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Decision Making for Designing Infrastructure Projects: The Case of the City of Larissa, Greece

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Abstract

Engineers are aware of the fact that uncertainties in planning, designing and studying technical systems and projects are unavoidable. It is therefore necessary to include, in the equipment of engineers, the methods and concepts used to assess the importance of uncertainty in the study of technical systems. According to this position, the principles of probability and related fields of statistics and model development theory, express the uncertainty and allow the analysis of its impact on the design of technical systems. An important role in minimizing uncertainty today, plays the decision-making theory that enables complex problems to be solved under the conditions of the environment in which work is generated. Techniques for managing decision uncertainty depend on the level of knowledge of future conditions, on the number of alternatives under consideration, and on all the uncertainty parameters that appear in the problems. Decision making is a very important aspect of the engineering design process. While many real-world decisions are made under conditions of uncertainty and risk, current undergraduate engineering curricula rarely include any principles of decision theory or use probabilistic modeling and computational techniques. For example, while utility theory is a crucial component of the decision-making process, it is typically omitted in engineering curricula (Chen et al., 2013). This paper describes the aims, methodology and results of an empirical research project. The main purpose is to investigate the factors of work satisfaction in the construction sector of the city of Larissa, in combination with the increase of the employees' performance, while also drawing useful conclusions based on the decision-making theory.

Keywords: engineering design, road works, construction companies, decision process, infrastructure works.

1. Introduction

There are many definitions of the concept of "decision". More generally, the decision-making process is the process whereby the individual chooses between two or more alternatives to solve a short or long-term problem or to take advantage of an immediate opportunity. The decision, then, is a process that results in a result and is not just the time of choice. The factors that influence the individual in decision-making have been studied by many researchers (Dimitropoulos, 2003). The decision-making process is a set of eight steps that involves identifying a problem, choosing a solution, and evaluating the effectiveness of the solution.

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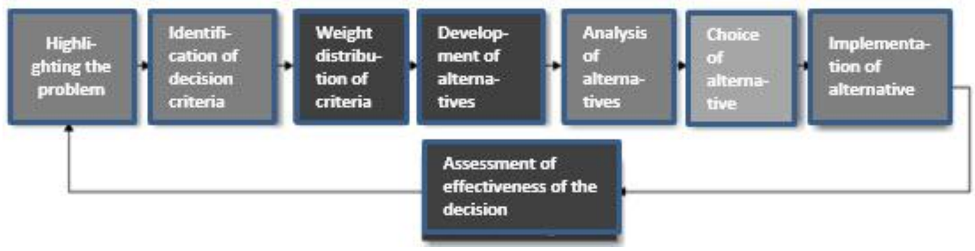

Figure 1. Stages of decision-making
(Source: Koumparelis and Makridis, accessed in 20/06/2019)

It is necessary to allocate weight to the factors that result from the identified criteria in order to give them priority in the decision (Koumbarelis-Makridis). Decision-making takes the whole administrative process and takes place at different levels. The first level is called individual decision making and concerns all the actions the individual takes to satisfy his or her desires. It may well be said that this level is also the starting point of the decision-making process since individual is always the starting base-point for the entire administrative process. In addition, other decision-making levels are recognized: group decision making, organizational decision making and meta-organizational decision making. The operation of these levels consists, on the one hand, of the transfer of inputs(decisional inputs), on the basis of which a decision is taken, from the external environment to the organization and on the other hand the transfer of outflows resulting from the decisional outputs and the organization to the outside environment. Inputs and outflows occur at all levels of the administrative hierarchy, which reinforces the perception that decision-making levels are in direct relation to each other (Christopoulos and Diamantopoulos, 2004).

2. Decision Process in Engineering Design

Engineers are decision makers, and decision making is what distinguishes engineers from scientists. The decisions that engineers make are often of very high consequence, to the engineer himself or herself, to the engineer's employer, and to society at large. The decisions that an engineer makes often affect his or her job security, income and opportunity for advancement, they impact the profitability or performance of the engineer's employer, and they often impact the environment and our safety. Thus, it makes sense that engineers study the mathematics of decision making in order to become better decision makers (Hazelrigg, 2012).

