EU4Business

SECTOR STUDY OF PRECISION ENGINEERING IN ARMENIA

Support to SME Development in Armenia (SMEDA)
Աջակցություն ՓՄՁ վարգացմանը Հայաստանում

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ABBREVIATIONS

AMD	Armenian dram
ANEL	Armenian National Engineering Laboratory
ASPE	American Society for Precision Engineering
CBA	Central bank of Armenia
CIS	Commonwealth of Independent States
DFA	Development Foundation of Armenia
DSPE	Dutch Society for Precision Engineering
EAEU	Eurasian Economic Union
EIF	Enterprise Incubator Foundation
EU	European Union
EUR	Euro
EUSPEN	European Society for Precision Engineering and Nanotechnology
FEZ	Free economic zone
GDP	Gross domestic product
GIZ	German Federal Enterprise for International Cooperation
GoA	the Government of Armenia
HR	Human Resources
HS	Harmonized system
IDF	Industrial Development Foundation
ISIC, Rev. 4	International Standard Industrial Classification of All Economic Activities, Revision 4
IT	Information technology
JSPE	The Japan Society for Precision Engineering
M&S	Machinery and Systems
NACE Rev. 2	Statistical classification of economic activities in the European Community, Revision 2
NSS RA	National Statistical Service of the Republic of Armenia
PE	Precision Engineering
PMC	Precision Modules Components
PPD	Private-Public dialogue
R&D	Research and Development
RA	Republic of Armenia
SEUA	State Engineering University of Armenia
SME	Small and Medium Enterprises
SMEDA	EU-GIZ Support for the Small and Medium Enterprises Development in Armenia
UAE	United Arab Emirates
UITE	Union of information technology enterprises
UN comtrade	United Nations Commodity trade database
US, USA	United States
USD	United States dollar

EXECUTIVE SUMMARY

Precision engineering (PE) has been declared as one of the 11 priority sectors for Armenian economy, which has a high development and export potential. Moreover, Precision engineering is one of three priority industries which have strategic papers on development and support adopted by the Government in 2013. During these years, a number of initiatives were undertaken by Government as well as international and industry support organizations to support the development of precision engineering sector in Armenia. Particularly, a number of laboratories, technological centers were established with cooperation of internationally recognized organizations and institutions, many initiatives in education and research institutions were launched.

Anyway, there are still a number of challenges for the companies in the sector. This report summarizes the results of a study on precision engineering sector and tries to understand challenges, weaknesses and ways to support further development of the sector. The study aimed to survey all the companies in precision engineering sector, included in-depth interviews with the government bodies, industry support organizations, established technological centers and free economic zone (FEZ), educational and scientific research institutions in the field of precision engineering.

The discussions with government bodies and industry support organizations revealed that there is a need for revisions in the strategy and action plan for precision engineering sector, taking into account recent development in the economy, such as membership of Armenia in the Eurasian Economic Union, slowdown of economic growth due to decrease of commodity prices and recession in the Russian economy. These changes slowed development of precision engineering sector also. It was acknowledged that recent initiatives of establishment of laboratories and technological centers in Gyumri and Vanadzor are expected to have positive influence on the development of the sector. Even with these developments it is still clear that the government should improve investment climate for the sector and continue support on establishing sufficient infrastructure for the further development of the sector. There is a need to raise an awareness of the sector representatives on strategies and action plans as many beneficiaries of the sector are not aware of specific action and plans for the development of the sector.

The companies in the sector as well as industry support organizations, scientific research and education institutions state the importance of the role of the government for the further development of the sector. The role of international organizations is also emphasized in assistance to bring international best practice, technical support and expertise to support the development of the sector.

SME development issues are very important for the ensuring growth of PE sector in Armenia. More than 50% of all companies in PE manufacturing industries are micro-sized units (companies and individual entrepreneurs with less than 10 employees), other companies are small or medium

sized and there are only few companies with over 250 employees. SMEs have larger difficulties in attracting investments, implementing new technologies and equipment, but also related to management and HR issues, sales and marketing, especially in external markets. The latter is very important for any company in PE sector as the small size of Armenian economy and demand for precision engineering products cannot create opportunities for development of a company.

"Manufacturing of computer, electronic and optical products" is the most promising PE subsector in terms of potential and development. Economic performance of this subsector is much better than in two other subsectors: Manufacture of electrical equipment and Manufacture of machinery and equipment. The latter (mechanical and machinery engineering) is well behind of other two subsectors. One of the advantages of electronic and optical engineering subsector is its strong links to and inter-dependence with IT sector, which has already observed high development pace in Armenia. Particularly, the IT sector may support the development of related industries by providing highly skilled professionals. Hence, it is expected that production of electrical equipment may exhibit growth in medium term period.

Economic activity in the sector showed large increase in 2016 compared to 2015, which is a positive trend after a slowdown and even decline in PE subsectors during 2013-2015. Majority of PE companies expects moderate growth of the subsector in Armenia during the next 3 year period.

Availability of export opportunities are very important for the development of the companies in the sector. The share of direct export in total sales of PE manufacturing companies is declining during recent years (from 42% in 2013 to 22% in 2016), which has its impact on the development trends of the sector. Moreover, export concentration by countries is high, around 60-70% of direct export sales from companies goes to CIS market (Russia), another destination with significant share is Switzerland, where clock and watches parts are exported. The companies (especially micro and small sized) have large difficulties with organizing sales and marketing, which is one of the reasons of low exports and current export concentration. Another, but not least important factors of low exports is perhaps in the types of products, most of which cannot be competitive and need investments in new technologies and equipment. It is interesting, that the companies think that the availability of foreign partners, improvements in sales and marketing are more important, than improvement of product quality and investments in technology. At the same time the prevailing majority of companies (87%) organize their exports through own resources without using any domestic or foreign distributor, trying to reduce their costs. On the contrary having a distributor may be one of the tools for successful accession to external markets, especially for SME type companies.

Availability of sufficient quantity of professionals in PE sector is another issue mentioned by the players in the field. It is interesting that most of the participants state that one of the comparative advantages of PE sector in Armenia is the availability of experienced and qualified professionals (engineers), due to traditional strong PE sector and education in Soviet times. At the same time

the lack of professionals in the field is mentioned as one of the obstacles for the development of PE sector. This could partially be explained by not sufficient involvement of young professionals. Hence, there is a need to attract young generation to the sector, which may need changes in education programs, vocational education trainings, cooperation of businesses with education/research institutes. The lack of young qualified professionals is more noticeable in mechanical and machinery related workers, such as locksmith, turner, miller, wrappers. These issues can be solved by strengthening vocational education institutions and attracting people through the cooperation between businesses and these institutions.

Most of the companies in PE sector lack HR management skills. Only 29% of companies in the sector have special HR related personnel in their staff, which can be also explained by small size of the companies. Moreover the companies are not mainly interested (or perhaps cannot afford) in professional HR outsource services, like payroll services, staff recruitment and other.

Along with perception on lack of professionals in the field, low competitiveness of the sector in Armenia is also frequently mentioned by the experts in precision engineering. Innovations and investments by the companies may increase competitiveness of these companies in the international markets which will increase competitiveness of the sector itself. Majority of companies in the survey (72%) reported about innovation activity in their company, mainly related to the development of new products or improvement of existing products. At the same time average level of investments in 2016 is lower than in previous 2 years. Average investments in manufacturing of electronic and optical products is times higher than in other PE subsectors, which explains development trend of the subsectors. Most of the investments (90%) go to acquisition of technology and equipment but taking into account the small size of investments they cannot increase significantly the competitiveness of PE sector companies.

One of the main reasons for low level of investments is low access to finance. Most of the companies in the sector try to finance their investments from profits or owner's resources, which explains small size of current investments (taking into account also that most of the companies are SMEs). Only 4% of investments is financed by bank loan/leasing. The analysis show that issues to access to finance are not rely only on usual reasons, such as small size of company, absence of collateral, high interest rates, but also in business plans of the companies, development of quality products and available sales markets. So access to finance issues can be significantly improved with the development of technologies and product quality. Anyway some measures should be taken to facilitate access of start-ups to finance. Among ways to increase access to finance could be establishment of venture funds in precision engineering projects, establishment of credit guarantee fund for PE.

Main challenges of the sector are summarized below:

- Small internal market and unfavorable geopolitical location of the country.

- Low level of exporting activities, difficulties to access external markets. Transportation issues especially for large size products.
- Shortage of general infrastructure for further development of the sector.
- Access to finance. Not sufficient investments in new technologies and equipment in the sector companies.
- Need for young professionals in the sector. Taking into account strong traditional development of precision engineering related fields in Armenia (especially in Soviet era) there are qualified specialists, but not sufficient for the development of the sector (as their number is decreasing) and there is a need for qualified young specialists for further development of the sector.
- Educational programs and methods currently utilized by leading educational institutions in Armenia need substantial revision in order to become adequate to the current trends and requirements of the sector.
- Lack or absence of cooperation between the companies in the sector as well as between companies and science/research/educational institutions.
- Need for strong industry union for PE sector companies.

The assistance of international organizations can be crucial for the development of the sector. Particularly the following assistance can be productive.

- Strengthening cooperation of Armenian PE companies with foreign partners
- Raising awareness on current trends, new technologies in PE subsectors, international best practice
- Business trainings on product development, international certification,
- Trainings to assist sales and marketing in PE, international best practice
- Support to SMEs and start-us
- Cooperation with educational institutions to support changes of educational and training programs based on needs of the sector

INTRODUCTION

Since early 2000's SME development has been declared as one of the priorities of Armenian economy. All this time, the Government with support of international development agencies initiated different development programs to improve situation. There are many obstacles in this context, in particular, the lack of cohesion and coordination of different SME support programmes, inefficient steering mechanisms for the SME development process, a fragmented landscape of stakeholders, an inefficient public private dialogue, an inefficient decision-making process, as well as not government-driven donor coordination process in different intervention areas. Because of such obstacles, the SME sector still faces challenges regarding insufficiency of supporting services, access to finance, as well as knowledge transformation and R&D activities.

With this situation in the private sector of Armenia, EU-co-financed and GIZ-implemented project "Support to SME Development in Armenia" (SMEDA) was initiated in 2016. The objective of this project is to improve the national business and investment climate and support the creation and development of SMEs to enable broad based growth. In general, the project is focusing on the following result areas:

I. Improved policy making process and coordination of supports to SME development for a conducive business development framework,
II. Strengthened private sector organisations to implement SME policies,
III. Improved process of commercialization of ideas linking research institutions and businesses via cooperation networks,
IV. Improved design and management of economic clusters (business incubators, technological parks, and Free Economic Zones),
V. Diversified access to finance for innovative start-ups and small businesses.

To this end, there are several activities planned under SMEDA project, from which worth to mention followings from the perspective of this assignment:

- Provide technical assistance to private sector organisations to improve and expand services and to increase their network with European businesses,
- Strengthening the capacities of private sector organisations to participate in PPD platforms and to utilize the opportunities of technology transfer as well as to promote entrepreneurial skills, clusters and value chain development,
- Support to linking research institutions and the private sector to foster innovation,
- Support to improving cluster management, linking clusters to European networks as well as developing and promoting new areas for business incubation,
- Supporting the provision of grants to assist technology start-ups and SMEs promoting new services/products etc.

Being declared as a sector with significant export potential, the Precision Engineering sector appeared in the focus of the SMEDA-Project. In order to understand current situation in the sector and draw ways of further intervention, on 19th of July the SMEDA-Project organized a roundtable discussion with the purpose to bring companies, service providers and institutions active in the Precision Engineering sector in Armenia. The main results of this discussion are followings:

- Lack of modern technologies, laboratories and critical mass of expertise;
- Weak cooperation with science;
- Market actors are not aware of the market trends / opportunities;
- Lack of connection and experience exchange within the Armenian community;
- Difficulties in terms of applying for big projects;
- Difficulties with customs clearance.

In addition to the above mentioned, other issues in the Strategy of Precision Engineering Sector 2011-2020 were also identified, such as:

- Minor resource allocation for R&D by local companies;
- Poor marketing and managerial skills of local companies;
- Shortage of graduates with knowledge and practical skills, meeting the requirements of the companies.

A sector study of Precision Engineering sector was conducted by Ameria CJSC (the Contractor) during December 2016-February 2017, in order to understand the details of all these challenges and to find out the potential development directions of the sector, it is intended to conduct.

The **general objectives** of this study were:

I. **Mapping of all relevant stakeholders in the field** - including business support infrastructure (technological centres, free economic zones etc.), existing companies and start-ups, research institution etc.
II. **Sector analysis –** including:
   - challenges and barriers of economic activities by subsectors,
   - existing support approaches in the field and the Government Strategy
   - business activities with high export potential,
   - approaches of companies toward Human Capital, Finance and R&D.
III. **Outlining directions of possible intervention.**

This report presents the results of analysis undertaken during the study of Precision engineering sector in Armenia. In addition to this report the Contractor prepared and presented to the Client the database (mapping) of 193 companies engaged in activities in Precision engineering sector as well as the database of 24 educational and research institutes, industry support and other organizations performing activities related to Precision engineering sector in Armenia.

Data sources and methodology

The analysis presented in the report is based on the following main data sources:

1. **Desk research and Secondary data sources**: In order to clearly define the composition of sectors under the study and to analyze current situation with existing statistical data, desk research of available information, reports and statistics was conducted. Particularly, the following was done:

   ✓ reviewing of international and national classifications applied to define the sector of Precision Engineering
   ✓ reviewing Sector development strategies and other related policy papers in Armenia
   ✓ reviewing and analyzing available statistical information to describe the development of the Precision Engineering sector in Armenia

2. **Primary data sources**: In order to provide information needed for analysis of the sector in the study and to meet the main objectives of the study, qualitative and quantitative data collection surveys were initiated within the framework of the project. Particularly:

   ✓ **In-depth interviews with the key stakeholders** (25 in-depth interviews)

25 in-depth interviews with the key stakeholders of the PE sector and subsectors were conducted. The representatives of in-depth interviews can be divided into 4 main groups: public authorities and industry support organizations, technology centers and free economic zone, educational institutions and research institutions. Details on in-depth interviews are presented in the Annex 1.

Three different variants of in-depth interview tools (questions for discussions) were developed to capture relevant information from different participants. Additionally, the organizations participated in in-depth interviews were asked to provide detailed information on their laboratories and equipment to share this information on the special website, which can be used for all the participants in the PE sector. Most of the respondents have agreed to provide this information (summary details are presented in Annex 2).

   ✓ **Survey of companies in Precision Engineering sector** (aiming to capture all the companies active in the sector)

With the aim to capture all the active companies engaged in activities related to precision engineering sector, all available data sources on the list of companies were analyzed and database with contact information is developed. Then all the companies with available contact information (address, phone number) were initially screened to understand their relation to Precision engineering sector. As result 211 companies in Precision Engineering related sector were identified. 193 companies agreed to participate in the survey and were interviewed with the

pre-designed questionnaire. The questionnaire consisted of 2 main parts. First part of the questionnaire aimed to collect quantitative and qualitative information on economic activity, external economic activity, investments and innovations, HR related issues and challenges in the sectors, while the second part of the questionnaire aimed to collect detailed information on types of products produced, available technologies and equipment as well as available professionals in the company. The companies were informed that the information in the second part of the questionnaire will be made available publicly for all the interested participants through posting this information on the website. The companies were distributed by corresponding sub-sector in order to obtain quantitative and qualitative information on all subsectors.

As a result of survey phase: 193 companies provided information on the second part of the questionnaire and 186 of them provided information on both parts of the questionnaire.

Structure of the report

The report has the following structure.

Introduction includes the objectives of the study as well as the description of data sources and tools used during the study. Then the report consists of 9 separate chapters:

1. The analysis of Government strategy on Precision engineering
2. Sector definition and estimates on number of companies in the sector.
3. Overview of economic activity in the sector
4. External economic activity
5. Access to human capital and HR management practice
6. Investment, Innovation and R&D activity in the sector
7. Access to finance
8. Challenges of the sector and the ways to solve these issues
9. Main Findings and Conclusions
10. Recommendations

Each chapter includes analysis based on relevant information from desk research, survey of companies and in-depth interviews with key representatives of the sector.

1. THE ANALYSIS OF GOVERNMENT STRATEGY ON PE

Since the beginning of 1990s the Armenian precision engineering industry, inherited from the Soviet times, one of the key drivers of the economic development contributing around 30% of GDP, has started to observe gradual shrinking of the output. This trend continues until 2000s when, in order to ensure continuous economic growth and increase overall competitiveness of the economy, the Government of Armenia (GoA) started to pursue the policy of supporting the development of the knowledge-based economy and accordingly designing and gradually implementing export-based industrial policy. Among other sectors precision engineering was selected as one having high development potential, considering also the availability of highly skilled specialists on the market.

The most important document related to the development of precision engineering sector is the GoA decree N49 "*On the RA export oriented Industry Policy Strategy*", adopted in December 2011. The Strategy covers the period of 2011-2020 and has overall objective of supporting development of already existing or emerging export-oriented sectors. The eleven sectors chosen as priority ones were Diamond industry, Gemstone industry, Watch manufacturing, Cognac production, Pharmaceuticals and Biotechnology, Cannery, Winery, Mineral water and Juice production, Textile production industry and Precision Engineering. The launch of the activities under the approved strategy started with only three sectors, among which were also precision engineering. For each of those sectors the respective strategies for 2011-2020 and action plans for 2012-2015 were developed and approved on 6 December 2013. Adopted sectorial strategies envisage following directions for providing state support:

- Attraction of transnational corporations,
- Innovation support,
- Financial support for investment and export promotion,
- Capacity building,
- Sales promotion,
- Improving the legal framework of foreign economic activity.

Overall awareness on declaring precision engineering as a priority industry for the Armenian economy by the government is high among the key representatives of educational, research institutions, technology centers, government bodies and industrial support organizations engaged in Precision engineering sector. Anyway the awareness on the details of strategy and action plan is not so high.

In-depth interviews with the representatives of governmental bodies and industry support organizations revealed the need to improve dissemination of relevant information about the strategy and adopted action plan since some of those organizations were not fully aware that the sector is considered a priority one by Government decree; hence not able to utilize the existing opportunities.

Technology centers and FEZ representatives are aware about the declaration of the RA government in which Precision Engineering is considered as priority industry for the Government. But they don't have precise information about the strategy and its accomplishment.

Research institutions are mostly aware of the fact, that precision engineering has recognized one of the priority sectors of RA economy. Indeed most of them were familiar with its strategy and action plan. Yet, albeit, most of them preferred not to go into details, and share the opinion that despite some works are done, much still need to be done furtherly. One of the respondents mentioned that the approach to PE is very superficial, putting main attention mostly on information technologies, in particular on chemical technologies and added that an action plan need to classify the problems and the actions needed to meet them; this can rather be considered a strategy than an action plan.

Nine out of ten educational institutions representatives in in-depth interviews mentioned that they are aware of declared precision engineering as a priority industry of Armenian economy. However, overall they do not have detailed information about Governments program and its strategy. Several respondents had a negative opinion about program's essence and realization. As was mentioned by one of them it is "unrealistic and one sided". However, two respondents consider the declaration and the program a very important step for the future of the industry.

The Industrial Development Foundation (IDF), established in 2009 by GoA decree, was selected as implementation authority to undertake the actions envisaged in the sectorial strategies approved within the framework of the export oriented industrial policy strategy. According to the GoA decree N1523-N dated 18 December 2014, the IDF was reorganized and merged with the National Competitiveness Foundation. As a result, the Development Foundation of Armenia (DFA) was established to which the responsibility for the implementation of the adopted strategies was transferred.

Considering the above presented changes in the institutional arrangements, as well as the fact that the industry actual performance indicators are already behind those expected to be achieved by the approved strategies, there is need for substantial revision and adoption of new sector development strategies and action plans to reflect the changes occurred and new realities. This need was mentioned by respondents during in-depth interviews with representatives of governmental bodies and industry support organizations. Additionally, they highlighted the need to adopt cluster approach for the development of the sector strategies, considering that precision engineering has many different sub-sectors, i.e. machine-building, optics, laser technology, machine tools, etc., which could have specific development needs.

An important support to RA Precision Engineering industry was the establishment of Free Economic Zone (FEZ) - "Alliance" - in the territory of "RAO Mars" industrial complex (by RA Government decree N785-A, 18 July, 2013). "Alliance" is oriented to the production and exports of high and innovative technologies in the field of electronics, precision engineering, pharmaceutics and biotechnologies, alternative energy, industrial design and telecommunications. It can be said, that, this development was an important step in the launch of favorable infrastructure for companies acting in Precision Engineering industry. The goal of FEZ is attracting foreign direct investments, boost exports, create new jobs and provide for sustainable economic development. The priorities of the zone are the following: no foreign exchange restrictions, free transfer of capital, profits and dividends, which will help to reduce the cost-price and increase the competitiveness of manufactured goods. As of today there are already 9 companies operating in the FEZ. Overall number of employees in the FEZ is above 150.

Additionally, within the adopted industrial development strategies the Government by its decree N1083-A dated 3 October, 2013 approved state participation in the capital of the newly established venture fund – Granatus Ventures in the amount not exceeding Armenian dram equivalent of 3,300,000 USD. Purpose of the fund is to provide early stage product development and company formation funding for the high-growth enterprises targeting global markets in sectors that leverage the latest developments in social, mobile, analytics and cloud technologies. The Fund is supposed to provide funding for the companies operating in the precision engineering sector as well, however until now eight, mainly IT projects received support from the Fund.

Upon accession of Armenia to the Eurasian Economic Union in 2015, the economic development policies and strategies, implemented by the GoA, should be coordinated with Eurasian Economic Commission and government of other member states. Hence, the decision N9 of the Eurasian Intergovernmental Council (consisting of the Prime Ministers of member states) dated 8 September 2015 on *Main directions of industrial cooperation within the Eurasian Economic Union* is also impacting the industrial policy of Armenia. Some subsectors of the precision engineering industry – production of electrical machines, electronic and optical equipment - is considered as a priority for the development. Additionally, the adopted document assumes establishment of the

Eurasian Engineering Center (location yet to be determined) and **competence centers** for the implementation of joint research projects and development of innovation infrastructure.

Enterprise Incubator Foundation and US Agency for International Development signed an Agreement on establishment of Armenian National Engineering Laboratory (ANEL) at the State Engineering University of Armenia (SEUA), jointly with the National Instruments Armenian Branch. The main goal of the Project is to meet the demand of the engineering industry in quality specialists and graduates educated on up-to-date technological base to confront the employee shortage and to increase value-added and innovativeness of Armenian high tech businesses, thus increasing their international competitiveness. The objectives of the Project are to strengthen the educational capabilities and enhance the research potential of the Armenian engineering sector by upgrading and expanding the SEUA educational and research facilities to the world standard through the establishment of ANEL. Creation of such a Center for excellence in engineering addresses the following key challenges:

- Outdated laboratory equipment and the need to modernize engineering curriculum in Armenia;
- Increasing demand for Armenian engineering talent by the engineering and engineering design companies worldwide;
- Turning Armenia into an exporter of engineering technologies, products and services to the global market;
- Establishing strategic research directions and shaping Armenia as a vital engineering hub.

The ANEL key advantages are:

- State-of-the-art laboratory equipment;
- Coverage of most of the priority engineering areas of SEUA;
- Cost effective: one laboratory is used by different disciplines;
- Combination of learning process and research activities;
- Modern curricula and teaching materials;
- Incubation environment;
- Open use: being accessible for interested parties for other universities.

The ANEL cooperates with industry and research institutions in the country. In particular, Research Laboratories offers services to Armenia's industry and research institutes to quickly and inexpensively solve their technical and scientific challenges. Educational Laboratories compliment these efforts by providing facilities to train future personnel for the research institutions, Armenian industry and engineering groups.

The ANEL is located on four floors of the SEUA Yerevan campus building #10. The total area is 1,600 sq m. It is comprised of about 30 specialized and universal Educational and Research laboratories covering 6 major specializations of SEUA: Cybernetics, Radio Engineering and

Communication Systems, Power Energy, Electrical Engineering, Transport and Mechanical and Machine Building engineering. There are 18 different laboratories currently (13 educational and 5 research). Combination of Educational and Research labs ensure the students involvement in scientific projects and developments which help them to quickly integrate into the scientific and engineering projects, based on their experience in ANEL. Laboratories are equipped with the latest equipment and software in all engineering fields.

