

Analysis of needs of the processing industry in Montenegro for establishment of the Laboratory for industrial design

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Abstract. This paper analyzes the needs of the processing industry sector in Montenegro for the establishment of the Industrial Design Laboratory. The analysis was created as a result of the research done for the purpose of preparing the Preliminary feasibility study for the establishment of the "Industrial Design Laboratory", which would operate as a part of the d.o.o. Innovation-entrepreneurship center "Tehnopolis" in Niksic. The study was conducted on the basis of the Public Invitation of the Ministry of Science of Montenegro. The aim of the analysis is to get conclusions about processing industry needs in Montenegro, by using systematization of the parameters, its characteristics and conditions, especially in the field of product development and to identify further activities in order to correctly project directions of development of the Laboratory for industrial design. For the research, the "Delphi method" was used, as a special and recognized way to obtain relevant indicators in the world where it is not possible to reach the precise data, but the solution of the problem should be sought on the basis of estimates.

1. Introduction

D.O.O. Innovation and Entrepreneurship centre "Tehnopolis", was founded by the decision of Montenegrin government at 2013., and has started to work in its full capacity in the renewed building in Home of Army in Niksic at 17. September 2016.

IPC Tehnopolis is part of the Strategic plan of the Government of Montenegro for the establishment of the Scientific and Technological Park, as the first established regional impulse center. The activity of IPC Tehnopolis is in line with the strategic goals defined in the mentioned Strategy, which are:

- Creating and providing services to the regional and national entrepreneurial community and government services in order to achieve the mission and vision of the state in this domain;
- Creating innovative and sustainable startup companies;
- Creating sustainable jobs and jobs with high added value;
- Stimulating local entrepreneurship;
- Developing innovation in existing MSP; and
- Actions in terms of a networking center with existing research and innovation capacities and capital development projects in the country.

The strategy of the Government of Montenegro envisages that within the IPC "Tehnopolis" the Laboratory for Industrial Design operates, whose main objective is to carry out activities related to the development of products for the needs of small and medium-sized enterprises in Montenegro. The



laboratory would primarily be aimed at supporting the processing industry in Montenegro, primarily the metal processing industry, as the main production branch of most of the world's industrial systems. In order to properly design activities and define the direction of development of the Laboratory, the Ministry of Science of Montenegro has engaged a working team from the Faculty of Mechanical Engineering in Podgorica to develop Preliminary Feasibility Studies for the mentioned Laboratory. In order for this task to be solved properly, it was necessary to perform certain recording of the situation and needs of the processing industry in Montenegro, with the methodological elaboration of the problem, as the starting basis for the successful completion of the task. Precise quantitative (numerical) indicators, except in rare cases, were very difficult or impossible to get, or extensive research was needed to obtain them, with the collection of a large amount of data, which was impossible to conduct because of the time constraints for making this study. Therefore, the answer to most of the questions was sought based on the opinion of a number of experts, in their individual domain, whose work is more or less related to the processing industry in Montenegro. The "Delphi Method" was used as a special and recognized method for obtaining relevant analysis by summarizing the opinions of experts and their assessment of a given problem, through several survey circles in which experts responding to the questions asked give their opinion on the problem raised. The obtained results were statistically processed and in this way a qualitative assessment of the problem was obtained, on a scientific basis, which can be asserted with certainty that it is correct, but the precision of the obtained quantitative indicators can not be fully guaranteed. The results of the research using the "Delphi Method" are presented in this paper.

2. Description of "Delphi Method"

The "Delphi" method is very suitable for developmental research of complex problems in different technical areas. The method is a special way to search for an appropriate solution for a given problem, summarizing the opinion of the subject of study by recognized experts in its individual domain, looking into the future and in the context of anticipating the future development of a given problem (eg. product program, products, technologies, etc.). In order to realize this method it is necessary to participate experts from different professions and different scientific and technical fields.

Participants in the study are through several circles involved in scientific debate and give their opinion on the problem. They are asked questions in written form, for which they must choose one of the answers offered in each round of discussion. In this way, the obtained results, statistically processed, should show, in addition to assessing the current state and expected directions for the development of the subject of study, which can be a very important basis for industry, scientific and state institutions in decision making. The goal of the Delphi study is to bring the scientific thought into a practical world, and decisions on future developmental trends based on research using Delphi methods are based on a scientific basis.

The Delphi study is a rather complicated and expensive method and the questions themselves and the answers offered must be well selected and carefully planned by the researchers. The Delphi method itself envisages the implementation of several research circuits, with each subsequent logical extension of the previous one, thus achieving the desired crystallization of the thinking. In each circle, certain questions are answered with the offered answers, which completely cover a range of possible solutions (from black to white). Deciding on one of the offered answers, the participants in the discussion give their opinion on the problem of the asked question. In this way precise, easily comparable and statistically processable data is obtained [1].

