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Contents

Guest Editorial

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This Special Issue of the Studies in Regional & Urban Planning is devoted to the Joint Fourth Scientific Conference on Project Management (PM-04) & the First IPMA /MedNet Conference, which was focused on "Project Management Advances, Training & Certification in the Mediterranean" (http://2008.pmgreece.gr). The conference that was jointly organized by the Centre for Construction Innovation (CCI) (www.innovation.view.gr), Department of Construction Engineering & Management, National Technical University of Athens (NTUA) and the Department of Financial & Management Engineering (www.fme.aegean.gr), Business School, University of the Aegean was held at the island of Chios, Greece in May 29-31, 2008. The conference was also supported by the profPM project (http://cem.civil.ntua.gr/profpm), which is a Government co-funded effort aiming at developing a project management certification scheme in Greece, the International Project Management Association (IPMA – www.ipma.ch), PM-Greece (www.pmgreece.gr) and PMForum (www.pmforum.org).

The conference has managed to attract the interest of individuals from different fields of practice and academic research, however all related to project management advances. The knowledge and experience with regard to project management issues on several industry and research sectors including among others construction, information technology, public government, etc. were presented through some eighty papers that are included in the conference proceedings. This Special Issue comprises nine of these papers based on the criteria of quality of work and origin. The scope of this Special Issue is to present the recent work on project management performed by professionals and researchers in Greece and we believe that the selection of the invited papers is fulfilling this scope. The authors of the selected papers were asked to produce extended and updated versions of their work and submit it for publication in this Special Issue. The outcome has matured in the past few months at an appropriate level to meet the requirements of publication at the journal of Studies in Regional & Urban Planning.

The included papers are divided in four thematic sections that cover a wide range of applications and knowledge on project management practices and theoretical issues. From the most relevant to the journal's readership issues of tourism planning (Papapavlou-Ioakeimidou) and sustainability

(Panagiotakopoulos) to the presentation through a case study of theories and models of motivation and leadership (Zapounidis, Kalfakakou and Athanasiou) several other issues mainly related to the construction sector are presented. Legislation issues in public interest construction projects (Kostidis and Kirytopoulos), assessment of financial performance of construction firms based on indicators (Manoliadis and Tsolas), and a method of selection between investment alternatives (Kalfakakou, Pantouvakis and Xenidis) are highlighted and provide with interesting results and applicable tools for the practitioners and professionals with regard to planning and monitoring of construction projects. The last thematic section concerns the application of project management and operations research tools and methods to core construction topics: creative design and quality issues of building projects (Vissilia), earthmoving fleet size optimization (Marinelli, Lambropoulos and Pantouvakis) and productivity of construction operations (Panas, Pantouvakis and Lambropoulos) are investigated in high quality scientific papers. We believe that the papers that are included in this Special Issue provide a clear and sufficient insight of project management advances in several fields and we hope that this Special Issue will raise the interest of the journal's readers.

As guest editors, we would like to thank Professor Karkazis, University of the Aegean, Editor-in-Chief of the journal of Studies in Regional & Urban Planning for his valuable help and guidelines with regard to the editing issues of this publication.

Also, we would like to thank Dr. John Paris-Pantouvakis, Associate Professor, National Technical University of Athens, who contributed significantly acting on behalf of the sponsor of the publication of this Special Issue, namely PM-Greece: The Network of Project Managers in Greece, a member of IPMA, ICEC, SENET & MedNet (www.pmgreece.gr). Last but not least, we would like to thank all authors who contributed to this publication and made it possible for you – the readers – to have it in your hands and, hopefully, find it interesting and contributive to your work.

1.1 References

Pantouvakis, J.P. *(editor) (2008)* "Proceedings of the Joint Fourth Scientific Conference on Project Management (PM-04) & the First IPMA /MedNet Conference - Project Management Advances, Training & Certification in the Mediterranean"*, May, 29-31, Chios, Greece, ISBN 978-960-254-677-2, p. 538*

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TOURISM PLANNING AND OPERATIONAL RESEARCH: METHODS AND TECHNIQUES

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Abstract. Globally, tourism is a particular sector of the economy that presents significant perspectives of growth in the near future. Effective management of space and integration with tourism activities is a complicated task that requires a holistic approach including spatial, financial, and environmental planning as well as social analysis. Operational research provides methods and techniques that can assist the planning, monitoring, and control of tourism infrastructure. Evaluation of alternative strategies, action plans and policies as well as confrontation of performance and risk issues can be achieved in the rational and systematic frame of operational research. This paper presents the fields of application of the main methods and techniques of operational research to the regional and tourism planning. It demonstrates the advantages, benefits and limitations of the merging between operational research and regional and tourism planning and provides with certain suggestions to associate operational research techniques with regional and tourism planning steps.

Keywords: Tourism, Planning policies, Regional development, Operational research

1. THE EFFECT OF TOURISM ON ECONOMY, ENVIRONMENT AND SOCIETY

Tourism is not a stand-alone activity; it largely depends on changing economic situations, fashions, traditions, socio-political considerations, education and government policies, and publicity and promotional activities. Furthermore, tourism often relies on the policies of foreign governments mainly in destination countries.

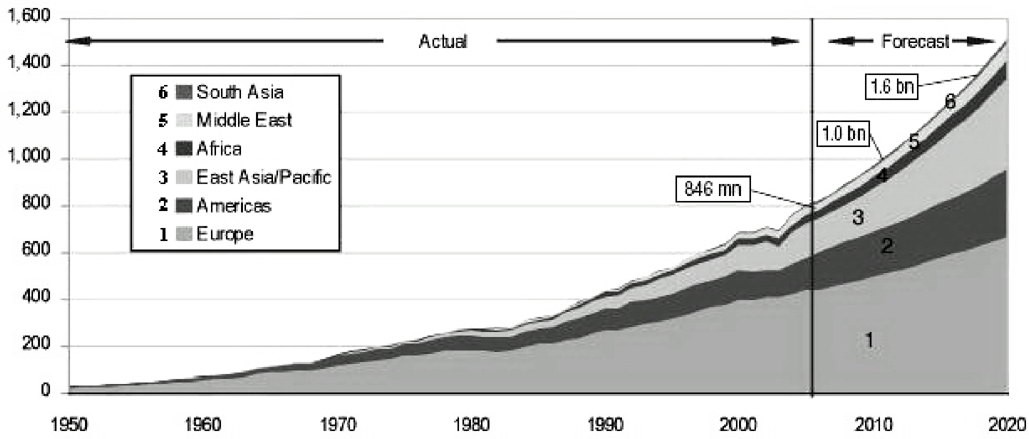
The term "destination" refers broadly to an area where tourism is a relatively important activity and where the economy may be significantly influenced by tourism revenues. Destination management is complicated by the fact that a single, recognizable destination may include several municipalities, provinces, or other government entities - in island environments it may be the entire country.

Furthermore, tourism is a sector of great importance for the global economy and growth. The facts and figures of international tourism receipts (Figure 1.1) provided by the World Tourist Organization (UNWTO, 2007) are very indicative of a growing sector, which is expected to develop even more in the short- and long-term (Figure 1.2). This prospect clearly indicates the demand for the development of adequate infrastructure that will assist – along with appropriate policies – to the achievement of higher quality standards and sustainability for tourism.

FIGURE 1.1. International tourism receipts (modified from UNWTO (2007))

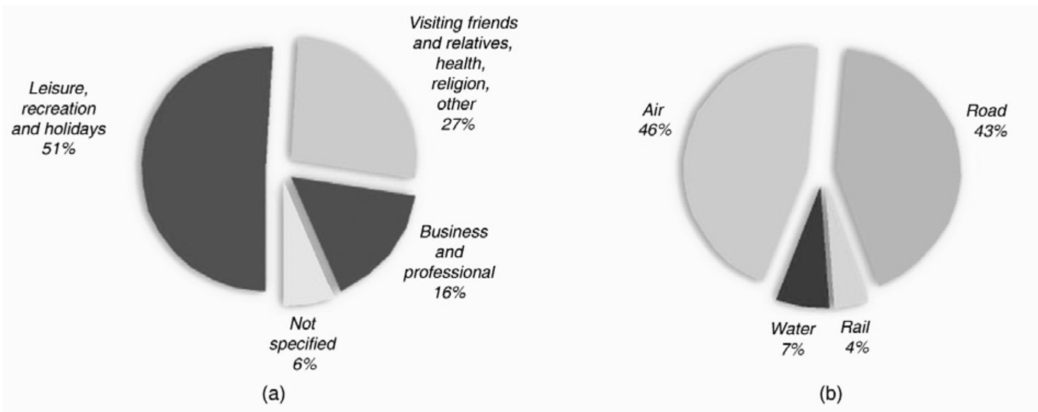
	Change local currencies, constant prices (%)				Share (%)	Euro		
						Receipts (billion)		Receipts per arrival
	03/02	04/03	05/04	06*/05	2006*	2005	2006*	2006
World	-1.5	9.8	3.2	4.3	100	544	584	690
Europe	-1.5	3.1	2.5	3.7	51.1	280.4	298.3	650
Asia and the Pacific	-8.7	25.1	4.0	8.9	20.8	108.1	121.5	730
Americas	-2.1	11.6	4.3	1.8	21.0	116.7	122.6	900
Africa	23.8	6.0	10.5	10.2	3.3	17.4	19.4	480
Middle East	27.5	25.3	-1.8	-1.4	3.7	21.1	21.8	520

FIGURE 1.2. Forecast for international tourist arrivals by the World Tourist Organization (modified from UNWTO (2007))



The development of the infrastructure requires a detailed and thorough analysis of quantitative and qualitative data that concern motivation and preferable destinations by tourists, demands, mode of transportation, etc. Figure 1.3 provides such quantitative data for the year of 2006, which constitute a general basis that should be further analysed to the regional and national level.

FIGURE 1.3. Data for 2006 world tourism: (a) Tourism, by purpose of visit (share), (b) Tourism, by means of transport (share) (modified from UNWTO (2007))



The required infrastructure when established in a specific area significantly affects the environment and the society. There are three main types of environmental impact related to tourism (Markandya et al. (2005), UNEP-Tourism (2002)):

- Deterioration of the natural environment (physical impact), which may appear in the form of: a) sand mining, b) beach and sand dune erosion, c) soil erosion and extensive paving, d) land degradation, e) ecosystems degradation, f) loss of biodiversity, and g) deterioration of scenery.
- Depletion of natural resources and especially: a) fresh water, b) energy resources, c) forests, d) minerals and fossil fuels, e) fertile soil, f) wetlands, etc.
- Pollution of soil, water and air, which may appear in the form of: a) solid wastes and littering, b) releases of sewage, c) air emissions, d) noise pollution, d) aesthetic pollution (visual/architectural).

With regard to the societal impact the following main risks are highlighted (UNEP-Tourism (2002), Sawkar et al. (1998)):

- Commercialism of local culture, religion and habits that results to the conformity with the tourists' expectations and finally to: a) the loss of cultural identity and authenticity and b) cultural erosion.
- Standardization of the tourism facilities for accommodation, recreation and transportation, which results to radical changes of local inhabitants in their normal living.
- Cultural clashes, which may have their origin in economic inequalities and various differences in cultures, religions, moral values, lifestyles, languages, levels of prosperity, etc.
- Increase of crime, child labour and illegal prostitution.
- Resource use conflicts between local populations and tourists, especially in cases of scarcity of supplies.
- Conflicts in the local community for the use of land (tourism infrastructure vs. local traditional land-use), especially in intensely exploited areas.

From the above it is inferred that tourism planning and development require a very systematic approach of implementation to achieve the successful integration of tourist systems into pre-existing local economic, environmental and societal structures, thus gaining only prosperity and benefits for the local communities.

1.1 Tourism planning factors and requirements

The general concept of tourism planning seems very abstract until it is brought into applicable levels. Tourism covers all scales of development from national to local. Even though the planning goals may be the same, the approaches and processes may be different for several geographical and political levels.

Tourism planning introduces several factors and requirements of economic, spatial and temporal nature. These factors are the variables of the tourism planning problem which may be optimised by the use of operational research methods and techniques. The most important of these factors are:

1. The tourist system, which is defined as the precarious locomotion of persons from the place of their permanent stay to another, with exclusive aim the satisfaction of tourist needs (demand-side), and the organised effort for the attracting, reception and service of those persons (supply-side).
2. The tourist supply-side and the tourist demand-side presuppose the existence of a product that has quantitatively and qualitatively features, that is to say the Tourist Product.
3. A third dimension beyond the productive and consuming dimensions, which is indirectly connected to these two, is the territorial and environmental dimension that is the use and management of natural and human resources.
4. The territorial factors of tourist phenomenon are reported: a) In the place of destination, that is places where tourist activities take place) b) In the movement, that is the travelling of tourists from their settlements to the place of reception) c) In the time (The time period when a tourist activity occurs and the time duration of a tourist activity).

In addition to the above factors, tourism planning should integrate respective strategies, policies, and action plans to develop the tourist potential of a particular place. There are basic requirements of spatial policies in regional and tourism development planning: a) The establishment of objectives, b) The incorporation of these objectives into a policy statement, c) The formulation of policy guidelines to establish planning parameters, d) An implementation programme to achieve what is set out in the plan, e) A monitoring mechanism to assess whether the tourism development plan is meeting its objectives, f) A review process to revise and refine objectives and policies as necessary. The study of diverse and changing spatial relations and existence of spatial variations with their impacts on several functions in different regions and sub-regions systems is a complex task.

The process of regional development under these conditions is consequently very complex, and attempts have been made by economists, geographers and planners to understand this process through the formulation of models of development, and other methods and techniques of regional analysis.

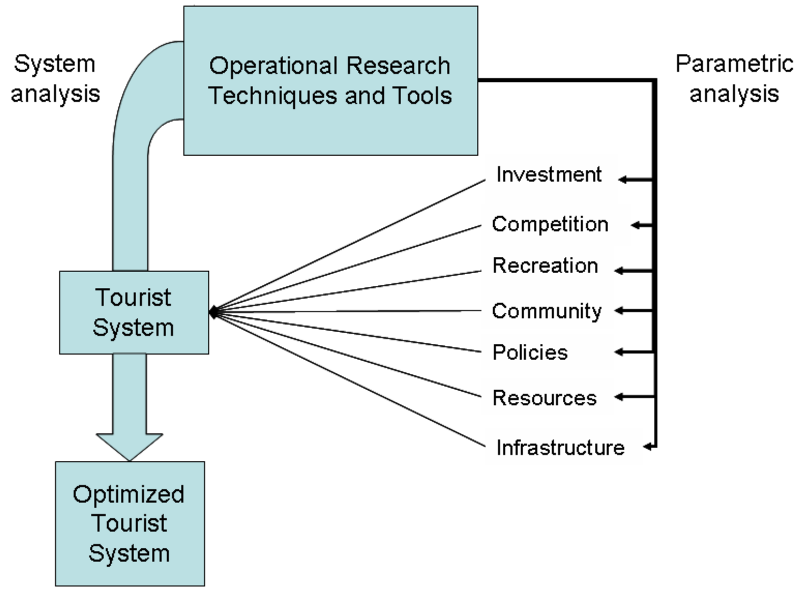
An adequate regional analysis has to meet three requirements.

- It must clarify the reordering of spatial relations that occurs under conditions of growth.
- It must be able to account for changes and spatial variations in regional subsystems.
- It must explain the changing influence of spatial patterns on system-wide growth.

2. THE INTEGRATION OF OPERATIONAL RESEARCH AND TOURISM PLANNING

Operational Research (OR) introduces applied mathematics to solve the optimization problem in cases of complex systems. The mathematical content of OR framework and tools provides with a systematic approach for problem solving that reduces model uncertainties and results to optimized solutions. An important feature of OR is that it can be used, equally, to examine entire systems and specific parts of those. Therefore, OR can be extremely helpful in tourism planning since it can be used to optimize, either: a) The entire tourist system (system analysis) based on the specific requirements of spatial and other local characteristics of the system's establishment area, or b) Specific problems related to certain parameters of the tourist system (parametric analysis), which may be preferable to examine individually for simplicity in planning (e.g. competitive tourism activities). A graphical presentation of the integration of OR with tourism planning is shown in figure 2.1. The methods and the techniques of operational research provide a rational and systematic frame for the evaluation of alternative policies and action and the choice of most optimal solution in complex problems of decision-making [Dann, G., Nash, D. & Pearce, P. (1988)].

FIGURE 2.1. A generic presentation of the integration between Operational Research and tourism planning



The operational research methods and techniques that can be integrated with tourism planning can be classified in four categories (Komilis and Vagionis (1999)) as presented in table 2.1. Qualitative methods and techniques (M&T) are mainly approaches based on experts' judgments, multicriteria M&T treat, simultaneously, more than one problem dimensions (e.g. environmental, societal and economic) by the use of, both, qualitative and quantitative data. Economic M&T are mainly focusing on the economic impact of tourism development, while ad hoc processes are used individually provided their appropriateness for application on a "per case" basis.

TABLE 2.1. Classification of Operational Research methods and techniques that can be used in tourism planning

Category	Methods and Techniques (M&T)
Qualitative M&T	1. DELPHI Method 2. Contingent Valuation Method 3. Analytic Hierarchy Process (AHP)
Multicriteria M&T	1. Dominance and Frequency Analysis 2. Concordance Analysis 3. Compromise Solution 4. Multidimensional Scaling 5. Regime Analysis
Economic M&T	1. Input – Output Analysis and the Multiplier Process 2. Cost-Benefit Analysis 3. Economic Base Analysis Hedonic Pricing 4. Travel Cost
Ad hoc M&T	1. Content analysis 2. Goal Achievement Matrix (GAM) 3. Ultimate Environmental Thresholds Method (UETm)

The methods and techniques listed in table 2.1 can be implemented in various steps of tourism development planning and in relation to specific requirements. It is noticeable, in general, in tourism studies that the choice of themes of interest and the methods of approach have more often been determined by practical rather than theoretical considerations. The introduction of operational research methods and techniques into tourism planning provides with certain benefits as the effectiveness of economy (efficiency), the social equality and justice (equity) and the protection of the environment (conservation) [Smith, S.L.J., (1991)].

3. CONCLUSIONS

Even if tourism is often represented as an industry of low impact, contemporary research begins to recognize tourism as a factor of environmental change and considers the heterogeneous nature of the tourism phenomenon and organizational and functional structures of tourist destinations. Today, the increased awareness of the developed world for the impacts of tourism in developing societies, and the subsequent need to see the unknown before its destruction, leads from the small scale tourism labels in the 1990s to new tourism patterns such as alternative tourism, appropriate tourism, soft tourism, responsible tourism, people to people tourism, and eco-tourism, all displaying the industry's recent popularity.

Therefore, planning for tourism development can take place at various levels. The process of analysis of phenomena of tourism and their expression in the space, national, regional or local, the export of conclusions, the localisation of peculiarities of problem and finally the formulation of feasible proposals and solutions presuppose complete knowledge of processes of production of phenomena, interaction with the environment but also the detection of mechanisms and particular conditions, combinations and interactions that act upon the creation and appearance of concrete problems.

The examination and the evaluation of terms of tourism development presuppose the economic, social and ecological systems simultaneously in a single frame of analysis that aims at the reduction of intensities and oppositions from the complex interactions between the tourism industry, the local communities and the environment.

The complexity, on one hand, and, on the other hand, the extensive problem of effective management and planning of tourist destinations, along with the need for harmonised diachronic and interdisciplinary collaboration, obviously, demand for an interdisciplinary approach, which is required for the complete assessment and evaluation of the quantitative and qualitative characteristics of space, their cross-correlations and their changes through time.

Therefore, it is inferred that the process of tourism planning, essentially, connects all phases of energies and actions and is in synergy with other parallel or relative processes of developmental planning. Consequently, development and application of operational research methods and techniques provide a rational and systematic frame for the evaluation of alternative policies and actions and the choice of the most optimal of them.

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THE SUSTAINABILITY DIMENSION IN IPMA COMPETENCE BASELINE TECHNICAL ELEMENTS

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Abstract. The performance of the project manager (PM) is assessed through criteria expressing the values and priorities of the Organization financing the project. The prevailing socio-economic framework sets bounds on the project's scope and its environmental and social impacts. These bounds affect the PM's performance which is tied to the organization's behavior; he must adhere to the organization's strategy and enhance its sustainability which is tied to the project's sustainability. The objectives of this paper are (a) to refer to notions regarding project sustainability and (b) to examine the PM's share of responsibility in enhancing sustainability. The PM's role is analyzed with reference to the twenty technical competence elements identified in IPMA Competence Baseline. A Study Table is proposed as a basis for further study showing, for each of those elements, the PM's authority and his impact on the parameters affecting project's sustainability. Essentially, this paper proposes a sustainability criterion for assessing project management success.

Keywords: Project management, Sustainability, ICB/IPMA

1. INTRODUCTION

According to IPMA Competence Baseline (2006), a project (or a programme or a portfolio of projects) is an operation to realize deliverables which define the scope of the operation; the project may vary from simple projects to complex endeavours (such as enhancing the profitability of a multinational corporation to the satisfaction of its shareholders). Project Management Success is the appreciation of the *project management results* by the relevant interested parties. The performance of the project manager (PM) is assessed on the basis of criteria which are set by (and express the values and priorities of) an Organization (government, corporation, construction company, business firm, NGO, etc.) which is financing the operation and is interested in its outcome.

Regardless of *hierarchy* (project, programme, or portfolio) and *scope*, the project unfolds within a specific socio-economic framework, generating (as by-products) undesirable environmental and social impacts. The socio-economic framework sets bounds on the scope of the Organization's projects and imposes limits on their impacts, aiming at a sustainable behaviour by the Organization. These bounds must be taken into consideration by the PM who is also keen on adhering to the organisation's strategy and on enhancing its *sustainability*.

The sustainability of any system is assessed by the system's contribution to the sustainability of its hierarchically higher system. Thus, the sustainability of a project (and, thus, of the PM's performance) is tied to the behavior of the Organization creating the project. The objectives of this paper are (a) to refer to notions regarding project sustainability and (b) to examine the PM's share of responsibility in enhancing sustainability. This role of the PM is analyzed with reference to each of the twenty technical competence elements identified in IPMA Competence Baseline (v.3) and listed in table 3.1. It is hereby assumed that the reader is familiar with the content and essence of these elements.