The engineering design community is now keenly aware that decision-making is integral to the design process, rather than an afterthought relegated to others. It is an important element in nearly all phases of design, from defining the problem, synthesizing alternatives, evaluating what is acceptable and what is not, identifying which design elements to work on first, specifying what information is needed and by whom, selecting which alternatives are worth pursuing further and finally configuring the optimal design**.** The role of decision making in an engineering design context can be defined in several ways. As shown in next figure the decision process is influenced by sets of conditions or contexts.

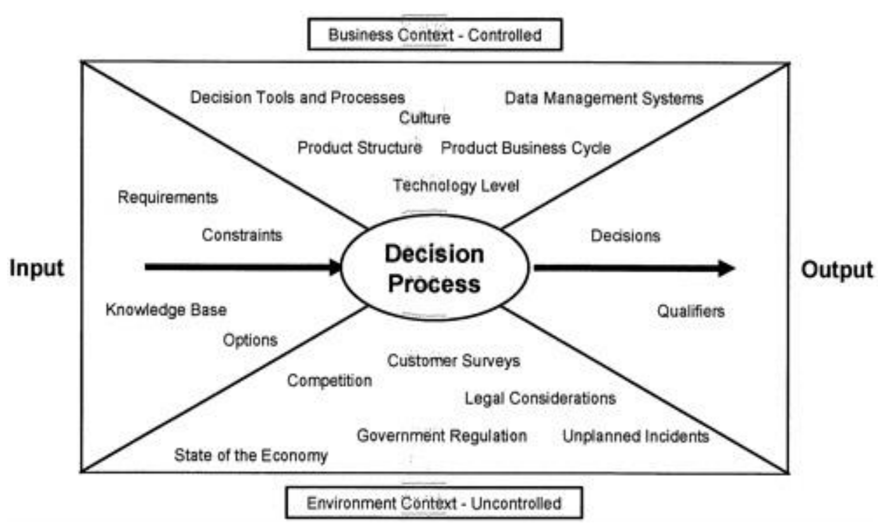

Figure 2. Decision process in the context of business and environment
(Source: The National Academies Press, 2001)

The business context represents the long-term view of the engineering company and is largely in the control of the company. The environmental context, such as the state of the economy, is not controlled by the company and must be considered a variable. The input context, such as the completeness of and variation in requirements and constraints, is established by the customers as is the output context, such as state of readiness to implement decisions, risks, and qualifiers.

Closing with the customer is an iterative process reconciling the customer's needs with the developer's design capabilities and requiring collaboration and experience with the product. In the real world, decisions made by the experts can be delayed and overturned by higher-level management based on poorly defined or unstated environmental issues. In today's engineering environment routine decisions can involve geographically dispersed teams working under challenging cost and timing constraints.

Under these conditions, the quality of most decisions can be improved through the application of computer-based tools. These tools can be put in the following categories: knowledge-based engineering, workflow, and collaboration.

During the design process the engineering designer or design team has to make decisions repeatedly. These decision episodes are modelled in the decision node model. The node, see Figure 3, is a generic, elementary decision-making activity consisting of six sub-activities: to specify, to evaluate solution alternatives, to validate a design solution, to navigate through the solution/activity space, to unify the current decision into consistent wholes, and to decide.