3. Procedure for conducting the research

It was anticipated that the research presented in this paper is carried out in two or possibly three survey circles, depending on the results obtained and the degree of "crystallization" of thinking in the previous two rounds of research. However, due to the complexity of the method, and most of all due to the short deadlines that were envisaged for the study itself, so far only the first round of research has been carried out. Therefore, the results presented in this paper can only have a preliminary character.

Nevertheless, it is estimated that the results obtained deserve particular attention and that the issues that are dealt with in this paper can be sufficiently relevant, especially for analyzes related to the current state of the processing industry in Montenegro and its need for the formation of such a Laboratory. It is considered that the obtained results can serve as a good basis for making conclusions about the directions of the development of the Industrial Design Laboratory, especially if they are carried out and the other two envisaged rounds of research.

3.1. A survey list

In the first round of the survey, 100 questions were raised, which are divided into two thematic units:

- Questions related to the general development of the processing industry of Montenegro
- issues that relate directly to Industrial Design Laboratories

In order to make the most relevant answers, the issues related to the overall development of the processing industry of Montenegro are divided from time to time in three periods: before 1990, from 1990 to the present, and issues related to the next ten years. The last set of questions relates, therefore, to the predictions of the future state of the processing industry, which should also be the main subject of research in the next rounds of consultation of experts.

3.2. Expert team for "Delphi" study

The quality of the research under the "Delphi" method depends to a large extent on the selected experts. In principle, the results obtained in this way would be sufficiently objective and useful for making appropriate development and strategic decisions, it is necessary to consult a wider range of experts, of different occupations, from various fields. In their choice, their professional, scientific and professional competence should be especially appreciated.

To participate in the discussion in these researches, 100 experts were invited, from different geographic locations in Montenegro. 74 experts responded to the first round of research, and 74% of the total number of respondents accepted the research cooperation.

When selecting experts, it was taken into account that experts from different profiles, whose activity is in direct or indirect relation with the function of product development in companies, but also experts working in other fields of economy and science, who are independent of this problem, in order to reduce the risks biased thinking and conclusions. Thus, in the selected expert team, the number of experts who directly or indirectly deal with the function of product development, who accepted cooperation in the research, is 61, i.e. 82.4%. It is also worth mentioning that all the experts have a faculty education, and a good number has the scientific degrees of Doctor and Master of Science. The most experts in the team are graduated mechanical engineers (53%), then experts in metallurgy (11%), economics (11%) and electrical engineering (10%). Experts are also experts in the fields of agriculture, construction, forestry, natural science, and some social sciences (Figure 1).

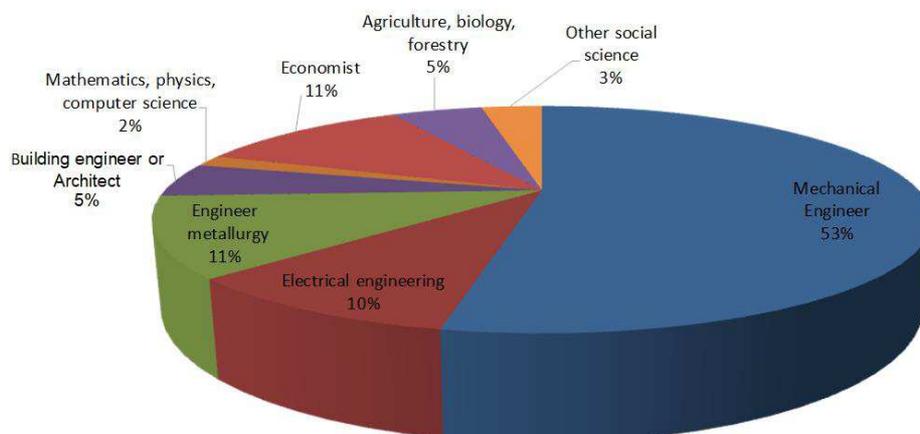


Figure 1. Occupations of participants in the survey.

Expert team is represented by experts from all three sectors: public administration, business sector and science and education. The most frequent are science and education and the economic sector, with 37% and 35% respectively. 10% of the experts work in the public administration, while 18% of the other sectors are employed. 71% of the experts are employed in societies or companies founded or owned by the state, while 29% of experts come from the private sector, which is unsatisfactory according to the working team's assessment. Calls were also sent to private sector experts. However, a large number of invited private sector experts did not respond to the call of the working team to complete the survey.

However, according to the selection of the expert team, and especially the number and structure of the experts who accepted the cooperation, it is estimated that conditions have been created for obtaining relevant and objective results. Of course, this could certainly be better given to the court, when all three envisaged rounds of research were conducted.