2. THE SUSTAINABILITY DIMENSION OF PROJECT MANAGEMENT

According to Decleris (2000), "*sustainability is the self-evident term for the dynamic equilibrium between man and nature and for the co-evolution of both within the Gaia mega-system*". Man-made systems, seemingly separated from ecosystems, are entirely dependent on them to the extent that man-made systems:

- convert ecosystems elements into useful natural resources and
- discharge into ecosystems the undesirable by-products of their operation.

This relation is restricted by the exhaustion of the *finite resources* (bounds on resource availability) and of the *carrying capacity* of ecosystems (bounds on allowable impacts). The PM is expected to deal with both of these bounds.

In project management, sustainability refers to two distinct dimensions:

1. The *survivability of the project* itself, over its useful life-cycle, as an operational and productive structure, and
2. The *acceptability of the overall impacts* (economic, social, cultural, environmental) due to both the project's process and the project's products.

2.1 Complex adaptive systems and sustainability strategies

Let us consider the survivability of the project. In an ecosystem analogy, projects (or programs or portfolios) may be studied as Complex Adaptive Systems (CAS), characterized by non-linearity and potentially chaotic behaviour; these characteristics imply difficulty in predicting the system's behaviour. Ravetz (2000) identifies four key properties that usually characterize CAS (ecological or industrial; in our case, the project) which are sustainable:

- *Co-existence*: Ability to co-exist with other linked systems, at higher or lower scales; i.e. to respect the limiting factors of the environment in which it is embedded and to contain its pressure on other linked systems. In project management, co-existence is related to, at least, elements 1.06 and 1.09 (Table 3.1).

- *Effectiveness*: It refers to the utilization of resources by throughput of energy or other resources. It is related to, at least, elements 1.03, 1.05 and 1.12 (Table 3.1).

- *Robustness or Resilience*: As the context (i.e. the organizational or physical environment) in which systems are embedded may be dynamic and in constant change, the system (in our case, the project) should be resilient, i.e. able to maintain its structure in a variety of external conditions. It is related to, at least, elements 1.06 and 1.11 (Table 3.1).

- *Adaptability*: Apart from being resilient, a system needs to evolve and change its structure and functions; to survive changes of its environment as it moves into different attractors. Internal variety and complexity are needed for both robustness and adaptability. (Related at least to elements 1.15 and 1.18).

Regarding social acceptability of project processes and outcomes, it is noted that a project unfolds within an organizational context (e.g. within a corporation). The Johannesburg Declaration (United Nations, 2002) for sustainability states that: "*…there is the need for private sector corporations to enforce corporate accountability, which should take place within a transparent and stable regulatory environment*". Schot et al., (1997) distinguish four corporate strategies towards sustainability:

- *The defensive strategy:* minimum compliance with regulations and standards.

- *The offensive strategy:* go beyond compliance and gain competitive advantage.

- *The eco-efficiency strategy:* identify win-win solutions by reducing environmental impacts and costs.

- *The sustainability strategy:* focus on emerging partnerships between business and stakeholders and adopt the new values of sustainable development.

Today, all except the first strategies are voluntary and their drivers are related to business benefits (business case), such as (The Sigma Project, 2003):

- Improved operational efficiency
- Enhanced brand value and reputation
- Customer attraction and retention
- Enhanced human and intellectual risk
- Improved management of risk
- Attracting and retaining talented staff
- Preservation of licence to operate
- Promoting and increasing innovation
- Improved access to capital
- Building and sustaining shareholder value
- Generating increased revenues
- Identification of new opportunities

2.2 The Five Capitals Model

According to the Five Capitals Model (FCM) (The Sigma Project, 2003) of sustainability, each and every company needs five capitals to function properly:

- *Ecological or Natural capital (N)*: the natural resources (energy and material) and processes needed to produce the products and deliver their services.

- *Manufactured capital (M)*: the material goods (tools, machines, buildings, and other infrastructure) which contribute to the production process but do not become embodied in the outcome.
- *Human capital (H)*: incorporates the health, skills, intellectual outputs, motivation and capacity for relationships of the individual, which can contribute to the productive work. It is also about dignity, joy, passion, empathy and spirituality. For companies, human capital mainly refers to their staff, business partners and suppliers.
- *Social or organisational capital (S)*: It is any value added to the activities and economic outputs of an organisation by human relationships, partnerships and co-operation. It includes communication channels, communities, businesses, trade unions and voluntary organisations, as well as cultural social norms, values and trust.
- *Financial capital (F)*: Reflects the value of the four other types of capital and covers those assets of an organisation that exist in a form of currency that can be owned or traded, including (but not limited to) shares, bonds and banknotes.

Panagiotakopoulos (2005) extended this notion of the FCM to a project. The completion of a project requires the use of a combination of the above five capitals. At the portfolio level, where policies are formulated and the scopes of the projects are set, the potential of a manager to affect sustainability is far greater than at the much lower project level. A project is a vehicle for attaining the portfolio's objectives. It is the portfolio that counts, not the project per se. At the project level, the selection of the five-capitals combination concerns mainly the production process; at the portfolio level, it concerns mainly (1) the products and their lasting impacts and (2) the impacts on the employed capitals themselves.

3. SUSTAINABILITY OF A PROJECT – THE ROLE OF THE PM

A widely accepted, and politically convenient definition for a sustainable project is a project whose economic, social, environmental and cultural impacts are socially acceptable. The immediate concerns arising from such a definition are: Who and how expresses society? What of the economic and environmental externalities? What of yet unknown or incomprehensible impacts to present or future generations?

Realizing that there can never really be a universally accepted and unquestionable definition of a "sustainable project", the issue is bypassed by introducing the notion of a project's contribution to sustainability. This contribution is assessed through reference (a) to the employment of the five capitals and (b) to the social acceptance. Any action by the PM that enhances the project's contribution to sustainability is desirable. But how is sustainability enhanced? Here are some ground rules:

1. The broader the scope, or viewpoint, of the assessment, the better.
2. The wider and the more equitable the social acceptance, the better. The more the affected social groups that consent, the better. The group is preferred over the individual, the country over the city, the planet over the continent.
3. The longer the time horizon over which impacts are assessed, the better. Some impacts last for decades, others for centuries or forever. The bigger the concern for the future generations, the better.
4. Since a project is a subsystem of a program or portfolio, it is the sustainability of the higher system that counts. The bigger the contribution to the sustainability of the higher system, the better. The higher the hierarchical level of the system affected positively, the better.

Table 3.1 is a proposed *Study Table* for the potential of the PM to enhance project sustainability. The second column is a list of the IPMA (2006) technical elements.

TABLE 3.1. The PM's potential for enhancing sustainability at the project level

ICB TechnicalElement		PM's Role: D: Decisive C: Contributory	The PM mostly affects: V: Viewpoint E: Extent of social acceptance T: Horizon of impacts	Mainly affected form of capital
No.	Content (at the project level)			
(1)	(2)	(3)	(4)	(5)
1.01	Project management success	D,C	V	ALL
1.02	Interested parties	D,C	V,E	S,H
1.03	Project requirements and objectives	D	V,T	N,S,F
1.04	Risk and opportunity	D	T	F
1.05	Quality	D,C	T,E	
1.06	Project organisation	D		S,H
1.07	Teamwork	D		S,H
1.08	Problem solution	D,C	V,T	ALL
1.09	Problem structures	D		
1.10	Scope and deliverables	C	V,E,T	N,F
1.11	Time and project phases	D		N,F,M
1.12	Resources	D		N,F,M,H
1.13	Cost and finance	D		F
1.14	Procurement and contract	D,C	T,E	N,F,M
1.15	Changes	D,C	V	ALL
1.16	Control and reports	D	V	
1.17	Information and documents	D	V	
1.18	Communication	D	V	
1.19	Start-up	D,C	V	
1.20	Close-out	D,C	V	

The entries in columns 3 to 5 refer to the project level, not to Programs or Portfolios, and are supposed to express the PM's position vis a vis each of the 20 technical elements, as they are defined by IPMA. These entries, which are open to discussion, express preliminary assessments, by this author, of the PM's authority and his impact on the parameters affecting project's sustainability. They are supposed to show, on the opinion of this author and with regard to each element, how the PM appreciates the situation and whether he can affect it. Specifically:

Column 3: Expresses the PM's role regarding the element. Symbols D and C are employed as follows:

D: *Decisive*. The PM is the main, the decisive decision-maker.

C: *Contributory*. The PM contributes to relevant decisions that are taken at higher levels of management.

Column 4: Indicates whether the PM, *by his decisions*, affects mostly the:

- *Viewpoint (V), i.e. criteria, objectives and scope of the project*
- *Extent (E) of social acceptance*
- *Time horizon (T) of the impacts of decisions taken by the PM.*

Column 5: Indicates which of the Five Capitals (N, M, H, S or F) are involved in dealing with the corresponding element.

It is again noted that the entries in table 3.1 refer only to the PM's potential at the project level. The PM's authority, especially his impact on "extent" (E) and "horizon" (T), is limited. It is presumed that more critical, from the sustainability point of view, decisions are taken at higher organizational levels.

Let us see some examples from the entries in table 3.1: In elements 1.01, 1.02, 1.05 1.14 and 1.15, the PM has very limited authority, often none (the situation might be different at the portfolio level). At element 1.03, the affected capitals are mainly the social, the natural and the financial, since the requirements refer to resources and money; however, this is taking place within bounds concerning the social capital: rules, values, trade unions, etc. Similarly, in element 1.12, the PM takes most of the decisions and they refer directly to resources (N), equipment (M), expenses (F) and labour (H); here, it is assumed that existing laws and rules are beyond the reach of the PM and that the PM abides by them.

4. CONCLUSIONS

The main conclusion of this paper is the suggestion that Project Management has a crucial role in enhancing Sustainability and Sustainable Development. The attempt here is to open the discussion on the PM's role and to outline a procedure for assessing its significance. Essentially, here, an additional criterion, referring to sustainability, is added for assessing project management success and an indirect suggestion is made for a more definitively inclusion of these issues in the PM's training and certification. Regarding IPMA Certification, the emphasis should be increasing from level D to level A.

The entries in table 3.1 need to be re-examined and further studied. Possible expansions of this work can be as follows:

- At the program and portfolio levels.
- For the contextual and behavioural elements of IPMA (2006).
- Consideration of the critical levels of the capitals and their substitutability, distinguishing between weak and strong sustainability (Panagiotakopoulos, 2005).

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BEST PRACTICES IN PROJECT MANAGEMENT AGAINST THE GREEK LEGISLATION FOR PUBLIC INTEREST CONSTRUCTION PROJECTS

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Abstract. Although the execution of public-interest construction projects is mainly based on current legislation, a project manager should probably take into account best practices, in order to deliver a successful project. This research addresses the problem of connecting Greek legislation for public works to the project management best practices, as they are described through widely accepted standards. The outcome of the research is the 'LeBeMa2' matrix which offers the aforementioned connection. The practical importance of the research rests on the linking of the knowledge and competence areas of these standards to one another and the help to project managers activating in Greece to manage their projects according to current regulations as well as the best practices of project management.

Keywords: Project management standards, Construction industry, Public works, Legislation, Greece

1. INTRODUCTION

Project management has been raised as a very important management discipline during the last decades. Although, there are tangible evidences for the acceptance of its importance as early as in 1960's, more recently it has experienced a much more vivid acknowledgment. Lately, project based companies have enact rules for the relevant career paths of project managers that entail specific education and credentials. Thus, against the belief of previous years that a good scientist in a specific field could be also a good project manager of relevant projects, the trend now is that the subject matter experts are replaced with certified project managers. This evolution of the project management profession has emerged due to its importance and on the other hand due to the numerous disciplines, apart from the typical time and cost management (Diamantas et al. 2007), that have been included as knowledge areas of project management, such as risk management (Leopoulos and Kirytopoulos, 2002; Leopoulos et al. 2006), procurement management (Kirytopoulos et al. 2008), etc.

Sophisticated project managers base their knowledge on project management standards. Within the project management community, there are several international project management standards which recommend best practices for better results in project implementation. A standard is "a document established by consensus and approved by a recognized body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context" (PMI, 2004 p. 14).

Project management standards are needed as the discipline of project management encompasses a broad range of knowledge that is required from a project management practitioner to be successful and is a combination of the right knowledge, allied to personal experience and appropriate attitude (APMBoK – APM, 2006). The knowledge and practices are applicable to most projects most of the time, and there is widespread consensus about their value and usefulness (PMBOK – PMI, 2004). In a fast changing context with many interested parties and external influencing factors, the need for comprehensive descriptions of the competences for managing projects, programmes and portfolios, has created the demand for an adequate standard of professional behaviour (ICB - Caupin et al. 2006).

The standards used in this research are the International Project Management Association Competence Baseline (ICB – vs3), the Association for Project Management Body of Knowledge (APM BoK – 5th ed.) and the Project Management Institute (PMI) Body of Knowledge (PMBOK 3rd ed. – PMI, 2004).

Even though there is no official standard in Greece for project management yet, the Greek legislation demands by law, from the contractors and the supervisors of public works to follow certain processes to ensure effective management for the public-interest construction projects.

This paper aims to offer a linking proposal for the knowledge and competence areas of the aforementioned standards and on the other hand help project managers activating in the Greek region to manage their projects according to current regulations as well as the best practices of project management.

2. LITERATURE REVIEW

The US Project Management Institute began the development of its project-management body of knowledge at the beginning of eighties, with the objective of defining the scope and structure of project management as a prerequisite for the development of a distinct project-management profession (Allen, 1995). Since then, many associations edited guides and standards for project management with different general focus: projects, organizations, or people. Crawford (2004), points out the most widely known, distributed, and used guides and standards.

The existence of many 'bodies of knowledge' with different structure and content could cause confusion to the concept of a common project management body of knowledge. Allen (1995) stated that continuously aggressive development of PMBOK package requirements on an international scale is essential if project management is to be recognized as a bona fide profession in the 21st century. In order to facilitate recognition of one common Body of Knowledge (BoK) with multiple interpretations, Wirth and Tryloff (1995) compared project management documents developed by the PMI, Australian Institute of Project Management (AIPM), Association of Project Managers (APM), Projektmanagement Austria Institut (PMA), Norwegian Association of Project Management (NAPM) and International Standards

Organisation (ISO). They concluded that PMI, PMA and NAPM have written documents focused strictly on a description of the project-management subject matter while AIPM, APM and ISO have written documents focused on a prescription for project-management performance quality: competency standards.

Turner (2000) on examining the progress towards a universal body of knowledge presented a matching table for the ICB (IPMA), APM BoK, the UMIST's Guide to the PMBOK, the UMIST proposal for APM BoK and PMBOK (PMI). He notes that the versions produced by IPMA, APM and UMIST have substantially similar coverage. PMI has the lowest coverage, including only core elements used by all project managers.

Towards the same direction, Crawford (2004) summarizes the reasoning of developing a global body of project management and concludes that the need comes from the globalization which creates the necessity for international standards and qualifications. Crawford (2004) cites two initiatives relevant to global approaches to the project management body of knowledge and standards which are the Operational Level Coordination Initiative (OLCI) initiative and the Global Alliance for Project Performance Standards (GAPPS) initiative. Both of these initiatives have not yet been concluded thus indicating the complexity of the endeavor and the difficulty in reaching a global consensus.

Most recently, Morris et al. (2006) explore the development of project management as a profession and the role of the formal standards in this professionalization. They conclude that it is academia who should research what knowledge is needed rather than the industry that should impose what should be teached.

Apart from the aforementioned endeavors, the most formal and widely accepted initiative for developing a global standard has been undertaken by the ISO organization. Twenty nine countries participate in this initiative (Greece is one of them) plus six observing and the endeavor is in the preparatory stage (refer to ISO TC236).

On the other hand, public works in Greece and in other countries are not managed through standards but through legislation. Two basic phases are recognised for public works. The maturing phase and the implementation phase. During the maturing phase, the project is designed and documented by either private designers or public servants, funding is ensured and the necessary licences (environmental impact studies included) are obtained. Private contractors usually undertake the implementation of the government (or local authority or public organisation) planning for a project, while been subject to relevant legislation. A supervision authority is also appointed on behave of the project owner (public), to ensure the enforcement of planning and technical specifications and to solve any arising problems.

A plethora of regulations exists to specify the duties and responsibilities of both the supervision authority and the contractors. Duties coming from law are spread all over the life cycle of a project from the conceptual – initiating phase to the handing over and the closing phase. These duties include ensuring the legal execution of the project, management handling, quality control etc. There is a listing of regulations at the web site of G.S.P.W. (General Secretarial of Public Works), where one can find 29 Laws, 10 Decree-laws, and 14 Ministerial Decisions. The main laws are 3316/05 related to the design of public works and 1418/84 related to the construction. Decree-laws (mainly 609/85) and Ministerial Decisions particularize the implementation of the laws. The resent law 3669/08 attempts to consolidate the existing regulations. The relevant regulations can be found indexed or coded at law databases or books. These sources are extremely helpful to the practitioners, but they are not coded as a project management standard.

Due to this complexity, collective bodies such as the Technical Chamber of Greece (TCG), and Unions often point out a series of problems concerning the implementation of public works and ask for a modern framework including all the stages of a project.

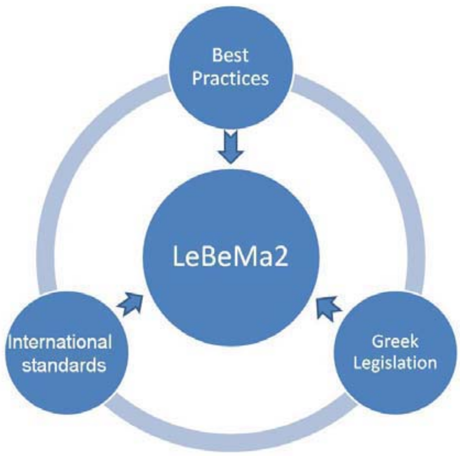
As a requirement of the new National Strategic Framework 2007-2013 is that every organisation seeking finance to implement public interest projects within this framework must be certified for its managerial capability. ELOT (Hellenic Organization for Standardization – Greek ISO member association) is in the process of developing the Greek standard for the managerial capability of organizations implementing projects of public interest (ELOT 1429). This standard is to be published shortly, as well as the ELOT 1431-1, guide for the application of ELOT 1429 for organisations implementing public works. For the transitional period until the publication of the ELOT standards, the organisations must submit for approval to the financing authority a management manual for the processes (along with proof of the necessary organisational structure and information system) that ensures the management competence for implementing public works.

This paper aims to provide a matching matrix of the proposed project management best practices and the Greek legislation for public works. The development of such a matrix will first offer a linking proposal for the knowledge and competence areas of these standards and on the other hand help project managers activating in Greece to manage their projects according to current regulations as well as the best practices of project management.

3. RESEARCH METHOD

In order to achieve the research goal, the authors had to combine the best practices included in the chosen well known standards APM, ICB and PMBOK. Next they had to go through the labyrinth of the Greek regulations concerning public works looking for best practices (refer to Fig. 3.1).

FIGURE 3.1. Combination of legislation and best practice – LeBeMa2 model



By taking into account the relevant work of other authors presented in the literature review section, an initial matching of the processes included in the standards was achieved. Since the publication of the previous works the standards were revised, and some elements were added or renamed. For this reason it was necessary to go back to the original standards. Instead of taking the nine areas in the PMBOK, it was decided to take the analysis one step lower, so the recommended processes in each of the nine areas were taken. Accordingly, instead of the seven sections in the APM, the elements that comprise the sections were processed, and in line with this concept, the ICB elements in the three competence areas, where taken as elementary elements. Since the standards have different structure and number of elements, and also the content in each element does not much exactly with anyone in the other standards, other arrangements could also have been a choice.

On the other hand all the relevant references of project management best practices in the Greek legislation covering the implementation of public works were gathered from indexed or coded law databases or publications. The law 1416/84 (public works) and its execution decree-law 609/85 (construction of public works), were taken as basis, and going through article by article, best project management best practices were hunted. Since many articles of the basic laws had been amended, it was necessary to take into account the amendments and the ministerial decisions that particularize the laws. By the time this research was ended, law 3669/08, that attempts to consolidate the existing regulations, was published. This law does not bring forward new best practices. The references mentioning best practices found in the Greek regulations were matched to the best practices recommended by the standards.

The combination of the aforementioned data along with the appropriate processing by the research team led to the development of the Legislation-Best practices Matching Matrix (LeBeMa2).

4. RESEARCH FINDINGS

By setting up the matching matrix of three widely accepted international standards, a complimentary gathering of best practices was accomplished. Table 4.1 presents visually the Legislation-Best practices Matching Matrix (LeBeMa2). It is clearly stated here that the matching among the areas – competencies of the standards is not a “black or white” situation and other alternatives could have also been proposed.

The general picture is that, although not straightforward, there is a matching among the standards. The study of three standards leads to ensuring the widest gathering of best practices. Concepts like quality may appear under the same name. Others are met under different names, like project requirements and objectives found in ICB which correspond to scope in PMBOK. Some cells in the table match to more than one element of other standards or some elements appear in more than one cell, meaning that the content of the elements in the standards differs. There are cells in the LeBeMa2 that are blank, meaning that the element is not covered in the corresponding standard. For example project, programme and portfolio implementation appears in detail only in ICB, as for APM and PMBOK programme and portfolio are out of scope, since they have published specific standards for these areas.

Thus it can be deduced that the knowledge coverage and extend varies among the standards. APM BoK comprise more topic titles and the PMBOK more extent (almost double). The visual presentation brings forward the greatest knowledge content inclusion in ICB. The table shows close matching between APM BoK and ICB, which is quite normal since APM is a member organization of IPMA. The PMBOK concentrates in the coverage of the core (mostly technical) elements (although is more extensive in volume). That could justify the absence of the topics of health, security, safety & environment, business etc., which are mostly implied rather than described in other sections.