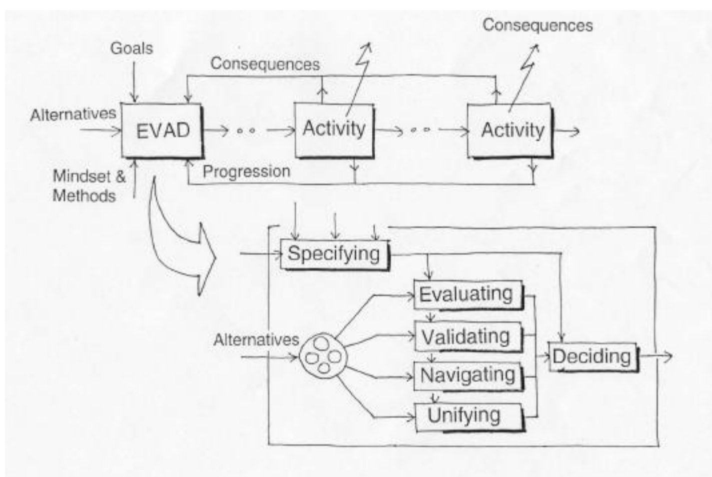

Figure 3. The decision node (Source: Hansen and Saeema, 2012)

The decision node is generic in the sense that it contains the full set of sub-activities, which are found in different design decision episodes:

To specify sets the criteria for the decision. It is the engineering designer's task to compile stakeholders' goals and translate these goals into product design specifications.

To evaluate a number of design alternatives is to identify the better ones or establish a ranking of the alternatives with respect to the current criteria.

To validate is to check whether the current design proposal is "fit for purpose" with respect to identified product life concerns, e.g. manufacturing, distribution, or use.

The skilled engineering designer is not only goal-oriented; he/she also understands the process for reaching the goal.
To navigate is to consider not only the current solution alternatives, but also these alternatives' influence upon the progression in the design project.

During the design process a solution is synthesised through a sequence of complex decisions. The engineering designer has to unify the current decision into the totality of process and solution in order to obtain a satisfactory result.

To evaluate, to validate, to navigate, and to unify are sub-activities, which result in a basis for making a decision. In a decision episode each of the sub-activities carried out provides a signal, and the engineering designer or design team has to decide based upon the signals obtained (Hansen and Saeema, 2002).

3. Decision making models

The aim of decision theory is to establish methodological approaches to support decision-making processes. Problem solving can be defined as the process of identifying differences between the actual and the desired situation and then taking steps to eliminate these differences. For issues so important as to require thorough analysis, the troubleshooting process includes the following seven steps:

1. Identify and define the problem.
2. Identify alternatives.
3. Definition of the criterion(s) to be used for the assessment of alternatives (options).
4. Evaluation of alternatives.
5. Choose an alternative.
6. Apply the selected alternative.
7. Evaluation of the results in order to decide whether it has been achieved a satisfactory solution.

Decision making is the term generally associated with the first five steps of the problem-solving process. Therefore, the first step in decision making is the identification and definition of the problem. Decision making ends with the choice of alternative.

Many decisions, especially strategic decisions, are of a long-term nature. In other words, the results from their implementation will emerge in the future and will continue to emerge for a long time, and any limited possibilities for revising the decision will usually be accompanied by serious - economic or other - impacts. Long-term decisions should therefore be based on knowledge of future treaties in order to make the best possible decision (Karamanidis, 2005).

Decision Making Models are divided into Analytical Models and Simulation Models, while the categories of modeling techniques in Optimization Techniques, Approach Techniques and Techniques Based on Model Simulation (Shifeleras, accessed in 20/06/2019).

Many researchers have embraced the decision-based design (DBD) approach and the need for concurrent design methods within industry has helped the growth of the DBD research community. In the wake of this growth, a number of new design decision support (DDS) frameworks ⁄methodologies have been introduced in recent years many of which are used specifically for concurrent decision-based engineering applications". The seemingly endless list of design-decision methodologies above goes a long way in proving that "a lack of agreement still exists on the exact implementation of DBD in engineering design". However, it could be suggested that there may never be one all-encompassing decision support methodology considering that companies that make use of such tools have different objectives and philosophies. Nevertheless, there should still be some criteria by which to judge these proposed decision support tools to ensure that their use will consistently yield the correct decision, i.e., that these methods are valid.

One of the most widely recognized classification systems for decision-making was suggested by Harren (1979), who talks about three more behavioral patterns that appear more systematically in decision-making and mark three decision-making modes: logical, intuitive and addicted. These ways indicate the extent to which the individual assumes personal responsibility for decision-making or blame responsibility at the fate or others and the extent to which he uses rational instead of emotional strategies in making decisions.