Precision Engineering Sector development prospects in Armenia (according to industry support and education, research institutes)

In-depth interviews with the representatives of *governmental bodies and industry support organizations* revealed that the majority of them consider knowledge-based industries, including the precision engineering sector, as those having high potential to become important drivers for the economic growth. Development of those sectors is an excellent opportunity to put Armenia on front line of ongoing and future technological trends. Strong precision engineering sector will also allow attracting international corporations to Armenia, which in its turn could bring new changes in the sector.

The respondents highlighted the opportunities created by the existing initiatives in the educational system, e.g. establishment of specialized laboratories like ANEL, which ensures continued supply of highly skilled professionals to the market. According to them, there is a need to drastically increase the number of such engineering laboratories, equipped with modern technology and machinery, since it is not possible to develop precision engineering industry without such infrastructure. While indicating high quality of technical education, the respondents stressed the importance of developing entrepreneurial skills among the engineers.

According to *technology centers and FEZ* the development of PE in Armenia will have positive effect on the economy of RA and may become one of the most beneficial fields of economy, like in Israel and Singapore. New workplaces will be opened and more educated specialists will be integrated in works, if new innovational technological programs are actualized. But there are some barriers, like lack of cooperation. Most of the PE companies in RA operate within their small market and don't cooperate with each other.

The representatives of *educational and research institutions* unanimously mentioned that PE sector development in Armenia has real perspectives. Most of them, emphasized, that countries like Armenia, with quite limited natural resources and, in contrast, rich intellectual potential, need to stress a production, based on intellectual capital not on material. Yet, the sector needs further educational support to ensure the unlimited supply of raw material, i.e. intellectual power. In other words, the government, the educational institutions and the sector representatives need to work together to ensure the proper conditions for the sector, that is one of the most promising industries for the country, which will support the sector's further flourishing, hence country's economic

development. One of the respondents' mentioned that PE is a supporting industry for production, the development of which can push the production and country's economic development as well.

<u>The supporting role of the Government and international organizations (perceptions of industry support and education, research institutes)</u>

The importance of the role of government in development of Precision engineering sector in Armenia is recognized by all the participant organizations in the sector, including state agencies, industry support organizations, educational and research institutes. The role of international organizations in providing assistance on international best practice and expertise is also very important.

According to *governmental bodies and industry support organizations* representatives, state plays very important role and stays ready to make all possible efforts to develop the sector. Particularly state is involved in ongoing projects to develop the required infrastructure, strengthening the educational institutions capacity, soliciting funding from international donor organizations. Additionally, the industry support organizations would like to see the involvement of state in bringing the expertise from countries with developed precision engineering sector to the Armenian educational system. Particularly they see state involvement in convincing companies from those countries to establish their research laboratories in Armenia and creating favorable environment for those investments. Additionally state should create stimulating environment for local companies to sponsor students, who upon graduation will work for them, as well as for establishing small engineering laboratories at secondary schools. Finally, they noticed that state should develop specific strategies and action plans not for the whole precision engineering sector, but separately for its sub-sector – machine-tools, instruments, laser technologies, etc.

According to the *representatives of Technology centers and FEZ*, the role that the government can play in supporting the development of PE, is by investing in this sector. Investments are needed for instance in education sector to prepare high quality professionals and in infrastructure, the state can also provide grants to newly established companies to support them in the first stages of their growths. Additionally, the state can play an important role in securing demand for PE organizations especially in defense sector and in all other sectors where it has influence. On the other hand international organizations could support the PE sector in Armenia by sharing best international practice and provide advisory support to representatives of local PE sector. They can do this in partnership with the state where the state would create innovations centers and cluster zones and international organizations can provide the expertise.

The representatives from *research institutions* see that the government is taking steps, however, 40% of respondents mentioned that the results are not seen yet - despite the strategy is developed no serious steps are taken so far, the government is trying to solve the large problems with small steps. According to them additional ongoing monitoring is needed, more investment, attention and privileges would be preferable. The opinions of research institutions' representatives towards

what the state/international organizations should do to further boost the sector development, were again quite dissenting. Only 1/3rd of the respondents shared the opinion about the necessity for state/international organizations cooperation and need for investment. Separate participants outlined, that the state should create new companies, use the international best practice, often organize employee trainings, create corresponding infrastructure, ensure the product has reached to the market, met the social issues (tangible impact on the field), etc. Nevertheless, the participants were unanimous that some steps are already taken.

Half of the representatives of educational institutions assessed the government's efforts as positive. As was mentioned by one of them "Governments policy is on the right track". On contrary, the other half is either unsatisfied or has a negative opinion. Seventy percent of respondents think that one of the ways in which either Government or international organizations can help to develop PE industry in Armenia is by providing financial incentives. As was mentioned by two respondents the Government can provide tax incentives to start ups and other PE market participants. The other method by which Government or international organizations can support is related to improvements in educational process. In particular, respondents valued the connections with international organizations which can be used for organizing exchange programs.

2. SECTOR DEFINITION AND ESTIMATES ON NUMBER OF COMPANIES IN THE PE SECTOR

2.1 Sector definition

Precision Engineering (PE) forms the backbone of manufacturing activity and includes the activities of manufacturing work pieces, which have low tolerance. The industry supports the ever-growing manufacturing sector, with a value chain that covers Machinery and Systems (M&S) and Precision Modules Components (PMC). It is also instrumental in providing specialist engineering services for the maintenance and overhaul of plant and machinery used in a multitude of production processes. PE forms the integral part of electrical, electronic, mechanical and optical engineering. From semiconductor chips, to the most advanced medical devices and the most sophisticated drill bits used in oil exploration, precision engineered products play a vital role in the development of the overall economy of every country.

Precision engineering sector definition in the report

The international classifications of economic activities (ISIC rev 4 and NACE rev 2) do not define Precision Engineering as a separate sector of economy. Overall definitions of precision engineering provided by international technical societies on precision engineering (ASPE[1], EUSPEN[2], JSPE[3], DSPE[4]) are limited to description of products and processes treated as Precision engineering.

Broadly speaking, the classic definition of Precision Engineering is an accuracy of 1*10-6 which is one part in one million or 1 micron in 1 meter. This is increased the fold to 1*10-7 to determine that the level of accuracy falls under the realm of Ultra Precision Engineering.

The PE is a sub-discipline of electrical engineering, software engineering, electronics engineering, mechanical engineering, and optical engineering that includes the manufacture of instruments and appliances for measuring, testing and navigation, irradiation, electro-medical and electro-therapeutic equipment, optical instruments and photographic equipment, power-driven hand tools, metal-forming machinery, other machine tools, other special - purpose machinery, air and spacecraft and related machinery and medical and dental equipment and supplies. It is concerned with the design, development, manufacture and measurement of components and systems as wide ranging as aerospace components, micro-electronic devices or grinding machines. It also deals with techniques such as scanning tunneling microscopy, diamond turning, computer-aided design, and dynamic modelling, as well as, involves design methodology, error budgeting,

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[1] American Society for Precision Engineering
[2] European Society for Precision Engineering and Nanotechnology
[3] The Japan Society for Precision Engineering
[4] Dutch Society for Precision Engineering

uncertainty analysis, metrology, calibration/error compensation, precision controls, and actuators and sensors.

The difficulties of definition of Precision engineering sector are the reason of absence of measurement by official statistics on international and national levels. Overall definitions of Precision engineering indicate that this sector is mainly included in the Manufacturing sector activities unless it is closely linked to Engineering services.

According to the "Strategy of Export oriented industrial policy" (adopted by the RA Government on 15.12.2011, N49 protocol decision), Precision engineering in Armenia is defined as "Manufacture of machinery and equipment n.e.c. (28[5]), Manufacture of computer, electronic and optical products (26), Manufacture of electrical equipment (27), Manufacture of games and toys (32.4), Manufacture of medical and dental instruments and supplies (32.5), Other manufacturing n.e.c. (32.9)".

All the activities defined by the Strategy represent Manufacturing activities and mainly correspond to internationally accepted definition of Precision engineering. Anyway internationally defined Precision Engineering does not include all the manufacturing activities of above mentioned subsectors, but only the production of products lying under the requirements of precision engineering products.

Another, slightly different definition was presented in the document approved by the Industrial Council on 6 December 2013 – "Precision Engineering/Engineering Sector: Activity plan for 2012-2015". This document defines overall Engineering sector not only Precision Engineering. Particularly, the document states that "Engineering sector includes companies producing (or having potential to produce) internationally competitive products in the following sectors:
- Manufacture of computer, electronic and optical products (26),
- Manufacture of electrical equipment (27),
- Manufacture of machinery and equipment n.e.c. (28) as well as
- Engineering activities and related technical consultancy (71.12).

This study in Precision Engineering is focused manufacturing types of economic activities mentioned above. Additionally, taking into account the definitions approved by the Industrial Council as well as close linkage of engineering services to precision engineering sector, the companies with the economic activities in the following service sectors are also included in the sphere of interest of the report
- Engineering activities and related technical consultancy (71.12),
- Research and experimental development on natural sciences and engineering (72.1).

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[5] Here and afterwards the codes presented in brackets indicate corresponding coding of type of activity according the classification of economic activities of the Republic of Armenia (which was developed on the base of European NACE rev.2).

2.2 Number of economic units (companies, individual entrepreneurs) in Precision Engineering sectors

There are 2 main sources to estimate the number of companies with activities in defined PE sectors in Armenia. These are:
1. The publications of National Statistical Service of RA (NSS RA) on industrial statistics (published on armstat.am website)
2. The database of Tax Service of RA on companies (published on taxservice.am website)

The information and coverage of these sources are different regarding to the main purpose of use. Here is the short summary of information for these 2 sources.

1. _NSS publications_

In the framework dissemination Industrial statistics for Armenia (official statistics), NSS RA conducts a survey of industrial companies on a monthly periodicity and publishes the data by types of activities (according to NACE rev.2). The coverage of companies by statistics depends on the number and size of companies in each type of activity. Particularly, monthly statistics does not cover small size companies and individual entrepreneurs, while quarterly and annual statistics has larger coverage. Anyway, the aim of official statistics is to provide statistically significant estimates on production level (output) in the country, and usually this can be reached without entire coverage of all companies in the country. So, statistical publications provide the numbers of companies engaged in statistical surveys and not necessarily provide entire coverage of all companies.

Table 1 shows number of companies by their main type of activity decided by NSS based on total output volume of company.

Table 1. Number of companies by PE subsectors 2010-2013 (NSS publication)

NACE r.2	Economic activity	2012	2013	2014	2015	2016
26	Manufacture of computer, electronic and optical products	40	43	37	39	45
27	Manufacture of electrical equipment	43	47	49	53	61
28	Manufacture of machinery and equipment n.e.c.	51	50	50	47	47
32.5+32.9	Manufacture of medical and dental instruments and supplies	34	37	39	41	41
	Total, Precision Engineering sector	**168**	**177**	**175**	**180**	**194**

Source: NSS RA data

It should be noted that these numbers refer to all companies performing activities in manufacturing subsectors which may have precision engineering component, but not necessarily they all are involved in PE activities, so the number of companies with PE subsector should be smaller. Moreover NSS does not publish number of companies in engineering service activities, part of which is also in PE subsector according to accepted definition of Precision engineering in Armenia.

2. _Tax service database_

The website of Tax service of RA presents data on registered companies in Armenia. Recently, codes for types of activities are added to most of the companies.

Table 2. Number of companies by PE subsectors (based on Tax service database, retrieved on 10 February 2017)

NACE r.2	Active	Temporarily suspended	New registered	Total
Manufacturing				
26.	41	13	1	55
27.	94	28	0	122
28.	44	16	0	60
32.5	5	1	0	6
32.9*	174	84	3	178
Total-manufacturing	**295**	**66**	**4**	**371**
Total without 32.9	**184**	**58**	**1**	**243**
Services				
71.12	89	37	1	127
72.1	87	30	3	120
Total-services	**176**	**67**	**4**	**247**

Source: Taxservice.am database

The large difference between the number of companies in NSS and Tax service database is noticed especially for codes 27.90 (Manufacture of other electrical equipment) and 32.9 (Manufacturing n.e.c.). This difference is mainly due to different treatment on decision of main type of activity, perhaps, many companies just were classified under these activities in tax service database on principle of «not elsewhere classified» and do not represent PE sector.

These data sources provide information on the number of companies and individual entrepreneurs in the types of economic activity, where precision engineering should be registered, but these types of economic activities also include many companies which do not perform any activity related to precision engineering sector. Identification of companies in Precision engineering is possible only during survey and in-depth interviews.

2.3 The characteristics of the companies in the survey

Field work to collect data on Precision engineering sector businesses was conducted during December 2016-February 2017, with the aim to cover all the companies (legal and physical entities) with activities defined as Precision engineering in Armenia. Overall 186 were identified during screening phase of the survey. These companies have provided data on their activity according to survey questionnaire. Unfortunately there were companies which refused to participate in the survey as well as those which were not reachable during the period of survey. Anyway it is estimated that the survey covers over 90% of the active companies with activities related to precision engineering in Armenia.

The companies are representing all the regions (marzes) of Armenia, with prevailing majority in Yerevan (72%). Domination of Yerevan is not only a peculiarity of this sector; it is also common for all spheres of economic activity in Yerevan.

Table 3. The distribution of surveyed companies by marzes (regions)

Marzes	No of companies	Share, %
Yerevan	134	72.0%
Aragatsotn	2	1.1%
Ararat	3	1.6%
Armavir	2	1.1%
Gegharkunik	3	1.6%
Lori	14	7.5%
Kotayk	11	5.9%
Shirak	12	6.5%
Syunik	4	2.2%
Tavush	1	0.5%
Total	**186**	**100%**

Source: Ameria Survey, 2017

According to the companies' representatives these companies perform activities in Precision engineering sector. The activities are classified according to the classification of economic activities used in EU and Armenia (NACE rev.2). Particularly manufacturing activities in Precision engineering are divided by Divisions (C.26-Manufacture of computer, electronic and optical products, C.27-Manufacture of electrical equipment, C.28-Manufacture of machinery and equipment n.e.c., C.29-Manufacture of motor vehicles, trailers and semi-trailers) and a group (C.32.5-Manufacture of medical and dental instruments and supplies) while service activities in Precision engineering include class M.71.12 (Engineering activities and related technical consultancy) and division 72.1 (Research and experimental development on natural sciences and engineering).

127 companies out of surveyed 186 (68.3%) perform activities in one of the activities of PE sector only, 49 companies mentioned 2 activities and 10 companies- 3 activities. It should be mentioned that activities were mentioned by companies and not necessarily they correspond to the activities which are mentioned in the tax database for that companies.

Figure 1. Number of companies according to the types of activities (mentioned by respondents)
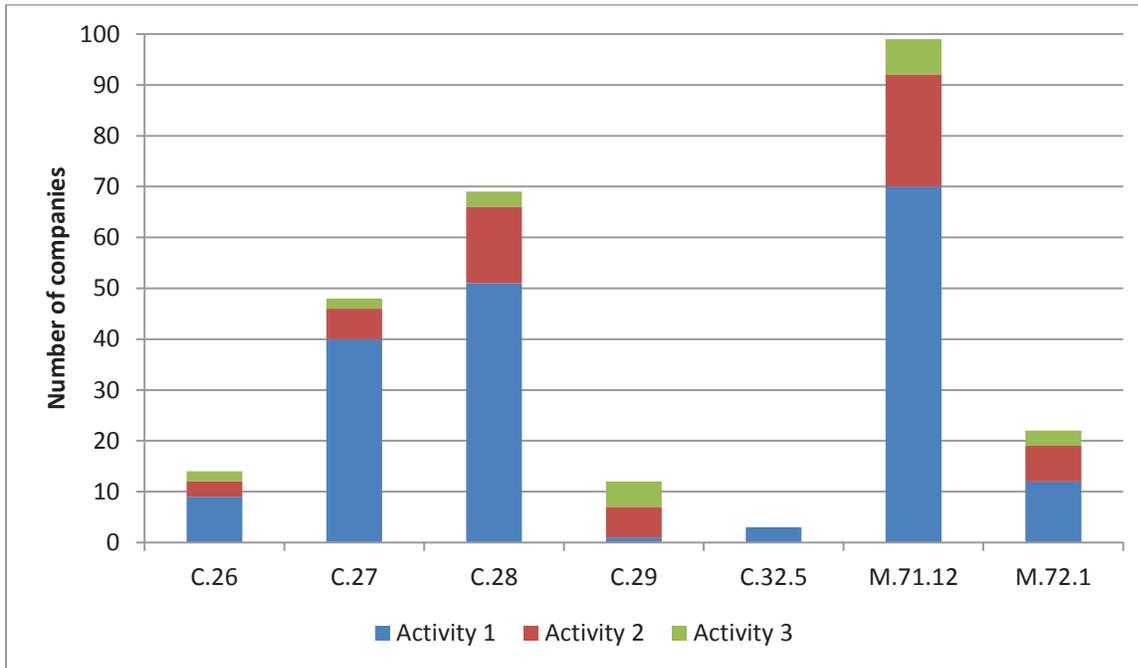
Source: Ameria Survey, 2017

Around 3/4th of companies have individuals from Armenia as main shareholder, additionally 8.6% are owned by private entrepreneurs. Only 6.4% of companies have foreign individuals or companies as main shareholder.

Figure 2. Distribution of PE companies by main shareholder
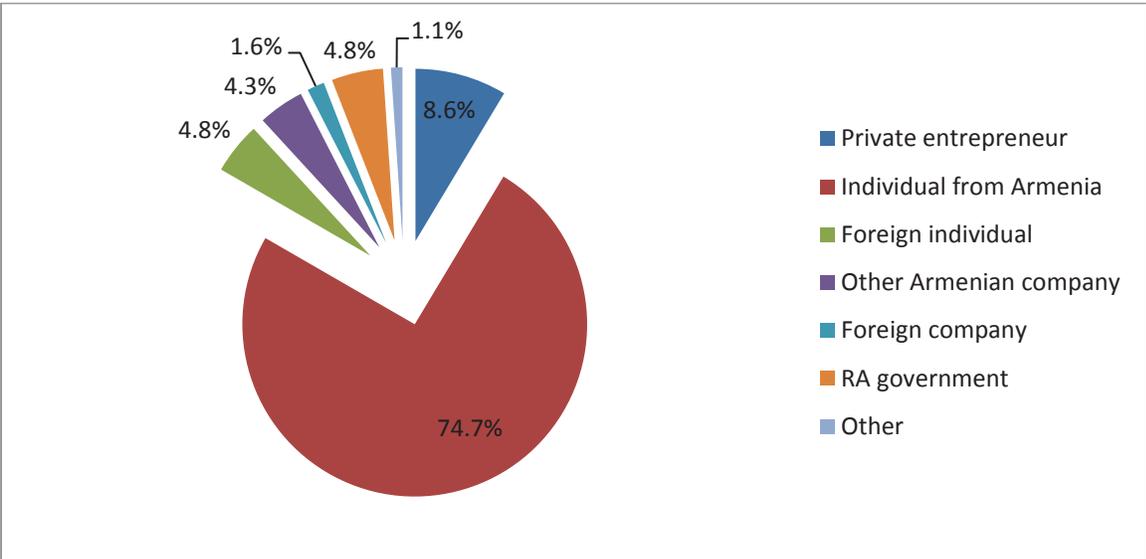
Source: Ameria Survey, 2017

Around 3/4th of CEOs are also the main shareholders of their companies. This is an evidence of large presence of SMEs in the sector.

3. OVERVIEW OF ECONOMIC ACTIVITY IN THE SECTOR

3.1 Production volumes by subsector and company size

Official statistics estimates

The overall production volume of companies classified in types of activities which is defined to describe manufacturing subsector of Precision Engineering in Armenia comprised 18.7[6] bln AMD (or 35.1 mln EUR) in 2016. The volume of production in nominal terms increased significantly compared to 2015 level: by 22.9% in AMD and by 22.6% in EUR equivalent. The growth in 2016 somehow compensates decline noticed in last 2-3 years in the sector: 2016 level compared to 2012 registered increase by 9.3% in AMD and 6.1% in EUR equivalent.

Table 4. Production volumes by PE sub-sectors 2012-2016 (mln AMD)

NACE r.2	Economic activity	2012	2013	2014	2015	2016
26	Manufacture of computer, electronic and optical products	5 223	5 948	5 315	5 259	6 707
27	Manufacture of electrical equipment	5 803	5 615	5 244	4 779	6 710
28	Manufacture of machinery and equipment n.e.c.	4 780	4 015	3 348	3 547	3 719
32.5+32.9	Manufacture of medical and dental instruments and supplies	1 265	1 407	1 385	1 590	1 516
	Total, Precision Engineering sector	*17 071*	*16 985*	*15 292*	*15 175*	*18 651*

Source: NSS RA data

Average annual real growth of production of total PE sector for the period of 2013-2016 comprised 0.9%. 2 out of 4 sub-sectors of PE have recorded increase in average annual growth terms within last 4 years, while the sub-sector "28. Manufacture of machinery and equipment n.e.c. (not elsewhere classified)" is the only subsector to record decline in last 4 years. *In other words, Electronic and optical engineering is growing, Electrical equipment is stable, while mechanical engineering has declined over the last 4 years.*

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[6] This is the overall production volume of companies with economic activities under the defined types of activities, which includes also types of products which could not necessarily be products of precision engineering. It is impossible to distinguish pure precision engineering products on this level.

Figure 3. Real average annual growth (decline) of PE subsectors for 2013-2016 and 2016/2015
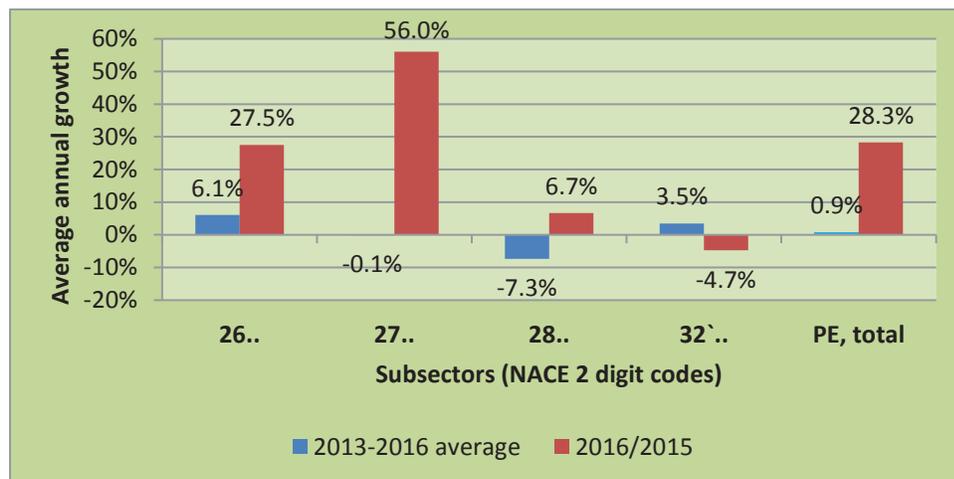
Source: NSS RA data

Anyway, real volume of total production in PE sector increased by 28.3% in 2016 compared to 2015. This significant increase comes to compensate slow growth/decrease in previous 3 year period, conditioned by uncertain macroeconomic developments in the country and the region. Real growth in 2016 to 2015 comprised 28.3%, which is much higher than overall real growth in the country.

Figure 4. Real annual growth in PE sector production 2010-2016 (% to previous year)

Source: NSS RA data

The growth/decline composition analysis of PE sector performance in last 6 years by subsectors shows 3 different periods: 2010-2012 – 11.8% average growth, 2013-2015- decline by 6.9% annually and 2016 – a year with unprecedented growth.

Table 5. PE subsectors real growth (decline) to previous year

		2010-2012, average	2013-2015 average	2016 annual growth
26	Manufacture of computer, electronic and optical products	7.8	-0.3	27.5
27	Manufacture of electrical equipment	20.0	-13.9	56.0
28	Manufacture of machinery and equipment n.e.c.	0.7	-11.6	6.7
32.5+32.9	Manufacture of medical and dental instruments and supplies	11.8	6.4	-4.7
	Total, Precision Engineering sector	**11.8**	**-6.9**	**28.3**

Source: NSS RA data

More detailed analysis of the subsectors shows that performance of subsectors can be much influenced by the types of activity that mostly produce products which are not treated as precision engineering products at all (although these types of activity are included in the subsectors which broadly characterize the companies engaged in PE).