4. Systematisation and analysis of research results

4.1. Analysis of the state of the processing industry of Montenegro in the previous period

In Figure 2 the most important answers of experts related to the general development of the processing industry for the period up to 1990 are shown. The overall development of the economy of Montenegro, in the period up to 1990, according to the expert's opinion was mostly "favorable" (46%), although a good number of experts believe that it was central (30%). The contribution of the processing industry to the overall economic and economic development of the state was "large" and "very large" ($53 + 18 = 71\%$), and metal processing was the mainstay of the development of the economy of Montenegro (48%). Most experts believe that the development of the processing industry in this period was strategically "well defined" (47%). The state, by means of economic policy "central" to "much" influenced the development of the Montenegrin industry, and investments in the development of the manufacturing industry were justified (76%).

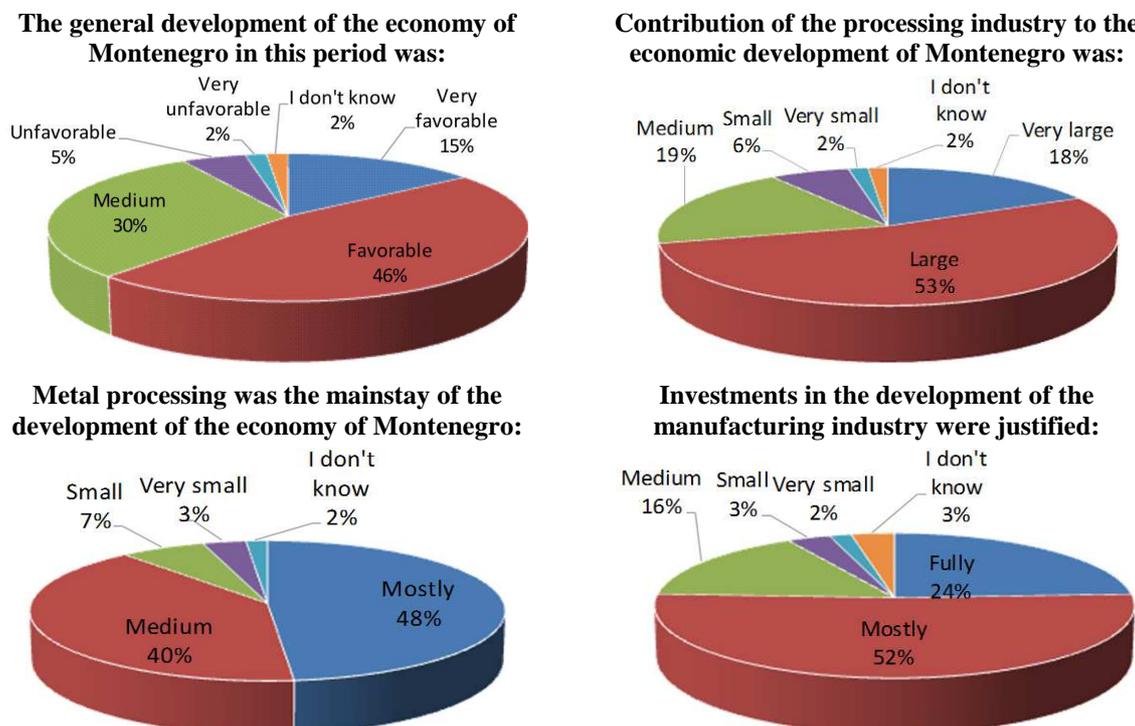


Figure 2. General development of the processing industry of Montenegro in the period until 1990.

On the other hand, in the period from 1990 to 2017, according to the experts (Figure.3.), The general development of the economy of Montenegro was "unfavorable" or "very unfavorable", which was answered by 78% of the experts. In the opinion of the experts, the development of the manufacturing industry was "bad" (45%) and "very bad" (34%) strategically defined and the development of the economy relied little on the manufacturing industry (80%) and the metal processing industry (73%). Experts also believe that the state did not favorably influence the development of the processing industry, and therefore, in this period, the contribution of the processing industry to the overall economic development of Montenegro was "small" (42%) and "very small" (24%). Also, in the period since 1990, there has been a drastic fall in the technological capacities of the processing industry of Montenegro. In the period 1990-2017 the capacity of the manufacturing industry was considerably lower than needed. 70% of the experts selected this answer. Also, there has been a significant outdated industry, so it is now technologically well below the level of developed countries. Even 90% of the experts gave the opinion that the processing industry of Montenegro today is technologically at a much lower level than the industry of the developed countries.