The Greek regulations concerning public works describe mostly the obligations of the contractors, and the supervisors acting on behalf of the state (owner). There is also extensive description of procedures for the process of choosing contractors and preparing the contract. The law (L.) 3263/04 is completely devoted to the description of this process. Law 3316/05 determines the procedures for the procurement of design works. The requirements of the design work depend on the project type (ie transporting, hydraulic, building) and are defined by the decree-law (D-L) 696/74. Law 1650/86 calls for the examination of the environmental impact. For the construction of public works the main law is 1418/85 that is enriched by the decree-law 609/85, and ministerial decisions (like Safety & health (Government paper issue GPI) 1176/00, 686/01, 16/02, project quality GPI 1265/00, 1013/01, 1539/03). The procedures for general procurements can be found in law 2286/95, and the decree-law 118/07.

The scrutiny of Greek regulations revealed the project management best practices enforced by law. An overview of the legislation covering the project lifecycle is as follows: Law 1418/85 starts by stating that public works are infrastructure projects for the country to meet basic needs for the pubic. The project requirements are well defined and documented during the project maturing phase (requirements and objectives, technical specifications, cost and time efficiency). A technical annex containing summary of the project scope, its main feasibility, cost forecast and other information is submitted to the project financing body. The project is approved by the relevant collective body and contractors are invited in a well defined process that will proclaim the one who will construct the project. The contract for the construction project is based on the documentation it was auctioned (L.1418/84: article 5). The contractor is obliged to submit organisation-resource chart (D-L. 368/94: a. 7), time table, quality program in accordance to the project documentation and all of them are subject to supervision approval. The project, during its execution, is monitored and controlled. Work packages are monitored for cost overruns, periodically, quality tests are submitted to the supervision authority which should approve the outcomes, before any payment can be released. Reports for the work progress are submitted (monthly or in a trimester basis) to the financing authority. Specific procedures specify changes to the original approved plans (L.1418/84 a. 4 §10), or additional works (D-L 609/85 a.43). As far as conflict resolution is concerned, the contractor may object to supervising agent actions (L. 1418/84 a. 12) and request for arbitration (D-L 609/85 a. 57), apart from court appealing (L.1418/84 a. 13). Handing over takes place in two stages (temporal and final) when the project ends.

The LeBeMa2 reveals that the Greek legislation regarding the management of public works embodies best practices recommended by the standards.

Among the most important limitations of the Greek legislation appears to be:

1. The absence of behavioral attitudes and skills of project members.
2. Project risk management (only workforce safety is anticipated).
3. The enhancement of the knowledge related to project management through tracking lessons learned.

TABLE 4.1. Legislation-Best practices Matching Matrix (LeBeMa2)

	APM 5th ed	ICB version 3.0	PMBOK 3th ed	Greek Legislation
Technical competences	2.1 Project success and benefits management/ 2.3 Value management/ 4.5 Value engineering	1.01 Project management success	4.1 Develop Project Charter/4.2 Develop Preliminary Project Scope Statement	Meet basic needs for the pubic. L.1418/84, A.1// Project Design L3316/05
	2.2 Stakeholder management / 1.5 Project sponsorship	1.02 Interested parties	10.4 Manage Stakeholders	Various communication references among interested parties (i.e. For changing the initial design L.1418/84, A.12.10)
	4.1 Requirements management	1.03 Project requirements & objectives	5.2 Scope Definition	Base for contract (L.1418/84: A 5) Technical description
	2.5 Project risk management	1.04 Risk & opportunity	11. Project Risk Management	Workforce safety & health GPI 1176/00, 686/01,16/02,266/01
	2.6 Project quality management	1.05 Quality	8. Project Quality Management	Project quality GPI 1265/00, 1013/01, 1539/03
	6.7 Organisation structure/ 6.8 Organisational roles	1.06 Project organisation	9.1 Human Resource Planning / 9.3 Develop project team	Project supervision on behalf of the owner L.1418/84 A.6.2, on behalf of the contractor A.6.6 Public service organization structure/ Designer's & Constructor's organization structure
	7.2 Teamwork	1.07 Teamwork	9.4 Manage project team	Project team is managed by the supervision authority manager D-L.609/85: A.28
	3.8 Issue management / 2.2 Stakeholder management	1.08 Problem resolution	9.4 Manage project team/ 10.4 Manage stakeholders	Additional works D-L. 609/85 A.44/Time extension L.1418/84:A.5.4 & 10.2
	6.1 Project life cycles	1.09 Project structures	2 Project Lifecycle and Organisation	Should be included in: Technical annex/ In the documentation for project auctioning
	3.1 Scope management	1.10 Scope & deliverables	5 Project Scope management	Should be included in: Technical description
	6.1 Project life cycles /3.2 Scheduling	1.11 Time & project phases	6 Project Time Management	Time table D-L.609/85:A.32
	3.3 Resource management	1.12 Resources	9 Human Resource Management	Organisation-resource chart D-L. 368/94: A.7
	5.3 Project financing and funding	1.13 Cost & finance	7 Project Cost Management	D-L. 609/85 Budget A.5, expense account- A.40// Work package grouping D-L. 218/99 A.3//Ways of payment L. 1418/84: A. 5
	5.4 Procurement	1.14 Procurement & contract	12 Project Procurement Management	Procurement L.2286/95, D-L.370/95// D-L.118/07
	3.5 Change control	1.15 Changes	4.6 Integrate Change Control	Change of the initial design L.1418/84, A. 4.10//Eargent additional work D-L.609/85: A. 44
	3.7 Information management and reporting	1.16 Control & reports	10.3 Performance Reporting	Project log book D-L.609/85:A.33, Measurement of quantities of work packages D-L.609/85: A.38

	APM 5th ed	ICB version 3.0	PMBOK 3th ed	Greek Legislation
	6.9 Methods and procedures	1.17 Information & documentation	10.1 Communication planning	
	7.1 Communication	1.18 Communication	10.1 Communications Planning/ 10.2 Information Distribution	Formal reports i.e. monthly progress
	1.1 Project Management	1.19 Start-up	2 Project Lifecycle and Organisation	Preparation actions for planning L3316/05 A.4 / Contractual issues D-L. 609/85 A. 5
	1.1 Project Management	1.20 Close-out	2 Project Lifecycle and Organisation	Hand over D-L.609/85: A. 52,53,55,56//Failure database GPI 624 B'/03
Behavioral	7.3 Leadership	2.01 Leadership	1.5.5 Interpersonal Skills	
	7.7 Behavioural characteristics	2.02 Engagement & motivation	1.5.5 Interpersonal Skills	
	7.7 Behavioural	2.03 Self-control	1.5.5 Interpersonal Skills	
	7.7 Behavioural	2.04 Assertiveness	1.5.5 Interpersonal Skills	
	7.7 Behavioural	2.05 Relaxation	1.5.5 Interpersonal Skills	
	7.7 Behavioural	2.06 Openness	1.5.5 Interpersonal Skills	
	7.7 Behavioural	2.07 Creativity	1.5.5 Interpersonal Skills	
	7.7 Behavioural	2.08 Results orientation	1.5.5 Interpersonal Skills	
	7.7 Behavioural	2.09 Efficiency	1.5.5 Interpersonal Skills	
	7.7 Behavioural	2.10 Consultation	1.5.5 Interpersonal Skills	
	7.5 Negotiation	2.11 Negotiation	1.5.5 Interpersonal Skills	
	7.4 Conflict management	2.12 Conflict & crisis	1.5.5 Interpersonal Skills	The contractor may object to supervising agent actions (L. 1418/84 a. 12) and request for arbitration (D-L 609/85 A. 57), apart from court appealing (L.1418/84 A.13,14)
	7.9 Professionalism and ethics	2.13 Reliability	1.5.5 Interpersonal Skills	
	7.9 Professionalism and ethics	2.14 Values appreciation	1.5.5 Interpersonal Skills	
	7.9 Professionalism and ethics	2.15 Ethics	1.5.5 Interpersonal Skills	
Contextual competences	1.1 Project management	3.01 Project orientation	1.2.1 Project Characteristics	Project management – supervision D-L.609/85: A. 28)
	1.2 Programme management	3.02 Programme orientation	1.6.1 Programs and Program Management	
	1.3 Portfolio management	3.03 Portfolio orientation	1.6.2 Portfolios and Portfolio Management	
	-	3.04Project,programme& portfolio implementation	-	
	6.7 Organisation structure/ 6.8 Organisational roles	3.05 Permanent organisation	2.3.3 Organisational Structure	The public service and the contractor have their own organisation.
	5.1 Business case	3.06 Business	-	
	4.4 Technology management	3.07 Systems, products & technology	-	
	7.6 Human resource management	3.08 Personnel management	9 Project Human Resource Management	The public service and the contractor apply their own human management
	2.7 Health, safety and environmental management	3.09 Health, security, safety & environment	11 Project Risk Management	Workforce safety & health (as in risk management)// Environmental protection L.1650/86, harmonization with EE L. 3010/02
	5.3 Project financing and funding	3.10 Finance	-	Local, national or EE sources for financing the project.

	APM 5th ed	ICB version 3.0	PMBOK 3th ed	Greek Legislation
	5.5 Legal awareness	3.11 Legal	-	Legislation awareness is assumed.

A.: Article, L. : Law, D-L : Decree-Law, GPI :Government Paper Issue, M-D : Ministerial Decision

5. DISCUSSION

The globalization of the economy creates opportunities for the Greek construction companies to work in a broader region such as Balkans and Middle East, and in parallel, international companies may easily activate in Greece and undertake public work projects. There is no official standard in Greece for project management. However the Greek legislation demands by law, from the contractors and the supervisors of public works to follow certain processes to ensure effective management for the public-interest construction projects. Many of the construction companies when realizing the benefits of applying project management best practices follow international standards. The proposed matching table LeBeMa2 has been created in order to help project managers activating in Greece to manage their projects according to current regulations as well as the best practices of project management.

The matching of best practices among the three most widely spread international project management standards resulted also in a linking proposal for the knowledge and competence areas of these standards.

This research has also concluded that the three project management standards vary in context, structure and purpose. PMBOK concentrates on the core technical skills that a project manager owns to have. On the other hand the ICB apart from technical emphasises behavioural and environment competences. The resulting LeBeMa2 is the closest matching among the elements of the examined standards, however, it cannot be considered a unique matching. The difficulty in reaching a global project management consensus is proved from the fact that initiatives towards this direction, although started many years ago, have not yet reached a sound statement, indicating the complexity of the endeavor. Among the difficulties that must be investigated, are also the consolidated customs and the general local culture.

LeBeMa2 presents the relevant Greek legislation, found spread over several laws and amendments, from a project management point of view. The fact that the Greek legislation concerning management of public works, as emerged by the LeBeMa2, embodies the best practices recommended by the standards is encouraging and shows that there is no need for new laws. Problems in public works (such as delays, budget overstepping, bungling) could be due to inadequate implementation of the existing regulations or to plethora of regulations.

The noted limitations of the Greek legislation are: 1) the absence of certification - evaluation of behavioral attitudes and skills of project teams 2) no requirements for project risk management and 3) absence of structured approaches to knowledge capitalization through tracking lessons learned.

The complexity of project management and the existence of too many laws bring forward the need for a methodology able to direct through out the project life cycle the project manager, by pointing out the appropriate best practices and tools that should be used.

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FINANCIAL PERFORMANCE INDICATORS OF LISTED GREEK CONSTRUCTION FIRMS

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Abstract. The aim of this paper is to assess the financial performance of Greek construction firms using a set of selected indicators. A composite index of performance at the firm level for a sample of twenty construction firms listed on the Athens Exchange is derived with the aid of compromise programming (CP). The relative weights of the component performance indicators were calculated using the opinions of a panel of experts. The performance evaluation using the derived performance indicators provides also practical issues for the implementation of the proposed model.

Keywords: Financial performance, Performance indicators, Compromise index, Key performance indicators, Construction companies

1. INTRODUCTION

Performance measurement and evaluation of business firms are important to shareholders, managers, investors and policy makers. Such evaluations provide the shareholders and managers with a tool to assess the strength and weakness of the firm as well as its competitive advantages over its competitors. Moreover, the outcomes are of the interest of investors (institutional and individual) and policy makers for guidance to their investment decisions and to policy formulation, respectively. The performance of a firm is clearly multi-dimensional, since it is affected by a variety of factors of different nature such as financial, economic and strategic factors. The aggregation of all these factors into a composite index is a subjective process that depends on the decision-maker's values and judgment policy (Spronk et al. 2005).

The activity of measuring performance (i.e. performance measurement; Lohman et al. 2004) using selected relevant indicators (i.e. metrics) is used as a tool for monitoring, measuring and evaluating performance. The need to develop performance management systems (i.e. softwares, databases, and procedures; Lohman et al. 2004) to execute performance measurement in a consistent and complete way at the firm level is more acute in construction companies due to the managerial effort required for the simultaneous implementation of various projects (Yu et al. 2007). The main objective of performance evaluations is to measure the gap in achieving performance objectives.

A performance indicator or performance metric is a variable that reflects the effectiveness or efficiency or both, of a part of or a whole process/system, against a norm or a target (Fortuin 1988; Lohman et al. 2004). In this paper we investigate the use of financial ratios such as return on equity (ROE) and debt ratio (DR) and other growth ratios such as growth in sales (GrSALES), growth in dividend (GrDIV), and growth in total net assets (GrTNA) for constructing a consolidated financial performance measure taking also into account the opinions of experts.

In this context, we focus on the development of a multi-criteria model for deriving a composite financial performance metric at the firm level. More specifically, our research objectives are: i) To propose and apply a compromise programming (CP) model for benchmarking construction firms using component financial performance indicators; and ii) to develop an implementation method focused on the calculation of relative weights of the component performance indicators and to integrate it with the CP model for the derivation of a composite financial performance metric.

The procedure used in the research is consisted of three phases: The first phase is to conduct a candidate indicator list for the financial performance measurement of construction companies. The second phase is to develop a CP model for the derivation of a consolidated measure of financial performance; this phase includes selection of financial performance indicators, and the relative weights of the performance indicators. Finally, the third phase is to derive a consolidated measure of financial performance using the model developed in the previous phase, and to perform a case study for the listed Greek construction firms.

The rest of the paper is organized as follows. In the next section we provide a brief review of the relevant literature. Section 3 presents the proposed methodology for the derivation of composite financial performance indicators of listed Greek construction firms. Section 4 deals with the sample of firms that is used for the implementation of the proposed methodology. Section 5 presents and discusses the results of case study. The final section 5 concludes the paper.

2. LITERATURE REVIEW

Methods used in performance measurement can be grouped under three headings: ratio analysis, parametric methods and nonparametric methods. In ratio analysis, the need for the development of key performance indicators (KPIs, i.e. quantifiable metrics that reflect the critical success factors of a company) is essential. Parametric methods and nonparametric methods (i.e. Data Envelopment Analysis, DEA; see El-Meshaleh et al. (2007), Xue et al. (2008)) are based on the construction of an efficient frontier (Düzakın and Düzakın 2007).

Multicriteria decision aid (MCDA) combined with ratio analysis has potential in supporting decision maker’s in making decisions regarding the evaluation of corporate performance (see also Spronk et al. 2005). Among the approaches and methods appeared in the relevant literature are: i) Multiattribute utility theory including the Analytical Hierarchy Process (AHP, see Lee et al. 1995) and other methods such as crisp (Diakoulaki et al. 1992) or fuzzy multicriteria analysis (Yeh et al. 2000), ii) outranking relations represented by ELECTRE family of methods (Elimination et Choix Traduisant la Realite, Roy (1968) and PROMETHEE family of methods (Preference Ranking Organization METHod of Enrichment Evaluations, pioneered by Brans and Vincke's (1985) work on PROMETHEE I and II methods and preference disaggregation including the UTA method (Utilites Additives, Jacquet-Lagreze and Siskos (1982)) and the UTADIS method (Utilites Additives DIScriminantes, Jacquet-Lagreze (1995)); see Spronk et al. (2005) for a survey on the use of outranking relations and preference disaggregation methods to evaluate corporate performance.

Among multicriteria decision making (MCDM) methods some of them such as CP, goal programming and its variants use the concept of distance to find a satisfying solution. Most of these methods choose the alternative that minimises a selected measure of distance between the alternative and reference set of criteria values. Distances are used as a proxy measure for human preference and reflect the degree of similarity, or proximity of alternatives with respect to individual criteria.

In this paper we use CP, a distance-based MCDM method introduced by Yu (1973) and Zeleny (1973, 1974), to derive a consolidated measure of financial performance of Greek construction firms. In the view of ratio analysis, the need for the development of KPIs has been discussed in the relevant literature (see Yu et al. 2007). Although recent works (e.g. Yu et al. 2007) on the development of performance of construction firms include indicators that reflect the perspectives of the Balanced Scorecard framework (i.e. financial, customer, internal business process, learning and growth perspectives); see Kaplan and Norton 1992), in this paper we focus only on the financial perspective –this is the case for the most construction companies (Kagioglou et al. 2001)– due to publicly available data concerning the financial performance of firms.

3. METHODOLOGY

The framework developed here for the performance measurement of Greek construction firms is composed of two parts: The performance measurement framework (Phase I: candidate indicator list; Phase II: CP model development, component indicator selection, and calculation of relative weights) and performance evaluation and management (Phase III: derivation of a consolidated measure of financial performance). In Phase I, an adequate candidate indicator list of 5 indicators for the performance measurement of construction companies was conducted by collecting research papers, reports, and books, real cases dealing with the KPIs of construction companies.

The following indicators have been chosen (Yu et al. 2007, Shergill and Sarkaria 1999): i) Return on equity (ROE), ii) Growth in sales (GrSALES), iii) Growth in dividend (GrDIV), iv) Growth in total net assets (GrTNA), and v) Debt ratio (DR). ROE is an indicator of profitability while GrSALES, GrDIV and GrTNA are representatives of growth (Yu et al. 2007, Shergill and Sarkaria 1999). ROE reflects the firm's success from the shareholders' point of view in terms of returns provided to them; GrSALES represents the firm's success in its markets; GrDIV reflects the short term return on investment by the equity holders; GrTNA is a general growth indicator (Shergill and Sarkaria 1999). Debt ratio reflects the firm's stability (Yu et al. 2007).

In Phase II, three feasible KPIs were chosen from the candidate indicator list, and real financial performance data relating to the feasible indicators were collected. The participant companies in our survey were limited to the construction companies listed on the Greek Stock Exchange, to acquire publicly financial data. Due to data availability at this stage of research the analysis conducted here concerns ROE, GrSALES, and DR.

For the calculation of relative weights of the performance indicators we apply the pairwise comparison method.

In Phase III, the indicators derived from Phase II are used to derive an overall CP index. The relationships between ROE, GrSALES, and DR are also examined. The resulting compromise distance can be aggregated using CP (see also Manoliadis et al. 2001, Pantouvakis and Manoliadis 2008).

A consolidated measure of financial performance is derived for the listed Greek construction firms over the 2004-2005 period using the calculated relative weights of the performance indicators and the following compromising model:

$$\min \left[L_p(A_j) - \left[\sum_{i=1}^{N} W_i \left[\frac{(f_i^* - f_{ij})}{(f_i^* - f_i^{**})} \right]^p \right]^{\frac{1}{p}} \right] \quad (1)$$

Where: $L_p(A_j)$ is the distance metric as a function of the decision alternative A_j and the parameter p (Tecle and Yitayew, 1990).

W_i, is the standardized form of the criterion weight, w_i, and represents the decision makers' relative preference structure among the *i* criteria where the sum of the criteria weights equal one.

f_i^* and f_i^{**} represent the ideal or best value and the minimum of worst value, respectively for criterion *i* as determined using equations (2) and (3) respectively:

$$f_i^* = \max (f_{ij}),\ i = 1, 2, ..., I \ \ and\ j = 1, ..., J \quad (2)$$

$$f_i^{**} = \min (f_{ij}),\ i = 1, 2, ..., I \ \ and\ j = 1, ..., J \quad (3)$$

The parameter p represents the concern of the decision-maker over the maximum deviation and it can have values from zero to infinity, where the greater the value of p, the greater the concern becomes. For p = 1, all weighted deviations are assumed to compensate each other perfectly though for p = 2, each deviation is accounted for in direct proportion to its size. As p approaches infinity, the alternative with the largest deviation completely dominates the distance measure (Zeleny, 1982) and in this case, CP corresponds to minimax (or Chebyshev) goal programming.

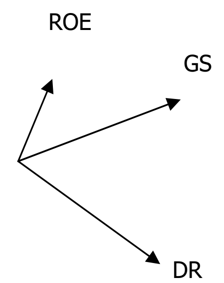
4. DATA

The performance data of the listed construction firms on Athens Exchange for the fiscal years 2004 and 2005 were collected to derive their overall CP performance score. Data used in this study come from ICAP databank. The 20 listed companies of the sample included nine (45%) building and civil works construction-oriented companies, ten (50%) highway, road, airport and sport complexes construction-oriented companies, and one (5%) special works construction oriented company (ICAP, 2007). Moreover, data for this research on the prioritization of the performance indicators used by the Greek construction firms were collected using a questionnaire survey. The survey targets were the financial directors of top Greek firms. The prioritization of performance indicators was as follows:

1. Growth in sales (GrSALES).
2. Return on equity (ROE).
3. Debt ratio (DR).

As ROE increases, GrSALES increases (high ROE projects give the firm good opportunities for growth) while DR decreases. Relations between ROE, GrSALES and DR are shown in figure 4.1.

FIGURE 4.1. Relationship between Return of equity (ROE), Growth of sales (GS) and debt ratio (DR).



Consideration of the different priorities in each performance criterion is required to estimate the composite performance indicators using the proposed framework. For weight calculation the

pair wise comparison based upon experts estimates is used. This method requires only two criteria to be considered at any one time, and has been tested theoretically and empirically for a variety of decision situations including spatial decision making (Malczewski, 1999).
The pair wise comparison is presented in table 4.1.

TABLE 4.1. Weight calculation using pair wise comparison.

