Abstract

Today's world is dominated by innovation and progress. As a sequel of rapidly growing worldwide research, we constantly hear that the only certainty is change. The life-span of products tends to shorten, great producers trying to stimulate the request for the products or services they offer.

At the same time, the production of material and spiritual goods has represented along the years, one of the most important and constant preoccupations of mankind. Thus, it has become a permanent activity, which has evolved into a more and more organized one, and which has allowed the satisfaction of the growing needs of mankind.

The area of productions is an ever present-day topic. The higher the living standard of people, the higher the consumer's demands towards the products they use. Producing goods tends to become quite scarce an activity in more and more countries. Global production and the borders of the producing country do not matter anymore, having in view that the goods can be sold in all corners of the world. The producers seek competitive advantages on all continents in order to set their production points. The top producing countries are generally the Asian ones, which offer the advantage of cheap labor force, there are other factors that have to be taken into consideration before opening a production point in a certain location. Monetary (fiscal) and political stability could be another criterion in choosing a country that should host the production systems.

The most important component of any production system is the decision-making one, which is made of managers who set up the strategies and combine the art of leadership with personal intuition. It is difficult to anticipate the request of the market, even if the decisions, in what production is concerned are taken as a result of complex marketing studies. A good manager knows how to adapt when taking the best profit generating decision, and ensures the sustainability of the organization. The adaptability of the firm to the market must be ensured by top-management, an entity responsible for the overall balance between request and offer. The companies have understood that adaptability comes from flexibility and have managed, to develop a profitable system, even if they don't have serial production. This means, that production must be programmed so that the effort of changing according to the requirements of the environment and the adapting of the machines to the task should be minimum and in the end different products with different characteristics should result.

Nowadays, when we speak of the globalization of the markets, competition has become multidimensional. The demand of merchandise imposed that industry should have the ability to make in a short period of time top-quality diverse products, at a competitive price. What is more, the producers must obtain benefits in order to continue their investments, which is a sine qua non condition for development. Financial crashes smoothen the pace of development and at the same time they may "fortify" the strong, the ones who know to adapt rapidly to the, given context. The economic crash also brings about the forced optimization of those who want to survive. The large corporations restructure their staff and activities, in an attempt to reach the highest point in performance. The need to survive, as the proverb tells us: "what doesn't kill us makes us stronger", may lead to new discoveries and may strengthen worldwide players as opposed to the disappearing inadaptable ones. The danger of the monopoly in many fields of activity is more real than ever.

A rapid response to this challenge is offered by the FMS, with flexibility as a main characteristic feature the FMS, though little known at worldwide scale, is not a very new concept. The high cost of implementing such a system is the main impediment in buying and using it. As a result of not knowing them, the potential of these systems is not yet well exploited. The manufacturing system differ from the regular production systems by the property of "flexibility", which actually change their entire functioning, being able to produce a family of products with similar characteristics, but different from each other. A FMS is generally implemented in order to reduce the production-time and to generate a large diversity of products out of a well-defined typological area.

Diversity in production is the reaction to the demands of the market that tends to ask for personalized products, even products that are unique, which should exclusively satisfy a particular client. We may this consider flexibility as being a key-factor of organizations which deal with the production of goods. Well - organized serial production is profitable, but tends to be "morally worn-out" nowadays, because it can satisfy a small part of the demands, creating many identical products in a world that wishes diversity and personalization.

The established principles of economy define scale economy as being performed by production at the lowest costs. Applying flexibility in production, one cannot see this mechanism. The market studies of the marketing departments within large corporations prove the desire of the consumer to own personalized products perfectly adapted to his needs. Those who survive are the ones who manage to make more complex and personalized products at the lowest costs.

Creating flexibility in manufacturing is a long term investment, and the indicators proving its profitability will be seen only on medium or long terms. If one sees the problem from this angle, the FMS prove themselves to be useful and profitable.

