Project report no. 3/2016

Automation and Re-industrialization

A zero-point analysis of robotization in industrial sectors in Agder

Bram Timmermans, Sissel Strickert and Kristin Wallevik

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Preface

Industrial trends towards increased automation, robotization and digitalization are all factors setting the industrial frameworks of what has been called *the fourth industrial revolution*. The industrial clusters in Agder differ in history, maturity and size, but face the same mega trends in manufacturing and processing of goods. This zero-point analysis is conducted in conjunction with two projects; *Future Robotics* and *Re-industrialization* (Norwegian title; Re-industrialisering). These projects were established in an effort to answer the challenges of changing industrial development and technology.

Future Robotics is a competence building initiative for future processing technologies where all industrial clusters in Agder participate. These clusters are GCE NODE, Eyde Cluster, Digin, Lister Alliance, SINPRO and Sørlandsporten teknologinettverk (STN), working together with the research institutions, University of Agder (UiA) and Teknova AS. *Re-industrialization* is a project established by GCE NODE and Eyde Cluster in close cooperation with *Future Robotics*. Both projects will use this zero-point analysis for further work towards their respective objectives. A coordinated effort will strengthen both competence and robustness of the industry. This report is also a response to the desire to obtain more knowledge about the level of automation and robotization in the firms within these regional clusters, enabling a more accurate support to increase future competitiveness.

In this report, Agderforskning has interviewed 37 representatives of industrial companies in Agder, including all members of the cluster organisations mentioned above. Together these clusters represent more the 220 firms. Eighty-four out of the 220 industrial companies manufacture or process goods at production facilities located in the Agder region. Our point of departure is from these eighty-four industrial companies.

The project has been organised by *Future Robotics*` project management on behalf of *Future Robotics* and *Re-industrialization*. The criteria for participation in the survey leading to this zero-point analysis is that the company manufactures or processes goods at production facilities located in the Agder region. *Future Robotics* project management has provided Agderforskning with names of appropriate industrial companies and contact persons in each company. The list of eighty-four companies was chosen from a base of 220 member companies. We appreciate the enthusiasm shown by project management during the project period. We would like to thank all industrial companies that have participated in the survey; the result would not have been possible without the productive cooperation of these member companies.

Senior Project Manager Sissel Strickert led the project. Senior researcher Bram Timmermans wrote chapters 2, 3, 4 and 5. Kristin Wallevik contributed to the report in general. Amna Drace, Nina Kyllingstad and Christine Svarstad contributed to the gathering of data.

Kristiansand, February 2016

Bram Timmermans, Sissel Strickert and Kristin Wallevik

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1 Introduction

In 2015, the industrial cluster organizations GCE NODE, Eyde Cluster, Digin, Lister Alliance, SINPRO and Sørlandsporten teknologinettverk (STN) were granted the project *Future Robotics*, financed by the Sørlandet Knowledge Foundation (SKF). The project owner is the University of Agder (UiA) with Teknova AS as the R&D partner. *Future Robotics* is a competence building initiative for future processing technologies. *Re-industrialization* is a project established by GCE NODE and Eyde Cluster in close cooperation with *Future Robotics*. These projects are a coordinated effort to strengthen both the competence and the robustness of the industry. Both projects will use this zero-point analysis for further work towards their respective objectives. Specifically, the zero-point analysis is part of the knowledge base for further development of taskforces and working groups in the *Future Robotics* project. The main task was to determine the density of industrial robots used in manufacturing or processing of goods at production facilities located in the Agder region.

We explore how widespread the use of robots is in regional firms and expect this to be significant information in developing targeted tasks in the *Future Robotics* project. Before we started the project, we expected, based on discussions with and information from industry representatives, to find little use of robots with a few exceptions in larger industrial companies. The results of this survey show that the actual deployment of robotics is in line with this expectation.

In this report, Agderforskning has interviewed 37 representatives of industrial companies in Agder, all members of the industrial cluster organizations: GCE

NODE, Eyde Cluster, Digin, Lister Alliance, SINPRO and Sørlandsporten teknologinettverk (STN). Taken together, these clusters represent more than 220 businesses. Eighty-four out of the 220 industrial companies manufacture or process goods at production facilities located in the Agder region.
Future Robotics project management has provided Agderforskning with names of these industrial companies and contact persons in each of the eighty-four industrial companies that manufacture or process goods at production facilities located in the Agder region.

Numerically, the sample size is not high; but given the response rate of 44%, it is acceptable[1]. Note that the sample of companies, are all members of the above-mentioned industrial clusters. This means that the sample consists of 84 industrial companies in the Agder region who are members of these cluster organizations and accordingly manufacturers or processers of goods at production facilities located in this region. This limits the generalizability of the findings, in other words, on the ability to compare the density of industrial robots in this report with other surveys.

The research team from Agderforskning that formulated and conducted the survey has extensive research and practical experience in these industries. During recent years, CEO Kristin Wallevik, together with several researchers in Agderforskning, have conducted studies related to these industries with a special focus on the mechanical industry. The latest study, from 2014 (Jørgensen og Wallevik, 2014), included 90 firms and 20 in-depth interviews in the industry related to the current status and challenges they face, as well as

[1] Note that several of the companies in the sample are member of more than one cluster organization.

possible solutions that could increase future competitiveness. In these interviews, the main challenges for the regional firms were identified as an ongoing general increase in costs relative to competitors, lower productivity growth than wage growth, increased foreign competition, and volatile markets. Part of the solution to these challenges seems to be a higher degree of automation and robotization in the production process.

Bram Timmermans has in his position as Senior Researcher at Aalborg University, conducted several industrial analyses. His field of research, as a quantitative researcher, ensures quality of research design, training of interviewers and analysis of findings presented in this report. Amna Drace, Nina Kyllingstad and Christine Svarstad are all qualified interviewers with experience from industrial projects that employed qualitative interviews. Two recent examples of their work can be found in Agderforskning's *Mekanisk Industri* and *Hidden Champions* reports.

Several studies argue that there is a fourth industrial revolution starting now, with emphasis on smart manufacturing for the future. Using the term Industry 4.0, Boston Consulting Group argues that Industry 4.0 will transform production in such a way that "isolated, optimized cells will come together as fully integrated, automated, and optimized production flow, leading to greater efficiencies and changing traditional productions relationships among suppliers, producers, and customers – as well as between human and machine" (Boston Consulting Group, 2015).