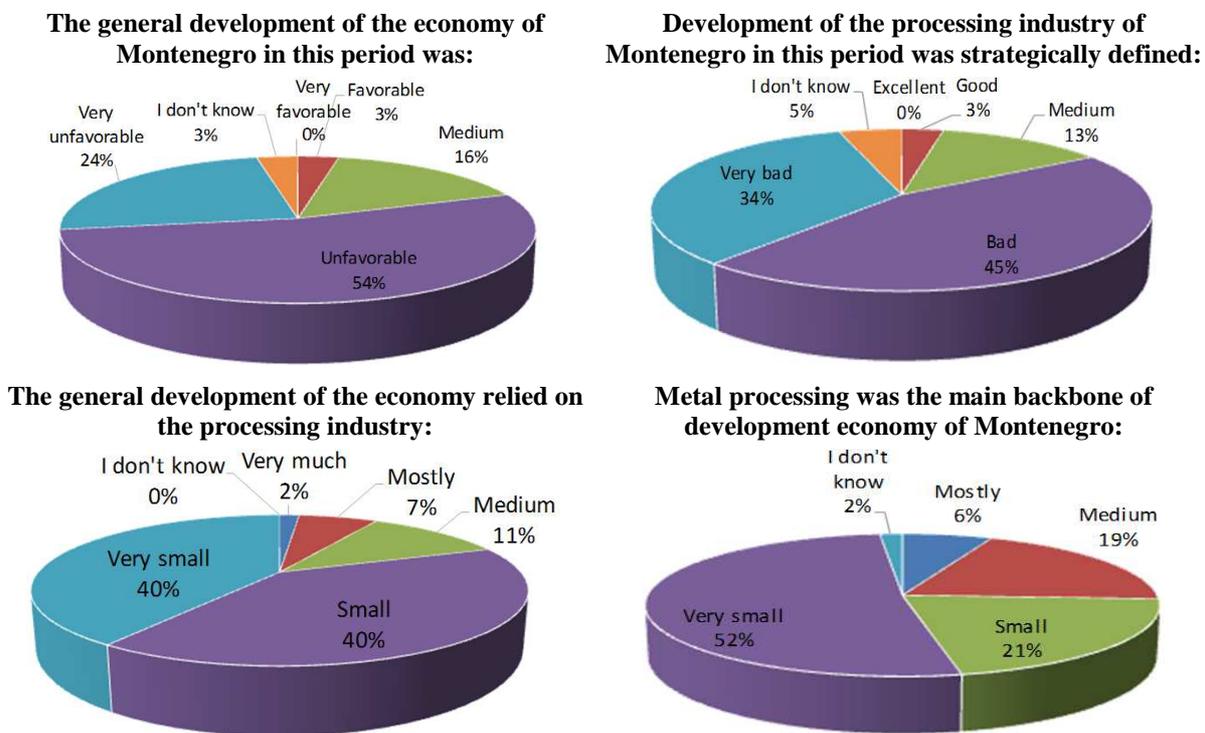


Figure 3. Development of the processing industry of Montenegro in the period from 1990. to 2017.

4.2. General development of the processing industry of Montenegro - Recommendations for the following period

Despite this disastrous situation, most experts believe that in the coming period it is possible to recover the processing industry of Montenegro. Opinion of experts on this issue is shown in Figure 3. According to these data, the vast majority of experts believe that in the coming period, the country's policy towards the processing industry and the metal processing industry should be drastically changed. The opinion of the experts is that in the forthcoming period the general development of the economy "very much" or "mostly" (32% + 52% = 84%) should be relied on by the processing industry and the metal processing industry "mainly" (31%) to "medium" (56%) should be a major part of the manufacturing industry. In this regard, the experts' opinion is that the processing industry should be raised to a higher level in the coming period (85%). When asked if this is possible, given the general

state of the processing industry, most experts consider it to be "mostly" (35%) or completely (39%). In order to do this, the experts' opinion is that the state needs to "much" or "very much" (47% + 42% = 89%) to influence the development of the processing industry. Investments in the processing industry of Montenegro in the upcoming period were justified "mostly" to "completely", which was noticed by (92%) experts, and very importantly, none of the experts gave the opinion that investments in the processing industry in the upcoming period are not justified.

In order to meet the needs of its market environment, the processing industry should be flexible (89%) according to experts' opinion in the upcoming period. In order to ensure the flexibility of the economy, the processing industry should be organized on the basis of small and medium-sized enterprises, through business cooperation by the formation of a cluster. Small and medium-sized enterprises should be the basis of the development of the processing industry in the following period, the opinion of the vast majority of experts (84%). The work of small and medium-sized enterprises should be organized through a public-business partnership in the form of clusters, as 92% of the experts said.