The analysis of subsectors by size of the companies shows that different size companies have different role for PE subsectors in Armenia (Figure 5 and Figure 6). Particularly, micro-sized companies (up to 9 employees) comprise over the half of companies in all 3 subsectors, but their share in total production volume of subsector is around 20%. Based on 2016 data we can state that:

- There are only Micro, Small and medium size companies (SMEs) in activities of manufacturing computer, electronic and optical products (26 code) and manufacture of electrical equipment (code 27), while SMEs share in manufacture of machinery and equipment (code 28) comprise 85% of all companies
- 15% of large companies in mechanical production (code 28) produce 41% of production volume in the subsector,
- Although 1/2rd of companies in subsectors are micro-sized companies they produce only around 20% of total production.

Figure 5. Structure of subsectors* by size of companies (based on number of companies), % in each subsector (2016 data)
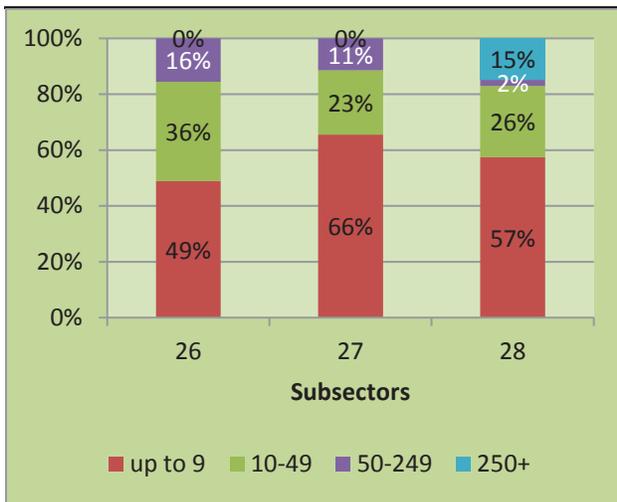
Figure 6. Structure of subsectors* by size of companies (based on volume of production), % for each subsector (2016 data)
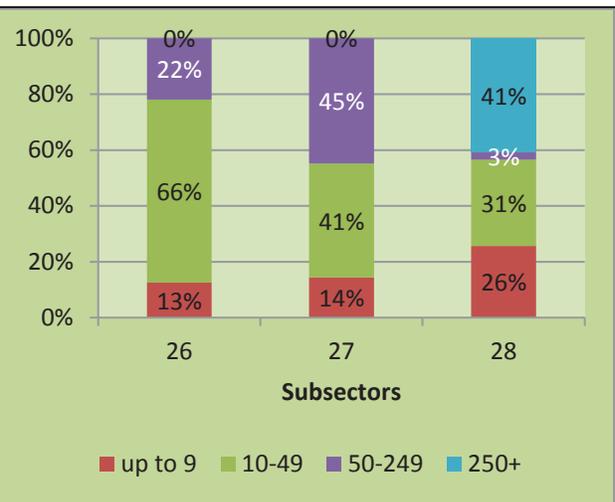
* Data for the activities under code 32 (Manufacture of medical and dental instruments and supplies) are not presented as no information is available on size of companies by 4 digit level to separate codes 32.5 and 32.9.
Source: NSS RA data

The size of the companies in the sector (according to survey)

Prevailing majority of the companies in PE sector belong to SME sector. Particularly, there is only one company among surveyed 186 that has more than 250 employees. Moreover around half of the companies have less than 10 employees, which is an evidence of being micro-sized according to the RA definition of SMEs. For analytical reasons, we have divided micro-sized and small companies to two parts according to the number of employees.

Figure 7. Distribution of PE companies by number of employees according to the survey
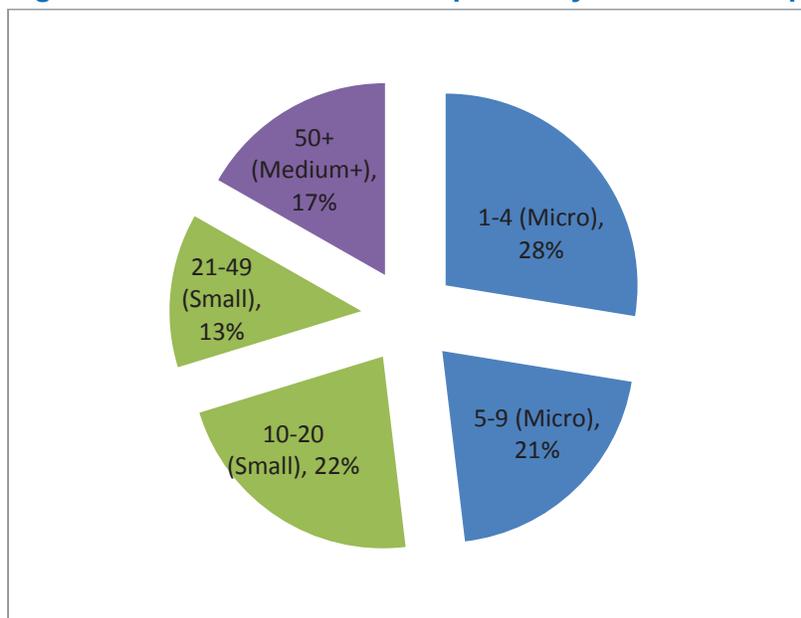
Source: Ameria Survey, 2017

The activity breakdown of the companies and sales (according to survey)

The questionnaire of the survey included questions on sales volumes of companies during 2014-2016 as well as breakdown of the sales by the types of activities in PE subsector. Unfortunately around 1/3rd of surveyed companies did not respond to the question on sales due to different reasons (did not want to mention, had difficulties to divide sales by activities and other). For analytical reasons we have used imputation statistical technique based on the size of the companies and other similarities. As a result our estimate of sales volumes of surveyed companies comprised 18.5 bln AMD for 2016.

54-55% of total sales of companies during 2014-2016 belong to the medium sized and large companies (while these companies comprised only 17% of total number), 9-12% - to micro-sized companies and 34-36% -to small companies.

Table 6. Estimates of sales volumes by size of surveyed companies

	No.	Sales (mln AMD)		
	employees	2014	2015	2016
Micro-sized	1-4	1 157	610	693
	5-9	1 034	1 056	1 564
Small	10-20	3 434	2 783	2 545
	21-49	3 013	3 745	3 653
Medium+	50+	10 214	9 831	9 997
	Total	**18 852**	**18 025**	**18 453**

Source: Ameria Survey, 2017and expert estimates

The respondent companies estimated share of each type of economic activity in 2016 sales volume. This allows understanding breakdown of total sales volumes by "pure" economic activities, unlike official statistics estimates, which allow to have sales only by main type of economic activity of the company. Particularly, according to these data 52% of sales in PE subsector belongs to manufacturing industries and 48% - to service activities. The estimate of sales of service industries in PE subsector is another advantage of survey data compared to official statistics (where separate estimates of engineering services at 3 digit level of NACE rev 2 are not available).

Figure 8. Distribution of PE subsector 2016 sales by "pure" types of economic activities
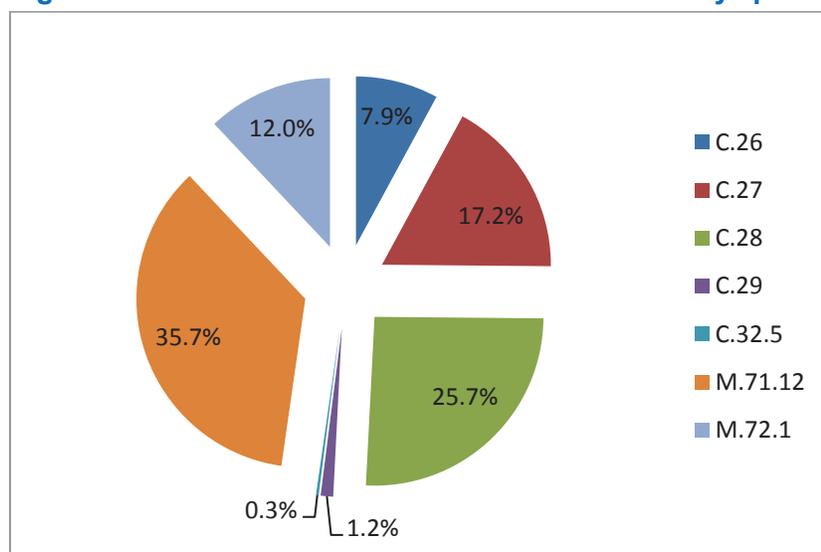
Source: Ameria Survey, 2017and expert estimates

3.2 Sales by destination: domestic market vs external market

Official statistics estimates

The official statistics on the companies with activities under PE sector allows monitoring the dynamics of direct sales to abroad (direct export of production by the companies). Particularly the share of exports in total sales of PE sector comprised 21.8% in 2016. The share of exports in total sales of the companies under the defined activities is declining during last 4 year period, which may be an influence of uncertain macroeconomic environment in the region, but also speaks about decreasing competitiveness of Armenian sector. Additionally, the share of exports into CIS countries is almost stable (60-70% of total exports), which may mean that decrease of exports is conditioned by decreasing competitiveness in both CIS and non-CIS countries.

Figure 9. Share of direct exports in sales of companies in PE sectors 2010-2013, %

Source: NSS RA

Data on share of exports by subsectors indicate that electrical, electronic and optical engineering production is comparably more oriented on exports, but the share of exports in sales is decreasing for all subsectors: «26. Manufacture of computer, electronic and optical products» - 38% of sales is direct export and, while «27. Manufacture of electrical equipment» - only 14% and «28. Manufacture of machinery and equipment n.e.c» only 16% goes to direct exports.

Overall trend over the 4 subsectors also shows that the share of CIS countries as export destination is more or less stable (Figure 11), with the higher and growing importance of CIS market for «27. Manufacture of electrical equipment» subsector exports.

Figure 10. Share of direct exports in sales of PE subsectors 2010-2016, %

Legend: 26, 27, 28, 32.5+32.9

Values visible: 56%, 52%, 58%, 54%, 47%, 47%, 48%, 42%, 46%, 35%, 37%, 38%, 29%, 23%, 24%, 22%, 16%, 14%, 16%, 14%, 9%, 8%, 0%, 1%, 2%, 3%, 5%

Figure 11. Share of CIS in total exports by PE subsectors 2010-2016, %

Legend: 26, 27, 28, 32.5+32.9
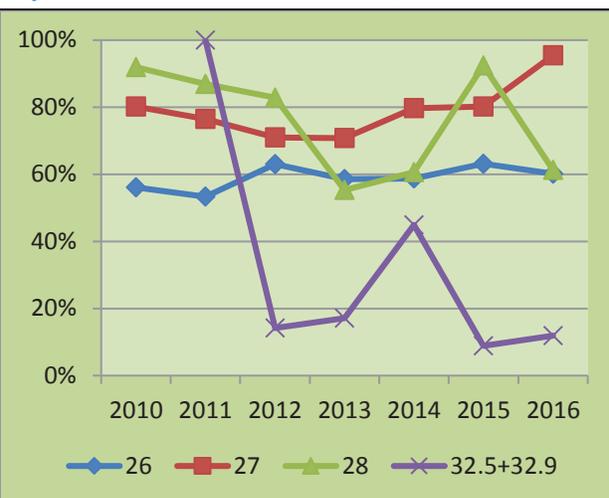
Source: NSS RA

The structure of sales by markets and clients (according to the survey)

According to survey companies 2/3rd of sales in 2016 were realized in domestic market, with 1/3rd of sales – directly exported. The share of direct exports in sales is comparably higher in medium and large size companies – 42%. It is also interesting that share of export is higher (40%) in the sales of the companies which indicated manufacture of machinery and equipment as their main activity.

Figure 12. Distribution of PE subsector 2016 sales by domestic market and direct exports

Main activity	Sales in Domestic market	Direct exports
M.72.1	70%	30%
M.71.12	69%	31%
C.29+C.32.5	82%	18%
C.28	60%	40%
C.27	64%	36%
C.26	90%	10%

Size by employment	Sales in Domestic market	Direct exports
50+	58%	42%
21-49	83%	17%
10-20	77%	23%
5-9	71%	29%
1-4	72%	28%
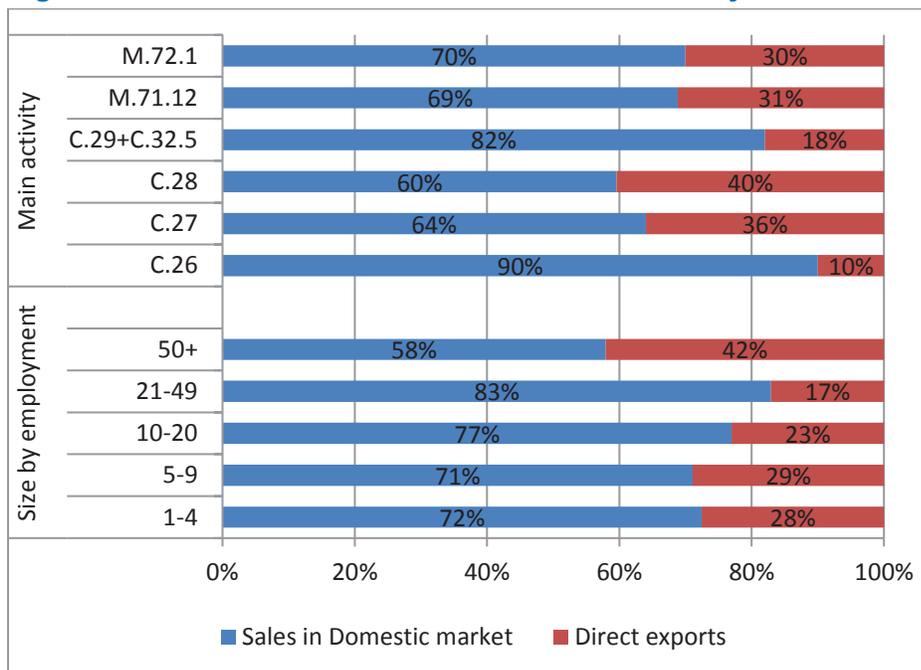
Source: Ameria Survey, 2017

The main buyers of products and services in domestic market are other companies, which may use the products as for their internal needs but also may export it. So, the real share of export is estimated to be higher than the indicator of direct export by producing companies.

The structure of buyers is quite similar for the industries: with other companies prevailing in domestic market and external one.

Table 7. Distribution of PE subsector 2016 sales by purchasers in domestic market and direct exports

| | Domestic market | | | | External market | | Total |
	Individuals	Companies	Gov RA	Other	Individuals	Companies	
Manufacturing industries	1.6%	59.5%	4.4%	0.0%	1.9%	32.6%	100%
Service industries	2.3%	59.7%	6.5%	0.6%	0.2%	30.7%	100%
Total PE	**1.9%**	**59.6%**	**5.4%**	**0.3%**	**1.1%**	**31.7%**	**100%**

Source: Ameria Survey, 2017

3.3 Employment in the sector

Official statistics estimates

Overall employment in the 3 subsectors of precision engineering manufacturing sectors is estimated at around 2950[7], with 1140 in electronic and optical engineering, 996- in electrical engineering and 814 in mechanical engineering subsector (Figure 13). More than half (53%) of employment in mechanical engineering subsector is provided by large size companies.

Figure 13. Number of employees* by subsectors of PE and size of companies, 2016
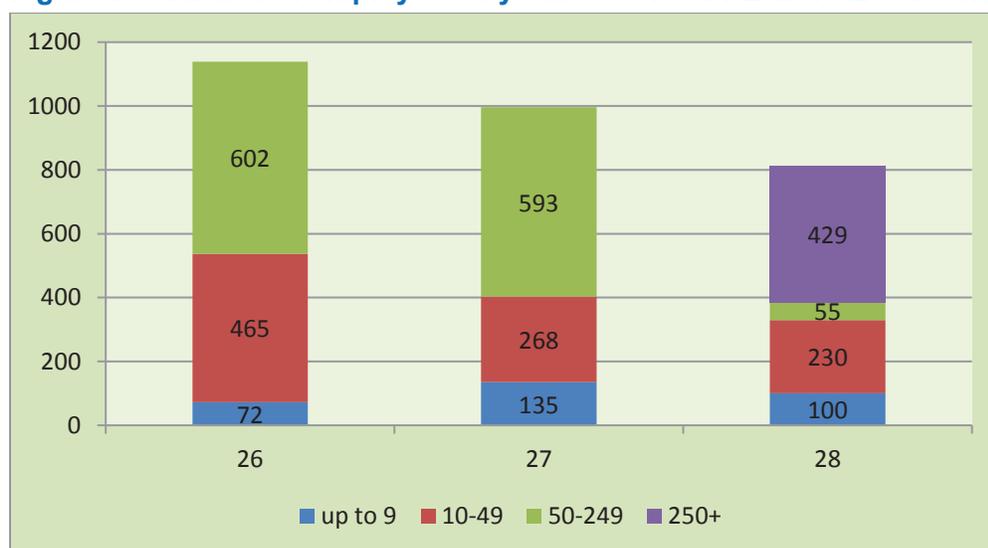
Source: NSS RA data
* The number of employees engaged in production activities only

No official statistics estimates on the number of employment in engineering service activities are disseminated.

Employment estimates according to survey

Total employment of 185 surveyed companies[8] as of December 2016 is estimated at 5,070 people, which is by 2.9% lower compared to the estimate as of end of December of 2015. Manufacturing subsectors (C26-32.5) employment in 2016 comprised 2298 (45% of total PE sector), while Service subsectors – 2772 (55%). It should be mentioned that larger size of employment in service subsector can be explained by existence of large research institutes (also financed by government).

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[7] Statistical data cover the number of employees engaged in production activities only, the overall employment in companies can be higher
[8] One company refused to mention number of employees.

The following trends are noticeable when comparing the employment in 2016 to the employment in 2015:

- Decline in employment of micro-sized and small companies, increase in employment of medium size companies,
- Large decline in employment of the companies which have indicated Manufacture of machinery and equipment as their main activity, while in most of other PE subsectors slow growth of employment is visible.

Trends in employment during 2015-2016 show that small companies struggle more with the development than comparably larger ones and Mechanical/Machinery precision engineering subsector is declining in Armenia.

Figure 14. Overall size of employment by main activity and size of companies
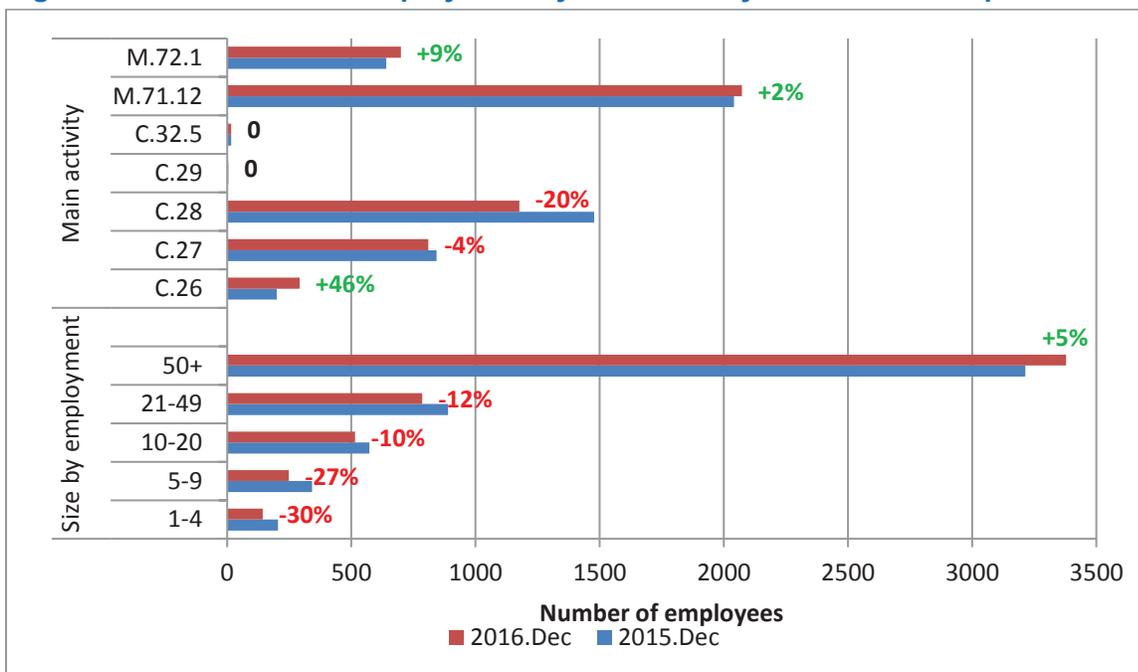
Source: Ameria Survey, 2017

Share of women in the employment of the companies of PE sectors comprised 30% (both in 2015 and 2016). Women are more engaged in PE service industries (35% of employees are women) than in PE manufacturing industries (25%).

3.4 Assessment of the factors influencing business activity (according to survey)

The companies in the survey were asked to assess several factors influence on their business activity with a 5 scale system, where 1-is negative influence, 3-is neutral and 5-is very positive influence. Aggregating overall estimates of companies we can compare assessment by different groups of companies in precision engineering sector.

"Small size of domestic market" is assessed to have negative influence of business activity of the companies in the sector. The assessment is very similar for all sizes of the companies. Manufacturing subsector enterprises seems to suffer more from small size of domestic market, than the companies in the service sector of precision engineering. Perhaps this is because service companies have better opportunities to reach external markets. Particularly, there is a difference in indicators of assessment on "barriers in reaching external markets" among manufacturing and service sector companies: Manufacturing companies believe that these barriers have more negative influence on their business activity, while the opinion of service companies on barriers is more neutral. Comparably smaller companies see more negative effect on their business brought by barriers to reach external markets, than larger ones.

Table 8. The assessment of factors by their influence on business activity (by size of companies)-average indicators of assessment*

	Size of company by employment					
	1-4	5-9	10-20	21-49	50+	Total
Tax administration	3.55	3.42	3.56	3.65	3.03	**3.45**
Tax rates	3.47	3.29	3.46	3.78	3.07	**3.40**
Lack of specialists	3.26	3.36	3.27	3.50	3.17	**3.30**
Barriers in reaching external markets	2.56	2.76	2.61	3.00	2.93	**2.73**
Small size of domestic market	1.78	2.00	1.98	1.83	1.87	**1.89**

* 1- negative influence,3-neutral, 5-positive influence
Source: Ameria Survey, 2017

Table 9. The assessment of factors by their influence on business activity (by main type of activity of companies) – average indicators of assessment*

	Main type of activity					
	C.26	C.27	C.28	M.71.12	M.72.1	Total
Tax administration	2.89	3.36	3.37	3.65	3.64	**3.45**
Tax rates	3.00	3.31	3.25	3.62	3.73	**3.40**
Lack of specialists	3.38	3.34	3.18	3.38	3.18	**3.30**
Barriers in reaching external markets	2.75	2.38	2.59	3.06	2.91	**2.73**
Small size of domestic market	1.56	1.38	1.55	2.39	2.25	**1.89**

* 1- negative influence,3-neutral, 5-positive influence
Source: Ameria Survey, 2017

It is interesting that the influence of such factors as: "Tax administration", "Tax rates" and "Lack of professionals" on business activity are not assessed as negative. According to the companies, these factors even could have some small positive effect on business activity. The assessment of these factors is mainly positive due to service providing companies, which receive grants and financing from the government, but anyway, other companies also assessed this factors at least neutral. These results seem to be very different from overall perception in the sector and country, that improvements of Government administration may have positive effect on private sector. In fact, the largest problems are with the businesses, their investments in technologies and human capital and access to external markets.

The factors preventing local companies from becoming more competitive (according to in-depth interviews)

Improvement in education system, favorable investment climate, state support for start-ups, and investment in technologies can improve competitiveness of Armenian PE companies.

According to *government bodies and industry support organizations* improvement of education system will create conditions for improving competitiveness of Armenian precision engineering companies. They mentioned that the engineering education, e.g. robotics, should start from the secondary school already. Next factor for improving competitiveness in their opinion could be creating favorable investment climate, since the sector requires high investments. State support spent for the sector companies could be in the form of tax exemption or decreasing the tax level, facilitating the customs clearance procedures to reduce the time. This is very important for the start-ups.

The lack of qualified and skilled workforce in the PE sector was mentioned by *technology centers and FEZ representatives*. Another factor hindering local companies from being competitive is the

lack of resources both financial and in terms of modern equipment and technology. The equipment that is being used by Armenian companies are mostly from Soviet times and cannot provide the speed and quality that is needed to be competitive. Other factors include the lack of good transportation links with other countries. It takes months while an equipment that is being delivered from abroad to arrive to Armenia which hinders the speed of production. The need for international investment is also highlighted as a necessity for local companies to develop resources and become competitive. International investors see Armenia as a risky country because of the geopolitical situation in the region. The state has a big part to play in this regards as it can create platforms for international investors, so they can visit the country and see the potential for investment in PE sector in Armenia.