Thus, the Flexible Manufacturing suits better the present day profile of the demand of products on the market, in other words, it shapes better the fluctuations of the market. Within this aspect, the arguments go both ways (in two directions), on one hand, the market is not of the producer, but of the consumers, the clients being the ones who tell the type, the quality, the quantities, the dead-lines, the terms and eventually the price. On the other hand, in a world that integrates itself and unifies, as a paradox, the individuals wish to assert and promote their identity and this way, the demand of products diversifies and gets personalized. Flexible manufacturing is able to answer significantly in both directions.

The actuality of this subject consists in:

- The ability of the producers to constantly adapt to the frequently occurring changes of the market. Once a new domain arises, the system is ready to adapt and create a competitive advantage.
- They economize resources, like manpower, which is partially or even completely replaced by industrial robots. One needn't worry about these costs when operating with such a system.
- By saving energy or other resources, these systems more sensitive towards protecting nature and the environment.

However, the disadvantage that tends to keep away the investors from such systems is represented by the high implementation costs, as well as by identifying the best programming method, according to the needs of the producer.

The investment costs are justified, because acquiring flexibility supposes providing the factory with top performance machines like: industrial robots, computer numeric control machines, automated conveyors and transporters and calculation systems of high performance.

After the investment, one would naturally expect a radically changed result in the profitability of the company that has adopted this system. This is not always a certainty, though, because one also needs to invest in the programming area. A performer, yet inadequately programmed system, may generate costs that are even higher than those of a rigid system.
Flexible manufacturing represents then a dynamic field of research that continuously offers new theoretical and practical solutions, and, irrespective of the subsequent difficulties, they have got the attention of the researchers, and absorb a great researching effort.

Having all this in mind, we are not surprised by the emerging intersection of multiple research that come from different areas of knowledge in this field of great scientific interest. The FMS represent, by even their definition and genesis, joining points of several disciplines. However, as a paradox, in the specialized literature it is often stated that until now, a formal method hasn't yet unanimously been accepted in order to generate a FMS.

Furthermore, one cannot but mention the fact that the results obtained in FMS are not entirely certain yet, a part of them being practically visible, another part still awaiting acknowledgement.

This is then an area of great novelty and potential in a context in which until the present this seems to be the only way in which production can answer the challenges of the future. There aren't significant common denominators for defining FMS, neither for designing them, nor for programming them for that matter. We could even say the same for the choice of the classes of products and for many other aspects. This area of research, scarce in consensual elements, naturally reprsents an intriguing environment for the researchers of this field.

On the other hand, the FMS are large targets that absorb a consistent investment. In this context, any reasoning or any entropic limitation of the stages of the birth and life of a FMS may generate considerable economical effects. This fact represents a powerful impulse towards research.

A FMS gives the consumer multiple benefits. Among these, the following must be mentioned:

- Diversified products, favored by every client;
- Products of high quality;
- Low costs in some cases, due to the optimization of the FMS;
- Rapid response to the demand.

Knowing the fact that investing in a FMS is an effort for most economic agents, one must know the demands this system will have to answer, even from the early stages of designing the system. Having in mind the calculations, the system can be dimensioned and its components can be adjusted so that it could face the demands and the types of products. A high flexibility leads to high transition costs and to not using the machines at a maximum capacity.

After the system is established, its management is very important, so that the system would have as little inefficient time as possible and the products would be diverse and of high quality. A long term, profitable FMS must follow a thorough programming of the production task. According to the complexity of the products of the system, the management effort of the flexible manufacturing grows. Flexible manufacturing actually means always producing the goods required by the market and the performance of programming these systems lays in bringing together all the characteristics of the required products. Reaching a balance between the demand and the production capacity is a challenge for many companies. The ideal moment is when the market is satisfied and the system works within certain acceptable economic parameters.

In the implementation and functioning stages o FMS appear different costs, according to which the whole production is defined. A lucrative production is one with low costs and qualitative parameters as high as possible.