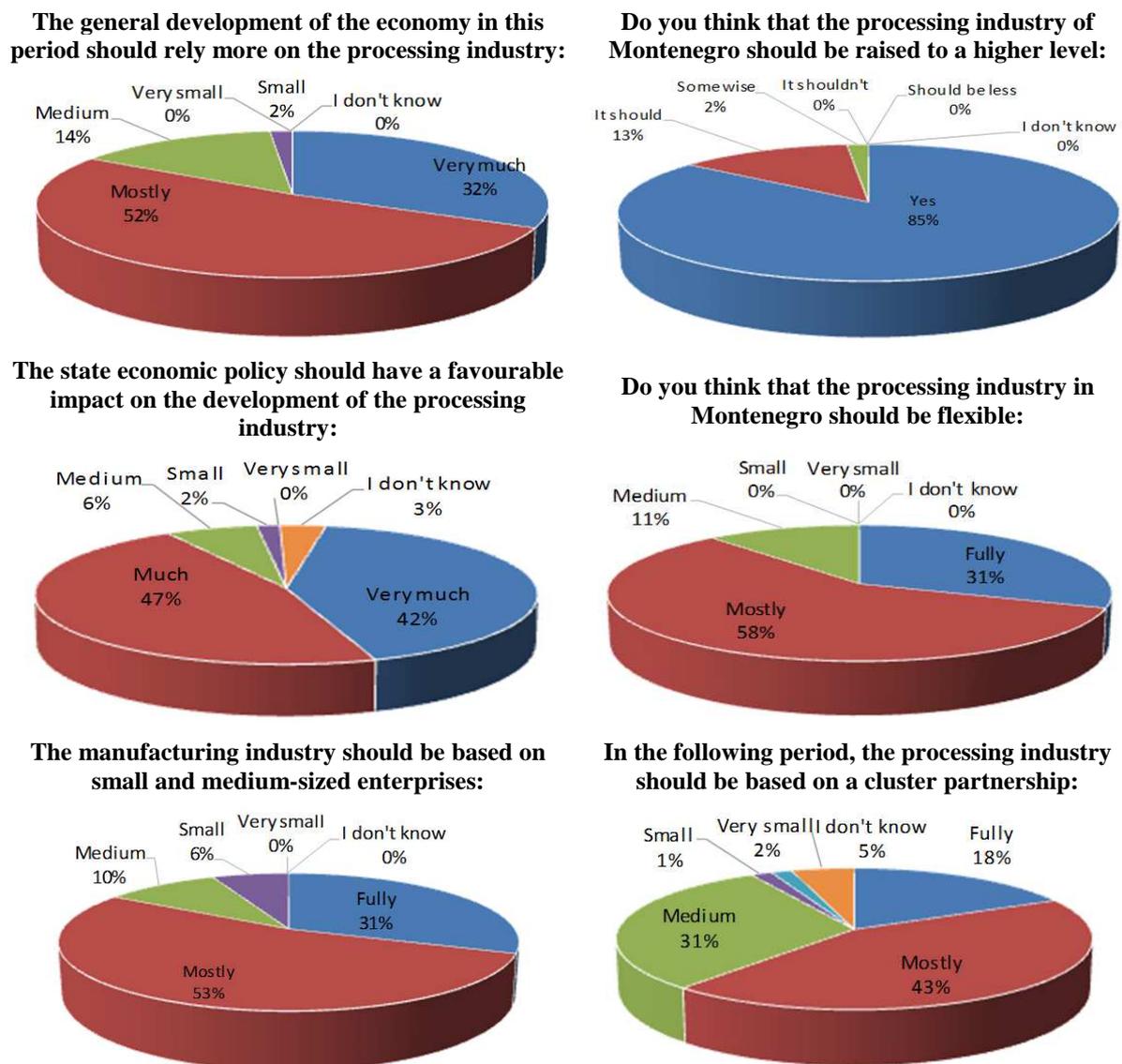


Figure 4. Recommendations for the development of the processing industry of Montenegro in the following period.

4.3. Recommendations of experts in designing the Industrial Design Laboratory

The general opinion of the experts is that it is necessary to establish one such laboratory, which would deal with work and research related to the development of products for the needs of small and medium-sized enterprises in Montenegro. The opinion of the experts according to this is given in Figure 4. In Figure 5. according to the opinion of the experts, priority is given to the goals for which the Industrial Design Laboratory should be formed. According to the experts, the basic goals for the

establishment of the Laboratory are support to small and medium enterprises, both through the increase in the number of small and medium enterprises and the development of personnel, as well as by increasing their individual skills and competences. Also, according to the opinion of the experts, the establishment of the Laboratory should be influenced by the increase in the number of employees and the retention and return of young staff who should find work through their work and cooperation with the laboratory. Only after that experts set goals for attracting foreign investments, promoting cluster creation, exporting knowledge and expanding to large companies.

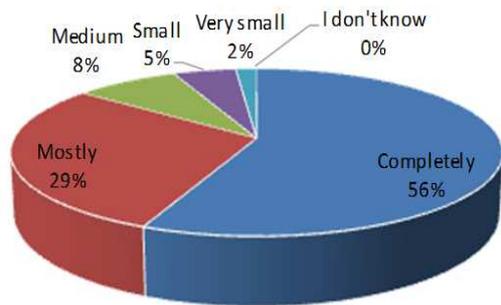


Figure 5. Validity of establishment of the Laboratory for industrial design.