More specifically, the Decision Engineering series focuses on the foundations and applications of tools and techniques related to decision engineering, and identifies their relevance in 'engineering' decisions. The series provides an aid to practitioners and applied researchers in the development of tools for informed operational and business decision making, within the industry, by utilizing distributed organizational knowledge.

4. Decisions on increasing the efficiency of employees in the construction sector of Larissa

4.1 Problems of the construction sector

The ultimate aim of this article is the targeted investigation of the working environment and the factors of work satisfaction, the human resources of the technical companies of Larissa and the way they relate to the efficiency and dedication of the employees and consequently to the smooth operation of the company.

It is global and time-honored that the construction industry, both in private and in public works, is the first, time-consuming sector affected by an upcoming recession of the economy, but also the industry that is first experiencing and signaling growth when it comes. According to current industry data, in the case of Greece, ELSTAT (Hellenic Statistics Authority) official data shows that, apart from the important issues of credibility and transparency of Greek public administration and economy, one of the main reasons for the continuing recession in Greece, the duration of which is unprecedented in modern historical data, is the deep recession of the Greek construction industry.

It is clear that the reduction in construction projects causes a reduction in the number of contractors across Greece and at the same time cancels any hope for a multiplier positive impact on the economy as a whole from the construction of the projects causing concern also in many other productive sectors, craft and trade. All of the above are problems facing every construction company in Greece and a potential part of them are the construction companies of Larissa.

4.2 Research methodology

The present research was based on a qualitative research method, as this method can achieve the formation of a realistic picture of the phenomenon investigated. The factors contributing to the satisfaction of employees in the case of the Larissa construction sector were captured through closed-ended questionnaires asking workers to declare their satisfaction or dissatisfaction about the various aspects of their work roles. Data collection was conducted using closed-ended questionnaires. After a telephone conversation or a personal meeting with staff of ten technical companies in Larissa, a number of questionnaires were given to the interested parties.

The questionnaires distributed to the respondents for reasons of confidentiality and freedom of opinion were anonymous and were accompanied by sealed envelopes (with the personal stamp of the supervising professor, Dr. I. Houliaras), which were collected. The above procedure was followed for the purpose of the most reliable and valid research possible. The process of sharing and collecting questionnaires lasted three months. Of the ten companies, only seven accepted to participate in the survey and out of one hundred and twenty questionnaires, 74 were returned. The instructions given to the staff managers were to share the questionnaires to the staff of their company regardless of the job, age and educational level.

5. Results of the survey

5.1 Demographics

The first part of the questionnaire was designed to collect demographics.

A) Gender

It is obvious that male sex is overtaking 69%, compared to the female sex, which holds 31% in the Larissa construction sector, as shown by the graphical representation below. Of the total number of seventy-four workers who responded correctly, fifty-one were men and twenty-three women.

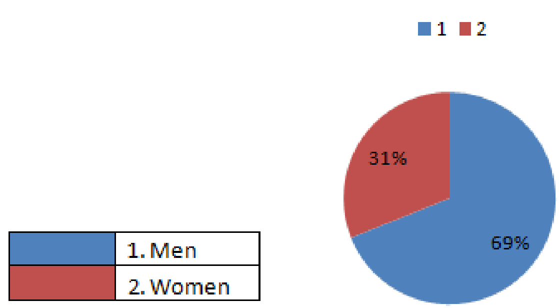

Figure 4. Sample composition based on gender (Source: Kapsali, 2018)

B) Age

With regard to the age distribution of the sample, it appears that the majority of the sample ranges from 36 to 45 years, with 36%. This is followed by the age of 26-35 years with 34%. 20% of the sample is the age group ranging from 46 to 55 years, followed by much smaller percentages by the age group of >56years with 7% and <25 years with only 3%.

