of the Institute of Computer Technology and Publications" DIOFANTOS "and other provisions.* | |
|---|---|
| Social and political context | Prime Minister G. A. Papandreou<br>Poor economic situation - risk of bankruptcy<br>Financial control by the IMF, the European Central Bank and the EU - loan agreements |
| policy          The educational | Combining school units<br>Law 4009/2011 for Universities<br>Unified Reformed Education Program at 800 Primary Schools<br>Remove all-day departments of multigrade schools<br>Removing Additional Support<br>Reduction of Grants to School Committees<br>Deficit of the administrative mechanism |

| | |
|---|---|
| Purpose of Experimental Schools | Education of future teachers<br>Teacher training and testing of new methods and teaching tools<br>Training students with high learning abilities and talents - supporting the goal of excellence through group function |
| Administration Institutions | Aggregate management system<br>National level: Governing Board of Experimental Schools (GBES)<br>School Unit: Scientific Supervisory Board (SSB)<br>College of teachers with limited competencies<br>Universities are linked to Experimental schools without administrative responsibilities<br>Experimental Schools are administratively assigned to the Regional Director of Education<br>Director of the Experimental Schools - four-year term - selected and evaluated every two years by GBES, Deputy Director of the Experimental Schools is selected by SSB - is evaluated every two years by Governing Committee<br>Administrative-support staff: Psychologist, two administrative officers, caretaker |
| Teaching staff | Continuous and systematic evaluation<br>Selection in a special way - five-year term, with positive evaluation by the Hellenic Environmental Protection Agency renewal of the mandate for another five years<br>Teachers of the Experimental School Standards are not transferred or postponed during the five-year term<br>Evaluation by SSB every two years, |
| Students of Experimental Schools | Registration in Primary Kindergartens and Primary Schools by lottery<br>Subscribe to Experimental Gymnasium on the basis of a decision by the GBES, after a proposal of SSB<br>Introduction of pupils to PC Lyceum is made after examinations or skill test, at the decision of the GBES, following a proposal of the SSB.<br>Registration and attendance of students with certified special abilities at a rate not exceeding 1%<br>Excellence groups that take advantage of the increased student abilities |

With Law 4371/2015 (Prime Minister Al. Tsipras, Ministry of Education Ar. Baltas) changes were made concerning the Experimental Schools. The Experimental Schools were separated from the Model Experimental Schools).

The introduction of students in the Experimental Schools is done only by drawing lots, while in the Model Experimental Schools, with examinations (v.4327 / 2015).

By a bill voted on 23-4-2019 experimental schools are administratively responsible for the Education Directorate and the scientific responsibility for the implementation of the research or training activities are the College of teachers, the body that has designed the research or training activity or the pilot implementation of programs and the SSB.

The five-year mandate and the evaluation of the teachers who teach them, are abolished and the posts already given to the existing staff are given. The link between previously connected Experimental Primary and Secondary Schools is abolished.


## 3.   CONCLUSIONS


The history of educational reform in Greece includes multi-annual law-making and reform processes, but they often do not progress. Greece's inability to make significant progress in improving its performance compared to other EU and OECD countries is directly linked to the difficulties of implementing "benevolent reforms" (OECD, 2011).

But even "cancelled" reforms such as those of 1913-17, 1929 -30, 1964 have paved the way for the changes that will follow. The placement of the Experimental Schools moves in two directions: the research and the training-exercise of students and teachers. In either direction, there was no organized and consistent implementation. None of the innovations of the last years have not been experimentally tested. Practical exercises of students are carried out in Experimental as well as in many other schools, without the Experimentation having an institutional central role.

The demand for Experimental Schools is now intensified due to social pressure on public schools as a response to "good" private schools, the revival of old standards with multiple selection filters and exams, and experimental schools that act as authentic pedagogical and teaching workshops.

The challenge is Experimental Schools to implement tomorrow's school today. Each of them, with the help of the University to which it belongs, should differentiate and shape its own character and direction. Such an Experimental School approach is not levelling, nor indifferent to students who have separate talents or capabilities.

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