In the functioning stage of flexible systems, the most significant costs, according to the specialized literature, are the "transition costs", that represent the defining "demand" of this system. Besides the regular costs of all production systems (energy, manpower, materials, etc), the transition costs represent the time in which the system makes the effort of adapting itself to the making of the new task.. This time is necessary for the changing of the tools, taking the data out of the computers, checking the new tools, solving errors, etc.

Starting from these costs, the specialized literature deals with the whole reasoning of the FMS, having as a main point their reduction. The production time of a modern enterprise is much lower than 40 years ago, and the performance of a system is beginning to depend on factors other than the technology of the enterprise. Only 8% of the time necessary for the production of a piece represents the actual operation time in which the tool works on the material. The rest of 92% represent logistics and organization, when the pieces or the materials are transported, the machines are prepared, the tools are adjusted, or other activities concerning the preparation or completion of production are performed. Thus we can notice the necessity of reducing the auxiliary time in order to increase the general performance of the enterprise.

Last, but not least, flexible manufacturing represents a fascinating research area, which not only points out the limitless significant aiming points, but also shows a multitude of aspects that are compatible with various domains in the field of knowledge. Thus, the topic of flexibility synchronizes with the development of calculation technique, of automation, cybernetics, robotics, logistics, mathematical design and so on. In this context, one can state that this is a "universal" topic that can absorb very different knowledge, skills and abilities.

The research performed by the author both in his doctorate paper and afterwards, tries to optimize some of the implementation stages and the exploitation of these systems and to bring novelty and usefulness to the theories already present in the specialized literature.

Performance is achieved by the correct choice of the task, so that the costs are as low as possible, as close to the serial production as possible; this could be achieved by minimizing the transition costs.

Motivating the research in the field of FMS programming had as a starting point the above argumentation and had the following underlying ideas:

- The research of the efficiency of the last- generation systems such as the flexible ones is an impulse that raises the enthusiasm of any researcher;
- After heavily investing in flexible production, obtaining non-profitable parameters seems a paradox which should be eliminated by devising new system management methods.
- Programming the FMS is the element that gives coherence to their functioning
- Current programming methods are classical and do not combine solutions offered by superior mathematical methods, such as the theory of mathematical games.

The opportunity of this paper is also given by a surprising situation existing in the specialized literature: although the FMS represent the peak of technological complexity, they do not have a unanimously accepted mathematical apparatus that should represent a scientific basis for their constitution and for the monitoring of their functioning, this issue being the preoccupation of many researchers in the field.

The Habilitation thesis represents a synthesis of the research and the results obtained by the candidate after acquiring the doctorate degree of the Technical University of Cluj Napoca,

confirmed by the degree no.182/27.06.2005. **This thesis briefly presents the main results obtained by the author as a sequel of the doctorate research in the area of FMS functioning. The thesis has been structured in five chapters.**

The first chapter presents the actuality of FMS development in the context of flexibility, the stages of FMS programming and the ways the FMS work. The second chapter follows the issue of mathematical game theory in a general manner (pointing out its applications, from early times up to the present, types of games and their applicability) and from a particular perspective – an application in management. The third chapter is the main part of the thesis and it presents the most significant results obtained by the author in the area of programming and simulation of FMS functioning, with the help of math game theory.

Thus, the paper presents the results obtained by using game theory in the analysis of a FMS production task and in a FMS programming. The fourth chapter presents, through an application, a possible future direction in research: FMS structuring with the help of value analysis. In the end, the fifth chapter presents the results of the research activity and the candidate's research skills, as well as future research directions and professional development of the candidate. All the original contributions are presented in the context of the present stage of the scientific research of FMS programming and management.