It is clear that in the technical professions, past service is an important factor in the choice of workers, and since the industry is currently suffering from a shortage of work, new graduates of technical schools are hardly starting their career, many are turning to other professions or continuing to study and leave abroad.

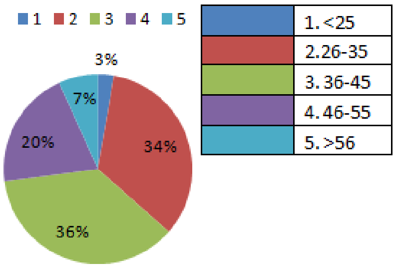

Figure 5. Sample composition based on age (Source: Kapsali, 2018)

C) Educational level

Since the current survey concerns technical companies, it was expected that the majority of respondents, with a percentage of 57%, would be graduates of Universities. They are followed by 20% of those with high school or high school diplomas, and then holders of postgraduate studies with 18%. The remaining 5% are graduates of Vocational Training Institutes and other schools, while it is noted that the percentage of doctoral students is zero.

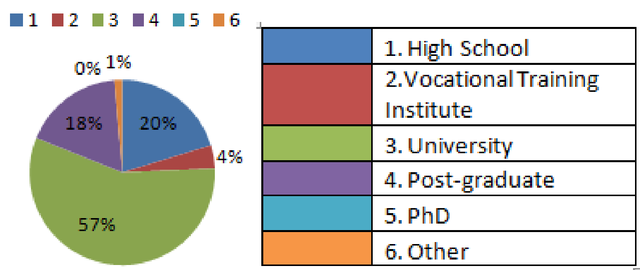

Figure 6. Sample composition based on the educational level (Source: Kapsali, 2018)

D) Work position

The composition of the sample with regard to the job position shows that most jobs are covered by scientific staff, ie engineers and accountants, with 39%. This is followed by 16% of workers as machine operators, who mainly belong to the age groups of 46 to 55 and over 56 and in the category of high school or high school graduates. This confirms the industry's concerns about the significant reduction of experienced operators and the lack of interest of the young generation in this profession. Subsequently, positions of officials of various tasks, such as secretaries and project managers, are followed by 14%. The remaining 17% belong to senior positions (8%), to workers (5%) and to foremen (4%).

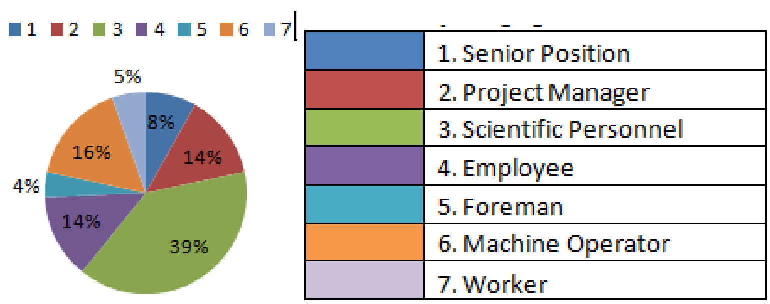

Figure 7. Sample composition based on job position (Source: Kapsali, 2018)

E) Work experience

From the chart below, it is clear that a significant number of 39% workers, although all companies are active for several years in the construction sector, are employed for between 1 and 5 years. The majority (53%) is people working in the same business from 6 to 20 years, while only 11% belong to those who work for more than 20 years.

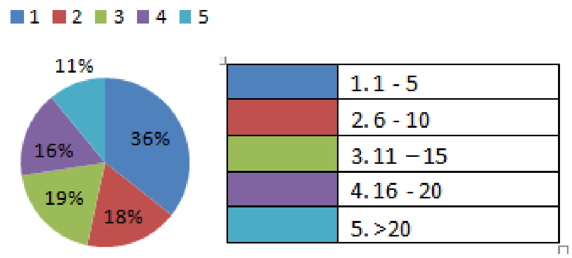

Figure 8. Sample composition based on past experience (Source: Kapsali, 2018)

5.2 Work satisfaction

The second part of the questionnaire includes a series of questions related to various aspects of job satisfaction.