	Criteria		
	1	2	3
1	1.000	2.000	2.000
2	0.200	1.000	2.000
3	0.143	0.330	1.000
Sum	1.343	3.330	5.000

5. RESULTS

We derive GrSALES, ROE, and DR for the sample of 20 Greek construction firms listed on Athens Exchange to assess their financial performance. Based on the pair wise comparison of the three dominant criteria we derive their relative weights. As a result, the performance from the GrSALES was recognized as being the most important criterion (0.58), following by ROE (0.28) though the DR was viewed as lowest in importance value (0.14). The composite performance indicators were calculated by applying weights shown in table 5.1 and using equation (1).

Table 5.1 shows the performance criteria and the weights of the performance criteria of construction companies derived by our analysis.

TABLE 5.1. Weight calculation for the selected criteria.

	Criteria			Criteria weights w_i (Normalized values)			Weight W_i
	1	2	3	1	2	3	
1	1.000	2.000	2.000	(1.000/1.343)= 0.745	0.740	0.600	(0.745+0.740+0.600)/3 =0.580
2	0.200	1.000	2.000	(0.200/1.343)=0.149	0.150	0.300	(0.149+0.150+0.300)/3 =0.280

3	0.143	0.330	1.000	(0.143/1.343)=0.106	0.110	0.100	(0.106+0.110+0.100)/3 =0.140
Sum	1.343	3.330	5.000	1.000	1.000	1.000	1.000

The descriptive statistics of the indicators used and the composite indicators derived here for p = 2 are presented in table 5.2. As shown in table 5.2, the overall mean performance score was 0.44 out of 1 (i.e. 44%). At the criteria level, DR rated the highest mean normalized score of 0.63 to the ideal score of 1, followed by ROE with a score of 0.56, and GrSALES with a score of 0.20. As a measure of the fluctuation of the normalized performance scores, the GrSALES ratio showed the highest value of coefficient of variance (CV=1.04), and the ROE ratio showed the lowest value (0.39); the CV value for the debt ratio was 0.41. As a result, the score of the GrSALES was the most sensitive variable that impacted on the performance.

TABLE 5.2. Descriptive statistics of the financial indicators used.

	Original values			Normalized values (0 – 1)			
Criteria	Growth in sales	ROE	Debt ratio	Growth in sales	ROE	Debt ratio	CP overall score
Criterion direction	Max	Max	Min	Max	Max	Min	
Min	-59.59%	-29.10%	33.18%	0.00	0.00	0.00	0.24
Max	245.42%	25.61%	90.06%	1.00	1.00	1.00	0.94
Mean	0.84%	1.62%	54.22%	0.20	0.56	0.63	0.44
Median	-10.77%	1.60%	53.03%	0.16	0.56	0.65	0.41
Standard deviation	62.86%	12.03%	14.72%	0.21	0.22	0.26	0.15
Coefficient of variance (CV)[a]	75.20	7.41	0.27	1.04	0.39	0.41	0.33

[a]Coefficient of variance (CV)=standard deviation/mean.

The causal relationship characteristics of the performance metrics used in this study can be identified using multivariate statistical techniques, such as multiple regression analysis. However, due to small size of the sample we perform a correlation analysis to test whether linear correlations existed among the three performance criteria (see also Bassioni et al. 2005, Yu et al. 2007) and moreover which one of them is governing the derived CP score. In the light of the results of this analysis there is no statistically significant correlation among the performance criteria; Pearson correlation coefficients between CP index and GrSALES and ROE suggest that the CP index is governed primary by GrSALES and ROE (0.772 and 0.709, respectively, both statistically significant at the 0.01 level); Kendall's rank and Spearman's rank correlation coefficients between CP index and ROE (0.713 and 0.859, respectively) are statistically significant at the 0.01 level.

6. CONCLUSIONS

The most important contribution of this research is the development of a framework based on CP to assess firm performance. The performance of a firm is clearly multi-dimensional, since it is affected by a variety of factors. The aggregation of three of these factors for the Greek listed firms (success in terms of returns to shareholders, success in markets, and stability) into a composite index is a subjective process that depends on the decision-maker's values and judgment policy and it is accomplished by means of CP. In summary, to apply our model, the following issues need to be considered:

It is very important to choose appropriate performance indicators (i.e. composite ratios) which can be representative of goals and targets of the construction companies. It is also essential to calculate the weights for the chosen performance metrics to apply the proposed CP model for deriving an overall index of performance.

The present work demonstrates that financial performance is, in reality, a decision-making problem that may need to meet numerous objectives. Among primary objectives for the case of Greek firms are GrSALES, ROE, and DR that are derived using financial statement data. The final index often involves a trade-off between these objectives and the relative importance of measures of these primary objectives can be obtained using the opinions of a panel of experts system.

The overall CP index can be used to investigate the financial performance of construction firms listed on the Athens Exchange. In the light of the results of this study, this consolidated metric is governed primary by ROE. Although ROE provides similar ranking compared with the overall CP index, the latter is more promising since it takes into account not only balance sheet data but also the opinions of a panel of experts. The results obtained in this study revealed tha the ramework presented here is capable of providing a consolidated measure of firm performance and it can be used as complement to traditional ratio analysis.

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SELECTING THE OPTIMUM INVESTMENT ALTERNATIVE WITH THE USE OF DECISION-TREES: AN APPLICATION

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Abstract. The selection of the optimum investment between different alternatives is a critical decision in construction business due to the, often, irreversible and of high cost consequences for the entrepreneur. This paper presents a decision-tree based tool that supports the decision maker in the selection of the optimum investment. The tool supports the analysis of various scenarios for the investment alternatives under consideration. For each scenario the expected income and the anticipated expenditures are introduced associated with respective probabilities. The final outcome is the expected profit for each investment alternative assessed according to an associated combined probability of occurrence. The various expected profits for each investment alternative are compared to identify the best alternative in terms of profitability and expectation to occur. A practical example is presented to demonstrate the utility of the tool and the ability it provides to implement in a simple and quick way an investment selection analysis.

Keywords: Investment selection, Investment analysis, Decision trees, Probabilities

1. INTRODUCTION

Uncertainties and risks are always inherent in investment decisions. The investigation between different investment alternatives or different implementation strategies of a single investment aims at the selection of the best alternative that reduces risks and maximizes the investment's return. Such an investigation is even more critical in construction business where wrong investment decisions have, most often, irreversible effects due to an inherent constraint to "get back on the rails" when problems arise. This constraint refers to the inappropriateness for the construction industry of the basic tools (e.g. regular monitoring, proper asset allocation, replacement of an investment of poor performance, etc.), which are, generally, used to retain profitable an investment portfolio (DeBaca (2007)). The ineffectiveness of traditional tools in construction business is due to the following:

- Construction projects – despite the similarities that often present – are unique in nature and in many cases there may be very complicated in terms of realization and functionality in the infrastructure system where they belong.
- Funding resources are, simultaneously, allocated in multiple activities in the same project or between projects. This renders a construction company's investment portfolio hardly diversified and therefore risk increases.
- Construction projects are characterized by high capital outlays, long lead times and long operating periods that make difficult the accurate forecast of future cash flows (Kim et al (2005)).
- Abandoning and replacing an investment of poor performance is hardly an option for construction business investments due to the social impact of the final product (i.e. a construction project) of the investment.

Another constraint is that a portfolio of a construction firm may include a wide range of activities from small building works to large construction projects. The interaction between these different types of investment must be comprehensively understood to identify the potential impact of each type of investment upon the whole context of the construction firm's business activities (Griffith (2007)).

As shown in the above discussion, investment decisions in construction business present particularities that require specific tools to treat them. Traditional economic tools such as Discount Cash Flows techniques, Net Present Value, and Cost-Benefit analysis are extensively used (Hendrickson and Au (2003)), although they present serious limitations (Ye and Tiong (2000)). Mattar and Cheah (2006) present a thorough discussion of other approaches (e.g. real option valuation and contingent analysis) and critical issues on investment evaluation in architecture, engineering, and construction. In their research, they identify real option valuation as a better alternative to decision analysis (DA); however they suggest that "*if applied correctly DA will yield the same results as any other market valuation method*".

In this paper, a decision-tree integrated with combined probabilities is suggested as an effective tool for the selection of the optimum investment alternative for construction business. The following sections present the notations used in the paper, the methodology for the development of the decision tree, and the generation of the combined probabilities. A practical example is given to demonstrate the tool's utility.

2. DEVELOPMENT OF THE TOOL FOR INVESTMENT EVALUATION

2.1 Notations

The following notations are used for the development of the decision-tree for the selection of the optimum investment alternative:

S_{tf} : alternative investment strategy for the various financial periods (t), with t = 1 to t^* and f = 1 to k.

r : income of a specific type, with r = 1 to n.

R_{rL} : amount of income of type r, with L = 1 to l.

$P(R_{rL})$: probability of occurrence of R_{rL}.

u : expenditure of a specific type, with u = 1 to m.

C_{uD} : amount of expenditure of type u, with D = 1 to d.

$P(C_{uD})$: probability of occurrence of C_{uD}.
K_{ta}^{Stf} : annual profit in a financial period for a S_{tf} strategy, with a = 1 to 5.
PP_w^{Stf} : combined probability for the profit of a w alternative, with w=1 to z.
K_t^{Stf} : overall profit corresponding to a S_{tf} strategy for a financial period.
K^{Stf} : overall profit corresponding to a S_{tf} strategy for all financials periods.

2.2 Construction of the decision-tree

A decision-tree is a graphical modelling of a real problem that allows the comparison of various solutions and the selection of the best among them. The organizing of the various levels of the decision-tree for the selection of the optimum investment alternative is the following:

1. At the first level, the alternative investment strategies (S_{1f}) for the first financial period are presented. These are the considered strategies from which a single alternative will be finally selected for the first financial period. The selection is based on the overall profit which is assessed by resolving the decision-tree.
2. At the second level, for each S_{1f}, a number of alternatives of implementation (w) is being considered each one with an associated combined probability (PP_w^{S1f}).
3. At the third level, the alternative investment strategies (S_{2f}) for the second financial period are presented. These investment strategies are directly related to the outcome of the selected strategy of the previous financial period. Therefore, the investment alternatives of the second period depend on the adopted investment strategy of the previous period and its performance.
4. Steps 2 and 3 are repeated for investment strategies of subsequent financial periods until the last one of them. There may be as many periods as possible or desired. However, due to the difficulty of accurate forecasts for investment performance in the long run and the large number of possible alternatives for the implementation of the investment, it is suggested that a maximum number of three financial periods of a whole duration of up to 5 years is sufficient for the analysis.

2.3 Estimation of the expected profit for each investment alternative

The annual expected profit of each investment alternative (K_{ta}^{Stf}) is estimated by the difference between the amount of income (R_{rL}) and the amount of expenditure (C_{uD}) for all possible different types of income (e.g. facilities exploitation, tolls and tariffs, etc.) and expenditure (e.g. operational costs, loan costs, etc.). A matrix of income-expenditure is drawn for each investment alternative, for each year of each financial period. The net profit of each year (K_{ta}^{Stf}) in the financial period is given from equation 1:

$$K_{ta}^{Stf} = \left(\sum_{\substack{L=1 \\ r=1}}^{\substack{n \\ l}} R_{rL} - \sum_{\substack{D=1 \\ u=1}}^{\substack{m \\ d}} C_{uD} \right) \qquad (1)$$

2.4 Generation of the combined probabilities

Each amount of a specific type of income and expenditure is associated with a probability of occurrence. The combined probabilities are generated by the product of the respective probabilities of each alternative. Equation 2 is used for the generation of combined probabilities:

$$PP_{w}^{Stf} = \prod_{r=1}^{n} P(R_{rL}) \times \prod_{u=1}^{m} P(C_{uD}) \qquad (2)$$

In equation 2, each alternative (w) corresponds to a specific scenario of amounts of income and expenditure; thus each alternative represents a scenario of different amounts for L = 1 to l and D = 1 to d, for all r = 1 to n and u = 1 to m of the alternative.

3. IMPLEMENTATION OF THE APPROACH: A PRACTICAL EXAMPLE

The developed methodology can be applied in all real case situations. A practical example is given below to demonstrate the mode of implementation. For simplicity reasons a case of two investment alternatives is presented.

Suppose that there is the option of involvement in one of two highway road construction projects located in different areas. These are the investment alternatives: f=1 and f=2. The evaluation for each alternative will be for one financial period (i.e. t=1), which lasts for 3 years. Therefore, there are two investment alternatives, namely S_{11} and S_{12}.

For the first alternative, S_{11}, two types of income are anticipated, namely: a) tolls for light vehicles (r=1) and b) tolls for heavy vehicles (r=2). Suppose that the empirical assessment indicates several probable alternatives for the transportation load that, consequently, result to several amounts of income. Table 3.1 presents the expected probable amounts of income with selected numerical values for the example:

TABLE 3.1. A numerical example for the anticipated income of S_{11}

Alternatives (w)	Transportation load	Income (mu*) per type of vehicle	R_{rL}	$P(R_{rL})$
r =1, L=1	6000	2	12000	0,30
r =1, L=2	10000	2	20000	0,70
r =2, L=1	4000	3	12000	0,40
r =2, L=2	6000	3	18000	0,60

*mu : monetary units

In table 3.1, there are two alternatives (L=1 & L=2) of transportation load for each type of vehicle. A toll price of 2mu/vehicle for light vehicles and 3mu/vehicle for heavy vehicles is, also, considered.

For the same alternative, i.e. S_{11}, two types of expenditure are anticipated, namely: a) loan costs (u=1) and b) maintenance costs (u=2). Suppose that the empirical assessment indicates several probable alternatives for the types of expenditures that, consequently, result to several amounts of expenditure. Table 3.2 presents a numerical example. In this table, the loan cost is considered as certain and with an annual interest rate of 4% for the whole financial period. The maintenance costs are differentiated from year to year in both alternatives, but the probability of occurrence for each year remains the same per alternative.

TABLE 3.2. A numerical example for the expected expenditure of S_{11}

	C_{uD} (mu)			
	Year 1	Year 2	Year 3	$P(C_{uD})$
u =1 L=1	50000 (ρ = 4%)			1,00
u =2 L=1	2000	2500	3500	0,90
u =2 L=2	3000	4000	5000	0,10

Based on the above, there are several alternatives of the annual profit K_{ta}^{Stf} with different probabilities of occurrence. The assessment of this profit can be presented in an income-expenditure matrix. Table 3.3 presents this type of matrix.

TABLE 3.3. A numerical example for the assessment of the expected annual profits

Alternatives	$K_{11}^{S_{11}}$	$K_{12}^{S_{11}}$	$K_{13}^{S_{11}}$	NPV ($K_{11}^{S_{11}}$)	NPV ($K_{12}^{S_{11}}$)	NPV ($K_{13}^{S_{11}}$)	NPV ($K_{1}^{S_{11}}$)
$R_{11}+R_{21}-C_{11}-C_{21}$	4000	3500	2500	3846,15	3235,95	2222,49	9304,59
$R_{11}+R_{21}-C_{11}-C_{22}$	3000	2000	1000	2884,62	1849,11	889,00	5622,72
$R_{11}+R_{22}-C_{11}-C_{21}$	10000	9500	8500	9615,38	8783,28	7556,47	25955,14
$R_{11}+R_{22}-C_{11}-C_{22}$	9000	8000	7000	8653,85	7396,45	6222,97	22273,27
$R_{12}+R_{21}-C_{11}-C_{21}$	12000	11500	10500	11538,46	10632,40	9334,46	31505,32
$R_{12}+R_{21}-C_{11}-C_{22}$	11000	10000	9000	10576,92	9245,56	8000,97	27823,45
$R_{12}+R_{22}-C_{11}-C_{21}$	18000	17500	16500	17307,69	16179,73	14668,44	48155,87
$R_{12}+R_{22}-C_{11}-C_{22}$	17000	16000	15000	16346,15	14792,90	13334,95	44474,00

In table 3.3, the loan cost is introduced as a discounted amount for each year of the financial period with a discount rate of 4%.

The combined probabilities for each alternative of annual profit are calculated from equation 2 for the probability values given in tables 3.1 and 3.2. Table 3.4 presents the numerical results.

TABLE 3.4. A numerical example for the assessment of the combined probabilities

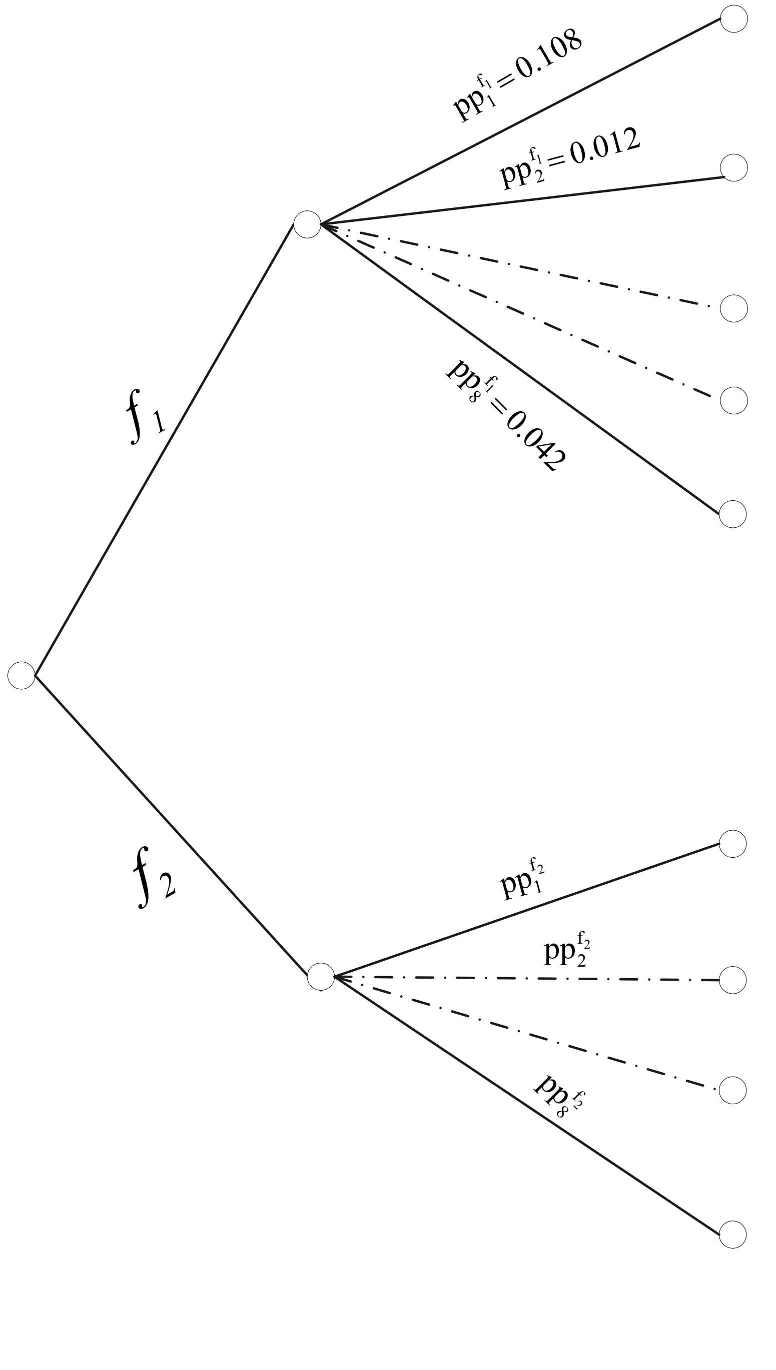
Alternatives	Combined Probabilities
$R_{11}+R_{21}-C_{11}-C_{21}$	$PP_1^{S_{11}} = P(R_{11}) \times P(R_{21}) \times P(C_{21}) = 0{,}108$
$R_{11}+R_{21}-C_{11}-C_{22}$	$PP_2^{S_{11}} = P(R_{11}) \times P(R_{21}) \times P(C_{22}) = 0{,}012$
$R_{11}+R_{22}-C_{11}-C_{21}$	$PP_3^{S_{11}} = P(R_{11}) \times P(R_{22}) \times P(C_{21}) = 0{,}162$
$R_{11}+R_{22}-C_{11}-C_{22}$	$PP_4^{S_{11}} = P(R_{11}) \times P(R_{22}) \times P(C_{22}) = 0{,}018$
$R_{12}+R_{21}-C_{11}-C_{21}$	$PP_5^{S_{11}} = P(R_{12}) \times P(R_{21}) \times P(C_{21}) = 0{,}252$
$R_{12}+R_{21}-C_{11}-C_{22}$	$PP_6^{S_{11}} = P(R_{12}) \times P(R_{21}) \times P(C_{22}) = 0{,}028$
$R_{12}+R_{22}-C_{11}-C_{21}$	$PP_7^{S_{11}} = P(R_{12}) \times P(R_{22}) \times P(C_{21}) = 0{,}378$
$R_{12}+R_{22}-C_{11}-C_{22}$	$PP_8^{S_{11}} = P(R_{12}) \times P(R_{22}) \times P(C_{22}) = 0{,}042$

Once the annual profits and the respective combined probabilities are calculated (Tables 3.3 and 3.4), the results are associated with the nodes of the second level of the decision-tree. Therefore, for each alternative (branch of the decision-tree), there is a single value of an expected profit for the whole period with an associated combined probability of occurrence. Transition to the node at the first level requires the sum of the products between the values of the combined probability of each alternative and the net present value of the respective annual profit for each financial period. Equation 3 is used for the assessment of the value associated with the first level nodes of the decision-tree:

$$K^{Stf} = \sum_{\substack{w=1 \\ t=1}}^{\substack{3 \\ z}} K_t^{Stf} \times PP_w \qquad (3)$$

The same process is being followed for all other investment alternatives (e.g. S_{12} in the example) and the final results are compared to select the optimum investment alternative. A schematic representation of the respective decision-tree is presented in figure 3.1.

FIGURE 3.1. A schematic representation of the decision tree associated with the numerical example



4. CONCLUSIONS

Construction business presents some particularities that prevent from an efficient use of traditional methods and tools for the selection of the optimum investment alternative. On the other hand, decision-trees are easy to apply and understand by the decision makers and can be used for the selection of the best among different investment options. In this paper such a decision-tree is presented and demonstrated with a numerical example. This tool can be used for up to three financial periods of duration of up to five years each, without problems due to complexity. Future steps are: a) to investigate and deal with possible limitations of the approach and b) to use the tool for a sensitivity analysis of certain parameters that affect the selection of an investment.