In 2014, robot sales increased by 29% worldwide, by far the highest level recorded for one year. Additionally, the sales of industrial robots increased in all industries compared to 2013 (www.ifr.org). Furthermore, in 2014, 70% of the global robot sales went to five countries: China, Japan, the USA, the Republic of Korea and Germany. The main drivers are the automotive industry and the electrical/electronics industry, but robot density in the other industrial sectors is still low (www.ifr.org). Due to the fact that the density of robots varies from industry to industry, and that countries have different industrial structures, it would be impractical to make comparisons between countries by measuring the number of robots per 10.000 industry employee.

Several countries have a well-established industrial policy based on the idea of the fourth industrial revolution. Some examples are Germany, Sweden, the Netherland and the USA. These countries have defined programs with the goal of securing their domestic manufacturing industry. In sum, current trends may represent a radical change in the way that industry develops and where our industry needs to go in the future. One could argue that the Norwegian industry debate focuses less on Industry 4.0 than in other European countries, and that this may represent a challenge for the future competitiveness of our industry.

This study is an initial respond to some of these challenges by collecting data on the ownership and the use of robots within the regional industry. The report consists of three main parts. Part one contains the Preface and Introduction. Part two consists of chapters 2, 3, 4: Method, Automatization and Offshoring and reshoring. In these chapters we explain methodology, sample considerations and the findings visualized in graphical tables. The third part of the report is the Analysis and Conclusion, where we sum up the results of the survey.

2 Method

To investigate automation and re-industrialization, we chose to conduct a survey among manufacturing firms that are member of at least one of the established cluster organizations in Agder. These are GCE NODE, Eyde Cluster, Digin, Lister Alliance, SINPRO and Sørlandsporten teknologinettverk (STN).

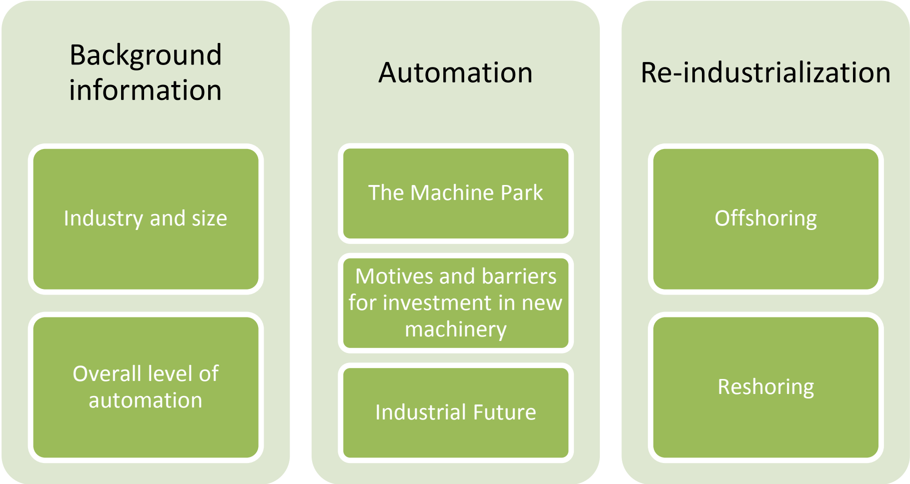
Agderforskning designed the survey in close collaboration with project managers of the *Future Robotics* project. The survey was divided into three overarching themes with a total of 17 questions[2].

In order to obtain an impression of the firms we interviewed, we first asked a series of background questions concerning size, number of workers in production and industry type, as well as their own impression of their level of automation. In the subsequent automation section, we wanted to know what type of machines the organizations use in their production process, the motives and barriers the organizations face when wanting to invest in this machinery and their familiarity concerning the future of their industry, particularly their knowledge of the concept of Industry 4.0.

The last section of the survey focused exclusively on the topic of offshoring, i.e. the extent that manufacturing firms in Agder have moved activities abroad, and reshoring, i.e. the action to move manufacturing activities back to the region.

[2] A more detailed version of the survey is presented in the Appendix

Figure 1: Survey Structure



Telephone Survey

We chose telephone interviews as the method for surveying the respondents. This method was preferred because: (i) the number of respondents made face-to-face interviews too time-consuming and too expensive, (ii) it allowed for interaction with the respondents, which means that the respondents are able to probe when questions were not clear to them or they were able to provide us with additional information that might be valuable when analyzing the answers, (iii) it reduced interviewer effects; (iv) it was easier to monitor and evaluate the validity of the answers, and (v) it generated a higher response rate compared to expected rates for postal or mail-based surveys.

The telephone interviews were conducted between week 49 and week 51, 2015, by four experienced telephone interviewers. Prior to conducting the interviews, we conducted a series of pilots to address ambiguity that might arise in the questions asked and to provide training for the interviewers to minimize inter-interview variation.

The Sample

The telephone survey covered representatives of firms that are member of one of the following cluster/network organizations: GCE NODE, Eyde Cluster, Digin, Lister Alliance, SINPRO and STN. As previously mentioned, as this project revolves around regional automation of manufacturing, and therefore these firms needed to have manufacturing activities in Agder. Based on these requirements we received a list with 84 companies (see Table 1 to see the distribution).

Prior to conducting the survey, these 84 companies were informed by their cluster/network organizations that they were to be contacted by Agderforskning. After this initial notification, those in charge of conducting the telephone interviews sent out a second email informing the respondents that they would be contacted by telephone in the upcoming days. This email also included the full range of survey questions regarding machines in use so the respondent could prepare for this interview where necessary. All respondents were contacted by telephone up to three times in order to make an appointment to conduct the interview – mostly the respondents participated immediately and required no further appointment. The respondent was listed as a non-response when we were not able to establish contact with him or her.

Following this procedure, the telephone interviewers were able to get in contact with 49 respondents. Twelve respondents indicated that they were not able to participate in the study due to time constraints or because they had concluded that the study was not relevant for them. The third column in Table 1 shows the response rate across the different cluster/network organizations. The total response rate for the survey is 44 percent based on our initial sampling frame. The results of this survey will be presented later in this report.

Table 1: Cluster/network Organization - Sample and Respondents

Cluster Organization	*Sampling Frame**	*Final Sample**	*Percent*
GCE NODE	31	11	35 %
Eyde Cluster	18	11	61 %
DIGIN	10	4	40 %
Lister Alliance	9	6	67 %
SINPRO	12	6	50 %
STN	14	5	36 %
Total	84	37	44 %

* *some respondents are member of multiple cluster organizations*

Potential Sample and Non-Response Bias

One issue that continuously arises when using this type of survey design, are potential problems in terms of sample and response bias. Sample bias occurs when particular members of a certain population are more likely to appear in the sample compared to others. Non-Response bias occurs when particular respondents in a given sample are less likely to participate in such a study, which might influence the results.