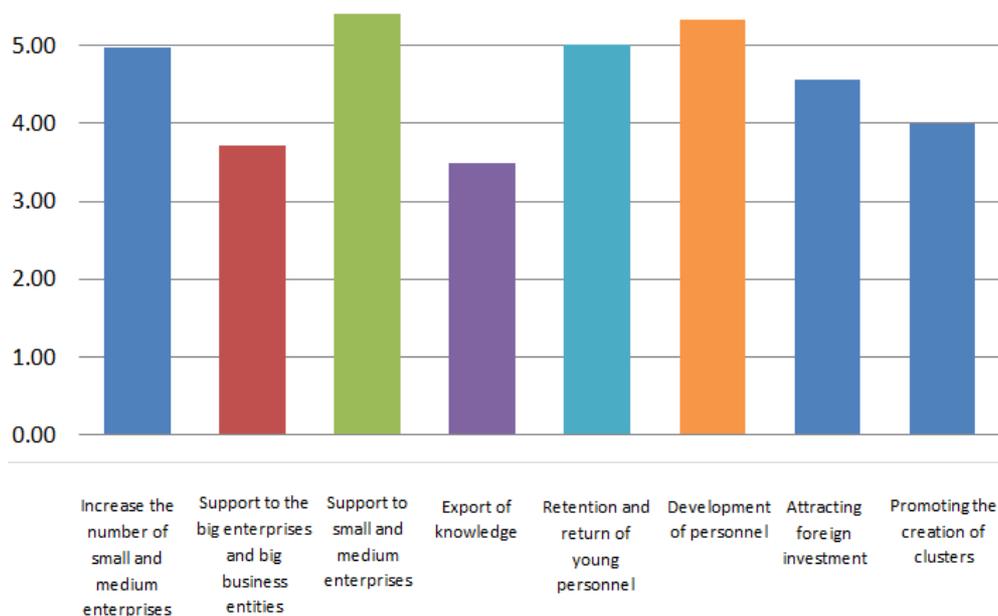


Figure 6. Objectives for the establishment of the Industrial Design Laboratory.

Figure 6 shows the opinion of the experts on the activities with which the Industrial Design Laboratory should deal with. Experts' replies on this issue fully match the above stated objectives. In the opinion of experts, the Laboratory's activity should primarily focus on the development of products for the needs of small and medium-sized enterprises, primarily through direct design and generating new ideas for product development, as well as development and training of personnel that will deal with designing new products and new technologies in companies in Montenegro. In addition, most experts suggested that one of the core activities of the Laboratory should be testing the prototype of new products for the needs of small and medium enterprises. Only after this if spare of resources occur, the Laboratory should focus on the testing of finished products and technical diagnostics for the needs of business entities in Montenegro, as well as on jobs related to reverse engineering.

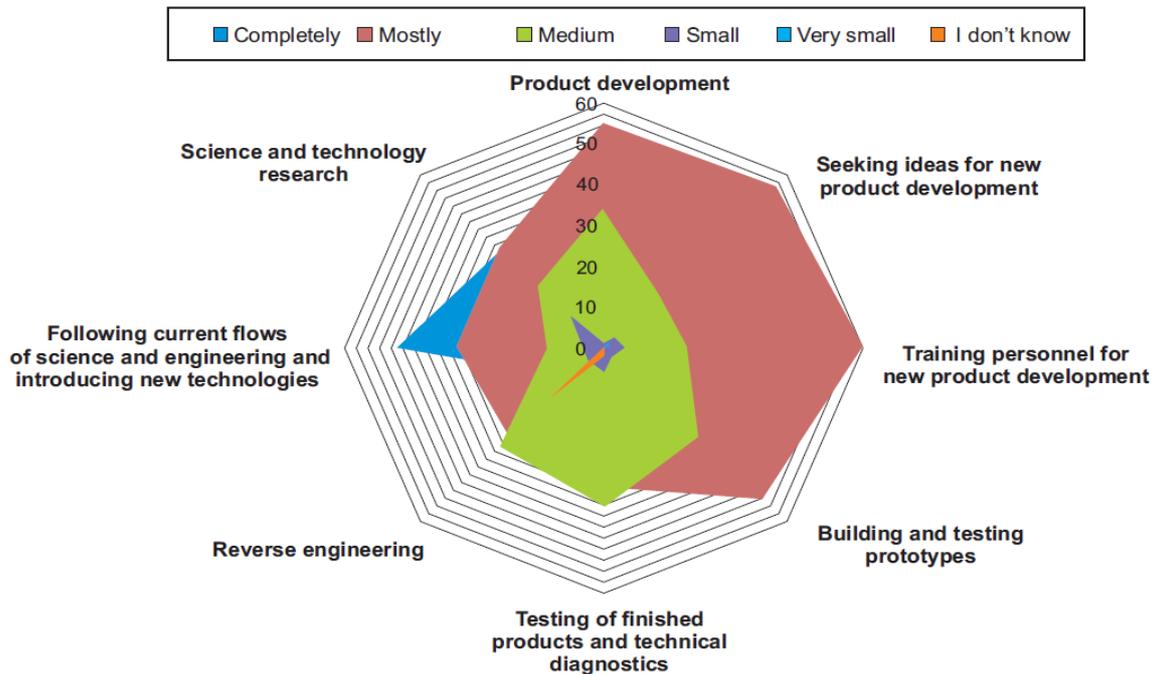
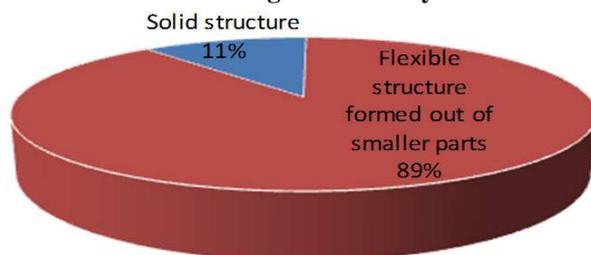