As the main factors preventing the local producers from becoming more competitive, more than 40% *of research institutions' representatives* pointed out the technological base; about 30% stressed the limited market/unfavorable geographical location as well as high custom duties. Separate respondents also stated the transportation problem, financial means' shortage, tax policy, expertise, etc. Some respondents also mentioned steps that will help the sector to become more competitive, i.e. circa 30% pointed out the importance of local brand establishment in engineering, cooperation between companies and engineering centers / universities (the Germany's expertise), etc.

According to *respondents from research institutions* there are two main obstacles for local companies to become more competitive. Those are lack of investments and low quality of education which later on develops into lack of specialists. Other obstacles which received attention are no centralized policy for PE industry development, brain drain, lack of modern technologies, production of middle stage products and lack of high quality information.

3.5 Expectations for PE sector development in 2017-2019 (according to survey)

Majority of the PE subsector companies is expecting moderate growth of the subsector in Armenia during the next 3 year period -2017-2019. Only 6% of the company representatives are expecting decline in the subsector for the next 3 year period.

Figure 15. Expectations on subsector developments in 2017-2019
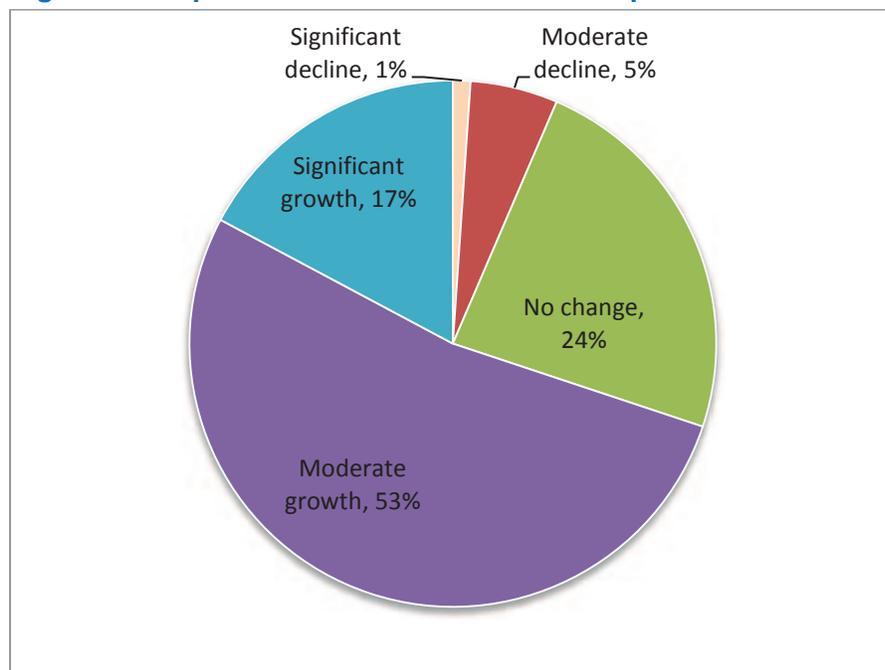
Source: Ameria Survey, 2017

To compare expectations of the companies by size of company and by main type of activity we have recalculated the answers on expectations using 1-5 scale where 1 is significant decline and 5 –significant growth expectations. According to the results the companies with main type of activity of manufacturing electrical equipment have highest expectation for growth, while the companies in manufacture of machinery and equipment (C.28) and in Research and experimental development on natural sciences and engineering (M.72.1) have the lowest expectations for growth of the sector. Another conclusion is that expectations of medium and large companies in the subsector are higher than those of micro and small companies.

Figure 16. Expectations on subsector developments in 2017-2019 by company size and main economic activity
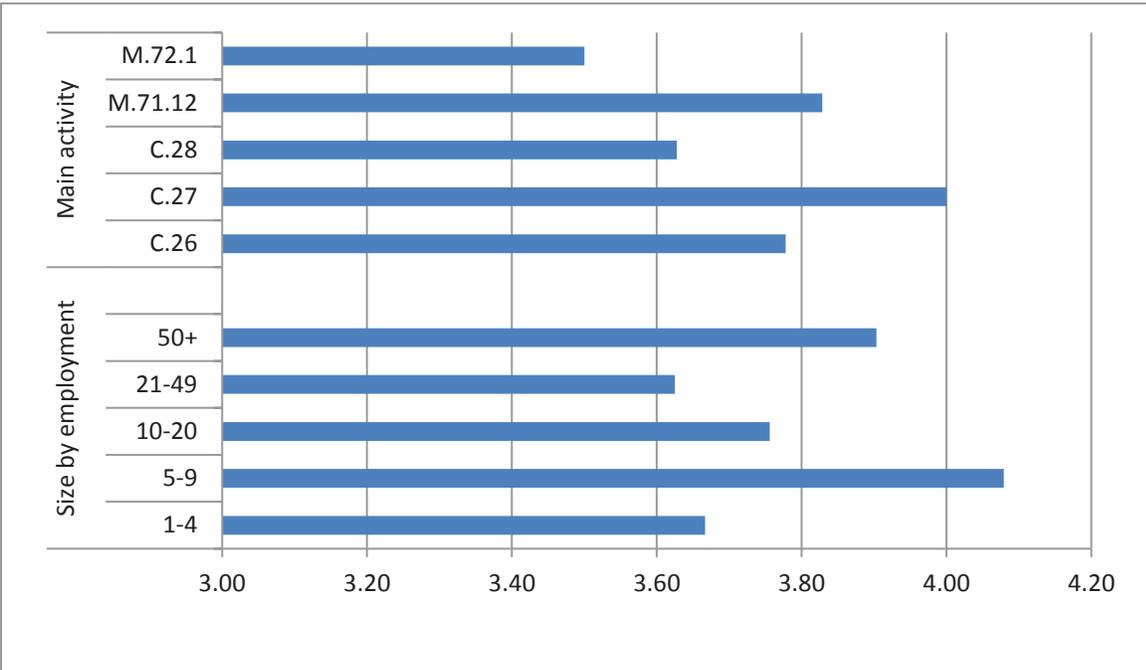
Source: Ameria Survey, 2017

4. EXTERNAL ECONOMIC ACTIVITY

Official statistics estimates: Exports on product level

According defined 4 manufacturing subsectors for PE, corresponding[9] HS code (4-digit level) 175 product lines were examined to understand dynamics of exports on a product level.

These are:

- 81 lines (5 lines are excluded10) from 84.XX,
- 46 lines (all) from 85.XX,
- 32 lines (all) from 90.XX,
- 14 lines (all) from 91.XX and,
- lines 8805 and 9402.

Overall export volume of defined product lines from Armenia comprised 54 mln USD in 2016, while the peak of export in post-crisis period was in 2012 – 60.8 mln USD.

Figure 17. Volume of exports and growth (decline) in 1995-2016
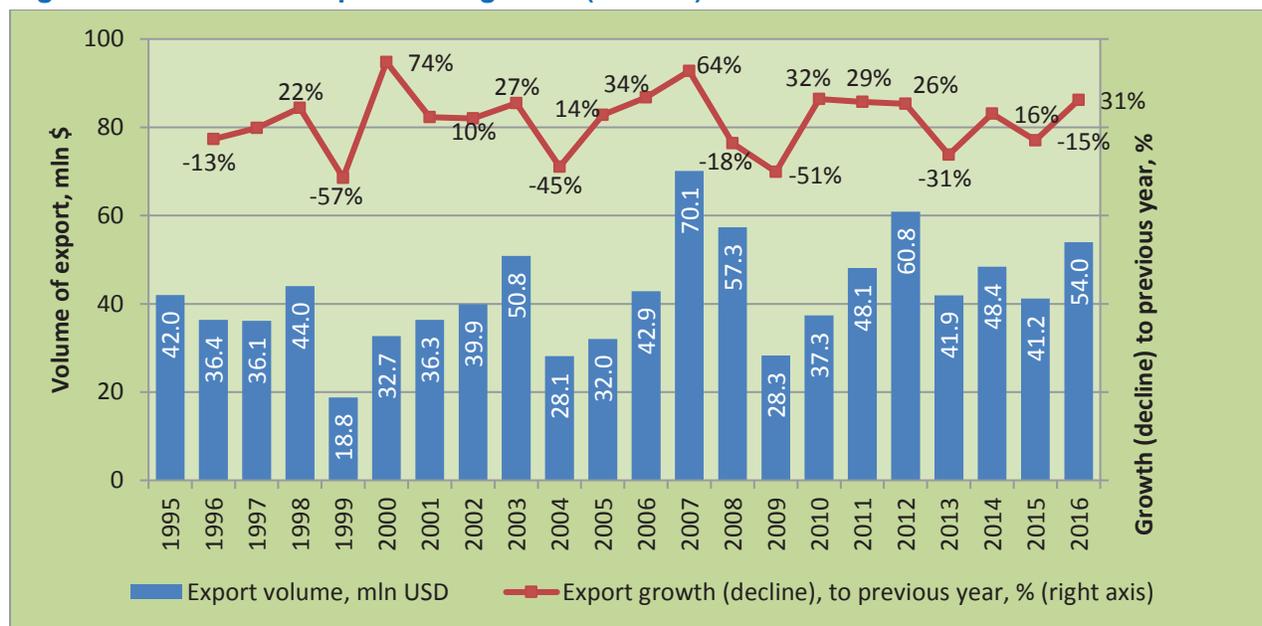
Source: NSS RA, foreign trade statistics

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[9] Correspondence between the types of activities (defined by NACE rev.2) and HS classification is established to define groups of products manufactured under the activities defined as PE. Correspondence is based on correlation tables between two classifications provided on UNSTAT website.
[10] HS codes 8402, 8403, 8404, 8409, 8480 refer to production of other types of activities – not included in PE sectors according our definition.

Foreign trade statistics data show the export volume from Armenia is much higher than the level of production (especially for Y2012), which can be explained by the following:

- According to International recommendations for Industrial statistics, the data on the total volume of industrial output (work, services) produced by organizations do not include internal turnover, the value-added tax and excise tax,
- Foreign trade statistics captures all the products crossing the border, regardless of their production origin and period of production,
- Possible coverage issue of production by statistical monitoring
- Re-export issues, etc.

The largest group of products by export volume in 2013 was «91. Clock and Watches», while in previous 3 years the leading group in export volume was the main production of mechanical engineering – «84». So overall trend noticed in post crisis period (2010-2016) is:

- Export of clock and watches is growing with high rate,
- Export of optical, controlling and measuring instruments group is growing moderately,
- Export of product of mechanical production (84 code) was growing with high rate until sharp decline in 2013 and moderate decrease thereafter,
- Export of electrical production (85 code) was growing moderately until sharp decline in 2013-2015, while 2016 again showed growth.

Sharp decline in the volumes of export in the production of mechanical and electrical engineering in 2013-2015 by small size of Armenian economy, the absence of permanent markets for exports, macroeconomic uncertainty and decreasing competitiveness. Particularly in 2012 the growth over 2011 was registered due to one-off export of some products to Singapore, and absence of this export to Singapore brought to visible decline in export volumes of 2013 and next years. Evidenced growth in 2016, perhaps is also conditioned by Armenia's membership in EAEU market from 2015 and slow recovery of the Russian economy.

Table 10. Export of PE sectors production, ths USD

HS- 2 digit	Description	2009	2010	2011	2012	2013	2014	2015	2016
84	Boilers, machinery and mechanical appliances	6 959	16 336	16 898	24 251	10 138	11 875	9 795	8 583
85	Electrical machinery and equipment	13 486	13 681	16 425	16 794	10 854	11 871	5 403	12 181
90	Optical, photographic, cinematographic, measuring checking	4 943	3 350	6 618	6 876	6 931	6 871	7 808	9 519
91	Clock and watches and parts thereof	2 925	3 975	8 118	12 885	13 981	17 778	18 200	23 674
8805 +940 2	Aircraft parts, medical furniture parts	0	1	46	39	0	0	0	1
	Grand Total	**28 314**	**37 344**	**48 105**	**60 845**	**41 903**	**48 404**	**41 205**	**53 958**

Source: NSS RA, foreign trade statistics

The export of «91.Clock and watches» has the highest cumulative growth in last 6 years: around 6 times growth of exports in 2016 compared to 2010. Export of mechanical and electrical machinery did not grow compared to 2010.

Figure 18. Dynamics of Export of PE sectors production in 2009-2016
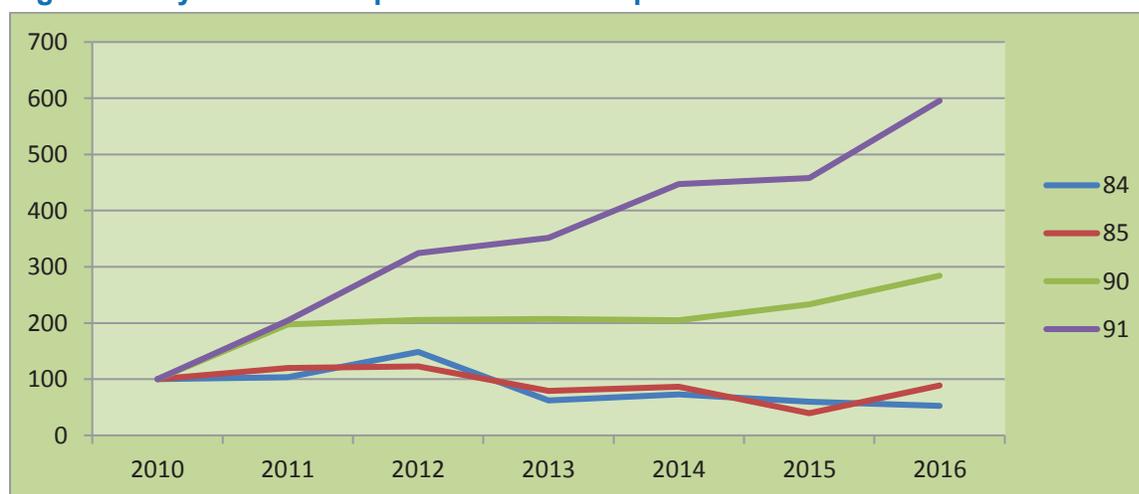
Source: NSS RA, foreign trade statistics

The exports by destinations are also different for groups of products. Particularly, over the half of export of mechanical and electrical production (84 and 85 HS codes) went to Russia during 2013-

2015[11]. Clock and watches products predominantly are exported to Switzerland, while optical and measuring products (90 HS code) have comparably less concentrated by countries (Figure 19).

Figure 19. Structure of Export by PE products for 2013-2015
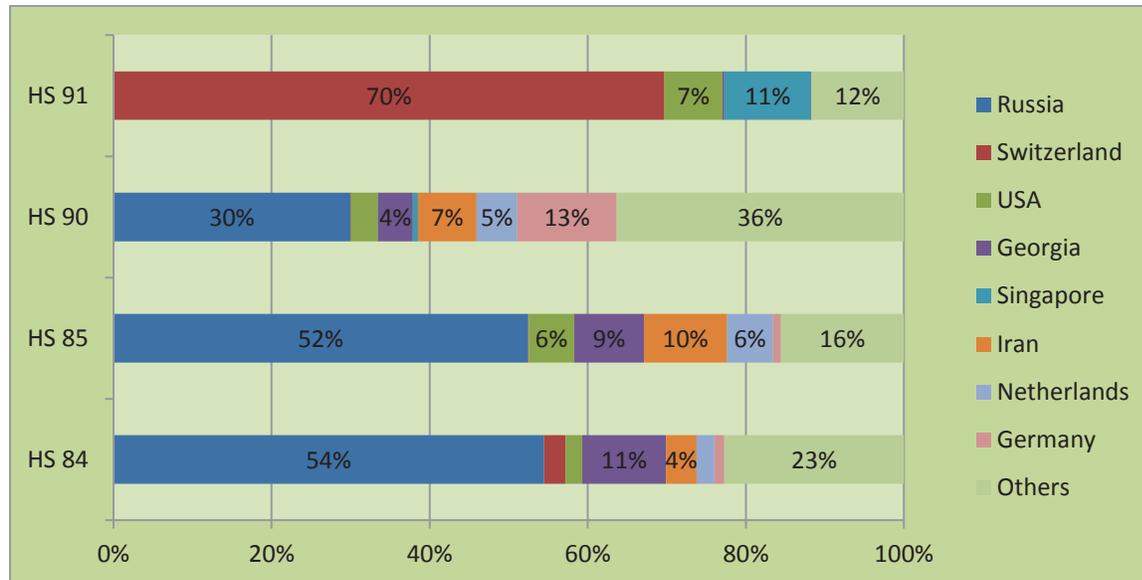
Source: NSS RA, foreign trade statistics

The largest cumulative export volume during last 4 years is registered for the product lines «9111. Watch cases and parts thereof» - 44.4 mln USD.

Table 11. Top export products from Armenia (2013-2016) - Cumulative volumes by HS 4 digit product lines

Cumulative exports in last 4 years (2013-2016)		
HS-4	**Description**	**ths USD**
9111	Watch cases and parts thereof	44 404
8414	Air, vacuum pumps, compressors, ventilating fans, etc	11 266
9102	Watches with case of, or clad with, of base metal	11 042
8536	Electrical switches, connectors, etc, for <1kV	8 119
9101	Watches with case of, or clad with, precious metal	7 446
9114	Other clock or watch parts	6 644
8517	Electric apparatus for line telephony, telegraphy	6 488
8468	Equipment for soldering, brazing or welding	5 276
9032	Automatic regulating or controlling equipment	5 239
9113	Watch straps, bands, bracelets, and parts thereof	4 064
9018	Instruments etc for medical, surgical, dental, etc use	3 574

Source: NSS RA, foreign trade statistics

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[11] Data on export for 2016 by country destinations is not yet available.

The product lines with largest volume of export in 2016 are presented in the Table 12. The last column in the table shows main destination of exports. Particularly, for almost all product lines there is one particular country (market) which usually has dominating share. This trend along with the comparably small volume of export speaks about large concentration of Armenian export market. Anyway there are already several product lines, where export seems to be more diversified. **Export market diversification will allow to increase the volume of exports and to avoid fluctuations of exports over small period of time.**

Table 12. Export volume by HS 4 digit product lines (2016) – Top products

HS-4	Description	ths USD	growth, %, yoy	Main destination
9111	Watch cases and parts thereof	16 899	51%	Switzerland (100%)
9102	Watches with case of, or clad with, of base metal	2 583	-16%	Singapore (51%), Switzerland (29%)
8536	Electrical switches, connectors, etc, for <1kV	2 548	69%	Russia (91%)
8508	Vacuum cleaner	2 088	~ 861 times	Russia (100%)
8415	Electrical parts of machinery and apparatus, nes	1 804	~ 130 times	Russia (98%)
9114	Other clock or watch parts	1 803	-17%	Switzerland (100%)
8414	Air, vacuum pumps, compressors, ventilating fans, etc	1 672	-23%	Russia (87%)
8517	Electric apparatus for line telephony, telegraphy	1 645	76%	USA (45%), Netherlands (18%), France (15%)
9032	Automatic regulating or controlling equipment	1 637	10%	Germany (39%), Russia (29%)
9113	Watch straps, bands, bracelets, and parts thereof	1 508	142%	Switzerland (97%)
9027	Equipment for physical and chemical analysis	1 232	58%	Russia (90%)
9022	Equipment using Xrays, alpha, beta, gamma rays	1 125	54%	Ukraine (37%), Korea (36%), Netherlands (14%)
9001	Optical fibres, lenses, mirrors, prisms, etc	1 059	37%	Germany (31%), Israel (15%), USA (13%), Netherlands (12%)
8548	Electrical parts of machinery and apparatus, nes	1 036	92%	Iran (100%)

Source: NSS RA, UN comtrade database

Availability of Exports and product types (according to survey)

More than half of the companies under the survey (51.6%) reported exporting activities during 2016. This is an evidence of external market importance for the development of precision engineering sector in Armenia. The share of companies with export activities is growing with the size of the company: 87.1% of medium and large companies have reported export activities in 2016, while only 27.5% of micro-sized companies reported that.

Figure 20. Share of companies with export activities in 2016 by size of surveyed companies
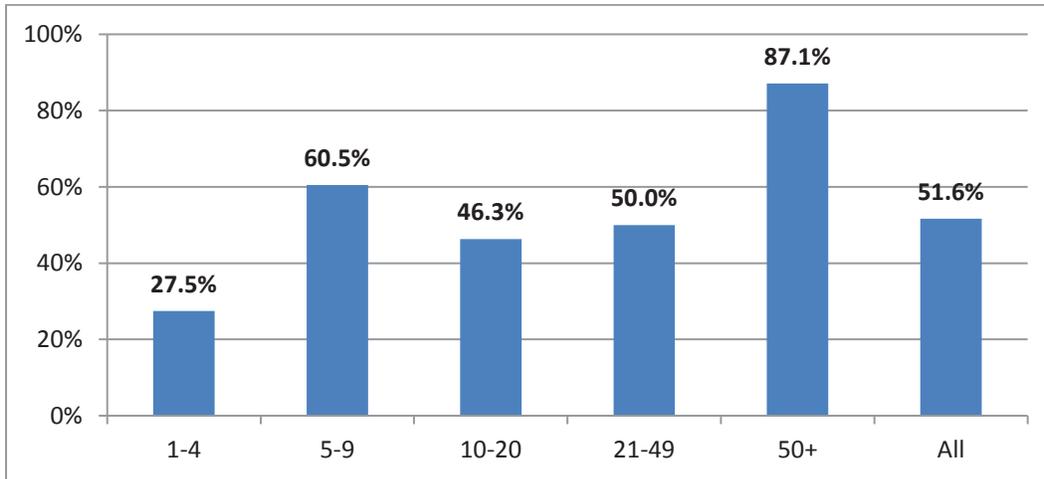
Source: Ameria Survey, 2017

It should be noted that the share of companies with export activities is higher for these companies which reported one of the PE manufacturing activity as their main activity (58.7%), compared to those who reported service activity as their main (42.7%). Having one of the economic activities as their main does not mean that only these types of products (goods or services) are exported.

The share of goods in exported products is higher than services by quantities reported (69% vs 31%). 90% of goods are exported by the companies which indicated PE manufacturing as their main activity. The types of goods exported are equally distributed: around 1/3rd are mechanical machinery and appliances, 1/3rd electrical machinery and equipment and 1/3rd – optical, measuring and checking instruments. Around half of the services exported (44%) are engineering design services.

Table 13. The structure of exported PE products according to survey companies (by number of mentioned units)

	Companies with PE manufacturing as main activity	Companies with PE services as main activity	Total
Goods-total	**90%**	**24%**	**69%**
Machinery and mechanical appliances	32%	0%	22%
Electrical machinery and equipment	28%	8%	22%
Optical, measuring, checking products	25%	14%	21%
Other goods	5%	3%	4%
Services-total	**10%**	**76%**	**31%**
engineering design	2%	38%	14%
software, hardware related	4%	11%	6%
testing, measuring	1%	14%	5%
scientific related	0%	8%	3%
other services	2%	5%	3%
Total	**100%**	**100%**	**100%**

Source: Ameria Survey, 2017

The share of goods in exported products is much higher than services by trade volume estimates (83% vs 17%).

Source: Ameria Survey, 2017

Exports by country (according to survey)

According to the survey results, taking into account reported sales volumes of surveyed companies and the share of sales in external markets by countries, Russia has predominant share in exports (over 37%). Switzerland has comparably less share in survey due to unreported sales volumes of clock, watch production.

Table 14. The structure of exported PE products by countries (survey company estimates)

		Share in exports, %
1	Russia	37%
2	USA	22%
3	Georgia	8%
4	Kazakhstan	6%
5	Iran	5%
6	EU countries	5%
7	UAE	4%
8	Israel	3%
9	Kyrgyzstan	2%
10	Other CIS countries	4%
	Other	4%

* Switzerland is missing from the table due to unreported sales data on watches, clocks (there are differences in customs reports and company reports – perhaps company reports indicated final destination, while customs reports shows actual destination of export from Armenia, without going into details of further movement of goods)
Source: Ameria Survey, 2017

Export logistics (according to survey)

Prevailing majority of companies organize their export through own resources without using any domestic or foreign distributor – 87% of total export of companies in the survey was done by own resources.