The current sample was created based on being a member in one of the six above-mentioned cluster organizations. Consequently, any findings can only be extrapolated to this particular population (assuming that there is no response bias); instead of a population of, let us say, all manufacturing firms in the region of Agder.[3] A reason for potential sample bias could be that there might be a significant difference between manufacturing firms that are member of the cluster organization and those manufacturing firms that are not.

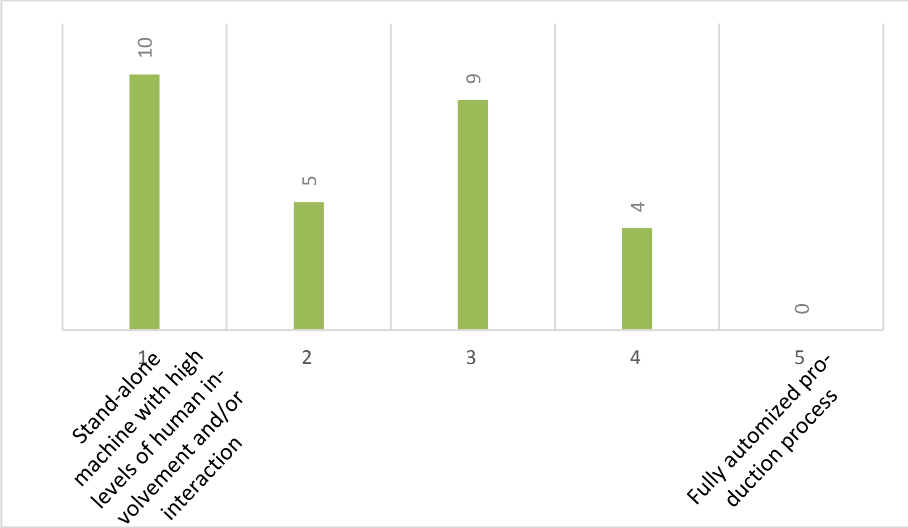
[3] This will also place limitation on comparability with other studies that have investigated the use of production technology on a higher level of aggregation, for example, nationwide.

Non-response bias is a common bias that occurs in survey research. This bias might be driven by observable characteristics (e.g. size) of the respondents. More specifically, small firms might be less inclined to participate compared to larger firms. This is particularly problematic if the behavior of larger firms is different compared to small firms; however, in this case non-response analysis shows that we have no response bias based on firm size. Another observable characteristic that we can test is cluster membership. Based on this observable characteristic we have a minor bias, as members of GCE NODE appeared to have a higher non-response rate compared to member organizations of other cluster organizations. In addition, there might be a non-response that we cannot test for based on observable characteristics of the organization. For example, a common problem that exists, because we cannot force organizations to participate, is that the organizations that cannot identify themselves with the theme of the survey are less likely to participate. In this particular case, if firms cannot identify themselves with automation and/or offshoring they might be less inclined to participate. Given that some of the respondents explicitly mentioned that the topic was not relevant for them, despite having been identified as meeting the initial criteria, there might be non-response bias that overestimates the level of automation among members of the above-mentioned cluster organizations.

3 Automation

To get an impression of the scope of automation among our sample of firms, we have asked the respondents how they would characterize their level of automation varying from only having stand-alone machines that demand a high degree of human involvement and interaction to fully automated systems. As demonstrated in Table 2, the majority of the respondents to this question (15 out of 28 or 53.5 percent) assessed that they have low to medium-low levels of automation and only four firms have a medium to high-levels of automation.

Figure 2: Overall Level of Automation



Note: numbers in the graph indicate the number of observations

In order to get an impression of what kind of advanced machines that are used in the production process, we asked the respondents to indicate whether they use any of the machines listed in Table 2 in their production process or not. Eight of the respondents stated that they use industrial robots in their production process. They reported deploying 125 industrial robots, where six of them own more than one robot. Nearly 80 percent of the industrial robots our respondents reported are owned by one firm. Four of the larger companies also own laboratory robots, reporting a total of 34 laboratory robots. Similar to the industrial robots findings, one company owns nearly all of the laboratory robots. Furthermore, the larger firms (i.e. more than 250 employees) in possession of an industrial robot also own a laboratory robot.

Table 2: Machine-types in Production Process

Employees	***Number Of Firms***	*Industrial Robot*	*Lab Robot*	*3D Printer*	*Smart Machines*	*OPC*	*PLC Systems*	*DCS Systems*	*3D Scanner*
<=10	**4**	0	0	0	1	0	1	0	0
11-25	**8**	0	0	1	1	0	1	0	0
26-50	**4**	1	0	0	0	0	1	0	0
51-100	**2**	1	0	1	1	0	1	1	0
101-250	**12**	4	0	1	3	2	7	3	1
>250	**7**	2	4	1	4	3	5	3	0
Total	**37**	8	4	4	10	5	16	7	1

In recent years, 3D printers have made their appearance on the production floor. In spite of this trend, the use of this type of printer is not common among the manufacturing firms in our sample. Only four firms indicated to the use of such a printer[4]. We would like to highlight that only one firm actually owns a 3D printer; the remaining three firms have access to a 3D printer owned by another firm. It appears as if 3D scanners are used even less among our sample firms.

Often machines are not stand alone independent units but have the ability to communicate with other machines in the production process. These types of smart machines are more common in the firms in the sample; ten of the sample

[4] We also asked about the use of 3D metal printers but none of the respondents mentioned using this technology.

firms have indicated to own such a machine. Again, these type machines are mainly in the possession of the larger firms.

Regarding Programmable Logic Controller (PLC) systems, one respondent, whose firm is a member of Eyde Cluster and active in the process industry, explicitly mentioned that all firms would have such a technology in their production process. While this appears not to be the case overall, looking more closely at the numbers reveals that those firms in the Eyde Cluster that classify themselves as process industry indeed answered positively to the use of this technology. Most likely, the respondent meant with “all firms” those active in process industries. (Although in some cases, the respondent answered this question with “do not know”.)

Moving from machines to data systems and digital communications (see Table 3), we quickly see that this type of automation is more diffuse among the manufacturing firms in our sample.