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FAST-TRACKING BUILDING PROJECTS: CREATIVE DESIGN AND ISSUES OF QUALITY

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Abstract. Fast-tracking practices have definite effects on the making of architectural decisions. The majority of architects are reluctant to participate in fast tracking architectural practices due to the commonly held opinion that creative processes cannot be subject to acceleration, if architectural quality has to prevail. This paper argues that creative architectural design holds innate attributes (complexity, flexibility, adaptability) which enables the making of buildings of high architectural quality produced by practices of fast-tracking. Such practices are by no means a contemporary innovation since their design roots go far back into the classical doctrines of proportion, modularity and designing within self-imposed boundaries. As major facilitators of the design process, architects still have an opportunity to aspire for creative design by adapting themselves to the new temporal order of events and resuming their traditional role of possessing sufficient constructional knowledge and ability to anticipate a variety of technical issues.

Keywords: Fast-tracking, Creative design, Quality, Construction, Built environment

1. INTRODUCTION

In recent years there has been an increasing interest about the ways designers and construction enterprises collaborate to produce buildings quickly and efficiently because of the competitive market, economic pressures, high interest charges and the need to obtain a quick return on capital employed. Fast-tracking practices of design and construction receive considerable attention since they offer a project delivery approach to compress the construction time involved in a particular project. Such an approach may prove both a significant challenge and an intriguing opportunity. (Fazio et all (1988)) Understanding its impact on the design process may affect furthering techniques and efficiency in fast-tracking design and construction.

The relationship between time and architecture is an intricately woven one. Throughout history time came to play an important role in the making of important architectural decisions, such as determining the timing, orientation and location of buildings. The modern conception of time as linear, standardized, measurable and manageable has created attentiveness to the passage of time and, hence, to productivity and performance. (Heery (1975)) In this paper, an attempt is made to unravel some of the interrelationships between time, architectural design and construction, by addressing the contemporary practice of fast-tracking in which "duration" is reduced by altering the "sequence" of design and construction. An evaluation of some tendencies and design trends common in fast-tracking projects is attempted and contrasted to their more "traditional" designed counterparts. It is possible, I argue, to produce design of high architectural quality under a wide variety of temporal circumstances, provided that the architect understands and accepts the limitations of each situation and conditions himself to creatively working within such boundaries.

2. FAST-TRACKING: A CRITICAL OVERVIEW

2.1 Temporal Aspects of duration and sequence: A historical context

Looking at architectural production as a whole, it may be argued that historically, man's changing attitudes toward the temporal aspects of duration and sequence considerably influenced design and construction of buildings and continue to affect current architectural practices. Duration is the actual length of time spent on design and construction. Sequence refers to the particular order of events within that duration, and whether the activities are continuous or phased, successive or overlapped. (Kholy (1991)) Three important issues arise from a historical overview on the subject who may become important in better evaluating current fast-tracking practices:

1. Fast-tracking is an old practice: The “traditional” building practice in which construction begins when the design is fully developed and documented is not always the norm, nor has it always been. In fact, historically, the reverse seemed to predominate. This is not surprising in view of the limitations presented by the media needed for design documentation and in view of the changing role of the architect throughout history. (Kostof (1977)) From the master-masons of antiquity to the artist-architects of the Renaissance, it is important to notice the architect’s presence on the site in order to work out details and handle problems as they arose; a practice which to some extent attenuates the effect of non-sequential design and construction. In addition, in lieu of drawings, it was rules of proportion that acted as a means of recording a design and of transmitting accepted norms over time. The importance of these rules of proportion in predicting the appearance of a building before it was built, led to the birth of the earliest form of pattern books, as recorded by Vitruvius. (Kholy (1991)).
2. Wet trades influence construction: The quality of architectural projects has always demanded and continues to require a certain amount of deliberate slowing down, to ensure the “firmitas” aspect of the Vitruvian triad. In the past, the duration of these lengthy pauses was dictated by technological limitations. It was eventually drastically reduced to much shorter periods of time with the advances in soil mechanics and foundation design. Nevertheless, the need for waiting periods between certain phases in the construction has always existed and continues to be necessary so long as the wet trades continue to play a role in the construction of buildings to ensure proper execution. (Kholy (1991)).
3. Fast-tracking relates to technology: When the demand for fast construction arose, it sometimes triggered the innovation of new building techniques that went beyond the common building practices of the time; it led to a gradual but steady removal of operations from the site to the factory, and the birth of the prefabrication industry as well as its

establishment and proliferation as an integral part of the building industry. Also, the time constraint did not only have its impact on the way buildings were produced, but also on their appearance, inventing such architectural qualities as transparency, lightness, rectilinear modern shape almost devoid of any decoration. (Arief et all (2002)).

2.2 Fast-tracking influences on the design process

Current handbooks of design and construction designate fast-tracking as a method of design and construction most suited as a means of achieving significant time reductions by overlapping design and construction phases, a method that is no doubt having its effect on how and when architectural design decisions are being made and on redefining the architect's responsibility and authority in the entire process. Such a response may pose an obvious danger, because when time and cost becomes the top criteria against which the success of a building is to be measured, then it is possible to no longer dealing with architecture of high quality. However, it is argued, that while the professionals dealing in fast tracked design undoubtedly sense the pressure the time rush creates and the limitations the altered design and construction sequence imposes, they struggle to design within the phased time and budget frames while maintaining overall control over the design without compromising quality. (Arief et all (2002)).Experience with fast-tracking practices to date suggests that no intrinsically new problems for the construction industry are created. Rather, these practices merely add a variety of new interrelationships between time, architectural design and construction modifying their "traditional" context. When detailed aspects of fast-tracking practices are observed, one may advocate that the quality of buildings produced depends heavily on the ways design and construction professions define their roles.

2.2.1 Fast-tracking and the architect's role in the design process

Architectural critics and writers point out that fast tracking architectural practices may limit opportunities for quality design and construction. It is the argument of this paper that fast-tracking projects may present unique opportunities for design excellence instead of adversely affecting the quality of architectural design. The quality of architecture rests not only with the individual architect's abilities, the amount of time he allots to design, his dedication to design excellence in face of the conflicting promise of financial gain, and his acquaintance with technological advances, but also with his potential assignment as head during the initial design phase and his abilities to fast-track the design process itself. (Gray et all (1984)).

Many issues are addressed during the design process which is the entire sequence of events leading from the first inception of a project to its final completion. The design phase itself is divided into three phases: schematic, design development and construction documents. While these three stages are not mandatory for any given project, architects tend to use them as a guide with only slight modifications depending on the construction method. (Bell (1996)) The actual design is conceptualized in the schematic and design development phases while the construction documents phase produces drawings from which the project is built. In the schematic design phase, the architect translates rules, guidelines and problem solutions into a concept design of volumetric spaces. Along with this initial design concept, decisions concerning structure and material options are also being considered and introduced. Structure and building envelope are critical elements to the achievement of high-performance construction. The building envelope sets the pace for subsequent activities through to completion because of the requirement for a dry, protected, working environment, whereas structure and its detailing establish how the building components will be joined to each other. The architect's creative mind may engage fast-tracking limitations to act as incentive to invent a simple, flexible construction system by which a variety of special subcontractors may be allowed to work independently, becoming concerned with detailing only their own work to ensure efficient fabrication and erection. The fast-tracking environment strongly suggests that the architect understands in depth constructional methods and potentialities of various materials and tools. Discussions with the construction manager, who is recommended to be involved from the very beginning of the design process, enable the architect to explore alternative design solutions until he arrives at a clearly defined, feasible concept that meets the project's time and budget requirements. (Gray et all (1984)).

The details of a design are determined in the design development stage. Not only the visual and aesthetic details, but also the infrastructures of the project are determined along with potential problems which are located and solved. The design development phase allows the architect to finalize space and function to a greater degree through fully developed floor plans, sections, exterior elevations, and key details for particular areas or aspects of the project. The focus is on the technical aspects of materials and building systems aiming at minimizing the possibility of major modifications during the construction documents phase that follows. It becomes evident that all major issues that could cause significant restudy during the construction documents phase should be resolved before the end of the design development phase. During the preparation of the design development documents, the architect will meet with the contractor and other parties involved who can become more comfortable with the scope of the project and proposed materials and systems and provide more accurate cost estimates. In fast-tracking processes the schematic and design development stages are combined, shortening the design process. (Bell (1996)).

In a fast track schedule, construction is begun before construction documents are completed. The construction documents phase is another level of the design process. It includes the preparation of working drawings and specifications, often called working drawings, describing, explaining and defining in technical detail the layout, location, quantity and quality of the materials and systems to be used in a project. During this phase it becomes necessary for the architect to obtain additional technical information from the parties involved through the construction manager's coordination to ensure that all interested parties are satisfied with the documents, a communication process that is often eliminated Any adjustments to previous construction estimates are also reported and addressed appropriately, which may include re-design or development of bidding alternates.. During the construction documents phase, any changes from the approved design development documents are to be made only with the construction manager's approval. (Bell (1996)).

The architect may not be necessarily involved in the preparation of the working drawings on the basis he establishes the framework and the performance requirements of the project within which other designers work. Therefore, many of the working details on the detailed working drawings may be left to other designers, either separate architectural firms or to the specialist subcontractors. Moreover, by fast-tracking the design process itself, architects allow working packages to proceed independently of each other and yet in parallel. The subsequent checking of the subcontractor's working details, often named "shop details", by the construction manager and design team may also be simplified. The primary check is to ensure the boundary limits are not broken whereas the secondary check concentrates on technical matters. Secondly, the subcontractor's work on site is clearly defined by being divided into individual work packages, enabling the pace of the construction to be accelerated. In conclusion, not only the design may be flexible enough to allow division of work packages, but also the architect's view is possible to be flexible to acknowledge the value of possible alternative design options promoted by the subcontractors and to incorporate them in his design concept. (Gray et all (1984)).

As fast-tracking practices become popular, more owners, contractors and professionals will be exposed to them, and have to adapt to this method's procedures. The largest amount of adaptation seems to occur in the architectural profession. Fast-tracking processes of design and construction seem to demand perfect technological approach in analysis, planning, design and construction of today's complex building projects to achieve high quality performance. Architecture is not an art independent from reality; rather hundreds of construction details are responsible to define architecture and architectural quality. Since the time taken to complete the project is also shorter than in "traditional" approaches, conceptual analysis and design solution, innovative material and new technology tends to replace the "traditional" materials and technology to meet these requirements. It becomes vital for architects to require constant up-gradation of knowledge in the field of advanced building materials, earthquake resistance structure, aerodynamics, construction management, rehabilitation and maintenance of structure, intelligent and energy efficient building, ground improvement techniques, solid waste management, water harvesting and sustainable development for environmental protection, and use of information technology in design and construction. Such a good rapport with technology allows architects to be creative, engaging the appropriate technology to fulfil their architectural vision in accordance to the tight construction schedule required by fast-tracking approaches.

2.2.2 Fast-tracking and the role of the construction manager

Fast-tracking environment is often viewed not as a method of buildings' delivery, but rather, as a management strategy within delivery methods. As soon as the design and construction phases are overlapped, a whole series of complex interrelationships between the various parties involved is formed which demands to be properly managed to achieve a successful marriage between high-speed construction and working drawings to ensure efficient performance. (Otter (2001)).

A very important aspect of fast-tracking design is the clarification of the exact hierarchical relationship that exists between owner, architect and construction manager in a particular project, especially regarding the degree of involvement of the manager in the design process and the extent of his influence on the entire process. He may have a position of authority over the architect that allows him to have a strong influence on the outcome of the design initiating and participating in the pre-design project analysis and heading sessions to determine the design concept development, or to monitor the activities of the designers and manage the construction trades to assure that the emerging design can be constructed within the budgeted time and cost. The engagement of the professional construction manager is suggested from the early design process in order to be involved in pre-construction cost estimating, value engineering, and constructability analysis with the goal of optimizing the balance between construction cost, construction quality, and construction schedule. (Otter (2002)) In either case, it is argued that fast-tracking processes may benefit from creative and dynamic management since such processes by definition are inserted into a wider context that involves not only the architect but also other practitioners in the design team, consultants, developers and statutory bodies that influence the final result of the building design as well. In fast tracking complex building projects, due to the enhanced technical complexity of the projects and the throughput time, the most important flow of information is not necessarily coming from the architect but might as well come from other design specialists. Also, within the concept of integral design, all team members, architects as well as specialist designers, tend to work parallel from the early stages of the design process, as well as closely together in an intensive, interactive process.

3. CREATIVE ARCHITECTURAL DESIGN: IS THERE AN OPPORTUNITY IN FAST-TRACKING PRACTICES?

To design is to exert thought, emotion and creativeness in an organized manner toward a specific situation. No matter which procurement method is engaged, the design process operates in much the same way. Creative architectural design holds innate attributes such as complexity, flexibility, and adaptability. Such an argument becomes evident by evaluating the ways architects conceive design ideas. Moreover, creative architectural design processes can – and ought to- be planned and managed to improve the effectiveness of building processes, as recent discussions within the area of architectural design management assume. (Otter (2001)) Fast-tracking practices seem not to adversely affect the design process itself; rather they bring a rearrangement in the design procedures and sequences.

Architects tend to gather all necessary information in the schematic phase of design, and view them as opportunities to the development of the design, which will limit some choices of design such as the building envelope, materials, space, and form, among others. Next, various alternative design schemes are presented and evaluated according to the priorities of each particular project. Such priorities are referred to as guiding principles rather than constraints, which are also subject to re-evaluation along the process when new information may be added. It is interesting to note that researches on architectural design point out that the lack of constraints and specific direction acts as an obstacle to define the main concept of design. This event proves useful to knock down the myth of endless opportunities needed in order to release creativity in architectural design. On the contrary, architects develop their creative ability by exploring aspects of possible design solutions which translate at best needs and aspirations, theories and technologies, and schedules and budgets. The linkage of rules and means may lead to a variety of acceptable results. In addition, a completely worked out design does not necessarily have to be put on paper. It is conceivable that architects in pre-industrial eras envisioned in their heads exactly how the building was going to be, with the help of a few rudimentary sketches; buildings of high quality were built without documentation and even without a clearly stated complete design, in an overlapped process. (Kostof (1977)) As major facilitators of the design process, architects still have an opportunity to aspire for creative design within the restrictions imposed by fast-tracking practices and, thus, to successfully shape the built environment.

A close examination of fast tracking buildings which have received severe criticism reveals the underlying design tendencies associated with time reduction achieved through an overlapped phasing of design and construction. The most obvious one is the dissection of the design process into two separate parts. First, the envelope of the building is established during the schematic process. As soon as a permanent footprint for the building is decided, usually a simple geometric shape, the construction may begin while the remainder of the design work is completed. Next, the treatment of the building envelope in terms of detailing is worked out. The plan layout, thus, becomes a fixed "given" to be worked with at later phases. This attitude to treat the building envelope as an independent entity inevitably leads to what may be called "surface architecture', which as the name implies is basically a two-dimensional treatment of the façade. (Leatherbarrow et all (2002)) However, even in such cases where the architect is confined to deal only with the treatment of the façade, creative design approach may result in buildings of high quality architecture. Detailing may become a matter of choosing the best available prefabricated alternative, from glass skins, to metal cladding and partitions instead of a mere "cosmetic" detailing, which is almost inevitably called for to compensate for imperfections that appear in the as-built situation, and particularly if wet construction is selected, to compensate for difference in tolerance between structure and manufactured finishes. (Kholy (1991)) The important architectural attribute of complexity does not necessarily come from geometrical complexity; rather it may come from texture, vibration, and the metamorphic capacity of the building to transform, to change, and to breathe interacting with the environment.It becomes evident that a certain degree of regularity, repetition, increased simplicity in plan composition, and restriction of vertical flexibility are preferred to more intricate design schemes based on the frequent misconception on the part of the clients who tend to think that the artistic part of architecture may prove dangerous.

While the urgencies of fast tracking tend to severely restrict aesthetic options, leading to the typical prefabricated commercially available choices, occasionally, well designed and executed fast tracking buildings occur, which in most cases result from design competitions; a process which by itself draws out the best, most creative and well thought out ideas, allowing for architecture that is vibrant, complex and very much alive. (Kholy (1991)) Such examples demonstrate how speed and overlapped design-construction can be adapted to produce design excellence, innovative techniques, and even deploy new materials and tools under a special set of circumstances. A close examination of such projects reveals a number of important issues underlying their success:

1. Presence of a creative architect: The quality and uniqueness of any architectural project relies on the concept design and assembly of thousands, perhaps millions of parts and pieces incorporated into a project through a progressive series of strategic decisions, actions which involve the subjective application of high quality professional judgment.
2. Employment of the finest and most efficient companies: A motivated team offering the best technical and professional service to work with is always a prerequisite for achieving high quality architectural design, and even more so in case of fast-tracking processes. Production of buildings is first and foremost a human endeavour; the skills and qualifications of the designers, builders and their interrelationships are far more important than any written contracts.
3. Presence of a creative construction manager: The support and guidance provided by the construction manager to the architect's pursuit of aesthetic and high quality along with a successful collaboration with the overall team who provide guidance in the same direction.
4. Presence of an ambitious owner: The owner's willingness and desire to seek the best workmanship and material for the building is also a contributing factor.
5. Fast-tracking processes require ample technological information: All parties involved, and especially the architect, develop skills that enable them to complete high quality construction documents for which they are responsible. In addition, the architect's own particular attention to detail, creativity, use of technological advances, and insistence on choosing the most suitable material for every little detail are also crucial.

4. CONCLUSIONS

Contemporary and much maligned practice of fast tracking, the overlapping of the design and construction phases, is by no means an invention created out of vacuum. It is simply a reversal from the now accepted sequential norm to a pre-industrial overlapped one, but under a new set of circumstances and influences. In discussing common overlapping design and construction, one is usually faced with a separation of the various levels of design thinking (plan layout, external form, detailing) and the freezing of the plan's general shape and layout, since these aspects dictate the layout of the structural system and foundation design which are the first to begin. Therefore, the practice of fast tracking today tends to produce a more planar architecture with a two-dimensional treatment of the façade, increased rigidity in layering of space, over simplicity, dull repetition, and employment of several dry methods of construction.

The majority of architects today are reluctant to participate in fast tracking architectural practices due to the commonly held opinion that creative processes cannot be subject to acceleration if architectural quality has to prevail. However, as this paper argues, there is ample opportunity to achieve quality in architectural design under a wide variety of circumstances and design methods and to successfully shape the built environment. Inherent to the design process are countless opportunities to consider a variety of issues in every project. Design challenges have a potential to be transformed into opportunities at every scale of design. It becomes incumbent upon architects to strive for a better understanding of the limitations and possibilities of the fast tracking method, to aspire to creative design within the boundaries the method imposes, and to make a concerted effort to develop and modify their leadership skills; after all the constraints of fast tracking are analogous to the predetermined vertical and horizontal boundaries imposed by such notions as modules and grids which fall into the old tradition of classical proportions. In other words, the ability to work within confined space is not foreign to the way architects formulate and visualize their designs throughout history. Constraints of time and cost may be viewed as delimiting guidelines within which design proceeds rather than as an impediment to creative design. Fast-tracking the design process itself not only puts a high claim on motivation, but also on creativity, exquisite professional skills and teamwork abilities.Moreover, architects may have to learn to adapt themselves to the new temporal order of events and plan ahead with enough flexibility for details that might not be fully resolved until later stages of the construction process. At the same time they may resume their traditional role of possessing sufficient constructional knowledge and of providing constant supervision and ability to anticipate a variety of technical issues.

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EARTHMOVING FLEET SIZE OPTIMIZATION

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Abstract. Traditional deterministic analysis of earthmoving operations has three main drawbacks: the full truck loading capacity is not utilized; free float of the earthmoving activity is not considered; and probable time and cost implications due to truck failures are not taken into account. To overcome these drawbacks an analysis is performed in this paper. More precisely, the full track loading principle is examined first. According to this, trucks are fully loaded in every operation cycle and consequent time and cost implications to the project are examined. In succession, free float is considered to determine alternative compositions of loading and hauling equipment which lead to more efficient procedures. Finally, a methodology is proposed to determine optimum fleet size taking into account the impact of truck failures and that of stand-by / replacement trucks. It is argued that this approach is more factual, and as such, more useful in real world analysis of earthmoving operations.

Keywords: Earthmoving, Fleet size, Match factor, Availability, Stand-by units

1. INTRODUCTION

Infrastructure construction projects (dams, highways etc.) involve the movement of large quantities of natural materials (soil, rock). Earthmoving operations usually include a sequence of activities such as: loosening; excavating; loading; hauling; placing; spreading; grading and compacting. In this paper we confine ourselves to loading and hauling of earth using loaders and trucks.

In loading and hauling of earth, the selection of the appropriate earthmoving equipment has a major performance implication. The correct selection may result in substantial savings in both time and cost. Traditional deterministic analysis for fleet size selection, however, is accountable for three main drawbacks which affect significantly haulage economics.

Firstly, the traditional analysis rounds down the decimal number of bucket loads that correspond to each individual truck capacity fulfillment. In consequence, trucks are considered not fully loaded and thus the number of required trucks increases.

Secondly, each earthmoving activity has a pre-set fixed deadline, ignoring the possibility of free float utilization. Furthermore, the analysis assumes that the activity cannot be completed much earlier than the fixed deadline. Thus, the fleet determined is the smallest possible (and timely completion is at stake, case unforeseen circumstances arise).

Thirdly, the analysis fails to address truck failures and their consequent implication (reduction) to hourly performance. Thus, actual equipment performance is lesser than the estimated performance.

In order to mitigate the above drawbacks, this research:

- Examines whether full loading of the trucks employed is an advantageous construction policy.
- Shows that the consideration of the free float leads to several alternative additional equipment fleet compositions that may have better matching between loading and hauling equipment and thus achieve lower unit costs.

- Proposes an extended deterministic method that considers the impact of truck failures on earthmoving performance and cost and examines a variety of alternative solutions involving a pool of stand-by replacement trucks. The truck availability estimation is based on past data analysis and includes appropriate statistical processing.