It is interesting that using own resources is higher for micro-sized companies (1-4 employees) – 91% of total export, and for comparably larger companies (21+ employees). This may mean that micro companies relay on their own resources due to lower export volumes, then with growing volumes the companies (5-20 employees) use services of distributors, while larger companies (21+) have the opportunity to hire sales personnel and decide to organize sales again by their own resources.

Figure 22. Export logistics structure of PE survey companies by size and main type of activity (weighted by export volume indicators)
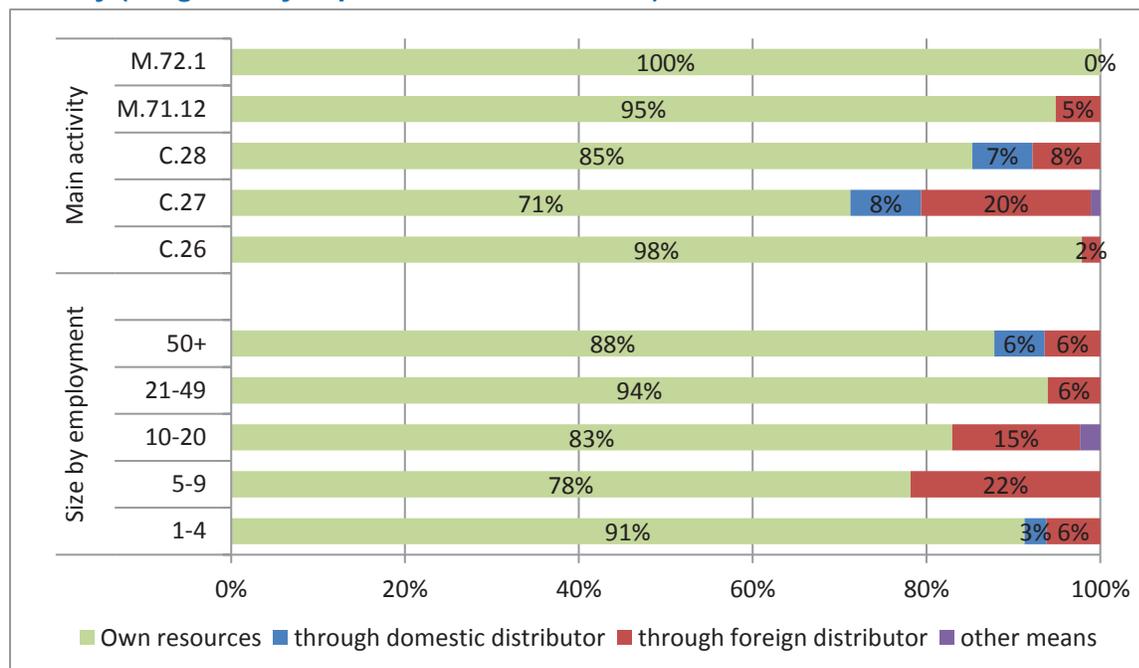
Source: Ameria Survey, 2017

Anyway, low rate of use of distributing services for the PE companies may be one of the reasons of low export volumes as companies do not use professional sales services due to different reasons.

Use of Imported products in 2016 (according to survey)

According to the survey results, 56% of companies imported products for their internal use, such as fixed assets and/or raw materials. Around 1/3rd of companies in precision engineering subsector imported fixed assets during 2016 and about 42% imported raw materials.

The companies which indicated manufacturing activities are more active in importing fixed assets and raw materials that those which are engaged in service activities of precision engineering subsector. Among companies which are engaged in manufacturing "Manufacture of computer, electronic and optical products" (C.26) subsector is more active, which may speak about higher potential of this subsector compared to "Machinery and equipment" (C.28) and "Electrical equipment" (C.27) subsectors. It is also logical that larger companies are more engaged in import activities than smaller ones.

Figure 23. Share of companies which imported fixed assets in 2016 by size and main type of activity
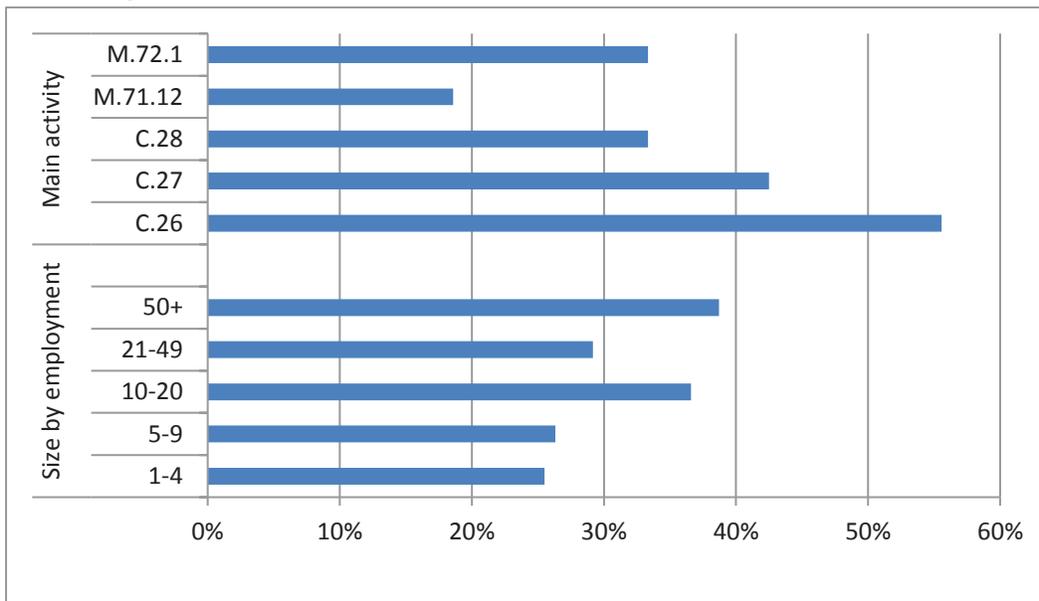
Regarding to the import of raw materials, the need for raw materials is much higher in manufacturing compared to services, so data show this trend. Again larger companies have more opportunities for import of raw materials than smaller ones.

Figure 24. Share of companies which imported raw materials in 2016 by size and main type of activity
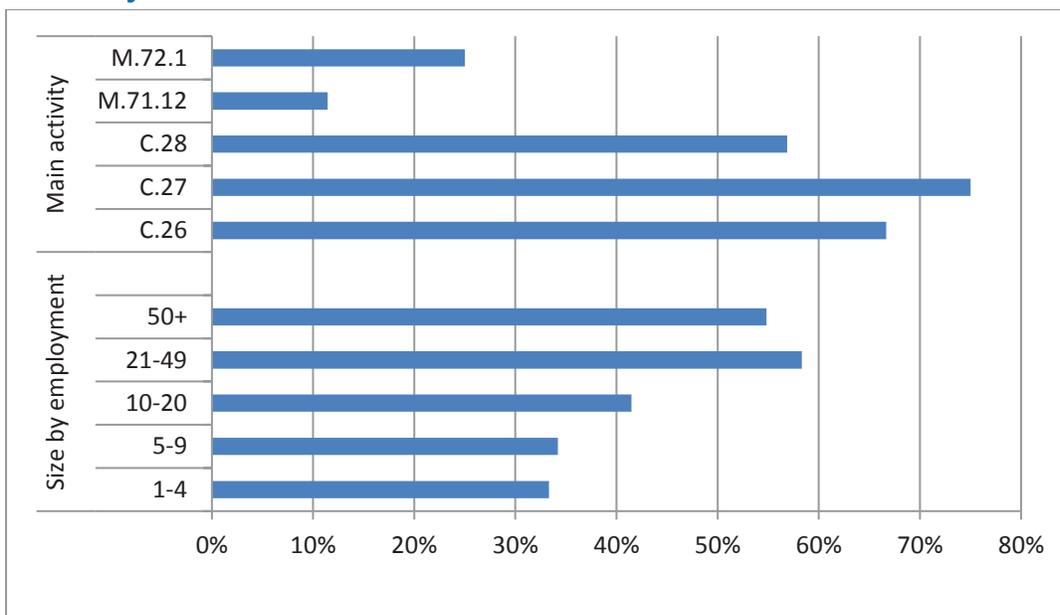
Main prerequisites for export and its growth

According to the companies, availability of foreign partners is the most important prerequisite for export growth. Other two most important prerequisites are participation in international exhibitions and product compliance with international standards.

Figure 25. The main prerequisites for export growth according to the companies in precision engineering
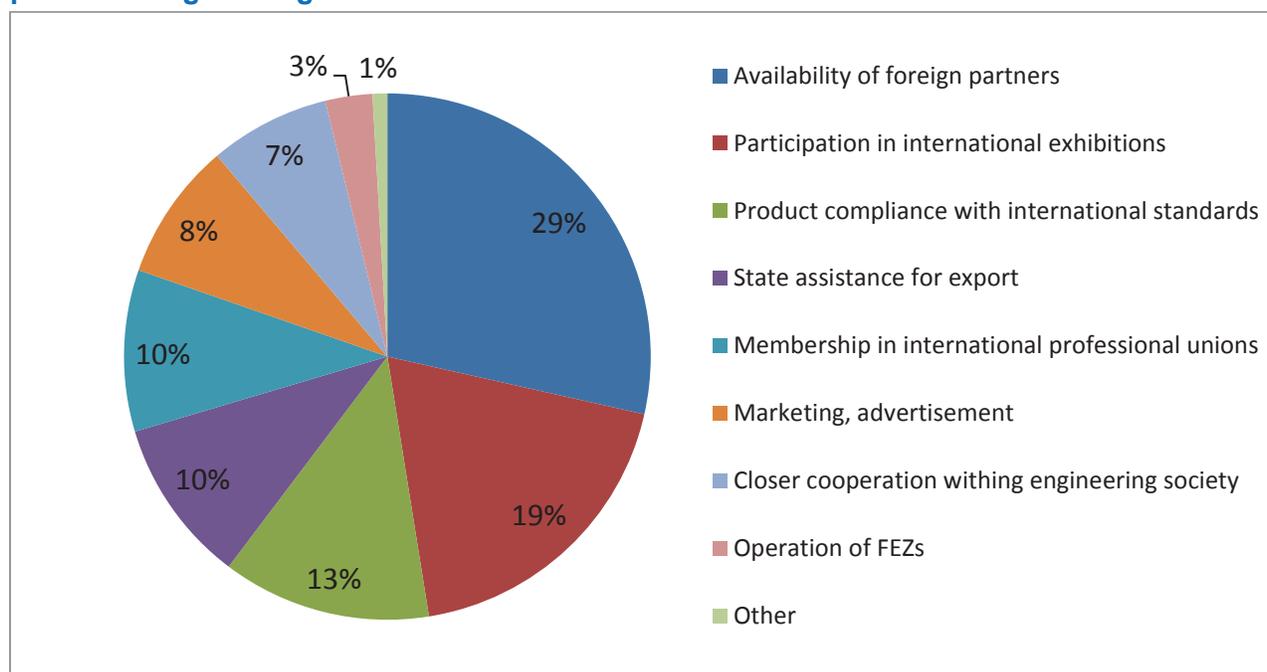
The importance of export opportunities for sector development

According to governmental bodies and industry support organizations representatives, creating export opportunities have vital importance for the precision engineering sector development in the country. Local market is very small and purchasing capacity of the population is limited; hence, all companies of the sector put efforts to identify export markets for their products. The respondents mentioned some export promotion instruments currently available for sector companies: assistance in product registration on foreign markets, co-financing for laboratory testing, interest rate subsidies, 50% co-financing for participation at exhibition on key markets, etc. At the same time, creating simplified tax and customs procedures for the companies operating in the sector is very important to allow them to concentrate more on the research of new products and production. Assistance in establishing necessary relations with companies in foreign markets is also important. Additionally, improvements in all aspects of FEZ operations (procedures, management, restrictions on the size of area per company, etc.) could be another export promotion instrument, which will allow easing the Eurasian Economic Union imposed customs procedures.

According to Technology centers and FEZ operator representatives, the export of PE products is considered as a vital factor for the growth of this sector in Armenia as the local market is very small. Hence the main focus of companies operating in this sector must be the export of specialized equipment to other countries. In order to support the export Technoparks and FEZ stated certain factors which must be considered by state. Namely, as it does for IT sector, the state can introduce special tax policies for exporting companies, which it actually does to certain extent; provide financial support to companies that are exporting their production. In addition, having representatives or production sites in foreign markets can be useful as the cost of transportation from Armenia to other countries and markets ultimately have negative impact on the unit cost hence the competitiveness of local products in foreign markets in terms of price.

Almost all the representatives of research institutions were unanimous on export importance, pointing out that the export is a priority for the sector development in RA, for most reasoning the limited local market. Yet, they were quite dissenting on the prerequisites / privileges necessary to boost it: one of the respondents spoke about tax privileges, customs' simplification, another one mentioned the need for lower transportation cost, border opening, there is also an opinion that giving privileges is a primitive step, mentioning that the foreign market representatives will find the means to export our product if it is of their interest.   Albeit, more than 50% of respondents agreed on what we should export to get the interest of foreign market - an unprecedented product, interesting, attractive and original; some at the same time also stressed the importance of low cost.

Regarding the means for increasing Armenian exports *respondents from educational institutions* had different viewpoints. Availability of high quality products for export is a need; moreover such products should be easy for transportation to resolve transportation costs issue. Other means mentioned by respondents include producing of non-energy sector products, advertising domestic products and organizing expos.

5. ACCESS TO HUMAN CAPITAL AND HR MANAGEMENT PRACTICE

When speaking with the representatives of precision engineering sector, availability of relevant specialists in the sector is mentioned as one of the main issues in the sector. This part of the report summarizes survey data related to HR resources and management issues.

Issues with finding a specialist

According to the survey results, around 32% of companies in precision engineering subsector have practice, when they could not find a specific specialist as needed. It is interesting that this issue is common for all size companies: micro, small and medium, which may mean that really these specialists are very few. Moreover the issues with finding a specialist are very similar also for Yerevan and marz situated companies, which show that it is not a regional peculiarity.

Figure 26. Share of companies which suffered with finding needed specialists
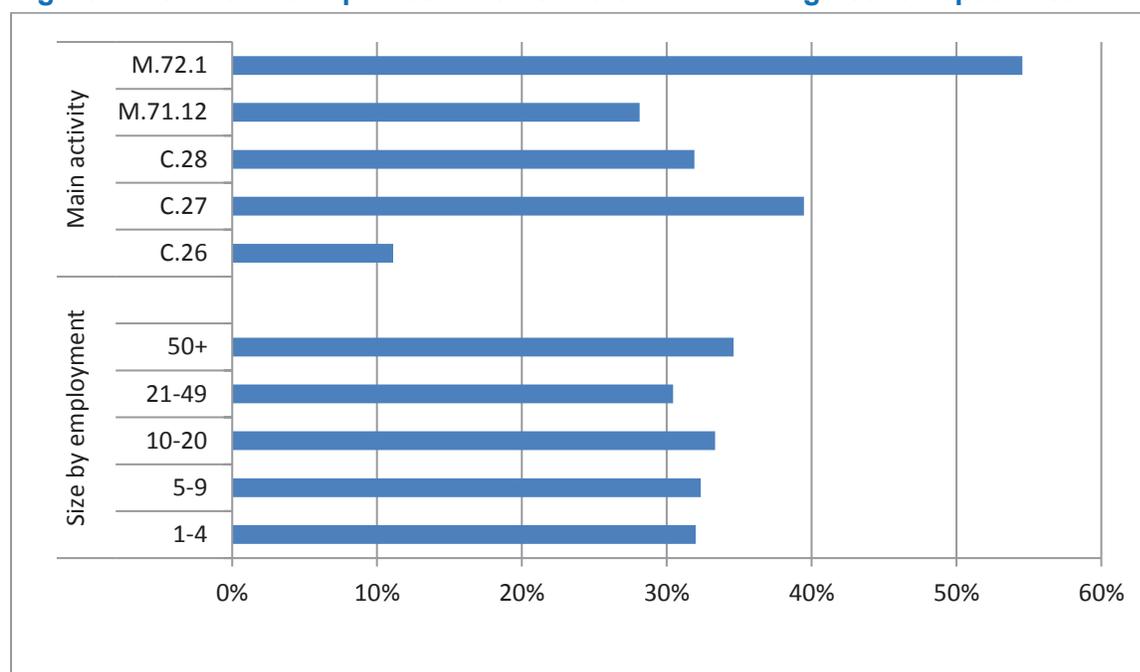
Source: Ameria Survey, 2017

It is also interesting, that companies with activity of "Manufacture of computer, electronic and optical products" have fewer problems with finding a specialist than those engaged in electrical or mechanical machinery and equipment production activities. This peculiarity can be explained by higher development of IT sector in Armenia in recent years which brings to increase of professionals in this subsector. Another reason could be the difference of wages or potential wages, in IT and mechanical production subsectors in Armenia.

It should be noted that engineering services (especially Research and experimental development on natural sciences and engineering) indicated higher need for specialists.

It is interesting that not only engineers of different specializations are missing in the market according to the companies. Particularly 23% of needed specializations that was difficult to find refer to mechanical and machinery related workers, such as locksmith, turner, miller, wrappers. One of the issues mentioned with these specialists is the absence of young age professionals in this field.

Figure 27. The structure of specializations that was difficult to find (according to the companies)
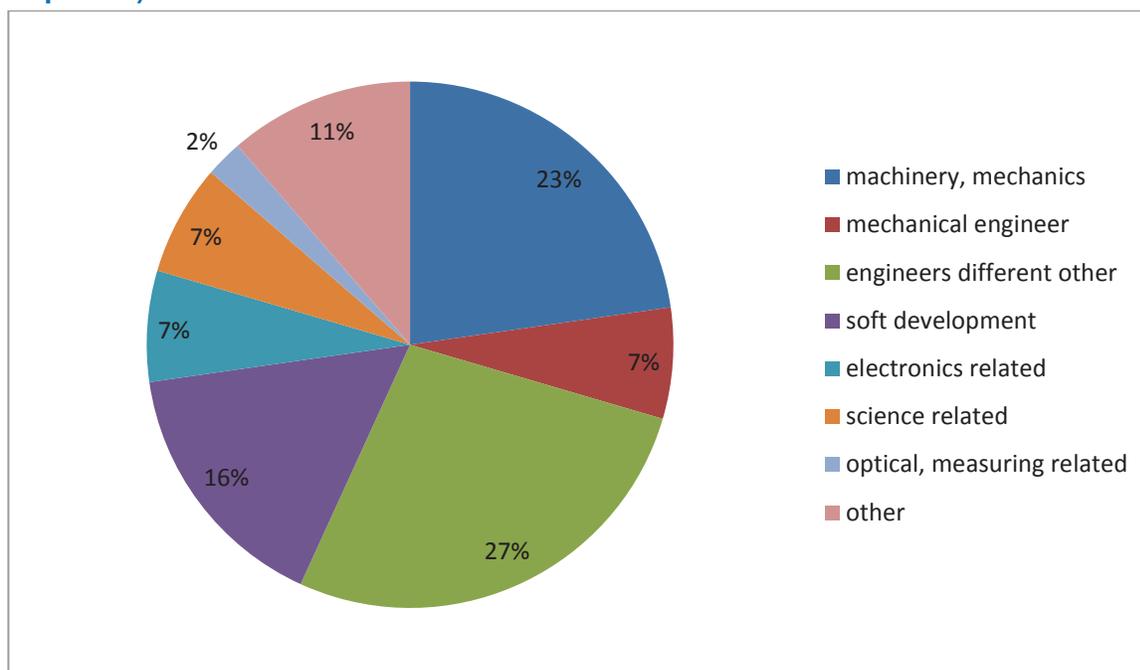
Source: Ameria Survey, 2017

Current need for specialists

According to the survey results, the need for qualified workers in machinery and mechanics is the highest currently. Prevailing majority of this type of specialists (locksmith, turner, miller, wrappers, etc.) is needed in the manufacturing of machinery and equipment (C.28), which is a mechanical subsector of precision engineering.

The need for software developers and programmers as well as mechanical engineers is mentioned by the companies in manufacturing of electrical equipment (C.27) and engineering activities and related technical consultancy (M.71.12). The companies in Research and experimental development on natural sciences and engineering (M.72.1) expressed need for science related professionals (physics, chemistry, other). It should be noted, that the companies

in manufacturing of computer, electronic and optical production did not issues with finding staff, which is perhaps an influence of well-developed IT sector in Armenia.

Table 15. Need for specialists mentioned in the survey by main type of activity (according to the companies)

Professionals/specialists	Main type of activity of company						
	Manufacturing				Services		Total
	C.26	C.27	C.28	C.32.5, other	M.71.1 2	M.72.1	
machinery, mechanics (locksmith, turner, miller, wrappers, etc)	-	4	19	1	3	-	27
soft development, programmers	-	12	-	1	7	1	21
mechanical engineers	-	9	2	1	5	-	17
engineers different other (energy sector, water sector, constructor, etc.)	-	1	4	-	7	2	14
science related (physics, chemistry, other)	-	1	1	-	3	5	10
electronics related	1	4	1	-	2	-	8
optical related	1	-	-	-	-	-	1
others	-	1	2	-	-	1	4

Source: Ameria Survey, 2017

HR operations in last year

The companies were asked about staff trainings and staff recruitment related HR operations in 2016. Particularly, 53% of the companies in the survey had used services of professional centers/persons for staff training in Armenia, 20% - use trainings organized by foreign professional centers/persons. There is a clear trend: the larger the size of the company, the higher the opportunity for staff trainings.

Regarding staff recruitment issues, only 11% of all companies have used announcements on specialized staff recruitment websites (such as careercenter.am, jobfinder.am, hr.am and others) and only 9% of all companies have applied to labor agencies to recruit staff.

Table 16. Share of companies with specific HR operation in 2016 (by size of the companies)

	Total	Size of company (employees)				
		1-4	5-9	10-20	21-49	50+
staff training in Armenia with professional centers/persons	**53%**	42%	53%	41%	**74%**	**73%**
staff training abroad with professional centers/persons	**20%**	4%	29%	8%	**43%**	**38%**
applied to labor agencies for staff recruitment issues	**9%**	2%	**15%**	10%	9%	12%
placed paid announcements on specialized staff recruiting websites	**11%**	4%	18%	10%	4%	**23%**
have special HR employees in company	**29%**	6%	21%	23%	**48%**	**81%**

Source: Ameria Survey, 2017

It is also interesting to discuss staff trainings by main types of the activities of the companies. Particularly, the companies in research and experimental development on natural sciences and engineering (M.72.1) are more active in staff trainings (both in Armenia and abroad), while companies in manufacturing of computers, electronic and optical products (C.26) are active only in trainings in Armenia. The latter can be explained by availability of professionals in IT related field in Armenia, so there is no much need to have trainings abroad.

For all HR operations, the companies in manufacturing of machinery and equipment (C.28) are most passive among PE subsectors. This may speak about lower development of this subsector and the needs to have investments in staff related activities.

Table 17. Share of companies with specific HR operation in 2016 (by main type of activity of the companies)

	Total	Main type of activity				
		C.26	C.27	C.28	M.71.12	M.72.1
staff training in Armenia with professional centers/persons	53%	78%	45%	40%	61%	82%
staff training abroad with professional centers/persons	20%	22%	18%	9%	23%	55%
applied to labor agencies for staff recruitment issues	9%	11%	5%	6%	13%	9%
placed paid announcements on specialized staff recruiting websites	11%	11%	8%	6%	16%	9%
have special HR employees in company	29%	56%	34%	19%	25%	73%

Source: Ameria Survey, 2017

Only 29% of companies have special HR employees in their staff, mainly in comparably larger companies. For those companies which do not have special HR managers in the company, the responsibilities of HR related works are taken mainly by top managers (predominantly by directors, occasionally by deputy director or other employee).

Interest in HR services

Interest to use professional services for HR is low according to the companies. The main reason, perhaps, is the need to pay for these services and most companies in Armenia (especially small ones) do not expect to receive true value for the payment and decide to do this activities with own resources (even if the quality is low).

Table 18. Level of interest in professional HR outsourcing services (according to the companies)

	Level of interest (1-not interested, 5-very interested)					
	1	2	3	4	5	Total
Payroll services	65%	20%	7%	4%	4%	100%
Organizing trainings	40%	13%	27%	14%	6%	100%
Staff recruitment	65%	21%	10%	3%	1%	100%
Preparation of vacation, hiring and termination orders	68%	21%	7%	3%	1%	100%

Assessment of Armenian market of professionals

Overall perception on availability of PE subsector related professionals in Armenia is that professionals are mostly available, but not enough. The lack of professionals is more noticeable in machinery.