Table 3: Data Systems and Digital Communication in Production Process

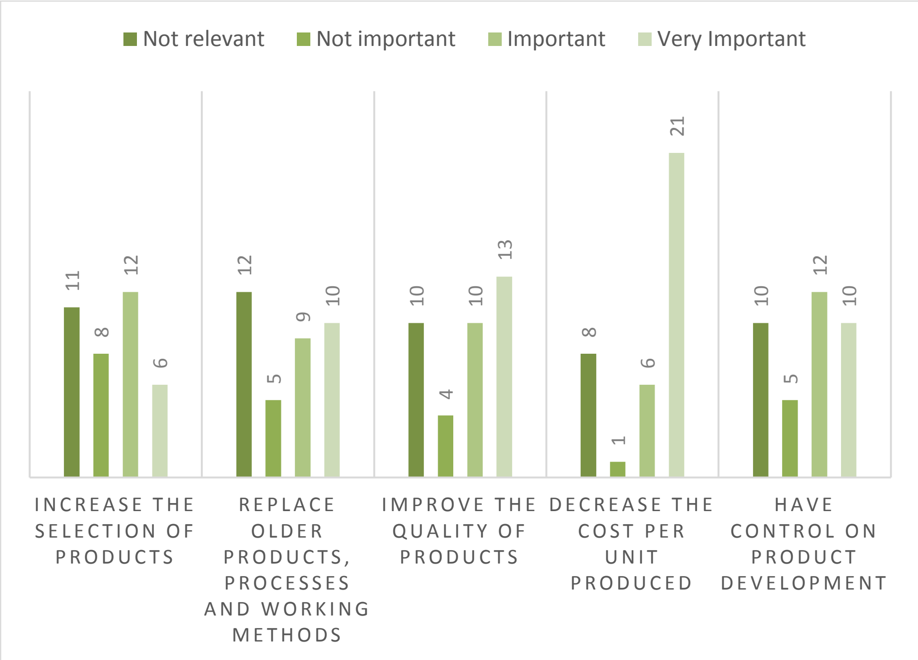
Employees	***Number of Firms***	*ERP systems*	*Automatic data-collection from external sources*	*"track-and-trace"*	*Sensor technology*	*Online process control system*	*Data collecion for maintance control*	*Wireless net in production system*	*Fieldbus*
<=10	**4**	0	0	1	0	1	0	1	1
11-25	**8**	3	2	1	0	0	0	2	1
26-50	**4**	0	0	0	0	0	0	1	0
51-100	**2**	1	0	0	1	1	1	1	1
101-250	**12**	5	1	5	2	3	3	7	3
>250	**7**	6	1	3	4	4	4	5	4
Total	**37**	15	4	10	7	9	8	17	10

Investments in Future Production Technology - Motives

There are a variety of reasons why firms want to invest in production technology for the future. To gain insight into the different motivations for firms in Agder, we asked our respondents to indicate how important a set of motives are for them. The motives to invest in future automation technology have been divided into: (i) product-related motives (see Figure 3), (ii) process-related motives (see Figure 4), (iii) market related motives (Figure 5), and (iv) miscellaneous motives (see Figure 6).

Product-related motives are related to the cheaper production of an existing product, the introduction of a new product, or improving the quality of existing products. Not surprisingly, the most important motive for manufacturing firms is to decrease the cost per unit produced. The second most important motive is to improve the quality of existing products. Replacement of older products, increasing the selection of the overall product portfolio, and having control of product development are important as well, but not as important as the first two mentioned motives.

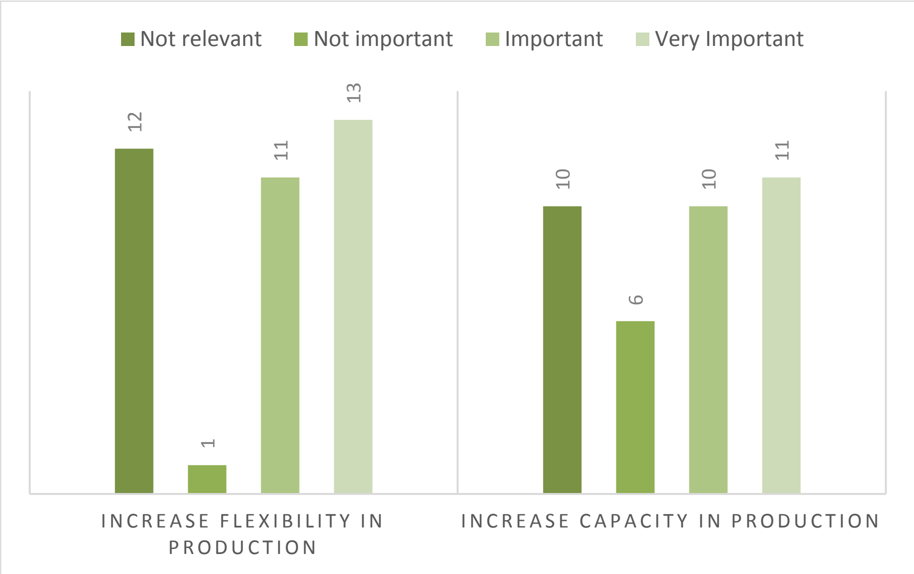
Figure 3: Product-related Motives for Investments in automation



***Note**: numbers in the graph indicate the number of observations*

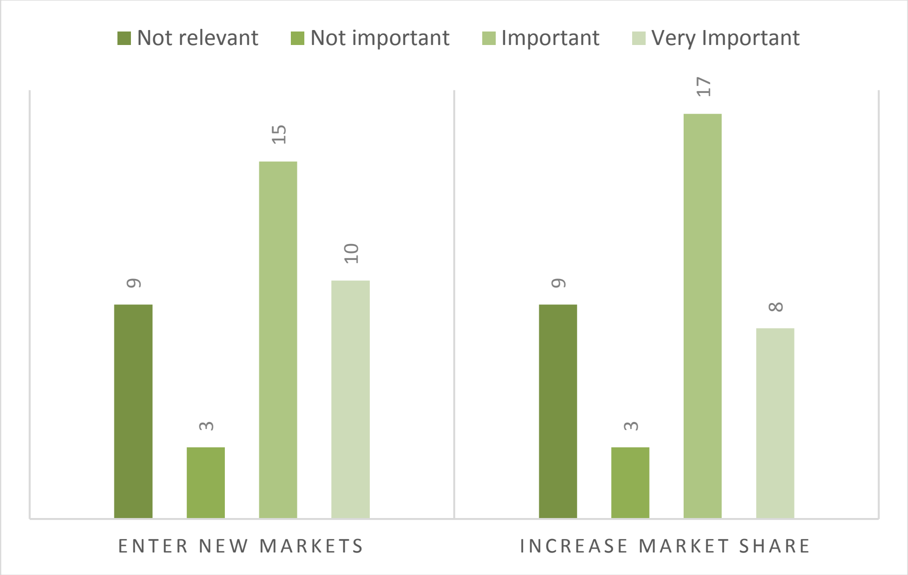
As for the process itself, future production technology is considered more important as a way of creating a more flexible production process rather than as a means for increasing the volume of production (see Figure 4). Respondents appear to be in general agreement that an important motive for investing in future production technology is to enter new markets and/or to increase their existing market share (see Figure 5).