F) Object of work

The decision regarding the response of each employee is based on the position of his / her responsibility, the working environment of the company and the subject of his / her work ("ΔΑ"stands for "I don't answer", "Δ" stands for "dissatisfaction", "O" stands for "neutrality", "Σ" stands for "I agree", "ΣΑ" stands for "I absolutely agree").

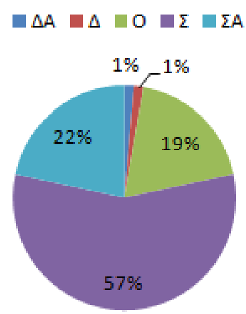

Figure 9. Sample composition based on Object of work (Source: Kapsali, 2018)

G) Working conditions - Working hours

The overwhelming majority of workers, 76%, is satisfied with the conditions and working hours and enjoys a sense of professional stability. They state that they work intensively to meet their obligations, they are moderately satisfied with the flexibility of their working hours, while half of them work overtime, which causes them tiredness and anxiety, so they are not so efficient. As far as working conditions are concerned, most of them agreed that the companies they work in provide the necessary equipment, take the necessary security measures and grant the permits to which each employee is entitled.

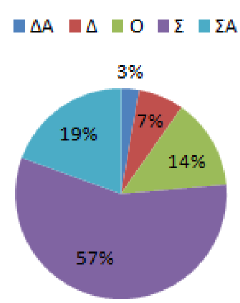

Figure 10. Sample composition based on working conditions & hours (Source: Kapsali, 2018)

H) Salary

As regards the salary of the sample in question, there is a modest state of satisfaction, since half of the workers consider their remuneration to be equitable in terms of their work obligations and the pay of their colleagues, while the other half find themselves wronged. On the part of the work beyond the agreed hours, the majority agrees that overtime work is not remunerated. In the field of education, whether companies invest in workers' abilities through education and seminars, the situation is similar, half of respondents declare that the company they are working on invests in the development of their capabilities, while the other half respond negatively. Of course, we do not know whether the employees themselves are interested in training and evolving and whether they suggest it to the business they are working for.

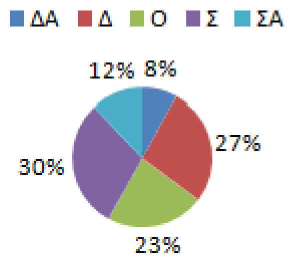

Figure 11. Sample composition based on wage conditions (Source: Kapsali, 2018)

I) Colleagues - Working Climate

As illustrated by the diagram below, the working climate on collegiality is very satisfactory in all companies. All employees trust their colleagues and have the freedom and the comfort to ask for help from them whenever they need, which enhances the pleasant working climate. On the subject of competition, everyone says there is no intense competition between them and they all work together for the good of the company.

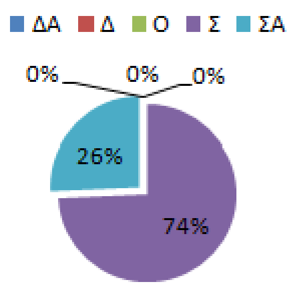

Figure 12. Sample composition based on colleagues (Source: Kapsali, 2018)

J) Supervisors

Relations between employees and their supervisors are consistent with their relationship. The results are very satisfactory and everyone agrees that the bosses take into account the suggestions that make them work better, have good attitude towards the employees and respect them, their judgment is fair, and consequently all the above is reinforced by the climate trust and good cooperation.

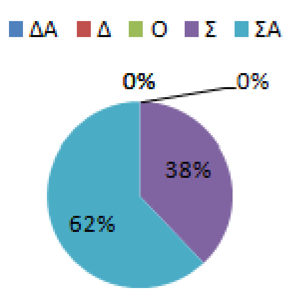

Figure 13. Sample composition based on supervisors (Source: Kapsali, 2018)

K) Leadership & Business

In part of the leadership, a fairly high percentage of workers is holding a neutral stance. The majority of respondents, of course, are satisfied with the attitude of the leadership and say that leadership shows the necessary interest in them, encourages them and rewards them, gives them the necessary freedom to appeal to senior executives whenever necessary, but not bypassing systematically their superiors and advancing favorable changes for the sake of the employees themselves and by extension the business. The small percentage that expressed dissatisfaction with the leadership says the leadership is not very interested in them and does nothing to change the, sometimes, unpleasant situations that arise.