Figure 7. The opinion of the experts on the activities to be dealt with by the Laboratory.

According to experts, one of the main activities of the Laboratory for Industrial Design in the coming period should be monitoring the state of science and technology in the world and introducing new technologies in the economy of Montenegro, as well as engaging in scientific and technical research. In this regard, the opinion of the experts is that the Laboratory should be firmly connected to the Universities in Montenegro, through appropriate contracts with interested faculties. In addition, experts think that Industrial Design Laboratories should be a teaching base for faculties, involving students in practical work.

Finally, the opinion of the experts on the organization of the Industrial Design Laboratory will be presented. Opinions on this issue are shown in Figure 6. A vast majority of experts think that the Laboratory should have a flexible structure composed of smaller units and that it must necessarily have its own marketing unit which, in addition to advertising its products, would also deal with the market research. The experts' opinion is that the Laboratory should primarily employ young talented personnel and that in the Laboratory the job should be sought by experts of different profiles. The opinion of the experts on the representation of certain professions in the Lab is shown in Figure 7.

In your opinion, what kind of structure should the Industrial Design Laboratory have?



Do you think that the Laboratory should have its own marketing unit?

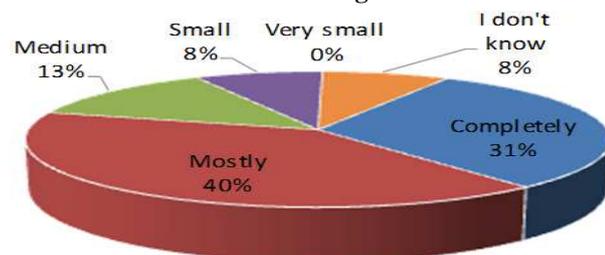


Figure 8. General development of the processing industry of Montenegro in the period until 1990.

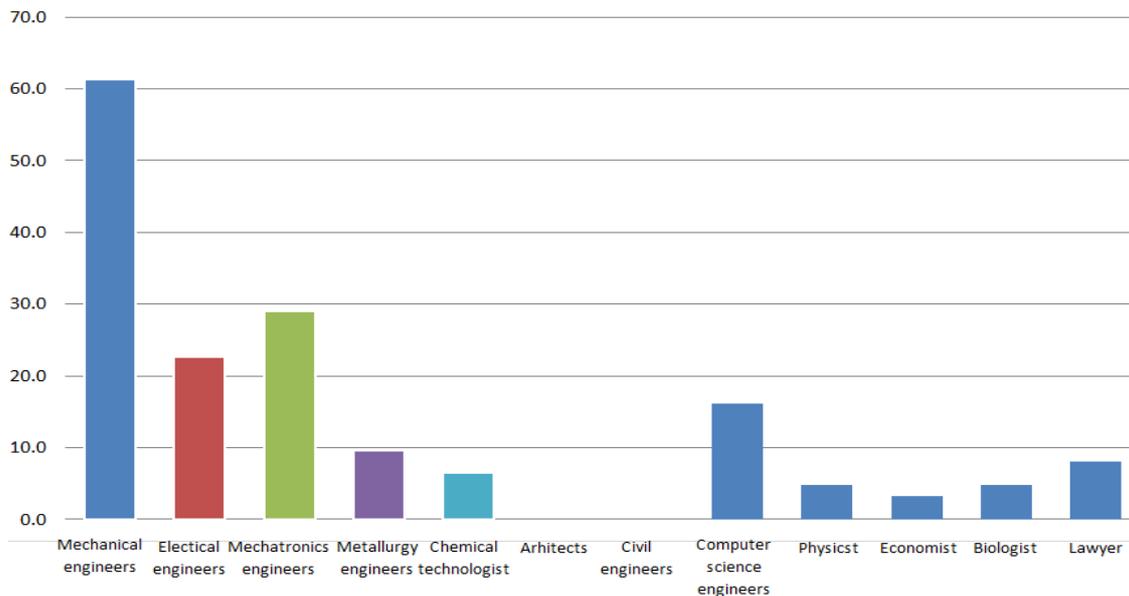


Figure 9. Opinion of experts on professions to be employed in the Laboratory.