Figure 4: Process-related Motives for Investments in Automation



Note: numbers in the graph indicate the number of observations

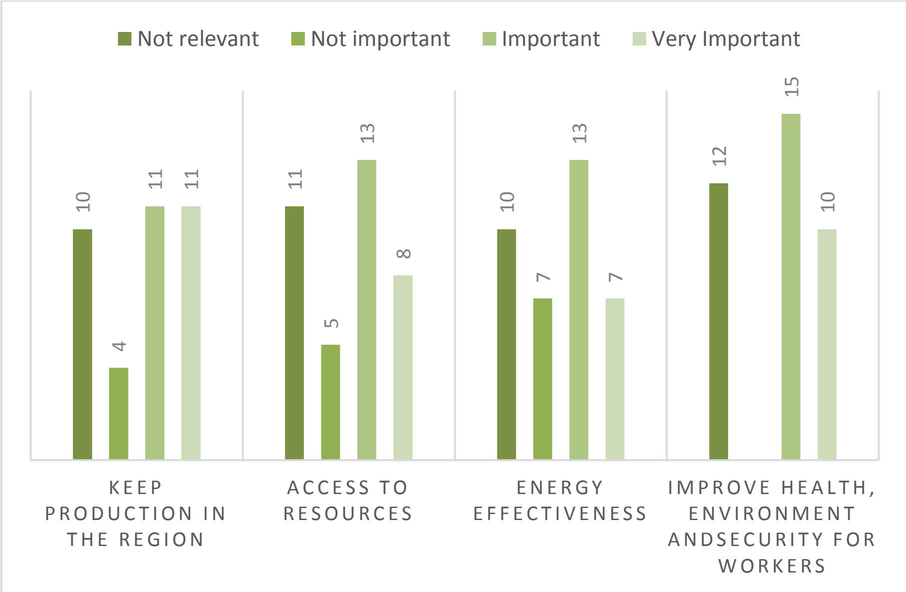
Figure 5: Market-related Motives for Investments in Automation



Note: numbers in the graph indicate the number of observations

In addition to the more economic motives listed above, Figure 6 shows other motives as to why firms would like to invest in future production technologies. In this category, one of the main motives is the expectation that these technologies will improve the health, work environment and security of workers. Some other motives listed include keeping production in the region (which is relevant in light of offshoring of manufacturing activities that will be discussed later in this report), access to resources, and energy effectiveness. Some indicate, however, that these are not important motives at all.

Figure 6: Other Motives for Investments in Automation

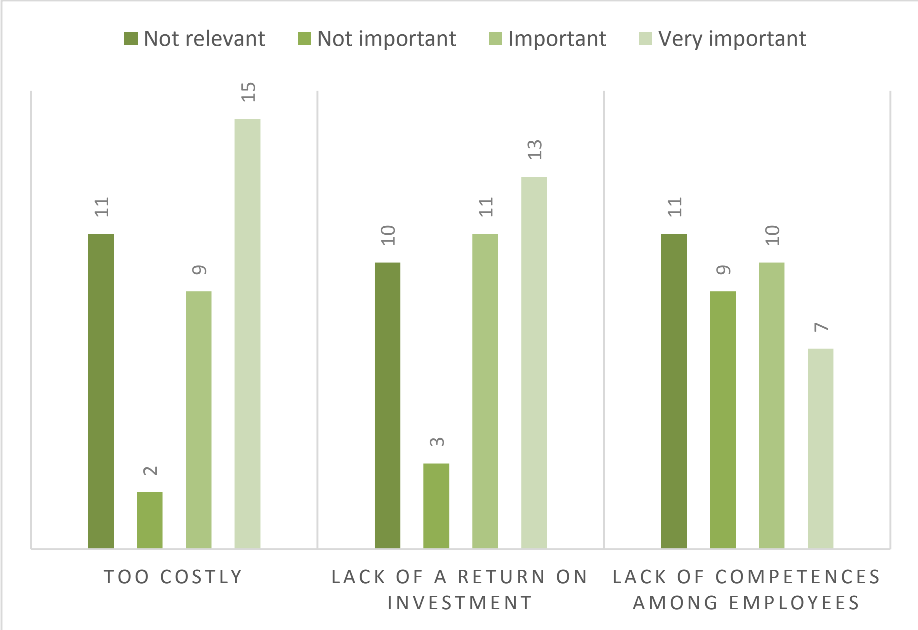


Note: numbers in the graph indicate the number of observations

Investments in Future Production Technology - Barriers

In contrast to the motives for investing in these technologies, there are also a set of barriers (see Figure 7, Figure 8 and Figure 9). As illustrated by Figure 7, the main barriers for investing in this type of technology are that these investments are too costly and/or there is the expectation that the investments would not lead to the necessary returns of investment. Lack of competence among employees, plays a role in the investment decisions as well. The availability of competencies is also an important motive explicitly mentioned by the respondents for investing in these technologies in general.

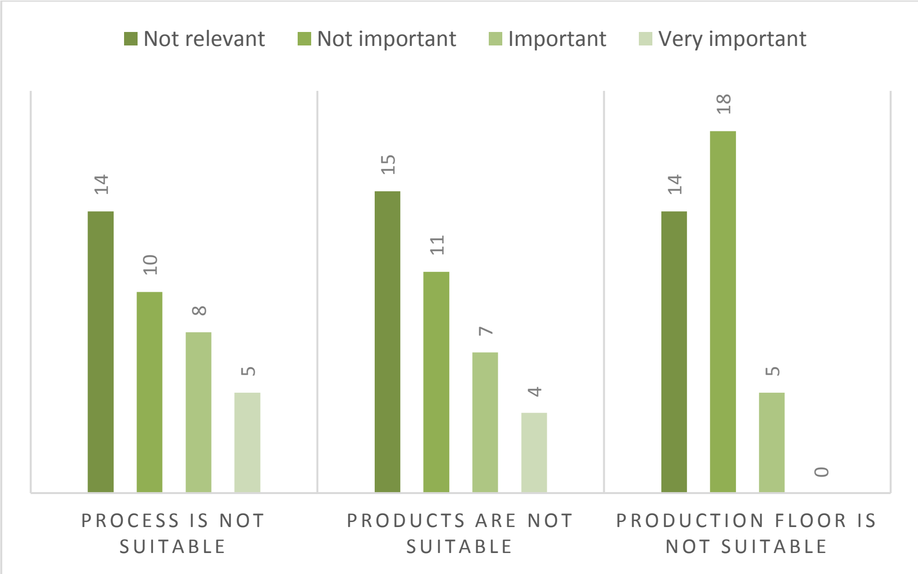
Figure 7: Barriers to Investments - Financial and Competences