The author of the present thesis stands out by hs expertise and experience within the Technical University of Cluj-Napoca. The main areas where the author has conducted his research since 2005, could be mentioned as follows:

1. **The programming and simulation of the production systems' functioning (operation, optimizing production systems).**
2. **Using the mathematical game theory in shaping management processes.**
3. **Research conducted in order to point out the common grounds of management and religion.**

In this respect, in order to illustrate the candidate's professional skills and achievements, the numerous accomplishments obtained after his doctorate degree, since 2005, must be mentioned: **Six published books** with topics focusing on the research area, **over thirty six scientific works** published in journals or presented at prestigious international conferences, **membership in the public presentation committee of eight doctorate research papers, membership in the committee that oversees and evaluates more than 40 PhD candidates** and the participation as a member/director of **nine contracts** in the previously mentioned research areas. The candidate has also supervised more than 100 Bachelor's degree graduation papers and 30 MA degree theses since 2005.

Since 2005, in the Department of Management and System Engineering and also in the Department of Management and Economic Engineering of the Technical University of Cluj Napoca, the candidate has been responsible for delivering courses in the following domains: Engineering of Production Systems, Industrial Management, Operations Management, Quantitative Analysis. The activity as a professor has been performed at the same time as the research activity.

An important step in the candidate's academic career was the 2007 title of lecturer. This confirmed the necessary experience required for the following step: coordinator/ leader of a research group and coordinator of doctorate research papers. In the following years and up to the present, the candidate has performed an intense research activity, collaborating with younger colleagues and Doctorate candidates of the Management and Economic Engineering Department. Since 2007, the candidate has been a member of the coordinating and evaluation committees of

more than 40 Doctorate candidates and a member in the committee of public presentation of 8 Doctorate research papers.

The research and development activity performed by the candidate all throughout his career (1993-2014) is rich and full of important achievements that can be mentioned as follows:

- **12** published books (sole author of two and main author of four);
- **97** scientific articles presented at national and international conferences, or published in specialized magazines as follows:
  - **2** articles published in ISI Thomson Reuters magazines;
  - **23** articles published in ISI Thomson Reuters conference volumes;
  - **15** articles published in magazines and volumes of several scientific events included in international data bases
  - **57** articles published in B+ journals or/and presented at prestigious international conferences
- **3** grants won in national competitions, with the candidate as project director
- **2** international grants as project responsible;
- **2** national grants as grant responsible;
- **2** international projects with the candidate as a member of the research team;
- **9** national projects with the candidate as a member of the research team.

Career development directions that need habilitation

It is considered that the research conducted by the author of this habilitation thesis is thoroughly focused , having a well defined main objective. Thus, the author will consider of utmost importance the topic- focused collaborations, as well as the dissemination of the acquired knowledge towards the interested scientific and industrial parties. The possible solutions provided by the author for the problems highlighted as not being consistently dealt with up to the present moment, represent a sufficiently solid motivation for the author to continue his research on the 3 directions previously mentioned.

As a potential future career development within the Technical University of Cluj Napoca, I point out:

- Offering opportunities for education and improvement: a large part of the results of the research will constitute the material for the completion of certain courses (master and post graduate courses) at the Technical University of Cluj-Napoca and of certain courses for industry specialists.
- Continuing the collaboration with firms and companies whose activities have common grounds with the results obtained by the author in the previously mentioned areas of research, this being a catalyst in their development.
- Stimulating the promotion of the aims of the research areas in the academic environment by scientific works and reports, and in the interested industrial environment by focused presentations which could generate funding. There will be attempts to strengthen the ties with important researchers in the field at a national and international level. We will also try to propose new collaborations within HORIZON 2020.
- Increasing the number of research projects as manager and also developing new national and international ties (mainly European), thus attracting extra-funding. This objective may also be

reached by extending the teaching and the research partnerships with universities and private companies in Europe and other countries.

- Attracting a large number of young graduates towards research as Doctorate candidates and post-graduates both in our country and abroad;
- Creating a powerful research center around the “Operations’ Management” staff within the Department of Management and Economic Engineering.