5. Conclusions and proposals

Based on the obtained results, the following findings can be made by research through the Delphi study:

- In the development strategy of Montenegro, the processing industry and metal processing in the future must be one of the most important factors for the development of the economy and for the development of society in general, so investments in this segment of the economy are fully justified in the future.
- The collapse of the SFRY and the long-standing isolation of the economy of the 1990s caused catastrophic disruptions in the manufacturing and mechanical engineering industry in Montenegro, with a drastic reduction in production volumes and a high technological lag. And beside this, there is a great optimism among the experts and the opinion that a favorable economic policy can lead to the recovery of the processing industry in Montenegro. For this, it is necessary in the following period to precisely define the goals and strategy of product development, whereby the processing industry should have a maximum degree of flexibility, based on the development of entrepreneurship and small and medium enterprises.
- To this end, the experts highly appreciated the initiative to establish the Laboratory for Industrial Design within the Innovation and Entrepreneurship Center "Tehnopolis" in Niksic, whose primary task would be to carry out product development tasks for the needs of small and medium-sized enterprises, carry out research in the field of development products, provides expert assistance and provides education services, through the dissemination of innovations, transfer of knowledge and technology transfer to small and medium enterprises, encourages cooperation between small and medium enterprises through the creation of clusters and helps to coordinate work among cluster participants..
- In the opinion of experts, the role of the Industrial Design Laboratory is to be the leader in stimulating the development of entrepreneurship and the establishment of small and medium-sized enterprises. The Laboratory in the future should represent the backbone of the development of private entrepreneurship in the field of metal processing, not only through the linking and coordination of work between small and medium enterprises, but also by encouraging and developing diversification in the economy, so that the economy of Montenegro could catch up with the growing needs and requirements of the market environment. In the first place, the activities of the manufacturing industry should focus on the adoption of new

technologies and the development of new high-profile products, which would create conditions for attracting foreign investments, creating new jobs and new opportunities for employment and job creation and increasing the state budget.

- In addition to direct design and product design services, according to experts, the basic mission of the Industrial Design Laboratory should be oriented towards the provision of professional assistance services for the needs of business entities in Montenegro, through education and research in product development, dissemination of innovations, knowledge transfer and technology transfer to small and medium enterprises, but also to other companies.
- The current crisis in which our processing companies are located can only be overcome by highly skilled staff. Product development must become a basic national goal, which is only able to open the way out of a long-standing social and economic crisis. Inadequate policy in the sphere of product development, inevitably leads to the neglect and insufficient use of their own human resources, which our country has always had. Therefore, it is inevitable in the future to define a product development strategy in our country, which should maximally rely on its own personnel potential, with the maximum use of domestic natural resources.
- In order to obtain a more precise and safer analysis for defining the product development strategy in Montenegro and within the framework of the development direction of the Industrial Design Laboratory, it would be better to explain some of the more important choices from the first round of research through the "Delphi" method, especially on those that indicate needs of economic and market environment for the services of the Industrial Design Laboratory. For these reasons, it would be good to do the other two envisaged rounds of consulting the experts on these issues. The obtained results would certainly be of great importance and useful for the planning of the strategy for the future development of the Montenegrin processing industry, and especially the development of the Industrial Design Laboratory.

Acknowledgments

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References

- [1] Tomović R 2000 *Application of Modern Machine Design Methods in the Development of the Machine Industry Products*, Faculty of Mechanical Engineering in Podgorica, MSc Thesis
- [2] Ivanović L, Kuzmanović S, Vereš M, Rackov M and Marković B 2015 *Industrial Design*, Faculty of Engineering in Kragujevac
- [3] Tomović R 2015 *Basics of Machine Design*, Faculty of Mechanical Engineering in Podgorica
- [4] Tomović R, Radović V and Prodanić B 2000 *State of the Situation and Forecasts of the Future Development of the Machine Industry in the Republic of Montenegro*, Scientific Conference on Research and Development of Mechanical Elements and Systems IRMES, Kotor, Montenegro, September 10-11, pp. 35-40
- [5] Tomović R 2000 *The Place and Role of the Design and Construction in Montenegro, with Regard to the Needs of Future Development*, Scientific Conference on Research and Development of Mechanical Elements and Systems IRMES, Kotor, Montenegro, September 10-11, pp. 41-46