Note: numbers in the graph indicate the number of observations

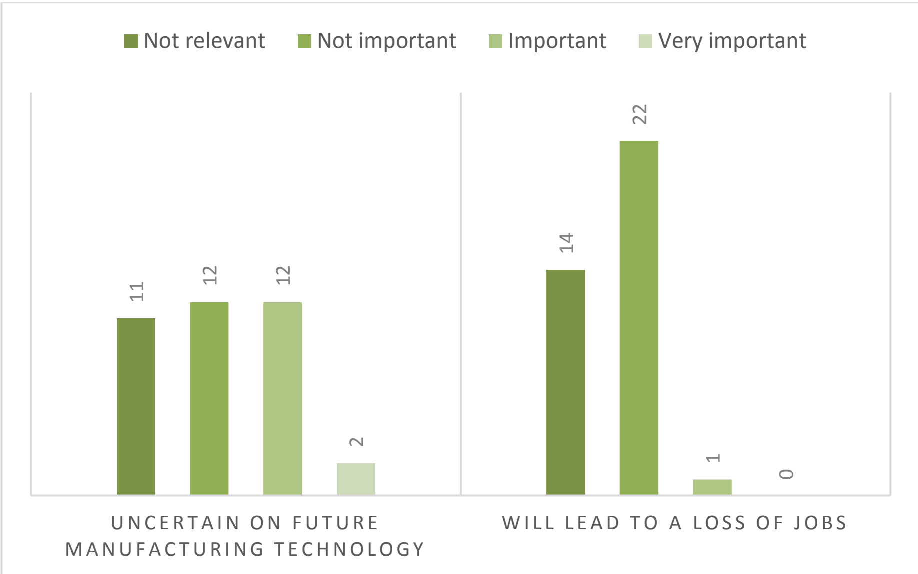
As for the suitability of current products, processes and the available place on the production floor, these are not regarded as barriers for the respondents (see Figure 8). The factors how this production technology potentially affects the number of jobs and the uncertainty concerning what this future technology will be, are only regarded as barriers to a limited or to some extent (see Figure 9).

Figure 8: Barriers to Investments – Suitability of Processes and Products



Note: numbers in the graph indicate the number of observations

Figure 9: Barriers – Uncertainty and Job Loss



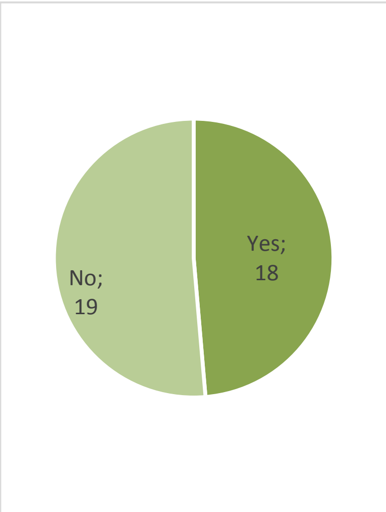
Note: numbers in the graph indicate the number of observations

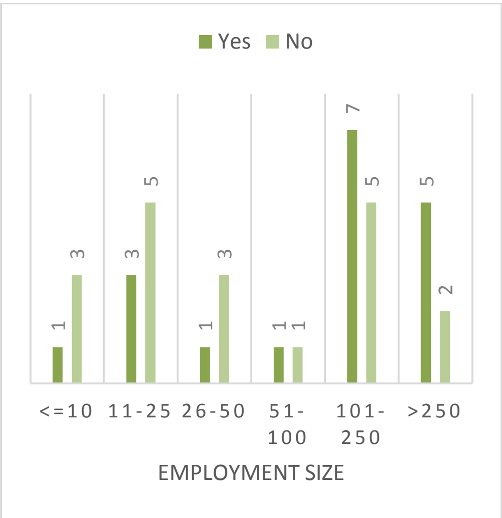
Industrial Future

A large number of the firms we contacted are involved in the *Future Robotics* project. Consequently, many of them have been introduced to the concept of *Industry 4.0*, including terms like *Industrial Internet* and the *Internet of Things*. Around 50 percent (see Figure 10) of the respondents also indicate knowledge of these concepts and, when asked to describe it, give a rather accurate appraisal. Those who stated that they have knowledge about the concept interpreted it as the use of internet in their production technology. Only a few mentioned or referred explicitly to the revolutionary nature of the change in the production process that included the adaptation of advanced manufacturing equipment in addition to the use of communication technologies.

Those who responded positively about having familiarity with the concept were mainly large organizations. In addition, it turned out that familiarity with the concept was confined primarily to members of GCE NODE and Eyde Cluster.

Figure 10: Familiarity with the Concepts of Industry 4.0

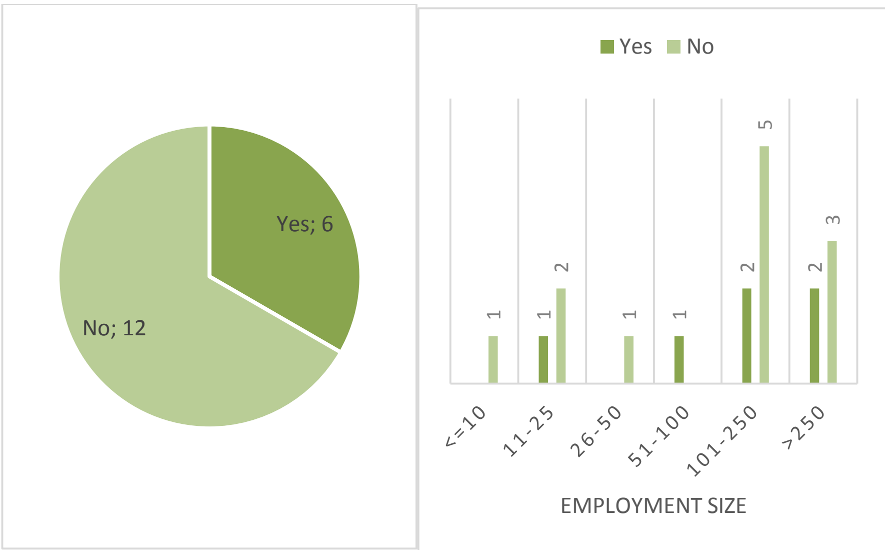




Note: numbers in the graph indicate the number of observations

Of those who are familiar with the concept, only six respondents, again larger firms, answered that they are currently putting features of Industry 4.0 into operation (see Figure 11). Two of these firms also are in the process of changing their business model as a result.