Figure 28. Perception on availability of professionals by fields (according to the companies)
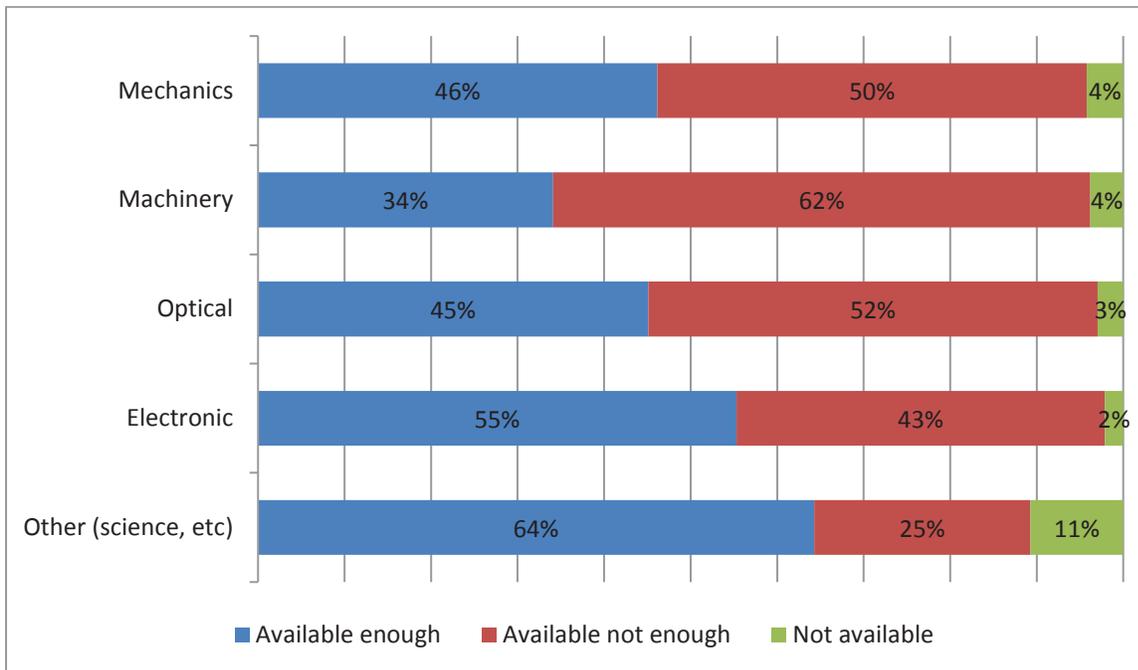
Source: Ameria Survey, 2017

Availability of specialists and professionals and vocational education opportunities (according to in-depth interviews)

Even if specialist and professionals are available in the field their number is not sufficient. There is a need for continuous trainings and specializations in narrow fields need for trainers, and changes in educational programs. Recently opened laboratories (like ANEL) are mentioned as good practice in increasing qualifications and specialization for the professionals in the field.

Representatives of governmental bodies and industry support organizations indicated that currently the availability of ANEL creates good opportunity for implementing training of the engineering staff. However, there is need to improve the available facilities and infrastructure at respective educational institutions, which will provide students the practical learning opportunity, rather than offering theoretical knowledge only. Also, the respondents indicated the need for having local trainers in more narrow engineering specializations, for which currently companies invite foreign specialists.

Research institutions' representatives have expressed different opinions on the necessity and possibility of the sector specialists' qualification improvement in Armenia. In particular, circa 40% of respondents clearly stressed the necessity and importance of qualification improvement, one of the respondents mentioned that the specialists' qualification level is sufficiently high; there was also an opinion that the need for qualification improvement should be a market cue. About 30% of respondents mentioned that the educational/training processes should be changed: specialists should master wider knowledge (project preparation, be familiar with business plan components, master foreign languages, etc.), students' knowledge evaluation methods should to be changed – students need to get knowledge and not the diploma. As means of qualification improvement, separate respondents stressed the importance of external training, others - internal and in place trainings (more efficient, requires the same financial resources yet involves more trainees).

Educational institute representatives indicated a need for increasing qualifications. Two qualification centers acting now were mentioned as good practice: Microsoft Innovation Center and National Armenian Polytechnic University. "Luys foundation" was also mentioned, but, as an unsuccessful program (according to them) because of brain drain issue. Respondents also mentioned that opportunities for increasing qualification include organizing exchange programs for students and experienced workers, by constructing new laboratories and by increasing employment opportunities.

Changes in sector students' characteristics noticed over recent years

Increase in female students in the sector and mostly growth of interest of some part of students is noticed overall according to education and research institutions representatives. The interest will grow with the development of the sector in Armenia.

Research institutions' representatives were for most positive about the recent changes in sector students' quantity, quality and interest towards PE. In particular, circa 40% of respondents stated that the number of students is quite acceptable; indeed one also mentioned that the number is increasing. About the same portion of respondents stated that the quality of students is average and high, and only one mentioned that only 30% of respondents are competent; regarding the interest, again circa 40% of respondents stressed the students' high interest towards the sector. Respondents' answers were more dissenting on gender: circa 30% mentioned that number of female students exceeds that of male student, another 30% - the opposite. There is also an opinion that the students' interest and quality towards the sector will not increase until PE is considered a trending specialization.

Majority of respondents from educational institutions mentioned that they have noticed increasing tendency of female students in entering PE industry. However, the total number of interested students remained constant, according to them. In addition, the majority of respondents consider the level of quality of students to be either unchanged or satisfactory. Only one of them thinks that

the quality level has increased, which the respondent backed up by the fact that more graduates of faculties related to PE work in according industries.

Improvement of professional education in the field

Changes in educational programs, integration of use of laboratories during educational process as well as cooperation between educational and research institutes with businesses are the ways to improve professional education in the PE sector.

Representatives of governmental bodies and industry support organizations indicated that they are ready to provide support for sector companies, in the form of developing new curricula for educational institutions, implementing training programs, providing financial and consulting support in cooperation with EU and GIZ for new product development and establishment of start-ups.

Representatives of Technoparks and FEZ emphasized that the link between the industry and universities is very loose in Armenia. Students learn theory but they don't have the opportunity to practice this knowledge in "real-life" environment. Universities do not have well-equipped laboratories without which engineering cannot develop as a profession. Universities should establish strong links with leading organizations in the industry and, for instance, organize internships for students in these organizations or involve senior managers from these organizations in the committees that check the final paper (theses) of students. This can add more objectivity in terms of the marking procedures and also can give high achieving students to get noticed by industry leaders. In addition, the topics of students' dissertations must come from the industry, from real challenges that companies face rather than being based on the preferences of universities or the resources that they have.

More than half of the _research institutions' representatives_, believe that the university – companies cooperation is the most efficient way to make the education process more effective, mentioning that cooperation will be mutually beneficial both for the educational institutions and the companies – the unity will help the universities to offer better and higher quality education and the companies to nurture the specialists they are in need of; indeed, this will also increase the students' motivation and interest towards the sector. At the same time one of the respondents, stressed the migration problem among youth resulting from social issues, pointing out that the cooperation today is actively developing yet it won't solve the youth problem. Other suggestions also include to revise the education programs, to create a science – based educational system, to integrate the science and technology in education, insure the existence of proper equipped laboratories in universities (i.e. similar to National Polytechnic University of Armenia), create a modern educational infrastructure, implement exchange programs with foreign universities, etc.

Seventy percent of _respondents from educational institutions_ agree that tightening collaboration between educational institutions and businesses will have a positive impact on developing better

specialists. That gives students an opportunity to gain practical experience, which increases their readiness to enter job market. Attracting higher qualified professors and creating research centers are other methods mentioned by respondents.

Willingness to initiate cooperation in the field, possible facilities for the companies in the sector

Research and educational institutions mainly are ready to cooperate with companies in the field by providing expert knowledge, as well as working space, and some of them even special grants for start- up businesses. Technology centers and FEZ are ready to provide working space and laboratories with special equipment as well as trainings.

To support the development of PE organizations, around 40% of the *research institutions* are ready to cooperate by providing the knowledge and expertise of their specialists. Separate respondents also suggested better pricing strategies. Some of the respondents mentioned that they are already cooperating with the sector companies, by providing the knowledge of their experienced staff, or by providing certain devices and equipment and professional advice. Meanwhile, one of the participants stated that they cannot grant any privileges as they are private enterprise.

In terms of the support, majority of interviewed educational institutions are ready to provide educational platform for developing specialists. In addition, there are ready to help in different stages of startup development: providing working space, consultancy for developing final products and also providing grants. Surprisingly, one of the respondents did not express any interest in cooperation due to lack of trust.

The support provided by *Technology centers and FEZ* to organizations in PE sector are mainly provision of space (including office space), laboratories with specialized equipment, advisory support both in engineering and in business development such as how to secure financing and various practical trainings. In addition some of them provide opportunities for prototype development and testing.

6. INVESTMENT, INNOVATION AND R&D ACTIVITY IN THE SECTOR

Along with perception on lack of professionals in the field, low competitiveness of the sector in Armenia is also frequently mentioned by the experts in precision engineering. Innovations by the companies may increase competitiveness of these companies in the international markets which will increase competitiveness of the sector itself.

The perception of innovations is usually very different and subjective. Anyway one of the questions in the survey was aimed to understand level of new innovations developed by the companies, even with their understanding.

Availability of innovation related activity in company

Around 72% of the companies in the survey reported about innovation activity in their company. The companies were also asked to provide some details on the type of innovations they produce.

So, 65% of all companies in the sector reported about development of new products and services, 61% - improvement of existing goods and services and 38% - Improvement of used technologies/equipment. The level of innovation is comparably higher at medium and large size companies, which seems logical.
Comparing types of activities of the companies in precision engineering sector with the share of innovative companies, it is obvious that Manufacturing of machinery and equipment lacks innovation activities, which can also explain their development and potential compared to other manufacturing subsectors.

Table 19. Share of companies with specific type of innovation activity (% to all companies in specific type of activity)

	C.26	C.27	C.28	M.71.12	M.72.1	Total
New goods/services	**89%**	79%	55%	63%	73%	**65%**
Improvement of existing goods and services	56%	**87%**	53%	52%	82%	**61%**
Improvement of used technologies/equipment	44%	**53%**	38%	28%	36%	**38%**

Source: Ameria Survey, 2017

According to the companies in the survey, 29% of PE companies have employees dedicated for innovation activities. Again, the least share among subsectors is in Manufacturing of machinery and equipment, where only 23% of companies have such employees.

It was difficult to understand the size of the budget of the companies dedicated for innovation activities. Particularly around 70% of companies could not provide any data, due to different

reasons, such as "no separate budget for innovation", "almost all budget is going for innovations", "hard to say".

Availability and size of investments in companies

One of the main reasons of low competitiveness and low level of innovations in the sector is explained by low level of investments and difficulties with access to finance.

Among the companies in the survey, 66% had investments in 2014, 73%-in 2015 and 79% in 2016. This data show that comparably more companies have made investments in last year than 2-3 years ago. But, when looking at the average size of investments, the picture is not as optimistic as with share of companies with investments.

Average size of investments per one company under the survey (among those who had investment in last 3 years) is 13.8 mln AMD, which is by 31% less than in 2015 and by 14% less than in 2014. This decrease can be explained by regional economic developments, such as recession in Russia and decrease of GDP growth in Armenia.

Table 20. Share of companies with any investment and average size of investment in 2014-2016

		Share of companies with any investment (%)			Average size of investment (mln. AMD)		
		2014	2015	2016	2014	2015	2016
Number of employee groups	1-4	66%	70%	80%	7.2	11.7	8.5
	5-9	58%	68%	76%	1.8	2.7	3.6
	10-20	64%	72%	77%	8.4	9.5	12.9
	21-49	69%	79%	83%	16.1	26.0	19.5
	50+	81%	81%	81%	60.1	66.6	33.8
Main type of activity groups	C.26	33%	57%	78%	163.3	179.6	69.4
	C.27	68%	85%	89%	17.9	20.9	21.1
	C.28	62%	61%	65%	4.9	7.7	5.5
	M.71.12	69%	75%	80%	10.6	13.1	9.4
	M.72.1	78%	78%	100%	10.4	14.4	12.4
Total-average		66%	73%	79%	16.0	20.1	13.8

Source: Ameria Survey, 2017

The average size of investments correlates with the level of development and growth potential of the companies. The companies in manufacturing of computers, electronic and optical products had 7-10 times higher average investments than the companies in other subsectors of precision engineering. Moreover, the smallest average investments are registered for companies in

manufacturing of machinery and equipment. It is also logical that medium size companies had higher average size of investment than micro and small ones.

Type of investment in 2016

The structure of investments in 2016 is very similar in the precision engineering subsector. Around 90% of all investments are dedicated to the acquisition of technologies and equipment. Anyway, taking into account total size of investments, this is not enough to increase competitiveness of the companies in most of the subsectors.

Table 21. The structure of investments in PE companies in 2016, by main type of activity

	Main type of activity					
	C.26	**C.27**	**C.28**	**M.71.1 2**	**M.72.1**	**Total**
Acquisition/capital renovation of buildings	8%	0%	11%	11%	1%	**6%**
Acquisition of technology and equipment	84%	98%	88%	83%	91%	**89%**
Acquisition of transport means	8%	2%	0%	5%	0%	**4%**
Other investment	0%	0%	1%	2%	8%	**1%**

Source: Ameria Survey, 2017

7. ACCESS TO FINANCE

The sources of investment

3/4th of all investments in the companies were financed from the profit of the companies. The second largest source is own resources/savings of the owners of the companies (14%). It is interesting that financing though bank loans/leasing has only 4% share, which is very low.

Low financing through bank loans may be one of the barriers for large technological investments, which may support increasing competitiveness of the sector.

Figure 29. The structure of financing sources for investment in the companies
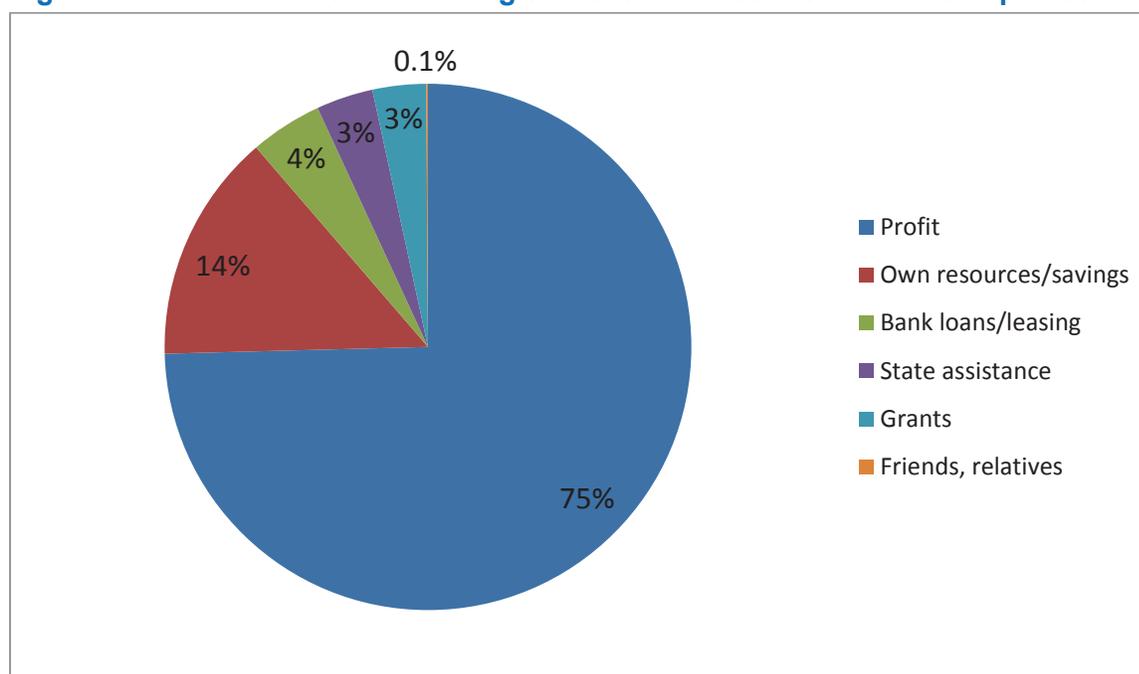
Source: Ameria Survey, 2017

Medium and large companies have comparably significant share of state assistance and grants as a source for financing investments. These are mostly due to the companies providing services in Research and experimental development on natural sciences and engineering (M.72.1), such as Institutes under RA Academy of science, founded by the Government.

Table 22. The structure of financing sources for investment in the companies, by size of the company

	Size by employees					Total
	1-4	5-9	10-20	21-49	50+	
Profit	70%	71%	87%	85%	61%	**75%**
Own resources/savings	20%	22%	10%	4%	10%	**14%**
Bank loans/leasing	7%	4%	3%	1%	6%	**4%**
State assistance	0%	0%	0%	10%	12%	**3%**
Grants	2%	4%	0%	0%	11%	**3%**
Friends, relatives	0%	0.4%	0%	0%	0.2%	**0.1%**

Source: Ameria Survey, 2017

Table 23. The structure of financing sources for investment in the companies, by main type of activity

	Main type of activity					Total
	C.26	C.27	C.28	M.71.12	M.72.1	
Profit	63%	88%	76%	75%	38%	**75%**
Own resources/savings	37%	5%	13%	20%	2%	**14%**
Bank loans/leasing	0%	5%	10%	2%	0%	**4%**
State assistance	0%	0%	0%	2%	33%	**3%**
Grants	0%	3%	0%	1%	26%	**3%**
Friends, relatives	0%	0%	0.3%	0%	0.4%	**0.1%**

Source: Ameria Survey, 2017

Applications for loans in last year and their success

To understand the reasons for low share of bank loan in financing of investment, let's look at other data. Particularly, the share of companies which applied for a loan during last year is around 13%. Mainly these are the companies engaged in manufacturing activities in precision engineering sector. There is a clear correlation with the size of the company: the larger the company the higher is the share of those which applied for a loan.

Figure 30. Share of companies which applied for a loan to a financial company in 2016
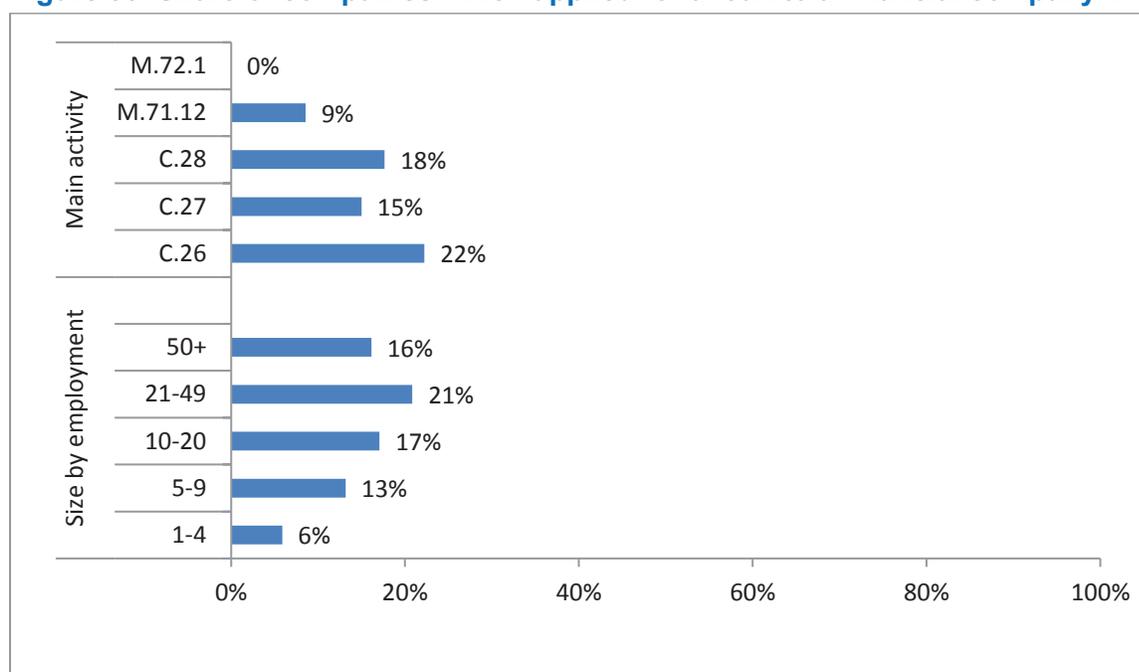
Source: Ameria Survey, 2017

Comparably fewer companies with activities in PE services apply for a loan which may have several reasons. First one is usually the companies providing services (especially if these services are exported) have less opportunity to get a loan from a bank than those which are engaged in manufacturing due to different reasons, such as need for collateral, proves on continuous profits and etc. Another reason could be that these companies work through grants and tenders and do not need any additional financing from the banks.

There were only 2 companies out of 25 which applied for a loan during 2016 and did not succeed to get a loan. So the issue is more related to the companies' plans, than to refusals of banks to provide loans.

According to the data from the Central bank of Armenia, overall level of loans provided by commercial banks to Manufacturing of computers, electronic and optical products (C.26) and Manufacturing of electrical equipment (C.27) comprised only 3,308 thousand USD as of January 2017. There were no loans to companies in manufacturing of machinery and equipment according to the CBA data. The level of loans to engineering related services in precision engineering is difficult to separate from whole sector of Architecture and engineering activities and scientific research, but it is estimated under 3 mln USD.

The majority of the companies in the survey have plans for new and expanding projects in 2017-2019: 72% will have projects and another 24% - "maybe".

Figure 31. Expectations on new projects and development plans in 2017-2019 (according to the companies)
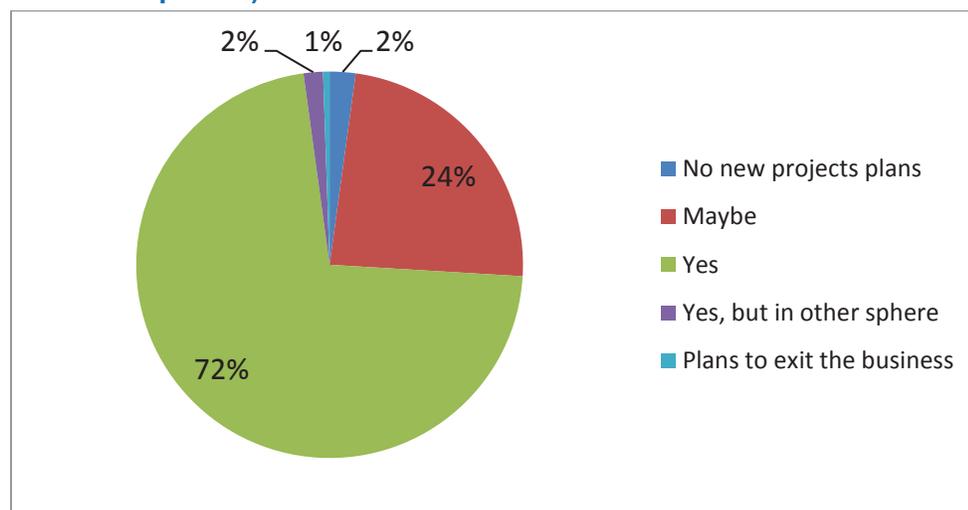
Only 2% of companies informed that they do not have any plans for new or expanding projects in 2017-2019. Mainly these are the companies in service activities, such as state-financed institutions. Interesting also, that several companies engaged in activities of electric equipment production (C.27) and machinery and equipment production (C.28) have plans for development in other spheres, which may speak about difficulties in these types of activities in Armenia.

Table 24. Expectations on new projects and development plans in 2017-2019, by main type of economic activity (according to the companies)

	Main type of activity				
	C.26	C.27	C.28	M.71.12	M.72.1
Yes	44%	70%	73%	77%	67%
Maybe	56%	25%	24%	20%	17%
Yes, but in other sphere	0%	3%	4%	0%	0%
No new projects planed	0%	3%	0%	1%	17%
Plans for business exit	0%	0%	0%	1%	0%
	100%	100%	100%	100%	100%

Source: Ameria Survey, 2017

The structure of financing new and expanding project in 2017-2019 is very similar to the structure of financing investments in the companies. The only noticeable difference is that the share of own

resources/ savings is lower here (8% vs 14%), instead 10% of new project financing is planned by grants, client advance payments and other cooperation initiatives.