2. LITERATURE SURVEY

Literature survey of the subject identifies several papers concerning earthmoving equipment planning optimization. For example, Gransberg (1996) presented examples of decisions made during the planning and construction stages that led to considerable impact on equipment fleet composition. The particular effect of actual and planned truck payload weight on production was investigated by Schexnayder et al. (1999). Dodin and Elimam (2008) presented a mixed integer linear program dealing with the integration of the project scheduling and equipment planning. Analysis concerning truck-loader matching have been made by Gove and Morgan (1994) and Burt and Caccetta (2007).

Besides, many researchers have addressed downtime caused by breakdown of construction equipment, e.g. Madu and Kuei (1994), Elazouni and Basha (1996), Edwards et al. (1998), underlining its non-trivial consequences on the equipment productivity and project performance. Methods contemplating the impact of equipment non-availability in terms of time and cost have also been developed. Tsimberdonis and Murphree (1994) presented an analytical approach for operational failures cost determination through numerical analysis in the form of discrete-event simulation. Edwards et al. (2002) developed a model to predict the hourly cost of tracked hydraulic excavators downtime based on regression equations. Nepal and Park (2004) investigated through statistical analysis how various factors and processes interact with each other to cause downtime. The literature survey also demonstrated several performance prediction proposals based on failure data statistical processing, such as Bedewy et al. (1989), Kumar et al. (1989) and Barabady (2005).

3. THE IMPACT OF PARTIAL TRUCK FILL

Earthmoving operations success is strongly dependent on hauling and loading equipment characteristics. The maximum gross weight or volume is the critical element in determining truck's load carrying capability. Traditional operational analysis calculates the decimal number ξ that represents the multitude of bucket loads satisfying both volumetric and gravimetric constraints (eq. 1). However, the number used is equal to the integer part of ξ; this means that the trucks are under-loaded.

$$\xi = \min \left\{ \frac{V_t * \varphi_t}{V_l * \varphi_l} ; \frac{B_0}{V_l * \varphi_l * \gamma} \right\} \tag{1}$$

Where: V_t : the truck volume

V_l : the loader bucket volume

φ_t : truck fill factor

φ_l: loader fill factor

B_o: maximum truck payload

γ: material specific weight

This consideration should be thoroughly investigated. The common assumption is that the greater payload weight results in a greater loading duration, as well as in a lower hauling speed. Thus, by approaching the load carrying capability, the truck cycle time increases, leading to a lower hourly production. However, it is conceivable that the concurrent increase of the volume loaded per cycle may counteract this loss and finally result in a greater hourly production.

Eventually, from the combined effect analyzed above, it becomes clear that it is possible to resolve a critical load increase that results in hourly production equal to the one corresponding to the integer number of loads. The critical value of bucket loads ξ_c representing this point arises from equation 2.

$$\frac{t_i}{\xi_i} = \frac{t_c}{\xi_c} \tag{2}$$

Where: t_i: truck cycle time corresponding to the integer number of loads

t_c: truck cycle time corresponding to the critical decimal number of loads

ξ_i: the integer part of number of loads ξ

Truck cycle time is a function of both payload dependent and independent durations. More precisely, it is the sum of times concerning loading, hauling, manoeuvring, dumping and returning as presented in equation 3.

$$t = \xi * t_l + t_c + t_h + t_r \tag{3}$$

Where t_l: loader cycle time

t_c: manoeuvring and dumping time

t_h: hauling time for loaded truck (function of ξ)

t_r: returning time for empty truck

Having calculated critical value ξ_c, it is possible to compare it to the value of ξ involved in any case under examination. Values of $\xi > \xi_c$ show that using maximum payload capability results in lower earthmoving cost.

4. THE IMPACT OF UPPER AND LOWER TIME BOUNDS

Traditional analysis contemplates that the activity deadline should be strictly met. As such, the smallest fleet size ensuring timely completion is determined. However, alternative fleet compositions should also be considered, at least as far as their entailing total cost is concerned. Working towards this, it should be presumed that project completion is allowed to be satisfied during a time period. For example, the earthmoving activity may profit from an existing free float within the project's overall time schedule. Furthermore, a lower time bound (shorter duration) may be imposed by the forecast of bad weather conditions, the need to transfer own machinery to other company's projects etc. An upper time bound (longer duration) may be imposed by financing limitations etc. Both could also be inherently implied by the contractual provisions for penalty and bonus.

The total cost entailing from each fleet is roughly considered as equal to the sum of two cost elements: the cost corresponding to the fleet setting-up, plus the earthmoving activity cost, including capital and various operational expenses. Obviously, both cost elements are directly related to the number of machines assigned to the project. Earthmoving activity cost is significantly influenced by the matching achieved between the different groups of equipment (loaders and trucks) composing the fleet.

Let assume a fleet of n trucks (t) and d loaders (l) that correspond to hourly production of Q_t and Q_l respectively; their matching is expressed by the match factor MF described in equation 4.

$$MF=\frac{n^*Q_t}{d^*Q_l} \tag{4}$$

Match Factor (MF) provides a measure of fleet productivity as it relates to the magnitude of idle periods occurring due to hourly production divergence between critical and non-critical units. Unit cost minimization is achieved when match ratio is equal to 1. Therefore, among several alternative fleet compositions it is highly probable to detect a fleet involving better matching and thus lower total cost. It must be noted that in cases where a smaller fleet leads to a better equipment match, it certainly represents the optimum solution, as it concurrently involves lower set-up cost and idle time minimization.

5. THE IMPACT OF EQUIPMENT AVAILABILITY

Availability is the most important measure of repairable systems effectiveness as it represents the probability that a system or component is performing its required function at a given point in time or over a stated period when operated and maintained in a prescribed manner (Ebeling, 1997).

Construction equipment can be in one of the two following states: in running condition, therefore available, and in non-running condition due to failure, thus unavailable. The state-corresponding time periods are uptime and downtime respectively. Total uptime and downtime define availability A, which can be interpreted as the percentage of time during which a piece of equipment is performing its function adequately.

$$A = \frac{\text{Total uptime}}{\text{Total uptime} + \text{Total downtime}} \tag{5}$$

Availability A is the major index for earthmoving equipment performance and it can easily be estimated through statistical processing of past failure data. Moreover, it is consistent to the rest average values involved in operational analysis. Considering a fleet of n trucks, a number of k simultaneous failures, k = 0…n, is possible to occur through different combinations of n-k functioning and k non-functioning trucks. Each combination represents an event of different occurrence probability, depending on availability of trucks involved. The multitude of probable events E_i, for given k, is:

$$\binom{n}{k} = \frac{n!}{k!*(n-k)!} \tag{6}$$

The formulation of all events E_i is indispensable for both the analytical computation of each event's likelihood to occur and the resultant probability of k simultaneous failures. However, the exact computation is not possible for great values of n, k due to the thousands of combinations arising.

A simplification reducing substantially the large variety of possible combinations is to consider all trucks as equivalent units: Introducing a common value of availability $\overline{A}$, equal to the average availability of trucks, a single event E_k, involving n-k functioning and k non-functioning identical vehicles, arises.

Therefore, the occurrence probability P (E_k), is:

$$P(E_k) = \overline{A}^{n-k} * (1-\overline{A})^k \tag{7}$$

The likelihood of k simultaneously occurring failures P(k) is equal to the sum of E_k corresponding events probability to occur. Thereupon, the equation used to calculate P(k) is:

$$P(k) = \binom{n}{k} * P(E_k) = \binom{n}{k} * \overline{A}^{n-k} * (1-\overline{A})^k = \frac{n!}{k!(n-k)!} * \overline{A}^{n-k} * (1-\overline{A})^k \quad (8)$$

Since productivity improvements usually translate into cost reductions, it would be particularly interesting to pond over encountering failure impact using stand-by trucks.

This research considers and evaluates financially the involvement of a varying multitude of stand-by units through several iterations of probabilistic calculations. Each iteration yields the unit cost corresponding to a specific number of stand-by trucks. The aim is to find the best trade-off between the added cost and the benefit that each extra vehicle involves. It is noted that stand-by trucks involve considerably lower hourly cost compared to operating and non-operating ones.

6. CASE STUDY

The points discussed above will be further clarified through a numerical example that involves loading and hauling of 1,800,000 m^3 of earth at a time span of 550 days. It is assumed that the material must be transferred over a one way haul road with length equal to 1,700m. The analysis is summarized in in Tables 6.1 to 6.4.

TABLE 6.1. Operational Analysis Data

General				**Itinerary**	
Volume (m^3) (V)	1,800,000	Loader fill factor	1.2	Length (m)	1700
Project Duration	25	Working hours/ day	8	Rolling resistance (kp/Mp)	40
Operator efficiency	0.8	Working days/ month	22	Grade resistance (kp/Mp)	0
Site efficiency factor	0.9	Mechanical efficiency factor	0.8	Maximum speed (km/h)	60
Swell factor (sf)	1.35				
Material specific weight (Mp/m^3)	1.65	Required hourly site production (m^3/h)	614		

TABLE 6.2. Operational Analysis Data

Equipment			
loader		**truck**	
Volume (m^3)	2.2	Volume (m^3)	12
Power (PS)	195	Power (PS)	280
Cycle time (min)	0.4	Max Payload (Mp)	20
Set - up cost (€)	2000	Set - up cost (€)	1500
Availability	1.0	Availability	0.85

TABLE 6.3. Cost Analysis Data

Cost Analysis	truck			loader
	Operating	Non-operating	Stand-by	Operating
Set-up cost (€)	1500	1500	1500	2000
Hourly capital cost (€/h)	6.818	6.818	6.818	6.818
Hourly repair cost (€/h)	2.272	2.272	2.272	2.272
Hourly fuel cost(€/h)	11.781			8.205
Hourly oil cost (€/h)	0.672			0.468
Hourly tires cost (€/h)	0.687			0.382
Hourly wage for operator (€/h)	14.065	14.065		16.930

TABLE 6.4. Cost Analysis Data

	percentage of original duration		
	0-10 %	10-15 %	15-20 %
bonus (€/day)	700	900	1100
penalty (€/day)	700	900	1100

The critical decimal value ξ_c, for balance achievement between concurrently increasing load and cycle time, is equal to 4.32 according to eq. 2. This means that in case that ξ is greater than 4.32 loading up to truck capacity leads to a lower unit cost. In this example ξ is calculated equal to 4.59 (from eq. 1). It follows that $\xi = 4.59 > 4.32 = \xi_c$; as such full truck loading leads to reduced costs.

Taking into account the previous observation, truck's hourly production is equal to 73.6 m^3/h. The loader's hourly production is equal to 316.8 m^3/h. For activity completion of 550 days, the traditional deterministic method concludes that a fleet of 2 loaders and 9 trucks is needed (case a); the unit cost is equal to 0.626 €/m^3. It should be noted that if MF is greater than 1, the critical group is the group of loaders.

Unit cost reduction requires the MF to be the dominant criterion for fleet selection, instead of deadline strict fulfillment. The following analysis confirms the assumption that a flexible

deadline results in more expedient machinery combinations (Table 6.5). However, the flexibility considered is not allowed to result in activity duration widely greater than that pre-estimated. On the contrary, it can lead to substantial, though reasonable, activity duration reduction.
More precisely, a fleet of 2 loaders and 8 trucks (case b) results in a lower unit cost. This is attributed to the fact that the trucks, representing the major part of the fleet, have become critical (MF = 0.93 < 1). Thus, the sum of idle periods concerning fleet b is considerably smaller compared to the one corresponding to fleet a. Moreover, due to the fleet size decrease by one truck, the total set up cost is equivalently reduced. However, using a fleet of 8 trucks, instead of 9, results in achieving activity completion is 573 days. Therefore, this solution could only be acceptable assuming equivalent deadline flexibility owning to adequate free float. Alternatively, deadline extension will result in penalties (case b).

Furthermore, a larger fleet, namely 3 loaders and 12 trucks (case c), involves substantially shorter operation duration, as well as a larger fleet set-up cost. As this combination leads to equipment match equal to the previous one (MF = 0.93), it is reasonably expected to involve the same unit cost. Eventually, this combination would only be preferable if earlier completion is rewarded by a bonus that counterbalances the extra set-up cost.

Similarly, an even larger fleet with MF closer to 1 would lead to further simultaneous cost and duration reduction. For example, using a fleet of 4 loaders and 17 trucks (case d), the match factor achieved is equal to 0.99 and thus unit cost is the lowest among all and equals to 0.605 €/m^3. However, due to the considerably greater set-up cost the selection of this case depends on the bonus provided.

TABLE 6.5. Alternative equipment combinations

	loaders	trucks	MF	Activity Duration (days)	Unit cost (€/m^3)
a	2	9	1.05	533	0.626
b	2	8	0.93	573	0.612
c	3	12	0.93	382	0.612
d	4	17	0.99	270	0.605

It is obvious that final fleet selection is strongly dependent on bonus and penalty contract provisions. In the example, the maximum total reward is considered equal to 6% of the activity pre-calculated budget and it concerns earlier or later completion up to 20% of the total programmed duration. The daily amounts considered per period of early or late completion are presented in Table 6.4.

Financial data corresponding to each case are calculated and presented in Tables 6.6 and 6.7. Table 6.8 presents alternative solutions in cost ascending order.

TABLE 6.6. Cost Analysis for alternative cases

	Earthmoving cost (€)	Set-up cost (€)	Penalty (€)	Bonus (€)
a	1,521,904	17,500	0	11,900
b	1,487,034	16,000	0	0
b’	1,487,034	16,000	16,100	0
c	1,487,034	24,000	0	93,600
d	1,470,013	33,500	0	93,600

TABLE 6.7. Total Cost for alternative cases

	Total Cost considering bonus and penalty (€)	Total Cost without considering bonus (€)
a	1,527,504	1,539,404
b	1,503,033	1,503,033
b’	1,519,134	1,519,134
c	1,417,434	1,511,033
d	1,409,913	1,503,513

TABLE 6.8. Alternative cases in cost ascending order

Evaluation considering bonus and penalty	Evaluation without considering bonus
d	b
c	d
b	c
b’	b’
a	a

The previous Tables show that traditional deterministic analysis results in the most unprofitable solution (fleet a). It is remarkable how the fleet of 2 loaders and 8 trucks turns to be more expedient than fleet a. In any case, the better matching counterbalances not only the loss of bonus, if any (case b), but also the penalty in case no free float is presumed (case b’).

Moreover, it is obvious that between cases c and d, the latter leads to a lower total cost despite the greater set-up cost, because of considerably better matching. Bonus (if occurring) has no impact, as for both cases, it turns out to be equal to the maximum reward for activity completion ahead of its due date.

However, it is quite probable that earlier finish is not rewarded. In that case, earthmoving cost minimization is achieved for a fleet of 2 loaders and 8 trucks provided that free float, arising from previous activities, is at least equal to 23 days (case b). Hence, particular attention should be paid to the avoidance of further delays. Towards this, failure impact alleviation dictates the employment of several additional trucks as stand-by units.

The average value of fleet availability A, is considered equal to 0.85. Equation 8 gives P(k) = Π(f), namely the probability of f = n - k functioning trucks for k simultaneous failures occurring. Table 6.9 presents corresponding fleet hourly production Q_f and unit cost C_f for each f value.

TABLE 6.9. Fleet hourly production and unit cost

A=0.85 n=8				
k	**f**	**Π(f)**	**Q_f (m^3/h)**	**C_f (€/m^3)**
0	8	0.272	588.8	0.612
1	7	0.385	515.2	0.674
2	6	0.238	441.6	0.757
3	5	0.084	368.0	0.873
4	4	0.018	294.4	1.046
5	3	0.003	220.8	1.335

Therefore, actual unit cost C_a and hourly production $Q_{fl,a}$ can be estimated from equations 9 and 10 respectively.

$$C_a = \sum_{f=3}^{8} \Pi(f) * C_f = 0.703 \text{ €/m}^3 \tag{9}$$

$$Q_{fl,a} = \sum_{f=3}^{8} \Pi(f) * Q_f = 500.48 \text{ m}^3\text{/h} \tag{10}$$

C_a is greater than the previously considered value C_8= 0.612 €/m^3 and $Q_{fL,a}$ is lower than the production Q_8 = 588.8 m^3/h. Due to this fact, further delays and the consequent penalties are expected to occur. Moreover, the divergence between the considered unit cost C_8 and the probabilistically estimated actual unit cost C_a results in a loss of 219,000 €.

The above methodology was further applied considering: a) several groups of similar trucks and their respective average availability and b) the exact value of A for each truck of the fleet and a low value for k (k= 0...3). For the above cases probability values ensuing from equation 8 differ slightly; thus the error occurring due to the use of average A can be considered negligible.

The use of stand-by trucks (with equal availability to the average value of the fleet) was further evaluated. Henceforth, the unit cost is symbolized as $C_{s,f}$, where s is the number of stand-by trucks involved, and f the number of functioning trucks (including stand-by ones) for k failures occurring simultaneously. When considering one stand-by truck, the unit cost $C_{1,f}$ turns to be slightly greater than the corresponding $C_{0,f}$ due to the extra vehicle entailing cost. When 1 stand-by unit is available the probability of 8 functioning trucks is $\Pi_{1,8}$ and equals to 0.657 (Table 6.10). Without stand-by unit involvement, the respective probability $\Pi_{0,8}$ is only 0.272. Evidently, the likelihood of f functioning trucks depends on the multitude of stand-by ones available. The unit cost corresponding to the cases of available and unavailable stand-by trucks can be calculated by using equation 9. The actual cost $C_{1,a}$ is the sum of the above, multiplied by their respective occurrence probability.

TABLE 6.10. Probabilistic cost analysis results for 1 stand-by truck involvement

		1of 1 stand-by truck available (85%)			**0 of 1 stand-by truck available (15%)**		
k	**P(k)**	**f**	**$C_{1.f}$**	**$\Pi_{1.f}$**	**f**	**$C_{1.f}$**	**$\Pi_{1.f}$**
0	0.272	8	0.628	0.272 + 0.385 = 0.657	8	0.628	0.272
1	0.385	8			7	0.692	0.385
2	0.238	7	0.692	0.238	6	0.777	0.238
3	0.084	6	0.777	0.084	5	0.897	0.084
4	0.018	5	0.897	0.018	4	1.077	0.018
5	0.003	4	1.077	0.003	3	1.376	0.003
C_{av} = 0.662 €/m^3					C_{unav} =0.721 €/m^3		
$C_{1.a}$ = 0.85*0.662+0.15*0.721 = 0.671 €/m^3 < C_a=0.703 €/m^3							

It can be seen that stand-by truck employment results in a lower unit cost and consequent reduction of total earthmoving cost. Therefore, the involvement of more than one stand-by trucks needs to be financially evaluated in order to determine the optimum fleet size. After several iterations of the above procedure considering a greater number of stand-by units each time, cost minimization finally arises for two stand-by trucks.

Data arising from the involvement of 2 stand-by trucks are presented at Table 6.11.

TABLE 6.11. Probabilistic cost analysis results for 2 stand-by trucks involvement

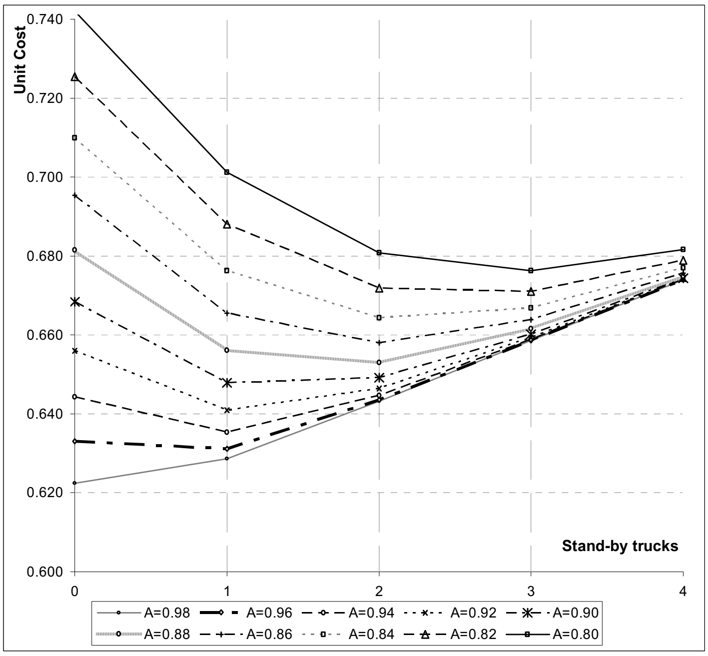
		2 of 2 stand-by trucks available (72.25%)			1 of 2 stand-by trucks available (25.5%)			0 of 2 stand-by trucks available (2.25%)		
k	**P(k)**	**f**	**$C_{1.f}$**	**$\Pi_{1.f}$**	**f**	**$C_{1.f}$**	**$\Pi_{1.f}$**	**f**	**$C_{1.f}$**	**$\Pi_{1.f}$**
0	0.272	8	0.643	0.895	8	0.643	0.657	8	0.643	0.272
1	0.385	8			8			7	0.709	0.385
2	0.238	8			7	0.709	0.238	6	0.798	0.238
3	0.084	7	0.709	0.084	6	0.798	0.084	5	0.922	0.084
4	0.018	6	0.798	0.018	5	0.922	0.018	4	1.108	0.018
5	0.003	5	0.922	0.003	4	1.108	0.003	3	1.418	0.003
C_{av} = 0.652 €/m^3					C_{unav} =0.678 €/m^3			C_{unav} =0.740 €/m^3		
$C_{2.a}$ = 0.7225 * 0.652 + 0.255 * 0.678 + 0.0225 * 0.740 = 0.661 < $C_{1.a}$ = 0.671 < C_a = 0.703 €/m^3										

Total financial savings S resulting from stand-by units use are equal to:

S = (C_a – C_{opt})*V * sf = (0.703 - 0.661)*1,800,000 * 1.35= 102,060 €.

Optimum fleet size can similarly be determined for any value of average fleet availability (Figure 1).

FIGURE 6.1. Unit cost variation for varying number of stand-by trucks and various values of A



Exact cost data for varying availability are presented in Table 12.