Figure 11: Are implementing Features of Industry 4.0 (n=18)

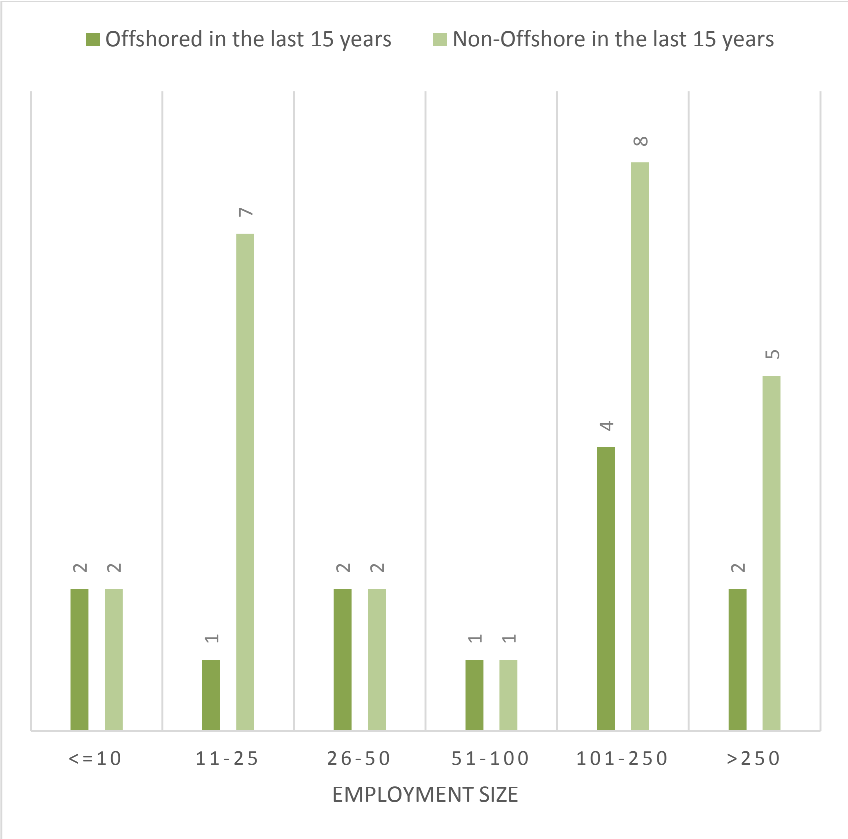


Note: numbers in the graph indicate the number of observations

4 Offshoring and Reshoring

The final part of the survey looks into the extent to which the sample firms have engaged in offshoring and reshoring. Offshoring occurs when a firm has moved production activities previously conducted in the region abroad. Reshoring occurs when these activities are moved back again.

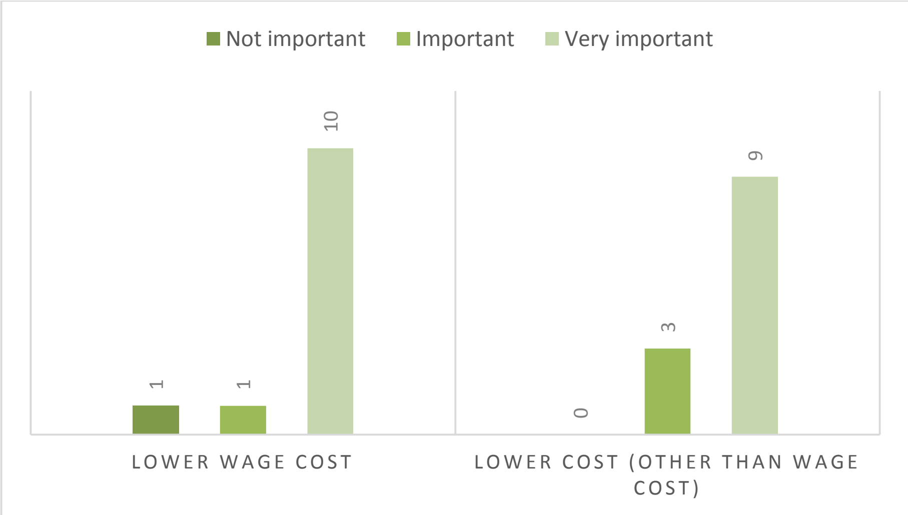
Figure 12: Offshoring of manufacturing activities in the last 15 years (n=37)



Note: numbers in the graph indicate the number of observations

During the last 15 years, 12 of the 37 firms (32.4 percent) in the study indicate that they have moved production activities abroad, primarily to Central and Eastern Europe. By definition, they have offshored their production (see Figure 12). Several mention cost motives as being the main driving force for this offshoring process (see Figure 13). Other motives often attributed to the offshoring phenomenon, including access to skills and competences, regulation, and access to new markets, are not regarded as very important by the firms in this study (see Figure 14 and Figure 15).

Figure 13: Motives for Offshoring – Costs (n=12)

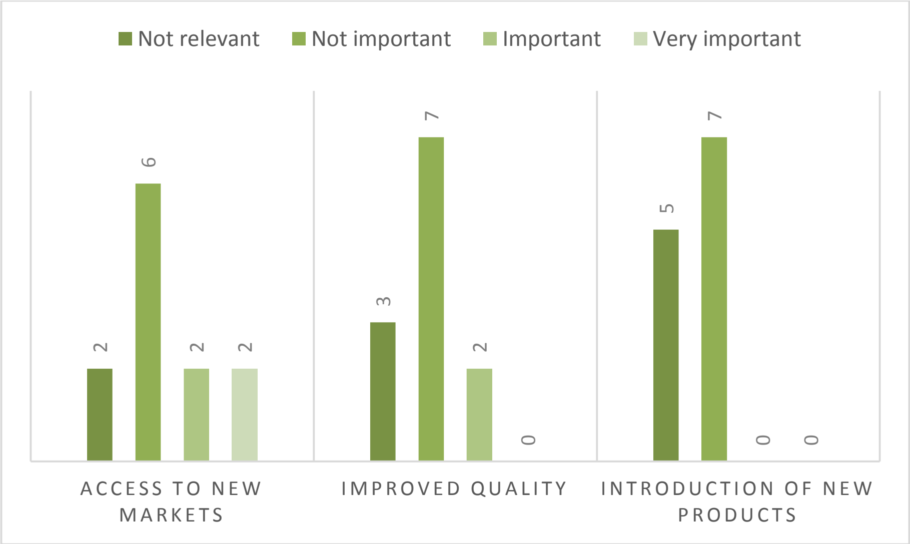


Note: numbers in the graph indicate the number of observations

Figure 14: Motives for Offshoring - Skills and Competences (n=12)