Figure 32. The structure of financing sources for investment in the companies
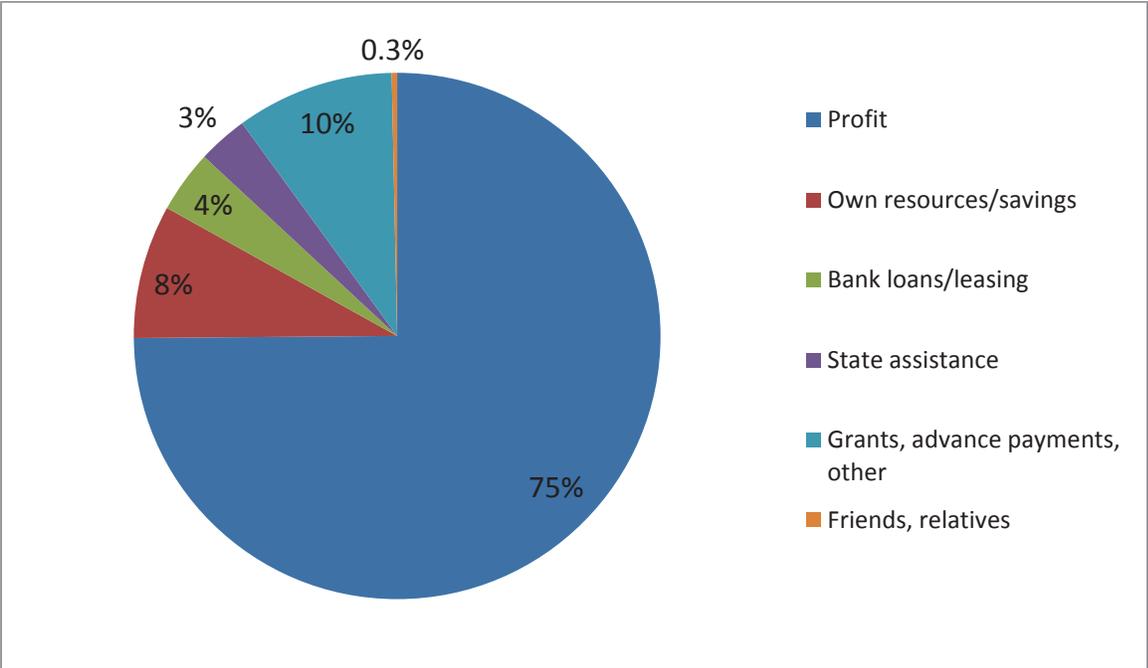
Source: Ameria Survey, 2017

8. CHALLENGES AND NEEDS OF THE SECTOR

Challenges and barriers for sector development and prerequisites for PE sector growth in Armenia

Representatives of *government bodies and industry support organizations* indicated several main problems for the development of the sector during the in-depth interviews. Among them one of the most important ones is absence of general infrastructure to be provided by the state to private companies. In this regard, they mentioned that the initiative to establish engineering city in Jrvezh could be the first, and hopefully not the last example of providing such support. Another key problem is educational programs and methods currently utilized by the leading universities in Armenia, which need substantial revision in order to become adequate to the current trends and requirements of the sector.

At the same time, along with the curricula, the technical infrastructure at the universities should be upgraded, since it is not possible to learn basics of precision engineering without having the opportunity to conduct extensive research and practical work. However, this requires substantial investments, which private companies and educational institutions cannot bear. Hence, state support is required in this field as well, since the created infrastructure requires continuous modernization due to specifics of the sector.

Next obstacle is not sufficient state support provided at free economic zone, which, according to the respondents, is main reason for companies, registered in FEZ, not succeeding in their operations. Particularly, the customs procedures currently in force at FEZ does not stimulate effective exporting of semi-finished or final products, as well as creating problems during import of vitally needed prototypes and raw materials. Those procedures create unnecessary delays in supply of materials, for which even hours could be decisive. As a result, the competitiveness of the Armenian produce becomes less.

Additionally, among the barriers for the development of the sector, mentioned by the in-depth interview participants, are:

- not sufficient funding for technological research resulted in shortage of new technologies,
- relative shortage of information about the global trends,
- limited number of international companies on the local market,
- gradual shortage of professional workforce,
- not adequate system of state support and incentives, including tax and customs,
- logistical restrictions during exporting.

As challenges for the development of the sector, *government bodies and industry support organizations* mentioned high level of investments required for the implementation of Greenfield projects or expanding the operations of the existing companies in the sector. Another field

requiring attention, in their opinion, is not strong PR implemented to attract and motivate youths to be more engaged in the sector. In this regard, they propose to include engineering education in the curricula of secondary schools, since it will allow familiarizing new generations with the opportunities, provided by the sector, and creating additional motivation for them to choose the sector for their future professional development.

Representatives of *technology centers and FEZ* pointed the following key problems in the sector: small domestic market, absence of legislation in this sphere, lack of new specialists and information and innovational equipment. Most of the companies in the subsector begin their activity in Armenia with small market sales, further they begin operating in international markets to increase sales. The lack of modern specialists and machinery and equipment impacts their competitiveness in the international markets. The EAEU legislation also makes barriers for exports. There are problems with VAT and interstate relations which decrease the FEZ activity. Free Economic Zone is new to Armenia and isn't formed completely, but there can be several prerequisites for reclamation in this sphere. Integration of new investors is one of the main objectives.

According to in-depth interviews with *representatives of research institutions*, the main obstacle for PE sector's development in Armenia is the limited number of professionals and the migration among especially young professionals (resulted from social issues existing in the country). Around 30-40% of respondents stressed the barriers related with the educational environment – not sufficiently enough developed (traditional education, the shortage of new technologies' usage in educational sector, etc.); the limited financial resources - needed to finance' the sector specialists' international trainings, to create multifunctional laboratories, etc.; tax legislation (need for tax privileges). Other factors include infrastructure, outdated technologies, insufficient level of confidence towards the sector, prior to the government's decision to recognize it as a priority sector, the regional blockage, isolation in terms of transport, disproportionate distribution of resources among IT and PE sectors (IT requires less resources, yet PE insures more valuable results for economy), mentality and organizational factors.

According to in-depth interviews with *representatives of educational institutions*, PE industry development barriers include lack of financial resources, no sophisticated demand from Armenian economy in PE market and no well-managed governmental policy. One of the respondents recalled the collapse of Soviet Union, after which a number of factories were destroyed causing considerable damages to PE industry. However, the most significant obstacle, as was mentioned by sixty percent of respondents and is partly caused by other barriers, is brain drain of PE industry specialists.

Prerequisites of PE sector development

It is interesting that availability of skilled and comparably low cost of professionals is mentioned as an advantage for Armenian PE sector (which is mainly based on traditions of engineering sector in Soviet times and availability of specialists with engineering education). Anyway, there is a need for raising interest of students in precision engineering; otherwise this advantage will be lost soon.

Representatives of *government bodies and industry support organizations* indicated several factors for the development of the precision engineering sector –mainly as opportunity to have skilled and low cost professionals. Particularly, there are people, who are able to quickly and easily learn new professions, and become highly skilled professionals, able to solve difficult technical problems, applicable for multi-sectors. Second is competitive labor cost, which is less than in other countries possessing comparably skilled workforce. Another advantage of the sector, according to respondents, is availability of skilled engineers and trainers, inherited from soviet times, who are still available in the market.

Representatives of *technology centers and FEZ* also mentioned the availability of specialists possessing high specific skills and knowledge as prerequisite for development of PE. There are experienced specialists who can carry the tasks. But most of the specialists in RA have old knowledge which isn't competitive in modern world. As responder from EPIC underlines "Most of the students are interested in business education and skip engineering. There is modern equipment in AUA but no much interest among students to use that". He thinks social changes should be carried on to increase the interest of Precision Engineering among the sociality. New operations should be done for forming high skilled and educated specialists such as cooperation with international famous universities in PE sphere.

The *research institutions representatives* have quite dissenting opinions on the main factors currently promoting the PE sector development in Armenia. Some 30% believe that the high scientific potential and high quality professionals are the main factors promoting the sector; one of them also mentioned the international well known companies' representatives acting in RA. Nevertheless, the respondents for most stressed not the existing, but the desired factors the existence of which, they believe, will boost the PE sector development in the country: some 20% stressed the importance of quality educational institutions and sector-specialists; separate respondents also underlined the importance of introducing Armenia to the world as a PE country (actively conducting investment activities in the sector, boosting start–up (easier and faster start-up establishment processes)), government support, the construction of new neighborhoods, new momentum in Country's construction industry, development of IT, high quality marketing, research specialists, etc.

Lack of enough infrastructures is still hindering development of PE sector in Armenia, while establishment of technology centers and laboratories is a positive development.

According to *government bodies and industry support organizations*, the infrastructure available in the country is not sufficient for the development of precision engineering sector. While the Gyumri and Vanadzor technology centers, ANEL, EPIC and EIF are creating highly demanded infrastructure, however there is still need for more facilities, providing equipment and working areas. In this regard, establishment of Jrvezh engineering city is step in the right direction, which should be supplemented by new technoparks and technocities.

The representatives of *technology centers and FEZ* also indicated lack of infrastructure in the sector. While several institutions are in place such as Gyumri and Vanadzor technology centers, where equipment is available for specialists, but because of lack of awareness and social interest they don't work productively yet. Technologic centers such as ANEL laboratory develop the PE sphere. EPIC center representative appreciated the UITE project activity related to forming small laboratories for pupils in schools to increase the interest towards PE.

Speaking about the infrastructure, *the research institutions' representatives* mostly (more than 50%) believe that there is not sufficiently enough developed infrastructure in Armenia for PE, even if some infrastructure is developed, yet with different reasons (incomplete and outdated, not satisfactory for all areas, only the first steps are taken) still needs improvement. At, the same time, one of the respondents believe, that, the infrastructure is never sufficiently developed, at the same time pointing out, that as of now we have quite well developed infrastructure composites, yet all of them work separately for their own and there is need for cooperation rather than further development. Nevertheless, important to mention, that the respondents have dissenting opinions on infrastructure composites, in other words, one of the respondents considers that infrastructure is first of all the legislative framework, another one - the knowledge.

Forty percent of respondents form educational institutions in consider that Armenian economy possess enough infrastructure for development of PE industry. On contrast, thirty percent has an opposing opinion. Also, it is worth mentioning that another thirty percent of respondents had no opinion regarding the level of infrastructure. However, what connects all respondents is that they all think that there is a need of more investments in the infrastructure.

According to the companies, the most effective ways of assistance are mainly related to sales, marketing, cooperation development and export related assistance. It is interesting that 57% of mentioned assistance is related to access to external markets.

The companies give less importance to access to finance and international certification of production, which primarily can help them to access external markets. It is a bit strange that companies care more about the quality of their production and implementation of new technologies, than sales.

Figure 33. The structure of most effective types of assistance to the companies in next 3 years (based on 3 most effective tools mentioned by each company)
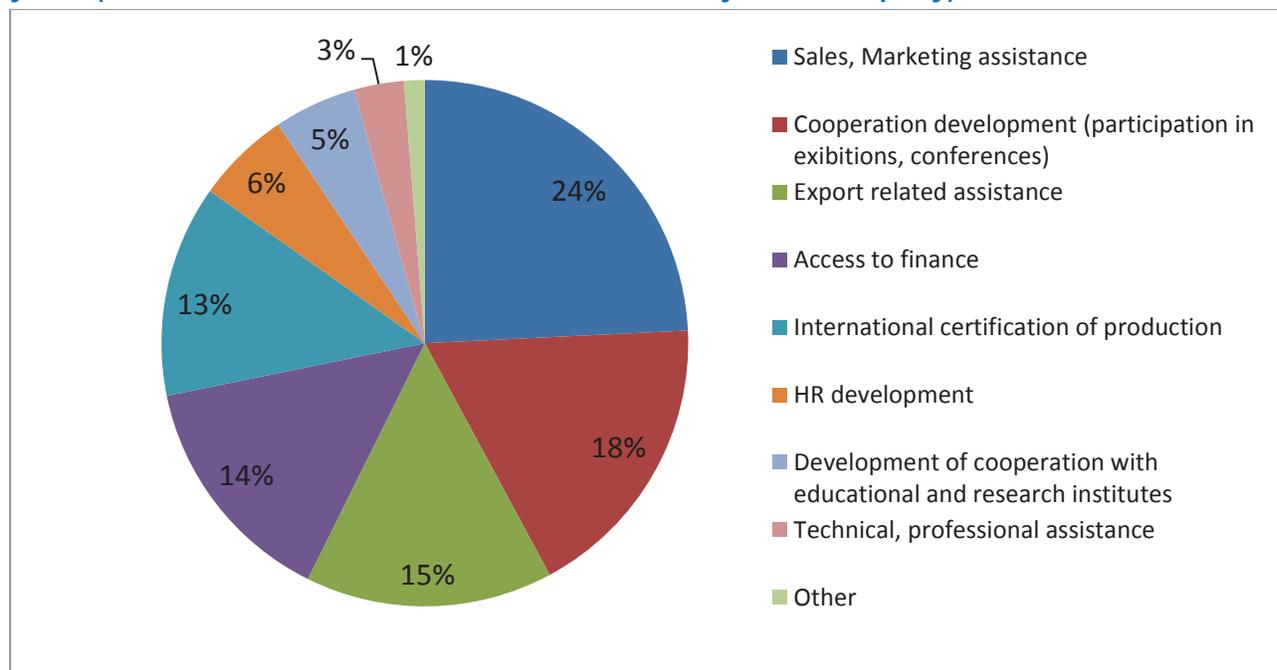
Source: Ameria Survey, 2017

The understanding of most effective assistance is different by subsectors also. Particularly, the companies in manufacturing of computers electronic and optical products give more importance to assistance for export, while other subsectors of manufacturing value more assistance for sales and marketing. Taking into account other information on the level of development of these sectors, we can state that most companies which value sales and marketing related assistance, perhaps, have issues with the quality of production and use of new technology, which is the main problem of low sales. It is strange that certification of products, access to finance, technical assistance have much lower importance for most of the companies in the field.

The companies in manufacturing of computers, electronic and optical products also value assistance in development of cooperation with educational and research assistance.

Overall level of importance for assistance related to HR development is low among the companies in the sector. This does not necessarily mean that the companies are satisfied with their HR development, but there are other spheres which are more important, according to the companies in the sector.

Table 25. The structure of most effective types of assistance to the companies in next 3 years by main types of activity (based on 3 most effective tools mentioned by each company)

Types of assistance	Manufacturing			Services	
	C.26	C.27	C.28	M.71.12	M.72.1
Sales, Marketing related assistance	15%	26%	27%	24%	11%
Cooperation development (participation in exhibitions, conferences)	15%	14%	14%	21%	26%
Assistance for export	19%	22%	16%	11%	11%
Access to finance	11%	13%	16%	14%	14%
International certification of production	11%	11%	16%	13%	11%
HR development	7%	5%	5%	7%	3%
Development of cooperation with educational and research institutes	19%	3%	2%	5%	17%
Technical, professional assistance	0%	5%	2%	3%	3%
Other	4%	3%	1%	0%	3%

Source: Ameria Survey, 2017

As a conclusion, sales marketing related assistance can be productive only if there are internationally certified products, produced with modern technologies, otherwise these efforts may not be productive.

9. MAIN FINDINGS AND CONCLUSIONS

Government policy, strategy

- Industry support organizations (including government, research and education institutions) have positive expectations on PE development in Armenia.
- Overall awareness on Government's declaration of precision engineering as a priority industry for the Armenian economy is high among the key representatives of different support organizations in Precision engineering sector. Anyway the awareness on the details of strategy and action plan is not so high.
- There is need for substantial revision and adoption of new sector development strategies and action plans, considering recent changes in economic policy and slowdown of economic growth in, as well as the fact that the industry actual performance indicators are already behind those expected to be achieved by the approved strategies.
- Several subsectors of the precision engineering industry – production of electrical machines, electronic and optical equipment - are considered as a priority for the development in EAEU.
- "Main directions of industrial cooperation within the Eurasian Economic Union" (adopted on 8 September 2015 by the decision N9 of the Eurasian Intergovernmental Council) assumes establishment of the Eurasian Engineering Center (location yet to be determined) and competence centers for the implementation of joint research projects and development of innovation infrastructure.
- The role of government in development of PE sector is very important according to all participants in the sector.
- The role of international organizations in providing technical assistance on international best practice and expertise is also very important.

Identification of sector and companies

- Definition of Precision engineering sector is complicated task. The sector is not fully and precisely defined in any international or national classifications. Economic activity classification (NACE) gives just some understanding in which types of activities PE companies may be engaged, but there is a need to identify companies in activity subsectors based on more detailed information on their production.
- It is noticed that IT industry is frequently mixed and included in Precision engineering in Armenia. Even if these sectors may be very close, they should not be mixed. Perhaps, this comes from inclusion of service activities related to engineering to Precision engineering sector defined in strategic paper in Armenia, which is not a case in international definition of PE. Service activities should be treated as supporting to PE, which is a manufacturing activity predominantly.

Sector economic activity

- Real volume of total production in PE manufacturing sector increased by 28.3% in 2016 compared to 2015, after slow growth or even decrease in previous 3 years.
- In medium term period: electronic and optical engineering subsector is growing; Electrical equipment's subsector is stable, while mechanical engineering subsector has declined over the last 4 years.
- Majority of PE companies expects moderate growth of the subsector in Armenia during the next 3 year period.
- Prevailing majority of companies engaged in PE manufacturing subsectors are SMEs, with over the half of companies are micro-sized.
- Although 1/2rd of companies in subsectors are micro-sized companies they produce only around 20% of total production.
- The largest subsector in PE manufacturing according to the number of companies is manufacturing of electrical equipment. The volume of production in manufacturing of computer, electronic and optical products is close to manufacturing of electrical equipment. The subsector of manufacturing of machinery and equipment (mechanical PE) is behind by all indicators: number of companies, production volumes and development trends and employment. The largest employment is registered in manufacturing of computer, electronic and optical products.
- Total employment in PE manufacturing subsectors is above 3 thousand according to official statistics.
- The following trends are noticeable when comparing the employment in 2016 to 2015: (i) decline in employment of micro-sized and small companies, increase in employment of medium size companies, (ii) large decline in employment of the companies which have indicated Manufacture of machinery and equipment as their main activity, while in most of other PE subsectors slow growth of employment is visible.
- Trends in employment during 2015-2016 show that small companies struggle more with the development than comparably larger ones and Mechanical/Machinery precision engineering subsector is declining in Armenia.
- Share of women in the employment of PE sectors comprised 30% (both in 2015 and 2016). Women are more engaged in PE service industries (35% of employees are women) than in PE manufacturing industries (25%).
- According to survey companies 2/3rd of sales in 2016 were realized in domestic market, with 1/3rd of sales – directly exported.
- The influence of such factors as: "Tax administration", "Tax rates" and "Lack of professionals" on business activity are not assessed as negative by the PE companies in the survey. "Small size of domestic market" is assessed to have the highest negative influence of business activity of the companies in the sector.
- Improvements in education system, favorable investment climate, state support for start-ups, and investment in technologies can improve competitiveness of Armenian PE companies.

External activity

- The share of direct exports in total sales of PE manufacturing companies is around 22% (official statistics estimate). Large decrease is noticed compared to previous years (42% in 2013). Total export of production (including those exported by trade companies or distributors) is much higher- at 30-40% according to estimates.
- The share of companies with export activities is growing with the size of the company.
- The share of direct exports is much higher in electronic and optical products (~38% in 2016), compared to other PE subsectors (14-16% in 2016).
- 60-70% of total direct exports goes to CIS market (mainly Russia).
- Overall export volume of defined product lines from Armenia (according to customs statistics) comprised 54 mln USD in 2016, while the peak of export in post-crisis period was in 2012 – 60.8 mln USD.
- Overall trends noticed in 2010-2016 are: (i) export of clock and watches is growing with high rate, (ii) export of optical, controlling and measuring instruments group is growing moderately, (iii) export of product of mechanical production was growing with high rate until sharp decline in 2013 and moderate decrease thereafter, (iv) export of electrical production was growing moderately until sharp decline in 2013-2015, while 2016 again showed growth.
- Export is very concentrated to countries: over the half of export of mechanical and electrical production went to Russia during recent years. Clock and watches products predominantly are exported to Switzerland, while optical and measuring products have comparably less concentrated by countries.
- Export market diversification will allow to increase the volume of exports and to avoid fluctuations of exports over short period of time.
- Prevailing majority of companies organize their export through own resources without using any domestic or foreign distributor – 87% of total export of companies in the survey was done by own resources.
- Availability of foreign partners is considered as the most important prerequisite for export growth. Other two most important prerequisites are: participation in international exhibitions and product compliance with international standards.

Human capital

- According to the survey results, around 32% of companies in precision engineering subsector have practice, when they could not find a specific specialist as needed.
- 23% of needed specializations that was difficult to find refer to mechanical and machinery related workers, such as locksmith, turner, miller, wrappers.
- 53% of the companies in the survey had used services of professional centers/persons for staff training in Armenia, 20% - use trainings organized by foreign professional

centers/persons. The larger the size of the company, the higher the opportunity for staff trainings.

- Only 29% of companies have special HR employees in their staff, mainly in comparably larger companies. Interest to use professional services for HR is low according to the companies in the survey. These may somehow explain difficulties in finding specialists.
- Overall perception on availability of PE subsector related professionals in Armenia is that professionals are mostly available, but not enough. The lack of professionals is more noticeable in machinery.
- There is a need for continuous trainings and specializations in narrow fields of PE, need for trainers, and changes in educational programs. Recently opened laboratories (like ANEL) are mentioned as good practice in increasing qualifications and specialization for the professionals in the field.
- Changes in educational programs, integration of use of laboratories during educational process as well as cooperation between educational and research institutes with businesses are the ways to improve professional education in the PE sector.

Investment, innovations

- Around 72% of the companies in the survey report about innovation activity in their company. 29% of PE companies have employees dedicated for innovation activities.
- 65% of all companies in the sector reported about development of new products and services, 61% - improvement of existing goods and services and 38% - Improvement of used technologies/equipment. The level of innovation is comparably higher at medium and large size companies.
- 66% of companies had investments in 2014, 73%-in 2015 and 79% in 2016. While the share of companies with investment grew during recent years, the average size of investments declined.
- The average size of investments correlates with the level of development and growth potential of the companies. The companies in manufacturing of computers, electronic and optical products had 7-10 times higher average investments than the companies in other subsectors of precision engineering.
- Around 90% of all investments are dedicated to the acquisition of technologies and equipment.

Access to Finance

- 3/4th of all investments in the companies were financed from the profit of the companies and 14%- from own resources/savings of the owners. Financing though bank loans/leasing has only 4% share.
- The share of companies which applied for a loan during last year is around 13%. Mainly these are the companies engaged in manufacturing activities in precision engineering sector.

- Only 8% of companies which applied for a loan during 2016 and did not succeed to get a loan.
- The majority of the companies in the survey have plans for new and expanding projects in 2017-2019: 72% will have projects and another 24% - "maybe". Only 4% of new and expanding projects is planned to be financed by bank loan.

Main challenges of the sector

1. Small internal market and unfavorable geopolitical location of the country.
2. Low level of exporting activities, difficulties to access external markets. Transportation issues especially for large size products.
3. Shortage of general infrastructure for further development of the sector.
4. Access to finance. Not sufficient investments in new technologies and equipment in the sector companies.
5. Need for young professionals in the sector. Taking into account strong traditional development of precision engineering related fields in Armenia (especially in Soviet era) there are qualified specialists, but not sufficient for the development of the sector (as their number is decreasing) and there is a need for qualified young specialists for further development of the sector.
6. Educational programs and methods currently utilized by leading educational institutions in Armenia need substantial revision in order to become adequate to the current trends and requirements of the sector.
7. Lack or absence of cooperation between the companies in the sector as well as between companies and science/research/educational institutions.
8. Need for strong industry union for PE sector companies.

10. RECOMMENDATIONS

1. **PE definition** - Exact identification of precision engineering sector is needed. Currently precision engineering is frequently mixed with IT sector. Definition of the sector should be linked to product types rather than to types of activities. Awareness on precision engineering activity should be raised among all participants in the sector. The sector should not be mixed with IT and other support service activities.

2. **Strategy and Action plan for Precision engineering** should be updated taking into account economic development changes (EAEU) and current developments in the sector. The strategy should have concrete and understandable goals and should focus on particular types of precision engineering aiming to ensure development of the sector in Armenia in line with global technological and innovative developments. Particularly, the strategy should clearly present the direction of the development of Armenian Precision engineering: for instance, support to current international value chains or development of new innovative niche for Armenia. The documents should be discussed with representatives of main companies in the sector, industry support organizations, and education and research institutions in order to be aware of opportunities and goals declared in the document.