TABLE 6.12. Cost data for varying average availability

$\bar{A}$	Optimum fleet size	Unit Cost for optimum fleet C_{opt} (€/m^3)	Unit Cost for 8 truck fleet C_a (€/m^3)	Total Financial Saving (€)	Percentage Financial Saving (%)
0.98	8	0.622	0.622	0	0
0.96	9	0.631	0.633	4,565	0.30
0.94	9	0.635	0.644	21,679	1.38
0.92	9	0.641	0.656	36,692	2.30
0.90	9	0.648	0.668	49,938	3.07
0.88	10	0.653	0.682	69,186	4.17
0.86	10	0.658	0.695	90,554	5.36
0.85	10	0.661	0.703	102,060	5.90
0.84	10	0.664	0.710	110,880	6.43
0.82	11	0.671	0.725	132,486	7.52
0.80	11	0.676	0.742	159,861	8.87

7. CONCLUSIONS

The purpose of this study was to improve the traditional deterministic operational analysis concerning fleet selection. The study illustrated the improvements' effect through a numerical example. First, it examined the influence of reaching truck volumetric or gravimetric full capacity with regards to project parameters. Secondly, it analyzed the repercussions of flexible time constraints in fleet size selection. Thirdly, it studied the impact of truck failure considering truck availability as a representative index easily estimated through statistical processing of past failure data. The proposed model considers, for practical reasons, an average value for fleet availability and presents a cost probabilistic analysis, which yields the optimum fleet size involving stand-by trucks.

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SIMULATION-BASED ANALYSIS OF CONSTRUCTION OPERATIONS PRODUCTIVITY

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Abstract. Construction productivity estimation is indispensable to the construction process as it forms the basis upon which both competitive bids and construction schedules are prepared. In calculating construction productivity, however, there are considerable difficulties to overcome which are due to the uniqueness of the conditions met at the different construction sites. The methodologies proposed in the relevant literature are either based on intuitive selection of productivity multipliers (such as those representing local conditions, condition of the equipment used or operator's ability) or on a generally unguided selection of statistical distribution parameters used to simulate construction productivity. As such, to-date the construction engineer can either opt for computer simulation algorithms which he cannot control or be confined with the traditional approximate techniques described in BGL or equipment providers' manuals. In this paper an extended approach is adopted. According to this approach, it is feasible to describe in a high-level language the selected productivity estimation methodology and then ask from the system to calculate the expected output. As such, different methodologies can be selected and compared before a final decision is made. The design of a basic system of simple construction operations is described in this paper and a discussion on how this system can be expanded to incorporate more complicated operations is made. A prototype in .NET has also been developed to demonstrate the applicability of the approach.

Keywords: Computer modelling, Construction industry, Discrete-event simulation, Object-oriented simulation.

1. INTRODUCTION

The determination of performance in construction operations prior to the commencement of the construction project is a major issue for effective management. Construction productivity forms the basis upon which both competitive bids and construction schedules are prepared. In calculating construction productivity, however, there are considerable difficulties to be overcome which are due to the uniqueness of conditions met at different construction sites. Planners rely upon three approaches to estimate productivity based on: (1) analytical methods based on historical data, (2) approximate techniques described in equipment handbooks and (3) particular methods such as simulation or statistical analysis (Han and Halpin, 2005). The methods based on historical data or handbooks are typically referred to as deterministic analysis. This type of analysis is based on intuitive selection of productivity multipliers, such as those representing local conditions, condition of the equipment used or operator's ability. In turn, the application of simulation-based techniques has been relied upon a generally unguided selection of statistical distribution parameters used to simulate construction operations. As such, to-date the construction engineer can either opt for computer simulation algorithms which he cannot control or be confined with the traditional approximate techniques described in BGL or equipment providers' manuals.

In this paper an extended approach is adopted. According to this approach, it is feasible to describe in a high-level language the selected productivity estimation methodology and then ask from the system to calculate the expected output. As such, different methodologies can be selected and compared before a final decision is made.

The structure of the paper is as follows: First, a generic productivity estimation process is step-wise presented and analysed. The analysis identifies the deficiencies of current practice and proposes the mitigation measures forming the research focus. Subsequently, the estimation process is integrated within a basic system for estimating basic construction operations and a discussion on how this system can be expanded to incorporate more complicated operations is made. A prototype in .NET has also been developed to demonstrate the applicability of the approach. A numerical example of a hypothetical land reclamation project demonstrates the relevant concepts.

2. CONSTRUCTION PRODUCTIVITY ESTIMATION METHODOLOGIES

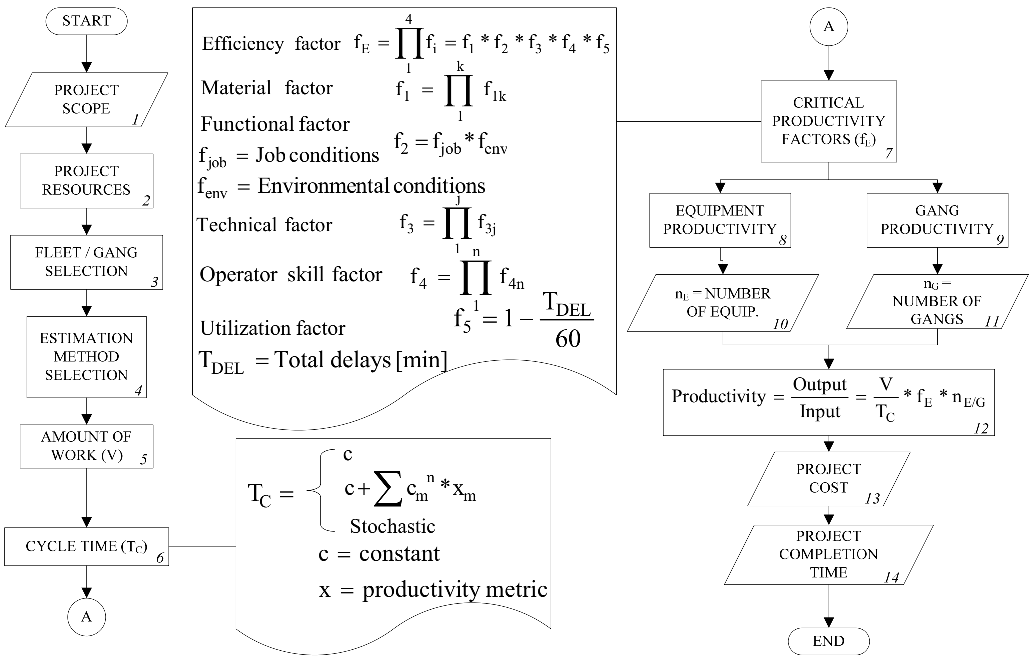
Construction productivity estimation is not a standard process (Park, 2006). It depends on the nature of the project, the resources that are deployed, the selected estimation method and the conditions under which it is executed (BGL, 2001; Anon., 2004; Park, 2006). However, irrespective of the partial differentiations, the different aspects of construction productivity estimation can be depicted as a generic estimation procedure as shown in figure 2.1. Example input data for a land reclamation project will be used to explain the steps of the estimation process:

- **Step 1**: Definition of the project's scope. Earth has to be removed from a contaminated site and safely hauled to a dumping site.
- **Step 2**: Definition of the projects resources. The deployment of earthmoving equipment is required.
- **Step 3**: Selection of the fleet/gang type and size. Initially, it is assumed that one excavator and ten trucks will suffice for the completion of the project.
- **Step 4**: Selection of the estimation method. For this project an analytical (BGL, 2001) and an approximate (Anon., 2004) method will be used and compared.
- **Step 5**: Amount of work. It is assumed that 12,500 m^3 of earth have to be removed.
- **Step 6**: Definition of activities' cycle time. The cycle time for each resource flow unit has to be specified. Resource flow units are independent work cycles which interact and define the system's productivity. Two working cycles are identified in this example, the excavator and truck cycle.
- **Step 7**: Critical productivity factors specification. When estimating construction operations, the unique project conditions have to be taken into account. This is expressed by the efficiency factor fE (BGL, 2001; Anon., 2004). The efficiency factor is further analyzed into specific multipliers that generally represent the influence of the material (e.g. soil swell, unit weight), the project-specific job's conditions (e.g. site organization), the environmental conditions (e.g. weather, altitude), technical factors related to the resources characteristics (e.g. equipment condition, labour competence), operator skill (e.g. professional ability, motivation)

and the utilization factor, which reflects the effect of any stalling in the efficiency of the operations (BGL, 2001; Jonasson, 2002; Anon., 2004; Dai et al., 2007).

- **Step 8/9**: Productivity is estimated for each piece of equipment and gang unit used in the project. In the example, there are only excavators and trucks to be considered.
- **Step 10/11**: The number of each type of resources specified in Step 3 should be taken into account.
- **Step 12**: Productivity is estimated based on the ratio of the operations' output to their input. In this example, productivity is calculated in m3/h.
- **Step 13**: For a given level of productivity and known unit cost rates, total cost of the project can be calculated.
- **Step 14**: Finally, the total duration of the project is being estimated.

FIGURE 2.1 Generic construction productivity estimation process



By critically evaluating the presented estimation process, there are some points that deserve more attention. Firstly, productivity factors are differentiated across projects (different sets of factors for different projects) and within projects (even for the same project different estimation methods define different sets and values for their productivity factors). This fact forms a basis for the comparison between methodologies in terms of their methodological and computational differences. The latter is demonstrated in the numerical example presented below, which illustrates the factors associated with the BGL and Caterpillar estimation methods.

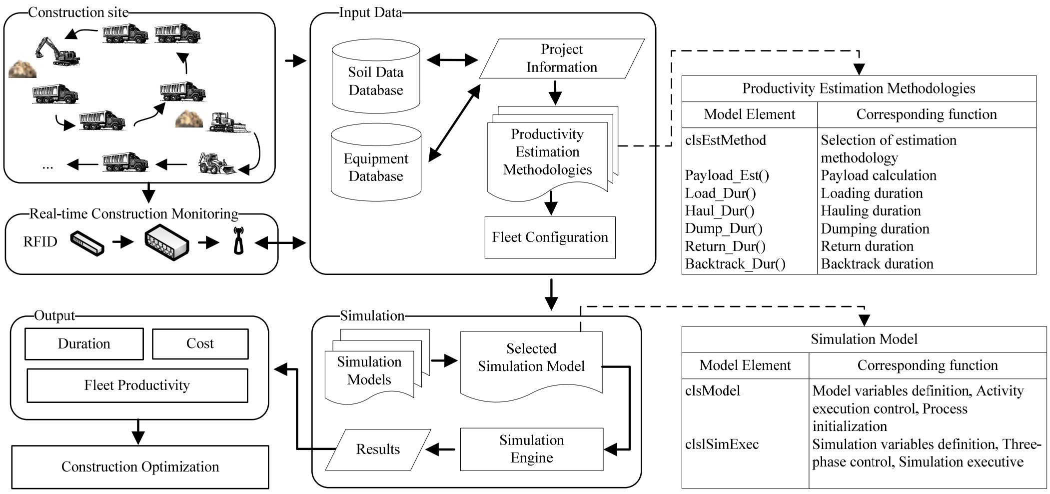
Moreover, two issues of research focus are being depicted in figure 2.1. They relate to the cycle time estimation and the excavation resistance specification. Regarding the former, depending on the estimation method, the cycle time is calculated deterministically (a constant number), statistically (through the use of regression models) or stochastically. In simulation-based productivity analysis theoretical and empirical distributions have been successfully deployed for both equipment-intensive (Hassan and Gruber, 2008) and labour-intensive (Al-Sudairi, 2007) operations. However, the validity of simulation estimation depends on the accuracy of the selected distributions' parameters in terms of reflecting the real construction operations and existing systems provide little or no guidance in their specification. The proposed model is intended to be fed with real construction data derived from workstudies of actual construction projects. Regarding the type of simulation, discrete-event simulation systems have dominated the construction industry (Palaniappan et al., 2006). Among the different strategies (world views) for producing simulation behaviours in a model, activity scanning (AS) has been identified as being the most suitable for modelling construction operations because of its ability to model complex systems (Martinez and Ioannou, 1999). AS follows declarative sequencing by scheduling activities based on a set of conditions associated with each activity and has been adopted for the development of the proposed system (Pidd, 1995). In addition, there has been a particular focus in developing simulation models with object-oriented features. Therefore, in the design of the proposed model there has been an attempt to apply object-orientation to capture the properties of key objects in earthmoving operations (Marzouk and Mosehli, 2003); the use of all these features is described subsequently. For verification and demonstration purposes deterministic durations will be used to model the excavation-loading-hauling operation of the theoretical example.

Traditional analytical and experience-based estimation methods are characterized by their inability to explicitly associate productivity estimation with excavation resistance. The specification of soil resistance forces on a tool that moves through a soil has been studied by many researchers. Kühn (1984) researched on excavation resistance for scraper operations based on empirical results. Singh (1995) proposed a method that learned to predict resistive forces based on force measurements during digging. Mrad et al. (2002) studied excavation resistance for backhoe excavators and validated a machine-automation model. Frimpong and Hu (2008) modeled the kinematics of front shovel excavators so as to define the envelope for optimum digging performance. However, thus far, there has not been an explicit linkage between excavation resistance and the resulting effect on productivity.

3. PROPOSED MODEL

The estimation process of figure 2.1 is integrated within an automated estimation system, whose architecture is depicted on figure 3.1. The system consists of three main components, as follows: (1) Input modeling, (2) Simulation engine and (3) Output module.

FIGURE 3.1. Model design



Input modeling corresponds to steps 1-11 of the generic estimation process. The desired estimation method (step 4) is selected from a library which contains details about each estimation method (e.g. necessary variables and parameters, productivity factors). Equipment specifications, labour crew characteristics, soil properties and productivity factors are derived from specially designed databases. An extract of such data is presented in the numerical example. An automated network for data transmission enables the collection of project-specific information (e.g. excavation resistance metrics) that reflects the project's local conditions (Fig. 3.1). The application of object-oriented techniques results in all model components being either built-in to the system or defined by the user automatically, without any additional code compilation being necessary. The methodology that enables these features to be realized is discussed in the development of the prototype model.

Once the input to the system has been determined, simulations for estimating construction productivity (step 12) can commence. As shown in figure 3.1, depending on the construction methods and their respective construction techniques, different simulation models are built. Input data for this module include the statistical properties of stochastic activities' duration derived from past historical data or workstudies and the selected simulation modeling method.

The simulation engine generates the results that are processed by the output module (steps 13-14). The simulation output contains information about the productivity of the deployed resources, the activities' duration and the cost of the operations. A set of user interfaces will facilitate statistical analysis of the results as well as the process of generating reports. The analysis is based upon the comparative analysis of the estimation methods in relation to their methodological and computational differences and the identification of the critical links of the working chains included in the operations, namely the flow unit cycles whose productivity determines the system's output.

4. PROTOTYPE MODEL LAYOUT

The possibility of materializing the previous model into a practical approach is demonstrated through the development of a prototype model. The model was coded utilizing Visual Basic.NET, which is a general-purpose language supporting object-orientation. The prototype models both labour-intensive and machine-intensive operations. The simulation system follows the three-phase approach (Pidd, 1995). Two types of activities are distinguished: those that are bound to happen (known as B's) and those whose start is conditional to the state of the simulation (known as the C's). The simulation engine performs a run in three phases. First, it scans all activities so as to find the ones that are to be executed at the current simulation time (A Phase). Then, all Bs due at that time are executed (B Phase) and then all Cs are tried consecutively until no more activities are left to be tried (C Phase). When no further activity is possible, the clock is advanced to the next event time and another three-phase run commences. The simulation model is built with the aid of the EZStrobe modeling elements (Martinez, 2001), whose functionality is explained in the next paragraph.

In order for the prototype to incorporate the innovative features of the proposed approach, a set of interfaces has been created that allow the user to describe the object types that are needed in the simulation. For instance, a general class (clsEstMethod) has been created for this purpose to allow for a high-level language definition of the preferred estimation methodologies (Figure 3.1). The user determines the input and each selection is translated into the usage of specific functions already included in the system (see table 4.1 for an example of the excavator technical factor estimation in the BGL estimation method). For the needs of the particular model, this system includes the CAT (Anon., 2004) and BGL (2001) estimation methodologies. The next paragraph presents the modeling and simulation process for a theoretical land reclamation project. The example is intended to stress the applicability of the model's existing features as well as denote the usability of its intended features in its full development.

TABLE 4.1. An example of the model's object-oriented structure

Type	Model Element	Input	Output
Class	clsEstMethod	Project data	Productivity
Object	objBGL	Productivity factors	Efficiency factor
Method	ExcTchnFctr()	Excavator technical characteristics	Technical factor (f_3)
Properties	ExcDpthFctr	Excavation depth [m]	Correction factors (f_{31}-f_{36})
	SwngAnlFctr	Swing angle [degrees]	
	UnldFctr	Targeted, Non-targeted unload	
	BcktTthFctr	Bucket teeth wear (low/med/high)	
	ExcAvlFctr	Usage hours [h]	
	TrckLctnFctr	Truck on/under excavation floor	

5. PROJECT SCENARIO

A contractor is assigned a land reclamation project in a restricted industrial area. Contaminated earth of 12,500 m^3 has to be cleared and moved to a safe depository. Due to space restrictions only one excavator can work on site and one truck is allowed in the loading area. Soil is excavated and dumped into trucks. The trucks drive to the depository area through three road segments, dump the soil and come back the same way. The system's model is depicted on figure 5.1. The EZStrobe modeling elements comprise of queues (round objects) which hold idle resources waiting to be used. The number of resources is depicted below each queue name. Unconstrained activities (B's) are being modeled by normals (rectangle objects) and constrained activities (C's), that start whenever resources in the queues that precede it are sufficient to support it, are modeled with combis (rectangles with upper left part missing). Deterministic cycle times are used to simulate the duration of the activities. A link (arrow) connects a queue to a combi. A draw link shows two pieces of information separated by a comma. The first part is the condition necessary for the successor combi to start. The second part is the number of resources that the combi will consume from the predecessor queue in the event that the combi takes place. Key project data is presented in table 5.1.

FIGURE 5.1. Activity cycle diagram for land reclamation example

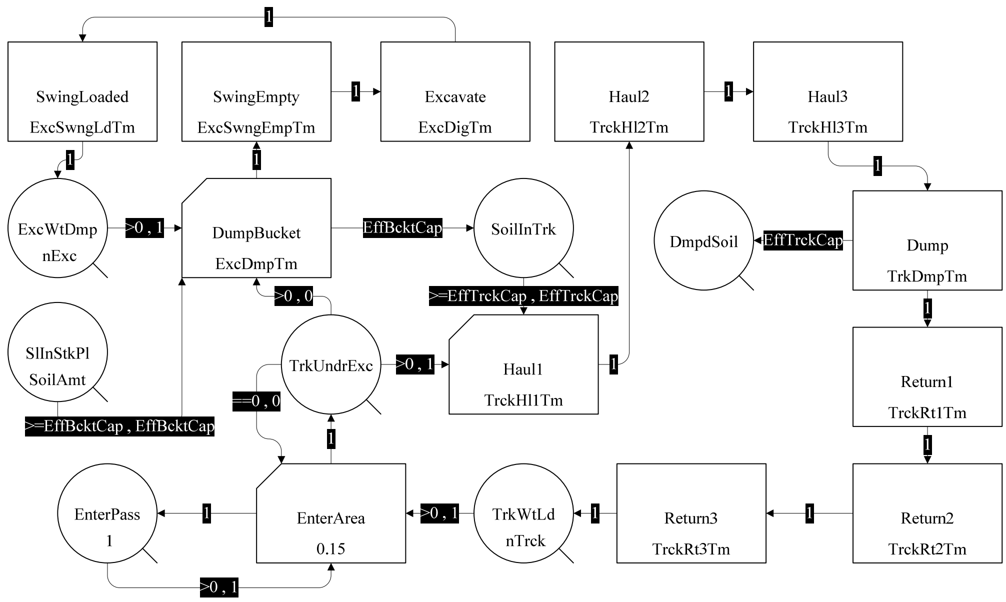


TABLE 5.1. Key project data

General data		Excavation operations data		Hauling operations data	
Soil	Hard clay	Rated bucket cap.	2 m^3	Truck cap.	12 m^3
Excavability	Medium-hard	Exc. Cycle time	0.36min	Haul time 1	6 min
Swell factor	0.80	Depth of cut	2 m	Haul time 2	4 min
Filling factor	1.20	Angle of swing	60 deg	Haul time 3	2 min
Soil density	1250 kg/m^3	Unload method	Targeted	Dump time	0.5 min
Jobs cond.	Above avg.	Bucket teeth cond.	New	Return time 1	1 min
Weather	Dry hot	Equip. usage	<1500hr	Return time 2	2 min
Altitude	280 m	Operator skill	Average	Return time 3	4 min

6. SYSTEM RESPONSE

The project's productivity has been calculated in two ways: through the BGL and Caterpillar estimation methods. Data reflecting the system response to the analysis is presented in figures 6.1a and 6.1b. Figure 6.1a shows the system's productivity in relation to the number of trucks. The combination of 10-trucks-1-excavator seems to be most suitable, which is verified by the calculation of the matching factor (f_M):

$$f_M = n_{trucks} * \frac{T_{spot\,\&\,load}^{trucks}}{T_{cycle}^{trucks}} = n_{trucks} * \frac{T_{cycle}^{excavator} * n_{loads}}{T_{cycle}^{trucks}} \approx 1$$

The differences (~16%) between the two methodologies are due to the different set and values of productivity factors taken into account as mentioned before. Figure 6.1b illustrates the results of a sensitivity analysis made to demonstrate the influence of the excavation resistance on productivity. It is known qualitatively that as the soil gets harder to dig, it takes longer to fill the bucket (Anon., 2004). In addition, soil resistance grows with increasing excavation depth (BGL., 2001). Therefore, a sensitivity analysis was made for the BGL estimating method for depths in the range 1-10m and excavator digging and cycle duration in the range of 0.06-0.12min and 0.20-0.40 respectively for the 10-truck-1-excavator combination.