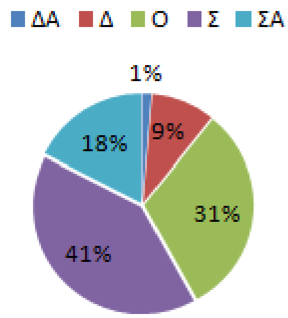

Figure 14. Sample composition based on business leadership (Source: Kapsali, 2018)

L) Loyalty

80% of respondents are fully satisfied and fully committed to the company they are working for. They are proud of the business and recommend to others to work in the company they are also working for. At the same time, they say they would not choose another company to do a similar job. A percentage of 19% holds a neutral attitude and a very small percentage indicates its dissatisfaction and easy change of working environment.

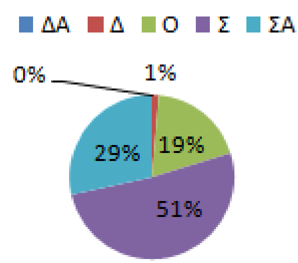

Figure 15. Sample composition based on dedication to the business (Source: Kapsali, 2018)

M) Most important factor of satisfaction

In the last questionnaire, respondents are asked to choose the most important factor for job satisfaction for them. The suggested answers were:

1. Subject of work.
2. Working conditions.
3. Hours.
4. Monthly earnings.
5. Good relations with colleagues.
6. Good relations with supervisors.
7. Stability of employment.

`The majority with 35% decided that the most important factor of satisfaction is the work. Respondents want to work on the subject they know, evolve through it and feel useful and productive for the business that employs them. This is followed by a 29% employment stability factor, which is an important parameter in the current age, which is affected by job insecurity and insecurity. When the employee feels unsafe, the stress that prevents him from losing his job reduces his efficiency and hence his self-esteem. Then, with a percentage of 16%, the factor is the monthly earnings.

A factor that employs the majority of employees as it emerged in the corresponding pay unit and could be an incentive to increase their profitability and also a means for changing workplace. Thereafter, 12% is followed by the factor working conditions. A key factor in employee satisfaction, which depends mainly on the company's consistency and interest in providing everything that its human resources need to be able to work properly under safe conditions.

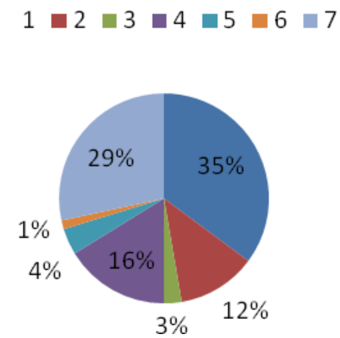

Figure 16. Sample composition based on the most important satisfaction factor (Source: Kapsali, 2018)

6. Conclusions

1. When people work for some purpose then they are active. Similarly, when an enterprise creates an environment where employees are satisfied, it achieves their profitability.
2. Achieving a favorable working environment for an enterprise is the beginning and end of its sustainability. The employer has to take care of maintaining a safe and pleasant work environment to meet the psychology of the human potential of his / her business.
3. Employers' encouragement of employees - particularly in the infrastructure sector - keeps their interest on the alert and increases their efficiency.
4. An important part, which is also a means of rewarding, is pay, so an employer must work with just salary criteria.
5. Proper education and continuous training are also important for job satisfaction. Employees must feel important for their work,
6. Management decisions should aim to ensure a pleasant work environment and the means that employees need to fulfill the tasks assigned to them.
7. Human resources are the most important assets of an enterprise. Investing in people, giving them the right supplies, boosting confidence and honesty, all they can do to a business is dynamic and growth.

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