3. There is a need to establish **strong sector union** (currently there are several unions in IT, ICT, but usually they are more focused on IT issues) dedicated to representing interests of the sector and uniting efforts to solve existing issues in precision engineering, which SMEs can hardly take care of on their own. Particularly the union could:

   a. Initiate cooperation of the sector with educational and scientific-research institutions,
   b. Initiate cooperation with international PE sector unions and large companies,
   c. Coordinate efforts of the government in PE sector and discuss current needs of the sector,
   d. Undertake export market research for products developed and manufactured in Armenia,
   e. Support organizations in exhibiting at professionals exhibitions in key target markets,
   f. Organize and/or support trainings for the professionals in the sector.

4. **Export related assistance** - assistance in product registration on foreign markets, co-financing for laboratory testing, interest rate subsidies, co-financing for participation at exhibition on key markets. Assistance in establishing necessary relations with companies in foreign markets is also important. Low rate of use of distributing services for the PE companies may be one of the reasons of low export volumes as companies do not use professional sales services due to different reasons. Need to have an unprecedented product, interesting, attractive and original; quality of products with low transportation costs.

5. **HR related assistance** (and improvement of education/trainings)- establish strong links between scientific and educational institutions with leading organizations in the industry; organize internships for students in these organizations or involve senior managers from these organizations in the committees that check the final paper (theses) of students. More internal training programs are needed; there is a need for trainers in Armenia.

6. **Investment climate support** through development of favorable investment climate in the country, which will take into account specifics of the PE sector.

7. **Access to finance** issues can be significantly improved only with the development of technologies and product quality in the companies. Anyway, some measures should be taken to facilitate access of start-ups to finance. Among ways to increase access to finance could be establishment of venture funds in precision engineering projects, establishment of credit guarantee fund for PE.

8. Based on the results of the research **the subsector with highest development potential** in PE sector is the manufacturing of computer, electronic and optical products: This is justified particularly by:
    a. Higher development trends in the subsector compared to other subsectors in the precision engineering
    b. Tight relations to IT sector, which is quite developed already in Armenia and is having positive influence on manufacturing of electronic and optical products
    c. Comparably higher existence of professions, interest in young generation
    d. The products are comparably small and valuable, which is advantage in exporting compared to larger products which have issues with export logistics

The assistance of international organizations can be crucial for the development of the sector. Particularly the following assistance can be productive:

- Strengthening cooperation of Armenian PE companies with foreign partners
- Raising awareness on current trends, new technologies in PE subsectors, international best practice
- Support to establishment of industry union,
- Business trainings on product development, international certification,
- Trainings to assist sales and marketing in PE, international best practice
- Support to SMEs and start-us

Cooperation with educational institutions to support changes of educational and training programs based on needs of the sector.

ANNEX 1. The list of conducted in-depth interviews

	Institution Name	Address	Respondent	Position	Date of interview
1	ANEL- Armenian National Engineering Laboratories	105 Teryan St., Yerevan	Amalya Mkhitaryan	ANEL Manager	17/12/16
2	Institute for Informatics and Automation Problems	Paruyr Sevak 1, Yerevan	Sahakyan Vladimir	Director of IDI Institute of Informatics and Automation Problems	17/12/16
3	Institute of Mechanics	24B M. Baghramyan Ave., 0019, Yerevan	Ara Avetisyan	Head of deformable system dynamics and related elements department of Mechanics Institute	19/12/16
4	Vanadzor Technology Center	12 Shinararneri str, Vanadzor 2019	Patvakan Hakhinyan	Business development responsible of VTC	19/12/16
5	Yerevan state vocational school №4 SNCO	20 Gyulikekhvyan St., 0076, Yerevan	Rashem Durgaryan	Master of production education	20/12/16
6	European Regional Academy	D. Anhaght St. Yerevan	Anush Melikyan	Educational process manager of Microelectronic circuits and systems	21/12/16
7	National Polytechnic University of Armenia	Yerevan, 105 Teryan St.	Areg Grigoryan	Prorector of Science and Scientific technological cooperation, professor	22/12/16
8	UEICT-Union of Employers of Information and Communication Technologies	3 P.Buzand St. 0010, Yerevan	Armen Baldryan	Chairman	22/12/16

9	Enterprise Incubator Foundation (EIF)	123 Hovsep Emin St., 0051, Yerevan	Mariam Davtyan	Director of Enterprise Incubator Foundation programs	23/12/16
10	Armenian-Indian Center for Excellence in ICT	Alek Manukyan 1, Yerevan: YSU, Faculty of Mathematics and Mechanics	Yevgeni Mamasakhlisov	R&D Manager	27/12/16
11	American University of Armenia	40 M. Baghramyan Ave., 0019, Yerevan	1.Rubina Danielova 2.Sargis Zeitunyan	1. Operations manager/engineer 2. Head of Industrial Engineering and Equipment Management department	10/01/17
12	DFA-Development Foundation of Armenia	5 M. Mkrtchyan St. Yerevan	Hayk Mirzoyan	Export Director	10/01/17
13	Russian-Armenian (slavonic) University	123 Hovsep Emin St., 0051, Yerevan	Vladimir Gevorgyan	Director of Mathematics and high technologies institutions	12/01/17
14	Alliance Free Economic Zone Sitronics Armenia (CJSC)	111 Raffi St., Yerevan	Armen M. Khachatryan,	General Director	12/01/17
15	Yerevan State University of Architecture and Construction	Yerevan, 105 Teryan St.	Artavazd Arzumanyan	Head of Productive materials and equipment production technology department	13/01/17
16	Yerevan State University	Alek Manukyan St., 0025, Yerevan	1.Samvel Sargsyan 2.R. Allahverdyan	1. Head of department of Mechanics 2. Head of optics department	17/01/17
17	Yerevan state college of informatics	52 Mamikonyants St., Yerevan	Qadjik Avetisyan	Head of Mechatronic department	17/01/17

18	UITE-Union of Information Technologies Enterprises	3. 3-th floor H. Hakobyan st. Yerevan	Hayk Chobanyan	Deputy Director	17/01/17
19	Institute of Applied Problems of Physics	25 Nersisyan St., 0014, Yerevan	Edgar Mkrtchyan	Researcher	23/01/17
20	Institute of Radiophysics and Electronics	1 Alikhanyan Yeghb., Ashtarak-2, 378410, Yerevan	A. Hakhoumian, Ph. D. in Mathematics and Physics	Institute Director	26/01/17
21	Institute for Physical research of National Academy of Science of RA	Gitavan-2, Ashtarak 0203	Professor A. Papoyan, Ph. D. in Mathematics and Physics,	Institute Director	26/01/17
22	Synopsis University of Armenia	41 Arshakunyats Ave., 0026, Yerevan	Vazgen Melkyan	Head of Education Department	01/02/17
23	EPIC- AUA Entrepreneurship and Product Innovation Center	40 Baghramyan St, 0019, Yerevan	Aram Kheryan	Operational manager	24/02/17
24	Gyumri Technology Center	1 Gayi Street, Gyumri 3105	Bagrat Yengibaryan	Director	28/02/17
25	Ministry of economic development and investment of RA	Mher Mkrtchyan St., 5 Building, Yerevan	Armen Yeganyan	Head of Industrial Development Department	06/03/17

Groups of institutions for analytical purposes

Groups
Educational & Research Institutions
Education 1. National Polytechnic University of Armenia 2. Yerevan State University 3. American University of Armenia 4. European Regional Academy 5. Russian-Armenian (Slavonic) University 6. Yerevan State University of Architecture and Construction 7. Yerevan state college of informatics 8. IDI Yerevan state vocational school №4 **Research** 1. ANEL 2. Synopsis University of Armenia 3. Institute of Mechanics 4. Institute for Informatics and Automation Problems 5. Institute of Applied Problems of Physics 6. Institute of Radiophysics and Electronics 7. Institute for Physical research
Infrastructural companies (technoparks, FEZ)
1. Vanadzor Technology Center **2.** Alliance Free Economic Zone 3. Gyumri Technology Center 4. EPIC
Governmental bodies & industrial organizations
1. DFA- 2. UITE- 3. UEICT **-** 4. EIF - 5. Armenian-Indian Center for Excellence in ICT- 6. Ministry of economic development

ANNEX 2. Information on education programs, students and staff

1. *Number of Students per Specialization/Majors and Educational Programs (according to information provided by Ministry of Education)*

National Polytechnic University of Armenia (Yerevan) -Students

Elementary vocational educational program   as of **February 1, 2017**

Specializations specified in the letter	University program covering the same or similar specialization	Number of students
Mechanical metalworking via machines and trains	Mechanical metalworking via machines and trains	4

Intermediate vocational educational programs

Specializations specified in the letter	University program covering the same or similar specialization	Number of students
Electronic devices and equipment	Maintenance and repair of Communications Electronics devices	86
Communication networks and systems	Communication networks and systems	123
Biotechnology and medical devices and systems	Installation, maintenance and repair of medical devices	6

Bachelor's program

Specializations/majors specified in the letter	University program covering the same or similar specialization/major	Number of students	
		In-person learning	Distance learning
Electronics	Electronics	184	53
Semiconductor physics and microelectronics	Semiconductor physics and microelectronics	57	-

Electrical engineering, electromechanics and electrical technologies	Electrical engineering, electromechanics and electrical technologies	147	44
Machine Science	Computer-aided design of mechanical systems	27	-
Production machinery and equipment	Production machinery and equipment	36	-
Instrument engineering	Instrument engineering	29	-
Metrology	Metrology	24	-
Radio engineering	Radio engineering	161	88
Computer engineering	Computer engineering	227	191
Aviation equipment of aircrafts	Aviation equipment of aircrafts	9	-
Medical purpose devices, systems and products	Biomedical engineering	28	-
Power systems and complexes and their control	Energy efficient technology and energy management	30	-
Telecommunication networks, equipment and systems	Telecommunication and signal processing	82	-
Automation systems	Automation	85	28
Mechanic engineering technology and equipment	Mechanic engineering and materials processing	41	30
Electronics, micro- and nanoelectronics (Synopsys)	Microelectronic Circuits and Systems major within Electric Engineering specialization (Synopsys)	51	-
Applied mathematics and physics	Applied mathematics and physics	4	-

Master's program

Specializations/majors specified in the letter	University program covering the same or similar specialization/major	Number of students	
		In-person learning	Distance learning
Electronics	Electronics	28	5

Semiconductor physics and microelectronics	Semiconductor physics and microelectronics	10	-
Computer engineering of integrated circuits	Computer engineering of integrated circuits (Synopsys)	40	-
Instrument engineering	Instrument engineering	8	1
Metrology	Metrology	3	-
Radio engineering	Radio engineering	19	1
Automation	Automation	19	6
Computer engineering	Computer engineering	49	9
Microwave radiophysics and electronics	Telecommunication and signal processing	14	7

National Polytechnic University of Armenia (Yerevan) –Graduates (recent 3 years)

Elementary vocational educational program

Specializations/majors specified in the letter	University program covering the same or similar specialization/major	Graduation year		
		20132014	2014/2015	2015/2016
Mechanical metalworking via machines and trains	Mechanical metalworking via machines and trains	8	-	-

Intermediate vocational educational programs

Specializations/majors specified in the letter	University program covering the same or similar specialization/major	Graduation year		
		2013/2014	2014/2015	2015/2016
Electronic devices and equipment	Maintenance and repair of Communications Electronics devices	20	32	39
Communication networks and systems	Communication networks and systems	18	22	40
Biotechnology and medical devices and systems	Installation, maintenance and repair of medical devices	12	5	9

Bachelor's program

Specializations/majors specified in the letter	University program covering the same or similar specialization/major	Graduation year					
		2013/2014		2014/2015		2015/2016	
		In-person learning	Distance learning	In-person learning	Distance learning	In-person learning	Distance learning
Electronics	Electric engineering	34	27	16	16	78	15
Semiconductor physics and microelectronics	Semiconductor physics and microelectronics	3	-	7	-	14	-
Electrical engineering, electromechanics and electrical technologies	Electrical engineering, electromechanics and electrical technologies	58	17	18	17	58	13
Machine Science	Applied mechanics	18	-	7	-	6	-
Production machinery and equipment	Production machinery and equipment	13	-	1	-	10	-
Instrument engineering	Instrument engineering	9	-	-	-	6	-
Metrology	Metrology, standardization and certification	10	-	-	-	5	-
Radio engineering	Radio engineering and communication	71	23	20	32	86	20
Aviation equipment of aircrafts	"Technical operation of aircrafts and their engines" major within "Construction, control and operation of vehicles and engines" specialization	8	-	-	-	10	-
Medical purpose devices, systems and products	Biomedical engineering	12	-	8	-	20	-
Power systems and complexes and their control	Energy efficient technology and energy management	15	-	9	-	16	-
Computing machines, complexes, systems and networks, their	"Computing machines, complexes, systems and networks" major within "Computer science and	28	44	22	60	60	49

elements and devices	computing devices" specialization						
Automation systems	Automation and control	16	11	4	9	21	12
Mechanic engineering technology and equipment	Mechanic engineering and materials processing	21	16	8	17	12	12
Electronics, micro- and nanoelectronics (Synopsys)	Microelectronic Circuits and Systems major within Electric Engineering specialization (Synopsys)	14	-	13	-	21	-

Master's program

		Graduation year					
		2013/2014		2014/2015		2015/2016	
Specializations/majors specified in the letter	University program covering the same or similar specialization/major	In-person learning	Distance learning	In-person learning	Distance learning	In-person learning	Distance learning
Electronics	Electronic devices	12	5	14	4	15	3
Semiconductor physics and microelectronics	Semiconductor physics and microelectronics	-	-	3	-	3	-
Computer engineering of integrated circuits	"Very-large-scale integrated circuit design" major within Electric Engineering specialization (Synopsys)	28	-	24	-	19	-
Instrument engineering	Instrument engineering	5	-	6	-	6	1
Metrology	Metrology, standardization and certification	5	-	6	-	5	-
Radio engineering	Radio engineering and communication	19	8	16	12	18	8
Automation	Automation and control	12	3	12	4	10	1
Computer engineering	"Appliance hardware" major within "Computer science	14	5	14	5	12	7

and computing devices" specialization		

Yerevan State University - students and 2016 graduates

	Number of students	Number of graduates
Bachelor's degree		
Semiconductor physics and microelectronics	56	15
Mechanics	66	24
Applied mathematics and physics	9	17
Radiophysics and electronics	235	61
Master's degree		
Semiconductor physics and microelectronics	6	5
Optics	8	0
Radiophysics (Microwave radiophysics and electronics)	26	11

Elementary and Intermediate Vocational Education Institutions

as of February 1, 2017

	Number of students	Total number of graduates
Syunik Regional State College		
Communication networks and systems	37	88
Ejmiatsin Vocational State College		
Welding technology	12	49
Ararat Regional State College		
Welding technology	49	250

2. *Educational programs, number of current full-time and part-time students and current educational fees (according to information provided by institutions in addition to in-depth interviews)*

Name of educational program	The number of current full-time and part-time students	Current educational fee (AMD)
Baccalaureate	-	-
Masters degree	-	-

Doctor of philosophy	-	-

Yerevan State University

American University of Armenia

Name of educational program	The number of current full-time and part-time students	Current educational fee (AMD)
Computer Science	360	-
Computer and Information technologies	40	-
Industrial engineering	40	-

European Regional Academy

Name of educational program	The number of current full-time and part-time students	Current educational fee (AMD)
Information Technologies	-	570,000

Yerevan State University of Architecture and Construction

N_0	Specialization	Number of current full-time students			Current educational fee (AMD)	
		Baccalaureate	Masters	Total		
		Full-time	Full-time		Baccalaureate	Masters
1	Production of construction materials, structures and other constructional products	13	6	19	590.000	700.000
2	Design of buildings	79	11	90	590.000	700.000
3	Geodesy and cadastre	39	7	46	590.000	700.000
4	Construction and operation of water systems	21	10	31	590.000	700.000
5	Construction, control and operation of transportation means	36	6	42	590.000	700.000
6	Industrial and civilian construction	75	25	100	590.000	700.000
7	Urban economy and supply of thermo-gas	36	6	42	590.000	700.000

№	Specialization					
8	Informatics and computing technics	141	3	144	480.000	620.000
9	Management information systems	66	8	74	500.000	620.000
	Total	506	82	588		

№	Specialization	The number of current part-time students			Current education fee (AMD)	
		Baccalaureate	Masters	Total number of students	Baccalaureate	Masters
		Part-time	Part-time			
1	Production of construction materials, structures and other constructional products	4	2	6	472.000	560.000
2	Geodesy and cadastre	61	0	61	472.000	560.000
3	Construction and operation of water systems	25	0	25	472.000	560.000
4	Construction, control and operation of transportation means	45	0	45	472.000	560.000
5	Investigation of real estate and management	15	0	15	472.000	560.000
6	Urban economy and supply of thermo-gas	101	130	231	472.000	560.000
7	Informatics and computing technics	100	0	100	384.000	0
8	Management information systems	28	0	28	400.000	0
	Total	379	132	511		

**Yerevan state college of informatics**

Name of educational program	The number of current full-time and part-time students	Current educational fee (AMD)
Mechatronics	90-100	210,000

**Yerevan state vocational school №4**

Name of educational program	The number of current full-time and part-time students	Current educational fee (AMD)
Testing of electrical equipment, machines and apparatuses	200	Free from charge

Synopsis University Armenia

Name of educational program	The number of current full-time and part-time students	Current educational fee (AMD)
Baccalaureate	172	Free from charge
Masters degree	102	Free from charge
Doctor of philosophy	16	Free from charge

Armenian-Indian Center for Excellence in ICT (governmental)

Name of primary education program	The number of current full-time and part-time students	Current Education Fee (AMD)
Java Programming	Phase 1 (48 hours)	69 000
Java Programming	Phase 2 (51 hours)	84 000
Java Programming	Phase 3 (48 hours)	93 000
Web Programming	Phase 1 (48 hours)	57 000
Web Programming	Phase 2 (57 hours)	78 000
Foundations of LINUX	Phase 2 (20 hours)	54 000
LINUX Management and Network Foundations	Phase 2 (30 hours)	67 000
LINUX Network Server	Phase 3 (30 hours)	79 000
C# -.NET Programming	48 hours	64 000
Objective C (iOS) Programming	32 hours	77 000
Android Programming	48 hours	79 000
Project Management	Phase 1 (16 hours)	40 000
Strategic Project Management	Phase 2 (36 hours)	90 000
QA	32 hours	55 000
UI/UX Design	20 hours	33 000
3DsMax:Modeling	Phase 1 (24 hours)	60 000
3DsMax: Material and Render	Phase 2 (24 hours)	65 000
3DsMax: Animation	Phase 3 (24 hours)	69 000
Adobe Illustrator: Graphic Design	24 hours	51 000
Advanced Adobe Photoshop	36 hours	70 000

- In addition, the center organizes on demand classes in Parallel Computing, Python, Macros & VBA, Database Management Systems, Share Point, MS Excel (Advanced Level), C++ etc.

Institute of Mechanics

Name of educational program	The number of current full-time and part-time students	Scholarship
Technics of deformed solid object	Full-time 4/ Part-time 1	Full-time PHD students received AMD 25,000 scholarship. Part-time students do not receive any scholarships.

Institute for Informatics and Automation Problems

Name of educational program	The number of current full-time and part-time students	Current educational fee (AMD)
Informatics and counting technics	50	AMD 300,000

Institute of Radiophysics and Electronics

Name of educational program	The number of current full-time and part-time students	Current educational fee (AMD)
Baccalaureate	-	-
Masters degree	-	-
Doctor of philosophy	10	Free from charge

The Institute for Physical Research

Name of educational program	The number of current full-time and part-time students	Current educational fee (AMD)
Doctor of philosophy	13	Free from charge

EPIC

Name of educational program	The number of current full-time and part-time students	Current educational fee (AMD)
EPIC start-up incubator	21	Free from charge

3. **The number of graduates over the previous three academic years (according to information provided by institutions in addition to in-depth interviews)**

Yerevan State University

Specializations	2015/2016
Mathematics	
Mechanics	
Actuarial and financial mathematics	
Mechanics of deformable solid objects	
Motion control and stability	
Physics of macromolecules	
Optoelectronics and physics	
Quantum technology physics	
Physics	

American University of Armenia

Specializations	2013/2014	2014/2015	2015/2016
Computer science	20	20	20
Computer and information technologies	20	20	20
Industrial engineering	20	20	20

European Regional Academy

Specializations	2013/2014	2014/2015	2015/2016
Means of communication, microelectronic schemes and systems	11	26	23

Yerevan State University of Architecture and Construction

Specializations	2013/2014	2014/2015	2015/2016
Production of construction materials, structures and other constructional products	89	79	77
Design of buildings	19	11	29
Geodesy and cadastre	34	25	45
Construction and operation of water systems	19	20	20
Construction, control and operation of transportation means	36	13	24
Industrial and civilian construction	27	16	11
Urban economy and supply of thermo-gas	38	16	21
Informatics and computing technics	42	30	48
Management information systems	33	19	32

Yerevan state college of informatics

Specialization	2013/2014	2014/2015	2015/2016
Technical mechatronics		First graduation year was on 2015 with 15 students	30

Synopsis University Armenia

Specializations	2013/2014	2014/2015	2015/2016
Microelectronics schemes and systems	Approximately 290	Number does not change significantly	Number does not change significantly

Armenian-Indian Center for Excellence in ICT

Specializations	2013	2014	2015	2016
Java Programming	37	49	58	93
Java Programming	16	34	24	56
Java Programming	7	10	20	
Web Programming	64	112	106	88
Web Programming	41	33	38	18

Foundations of LINUX	19	24	28	19
LINUX Management and Network Foundations	14	14	23	15
LINUX Network Server	9	-	13	5
C# -.NET Programming	-	-	-	19
Objective C (iOS) Programming	14	-	-	10
Android Programming	-	-	18	23
Project Management	16	29	56	37
QA	-	-	-	13
UI/UX Design	-	-	-	11
Graphic Design	13	30	17	10
Database Management Systems	25	28	19	-
Network/Information Secury	18	-	7	-
Parallel Computing	37	-	-	-
MS Excel (Advanced Level)	-	15	-	14

Institute of Mechanics

Specializations	2013/2014	2014/2015	2015/2016
Technics of deformed objects		4/3	3/1

Institute for Informatics and Automation Problems

Specializations	2013/2014	2014/2015	2015/2016
Informatics and information technologies	20	30	30

Institute of Applied Problems of Physics

Specializations for Doctor of Philosophy	2013/2014	2014/2015	2015/2016
Condensed matter physics	-	1	-
Acoustics	-	-	1
Plasm physics	-	-	-

The Institute for Physical Research

Specializations	2013/2014	2014/2015	2015/2016
Laser physics	Total number of graduates for all years combined is 15		
Optics			
Condensed matter physics			

EPIC

Specializations	2013/2014	2014/2015	2015/2016
Engineering	-	-	Starts from 2016

4. Faculties and appropriate numbers of staff, including instructors/lecturers (according to information provided by institutions in addition to in-depth interviews).

Yerevan State University

Faculty	Specialization	Number of instructors/lecturer
Optics	Optics	13
Mechanics	Mechanics	11

European Regional Academy

Faculty	Specialization	Number of instructors/lecturer
Microelectronics schemes and systems	-	25

Russian-Armenian (Slavonic) University

Faculty	Specialization	Number of instructors/lecturer
Mathematics and institutions for high technology	-	-

Yerevan state college of informatics

Faculty	Specialization	Number of instructors/lecturer
Mechatronics	Technician-mechatronic	10

Synopsis University Armenia

Faculty	Specialization	Number of instructors/lecturer
Microelectronics schemes and systems	Microelectronics schemes and systems	60

Institute for Informatics and Automation Problems

Faculty	Specialization	Number of instructors/lecturer
Informatics and counting technics	Informatics and counting technics	20

Institute of Applied Problems of Physics

Faculty	Specialization	Number of instructors/lecturer
Laboratory of X-ray optics in collaboration with Polytechnic University of Tomsk	-	17
Laboratory named after Alpik Rafayelovich in Artsakh State University	Condensed matter physics, acoustics, physics of acoustics	5
Laboratory of photons and basic particles in collaboration with Belgorod University	Nuclear physics, Condensed matter physics, chemistry and applied physics	15

The Institute for Physical Research

Faculty	Specialization	Number of instructors/lecturer
Quantum and optical electronics	Laser physics, optics, Condensed matter physics	6