Figure 6.1b implies that excavation resistance affects productivity in a dynamic fashion. When the digging duration (and hence the excavation resistance) is small, then excavation depth does not affect productivity substantially. For the 0.06min digging duration, the total difference in productivity is 3.1%. However, as excavation resistance increases there is a certain excavation depth beyond which productivity is reduced rapidly. For the 0.075min digging duration, the critical value is 7m. Respectively, this value falls to 4m for the 0.090 digging cycle. For the rest of the digging durations productivity is reduced in an almost linear fashion. For the 0.12min digging cycle total difference in productivity comes up to 36% which can have drastic consequences to the operations' efficiency. It should be noted that a prerequisite for the analysis' inferences to be valid is that the same piece of equipment is supposed to be deployed in the different excavation scenarios. In other words, the machine's power and the magnitude of its curl and crowd forces remain the same. This example intends to illustrate that excavation resistance is related with different productivity factors (excavation depth, cycle time) and can have a significant effect on the working methods adopted on site. The theoretical implementation demonstrates that in cases of adverse underground conditions the uncertainty of soil-tool interaction has to be taken into account so as to plan the project effectively.

FIGURE 6.1a. System's productivity

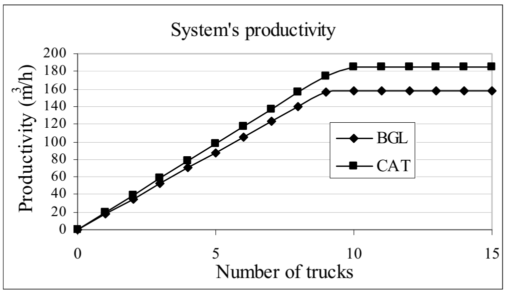
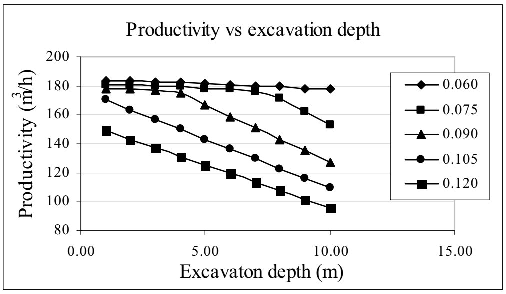


FIGURE 6.1b. Productivity vs excavation depth



7. CONCLUSIONS

This paper has discussed a new approach in estimating construction operations' productivity and has demonstrated its applicability through the development of a prototype model. The presented framework made use of declarative concepts to customize the selection of productivity estimation methodologies for construction operations; it was prototyped as a modeling template by using the .NET environment. A simple earthworks operation was simulated based on this framework in order to evaluate it and demonstrate its use. The prototype allows users to gain control of the productivity estimation procedure, a feature that is not addressed in other simulation models. The model makes use of the three-phase approach and object-orientation to facilitate its implementation as these approaches are widely accepted amongst construction operatives.

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Appendix 1 – Notation

The following symbols are used in Figure 5.1:

Activity names	Dump	Trucks dumping soil
	DumpBucket	Dumping loaded bucket
	EnterArea	Entering loading area
	Excavate	Excavating soil
	Haul1	Truck haul 1st segment
	Haul2	Truck haul 2nd segment
	Haul3	Truck haul 3rd segment
	Return1	Truck return 1st segment
	Return2	Truck return 2nd segment
	Return3	Truck return 3rd segment
	SwingEmpty	Swing empty bucket
	SwingLoaded	Swing loaded bucket
Queues	DmpdSoil	Dumped soil [m^3]
	EnterPass	One truck in loading area
	ExcWtDmp	Excavator waiting to dump
	SlInStkPl	Soil in stockpile [m^3]
	SoilInTrk	Soil loaded [m^3]
	TrkUndrExc	Truck in excavation area
	TrkWtLd	Truck waiting to load
Parameters	nExc	Number of excavators
	nTrck	Number of trucks
	SoilAmt	Soil amount [m^3]
	EffBcktCap	Actual bucket capacity [m^3]
	EffTrckCap	Actual truck capacity [m^3]

Activity times [min]	ExcDigTm	Excavator digging time
	ExcDmpTm	Excavator dump time
	ExcSwngEmpTm	Excavator swing empty time
	ExcSwngLdTm	Excavator swing loaded time
	TrckHl1Tm	Truck time for 1st haul
	TrckHl2Tm	Truck time for 2nd haul
	TrckHl3Tm	Truck time for 3rd haul
	TrckRt1Tm	Truck time for 1st return
	TrckRt2Tm	Truck time for 2nd return
	TrckRt3Tm	Truck time for 3rd return

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THEORIES AND MODELS OF MOTIVATION AND LEADERSHIP, CASE STUDY APPLICATION

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Abstract. An important problem confronted by many enterprises nowadays is low productivity, created mainly due to reduction of personnel's motivation, lack of leadership skills and absence of human resources management approaches adapted by enterprises' owners or/and directors. The aim of this paper is to analyse practices adapted by different enterprises regarding personnel motivation and human resources approaches, in order to increase their productivity and profitability. The method used was to approach enterprises of different type by distributing closed type questionnaire to individuals responsible for motivation, even if this was not a predefined obligation for them. The basic aim of the process was to define whether each enterprise was closer to the participating or to directive management model. Outcome of the analysis was that enterprises motivate their employees and are positioned closer to the participating management model, based on an approach that was rather unorganised and mainly on interpersonal relations.

Keywords: Motivation, Leadership, Participating/Directive management, Case study

1. INTRODUCTION

Low productivity is a common problem faced by an increasing number of organisations world-wide. When in an enterprise the productivity is not managing to keep up pace with the increasing work cost, then effectiveness, but also the existence of the enterprise, is under important threat. The question that derives by this situation is what the reasons of this annoying problem are. A number of executives are pointing as reason for low productivity the decrease of personal motives and the minimisation of "will to work". Moreover, the decline of devotion to the organisation in correlation with weakening of their commitment to the ethical laws for work is another important factor.

The aforementioned explanation has been challenged repetitively by experts on human resources management, based on an important number of results. According to these results, it is proved that, as a rule, an individual human being "wants" to work, "wants" to be productive and to contribute to the organisation's development. Supporters of the so called "motivation school" support that if the productivity of employees is inadequate, management has not succeeded to apply in a right way the conclusions of the modern science related to work environment attitudes. Rivals as the aforementioned lead to the conclusion that it is difficult to define what the "real" answer for low productivity is. To succeed a common accepted answer, a number of parameters should be taken into account as the possibility that motivation experts and academics could be wrong and the option that individuals are not willing to work or are obliged to work and for this reason do not perform in an efficient way.

The subjects analyzed previously are under study in this paper, through a case study research, in which organizations are examined for their practices regarding employees' motivation in order to lead to productivity and income increase.

2. LITERATURE REVIEW

Managing a company or an enterprise and achieving its targets requires the cooperation of human resources. The administrative actions are characterized by the efforts to motivate work force and to equate company's objectives with workers' objectives. The presence of a worker in a company's project does not contribute towards the promotion of company's objectives. The contribution could be either positive or negative, depending on the similarity of objectives (Kantas, 1998).

Every project team member is considered to be basically a passive element that could be motivated, could produce, but could not undertake initiatives. Thus the activation of the work force in order to produce is the baseline of every managerial effort. Two are considered to be the basic issues that preoccupy the administrative hierarchy of a company:

1. The finding of the level that employees could support efficiency or could increase efficiency in correlation with overall objectives accomplishment.
2. What are the motives related to the efficiency of the employees, in which level these are related to work productivity and in what degree a motivation system could be adapted, in order to support the effective motivation of human resources towards a predetermined direction.

Behavior motivators

Under the term of behavior motivators, it is signified the internal power that leads an individual to act. Motivators are for psychology one of the most important study subjects. The psychological theories for behavior motivators have their roots in hedonism, the aspect that each individual has the tense to aim pleasure and avoid pain. This tense leads to additional actions and to decision making that result to the avoidance of negative and unpleasant situations. These aspects emerged from the Epicureanism philosophy, based on the teachings of Epicurus (341-270 B.C.). Baseline of these were that pleasure is the supreme and dominant aim of life. According to Epicurus mind pleasure is preferable than senses pleasure that could disturb the mind tranquillity.

The theories for behavior motivators could be classified in three categories (Rensis, 1961):

1. Instinct theories
2. Theories of momentum and aid
3. Cognitive theories

2.1.1 Instinct Theories

Instinct theory is a theory that all actions, thoughts, and intents can be traced back to being caused by instinct. Human actions such as effort to avoid pain can be thought to be akin to an animal attacking a younger animal of the same species so as to deter them from trying to usurp a leader in the pack. It is often this that offers an explanation for why a person would act one way or another.

In order to explain human behavior on psychology terms-according to Freud, apart from other factors, it is required to analyze instincts and unconscience motivators. On the other side, McDougal supported that instinct is an inherited tendency that an individual could present, independently whether it will be expressed or not, based on internal or external factors (Storr, 2006).

2.1.2 Theories of momentum and aid

These theories, that came to substitute the instinct theories, accept that the decisions which refer to present behavior are based, in an important degree, on the consequences or the rewards that a past behavior had. The past actions that led to pleasant results have the tense to be repeated whilst past actions that had unpleasant results tend to be avoided. According to theory practitioners, especially Clark Hull (1943), the need for a behavior results from the lack of homeostasis-situation of physical operations equilibrium lack. For example lack of food or water leads the human organization in agitation and creates the need for return of the normal equilibrium and, as a result, created behavior that will lead to the decrease of this need. In this way the motive is related to the intensity of need and habit.

2.1.3 Cognitive theories

These theories have the following characteristics that differentiate them from the theories of momentum and aid (Kantas, 1998):

1. They do not offer primary importance to past time correlations of "stimulus-response" and already framed attitudes, but to temporary beliefs and expectations as conceived by the environment. Past facts participate in the degree that they influence present and future beliefs and expectations.
2. The beliefs and expectations for the future, present an important role in behavior-the expected correlations of "stimulus-response" and not the past correlations of "stimulus-response", as in the theories of momentum and aid.
3. Whilst in the theories of momentum and aid the size of the target is believed to be source of general distraction for a human organization, in the cognitive theories the results that have appeal value, act selectively in the behavioral challenge.

3. METHODOLOGY

The scope of the approach adapted was not to compare organizations of similar characteristics but organizations of different fields that could be activated in the same industry (especially in the construction industry). The reason of such a selection was the fact that the type of the offered services affects in an important degree the motivation policy and the level of employees' participation. All enterprises under examination were based in the same local environment (Pieria, Greece) and a predefined questionnaire of closed type was addressed to them.

Questionnaire completion process

The completion was consisted of the following steps:

1. Questionnaire composition
2. Distribution of the questionnaires to the executives responsible for human resources management and employment relations.
3. Provision of time in order the questionnaires to be studied and analysed.
4. Predefined on-site meetings and interviews for possible specifications.
5. Questionnaires collection.

Sample selection

Selecting the organisations that formed the sample for distributing the questionnaires was based on the aim to cover the following 4 axes:

1. Local characteristics.
2. Construction industry.
3. Private and public sector.
4. Word wide range local enterprises.

The sample was consisted of the following enterprises:

- A technical company constructing private projects (Organisation No.1). The company is activated mainly in the sector of building constructions, covering issuing building permits and constructing private owned buildings (either as constructors-design and build or as developers-design, build and sell). The company employs ten individuals and is operating for more than twenty years. The selection of this company was based on the fact that it reflects the typical example of a small company with two owners (engineers with horizontal relationship). The company is considered as medium sized, at local level.

- An important technical company of general construction operations (Organisation No. 2), employing more than forty individuals. The company is producing private and public works nationally. Moreover, they own concrete production premises, for internal and external, to the company, projects.
- A factory (Organisation No. 3) producing ready to use concrete (last of the construction industry sector). The company employs ten individuals and is operating for more than twenty years.
- A participative company which produces standardises and trades local agricultural products word widely (Organisation No. 4). It constitutes a pilot pioneering company at national level, exporting products in important markets, as the European Union and Russia. The company employs forty to fifty individuals, depending on the production level.
- As typical sample of the private sector, the local branch of an important Greek bank (Organisation No. 5) was selected, having fifteen employees.
- The local branch of a public sector organisation (Organisation No. 6). For this specific organisation, it must be noted, that the director responsible of answering the questionnaire could not answer all questions, as some of them could not be applied in the public sector. These questions were answered by a private sector expert, of the same profession discipline as the responder.

Questionnaire presentation

The questionnaire was based on the research work of Dr. E.S. Stanton, Professor of Management in the Business Administration School of St. John University-New York (Stanton, 1982). The initial thirty questions were adapted at local level and the questionnaire was enriched with fourteen more questions. Each question-proposal is graded from one to four depending on its subject. The possible answers to these questions were: totally agree, generally agree, generally disagree and totally disagree. In the end the grades are added, leading to a possible range of total grade between 44 and 176. The answers were weighed in the way that the lowest total grade results to adaptation of directive management model whilst the highest grade results to adaptation of participating management model, by the organisations under examination.

The questions included in the questionnaire are:

5. I create such atmosphere, that my subordinates tend to be more cautious and not risky.
6. I believe that in our department we have too many meetings.
7. In most cases, I believe that my subordinates have to be encouraged in order to decide by themselves how they will succeed their aims without "bothering" me.
8. When I assign one task, I tend to explain in detail how it should be done.
9. I offer my subordinates enough freedom in executing their tasks.
10. Usually I express to my subordinates the aims and scopes that I would like to be achieved during next year.
11. My superiors require that I have to take decisions for my department.
12. The administration owes to administrate. Managers should give detailed guidelines to their subordinates.
13. I believe that individuals should contribute in the decisions related to work and planning, that affect them.
14. I strongly believe that individuals have the ability to take over more responsibilities in their work.
15. To be honest, I fell less comfortable when I give my subordinates the ability to do things in their way and not in the way that I should act.
16. Usually, I manage my department in the way that I think is right and I give slight attention to the proposals of my subordinates.
17. My subordinates often approach me in order to provide me new ideas and advices.
18. Basically, my subordinates do not have the required skills to be more involved in my department's operation.
19. I often compromise in the discussions with my subordinates.
20. As a rule, I believe that my ideas are generally better than these of my subordinates.
21. I respond instantly to changes suggested by my subordinates.

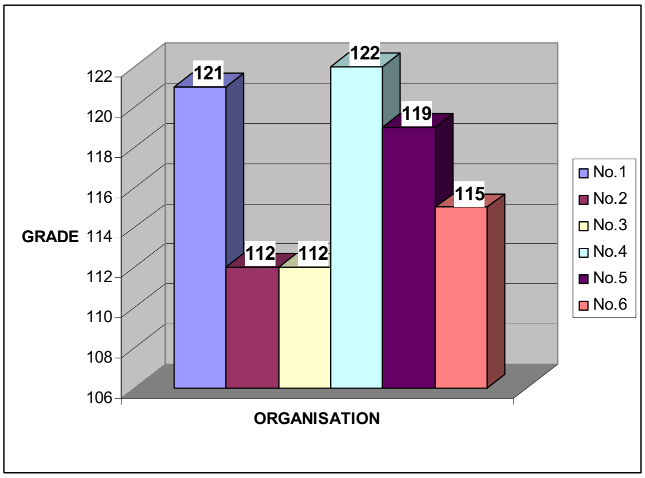
22. I feel that, as a manager, I have to display a powerful, stable and consistent way of managing regarding my subordinates.
23. I usually compromise with my subordinates regarding the process of works execution.
24. I usually determine exactly what it should be done by my subordinates.
25. As a rule I insist that my subordinates owe to follow exactly my directions fully.
26. I believe that I have to take into consideration the ideas of my subordinates before following a determined strand.
27. I usually insist that things have to done my way.
28. I often change the process of works execution, when my subordinates convenience me with proofs.
29. I usually lead myself with a stable, not changing and authoritarian way.
30. I usually encourage new ideas that come from my subordinates.
31. As a rule, I believe that my subordinates are pleased more with their families, their hobbies and the out of work activities.
32. I encourage my subordinates to execute their work; in the way they believe it is better.
33. The ideas of my subordinates, related to the work of our department, are as good as mine.
34. Generally, I encourage initiatives and modernity by my subordinates.
35. An employee detects that his/her position in the company is at threat. He/She has to work harder, in order to increase efficiency and convince his/her superiors that he/she is necessary.
36. An employee detects that his/her position in the company is at threat. He/She has to address to the trade-union organization in order to ask for support or to be a member of such an organisation, to be supported if required.
37. Factors that motivate each employee are not only financial, but also other as the job as itself, responsibility, progress, praise but also achievement.

38. Factors that prevent the dissatisfaction of an employee are the guarantee of permanence, the wage, the interpersonal relations, the good conditions of work and the policy of the enterprise.
39. A classical motivation method of an enterprise's personnel is that of threatening an employee to be substituted and loose his/her job.
40. In order to change the behavior of an employee it is required a superior with a philosophy of objectives' achievement who can recognize and reward positive contribution.
41. Need for success (at professional level) is something that can be developed in employees, within an enterprise.
42. The employees of an enterprise should be rewarded with economic rewards, direct and indirect. Direct as profits participation programs, various systems of economic motives and indirect as shares acquisition programs, health insurance, education possibilities etc.
43. It is not necessary for an employee to realize and understand the connection between additional financial rewards and job efficiency.
44. The system of connecting reward and performance, should be notified and analyzed in full detail to the employees and be checked that indeed it became comprehensible.
45. Each employee has the possibility, provided that he/she works hardly and performs, to be rewarded on time.
46. The influence of the financial reward to employees' behaviour is determining, independently of the age and the family status.
47. The wage of an employee should not be necessary related to the wages of rest employees of the same enterprise and also with the wages of other enterprises' employees with the same qualifications.
48. It is not important for each enterprise, to be re-informed by the employees, regarding to the effectiveness of the wages system.

4. RESULTS

All organization under examination have gathered total grade above 110 (average grade: (44+176)/2), characterizing their management style closer to the participating model.

FIGURE 4.1. Total grade of each organization



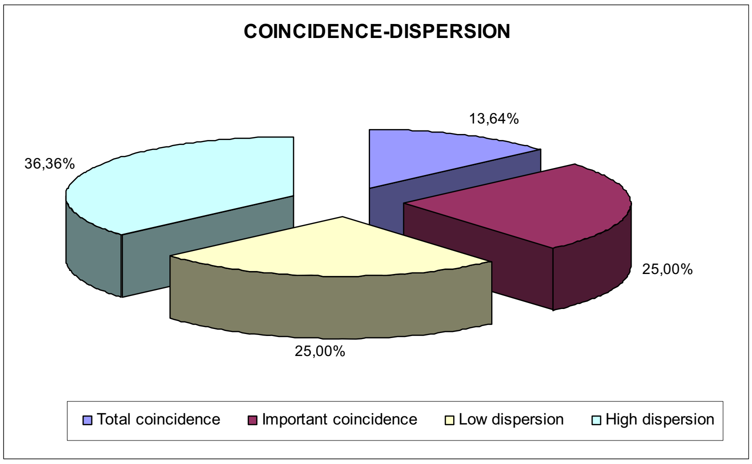
Despite the differences of each organization under examination, mainly due to the fact that they have different size, they are activated in different industries (construction, agriculture, finance) or in different sectors of the same industry, the grade range was rather narrow, 122-112=10, leading to 10/176=5,68% of total range.

In the organizations of the construction industry (No.1, No.2 and No.3) there is an important spread, mainly based in the different size but also in the different sector of action (private construction, public construction, concrete production). In this way, organization No. 1 is defined as the most participating, as personal relations are important between the owners but also within the hierarchy. Moreover, the organization size is not so enormous, especially in comparison with organization No.2.

Rather higher than expected proved to be the participation level in the local branches of the private bank (organization No.5) and of the public sector organization (organization No.6). The reasons could be the increased level of familiarity due to local based environment and the obvious tense for participation and collaboration. The higher grade was the one of organization No.4, which was an expected result, since this organization operates based on quality management systems (for management and production) as HACCP and ISO 9001.

Another interesting point that resulted from the analysis is the percentage of coincidence in the answers of all organizations, examining the percentage of coincidence and dispersion in their answers. This analysis was based on the grouping of the answers in four different categories: those that presented total coincidence (either totally agree or disagree), those that presented important coincidence (agree either totally or generally and disagree either totally or generally), those that presented high dispersion and those that presented important dispersion (one of the answers were different than the others).

FIGURE 4.2. Coincidence-Dispersion of answers



Six of the forty four questions presented total coincidence of answers, leading to a percentage of 13,64%. The proposals with coincidence are those stating that: the income is determining independently of the age and family status, the employee who works hard should be rewarded accordingly and in time, when tasks are appointed full details should be described, employees should be asked regarding their tasks and plans, not only financial factors affect the employees.

Although the range of total grades is limited to 5,68% (Fig. 4.1), the total and important coincidence is not proved to be so high (13,64+25,00=38,64%). Generally, high dispersion (36,36%) exists, nevertheless all organization were laying in the side of participating model. It is proved thus, that no “rule” exists to characterize a participating organization, due to the existing disperse of opinions.

Regarding the type of organizations, important results emerged. Local characteristics outweighed the possible barriers of participation in the national public and private bodies (organizations No.5 and No.6). Multi-sector action (even in the same industry) leads to more directive management of human resources (organization No 2). Organizations with typical production process (organization No.3) present limited participating style due to the standardized production process. The requirement for ideas and proposals (organization No.1) leads to higher participation level. Finally, all responders were rather cautious, whilst public sector responder required full discretion.

All responders agreed that they do not recognize threat as a motivation method, which is rather satisfactory. The sector of Human Resources Management including motivation is not incorporated in the wider management framework of the organizations, which could be expected for local based organizations. Human Resources Management is implemented (in the level that it is possible) by directors-founders-owners and not by experts of the discipline.

5. CONCLUSIONS

Outcome of the analysis was that although organizations motivate their employees, mainly by prompting them to participate in different levels of decision making, and are positioned closer to the participating management model, their approach was rather unorganised and based mainly on interpersonal relations. Generally, it is proved that organizations although positioned closer to the participating management model, they have important opportunities for adapting and developing motivation models and organising leadership tactics.

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