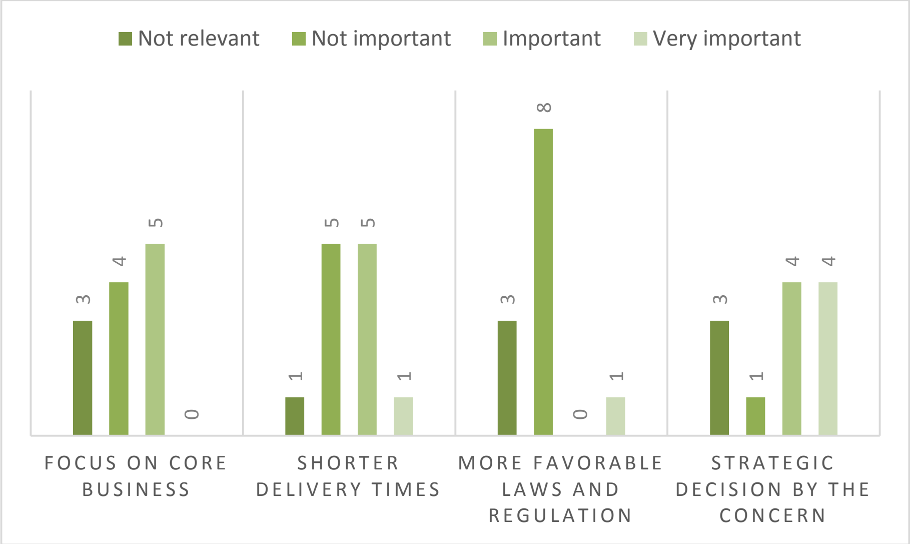
Note: numbers in the graph indicate the number of observations

Figure 15 Motives for Offshoring - New Markets and Products (n=12)



Note: numbers in the graph indicate the number of observations

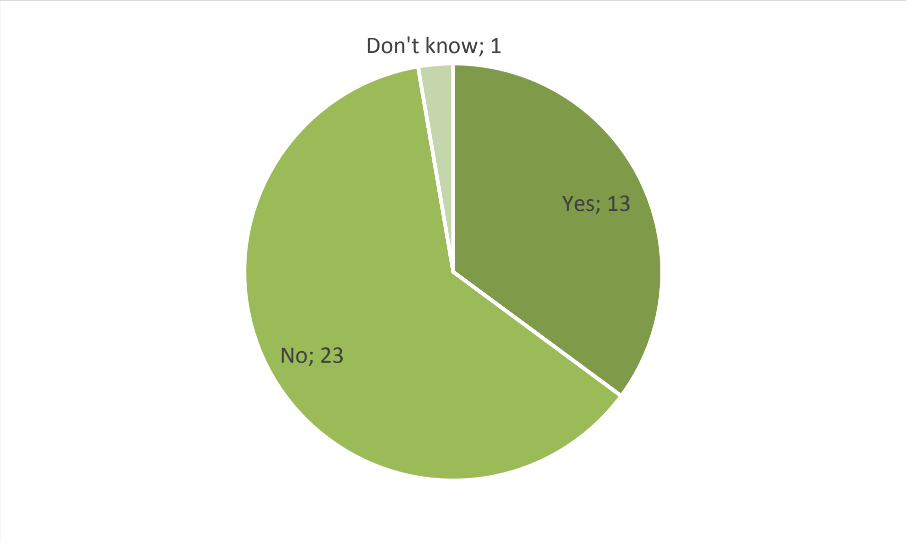
Figure 16: Motives for Offshoring – Other (n=12)



Note: numbers in the graph indicate the number of observations

In addition to having offshored manufacturing activities, we also asked the respondents if they have ever considered offshoring manufacturing but in the end did not proceed. As illustrated in Figure 17, thirteen firms (out of 37) considered offshoring manufacturing activities but did not proceed. Among those that did not proceed, five respondents have previously offshored manufacturing while eight have not (see Table 4).

Figure 17: Considered (additional) offshoring but decided not to offshore



Note: numbers in the graph indicate the number of observations

Table 4: Considered (additional) offshoring but decided not to offshore

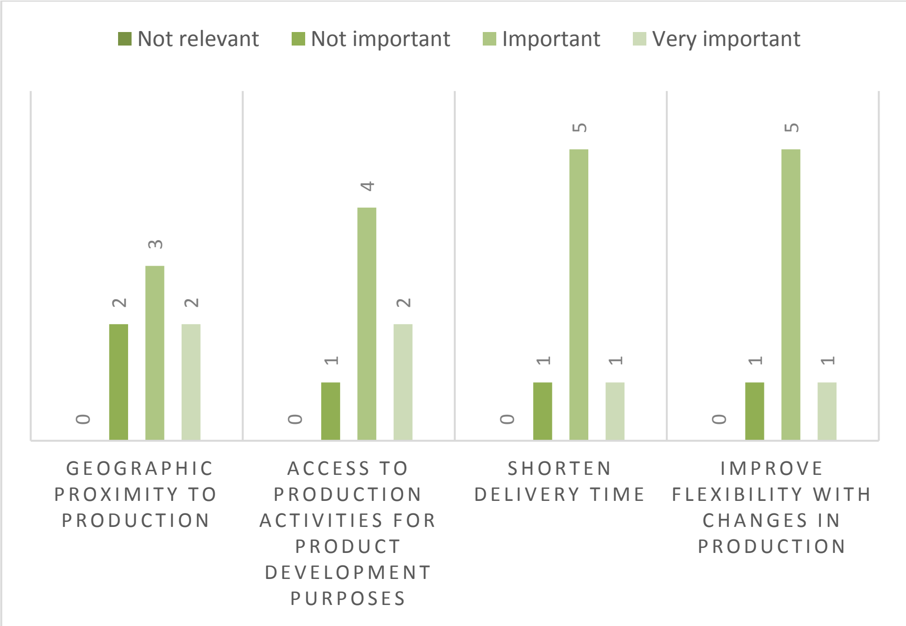
	Yes	*No*	*Total*
Offshore in last 15 years	5	6	12
Non-offshore in the last 15 years	8	17	25
Grand Total	**13**	**23**	**37**

The reasons why they did not pursue the offshoring activities vary. Some of these reasons are; lack of cost savings, too low volume in production, availability of skills and competences in other countries, and finally that they prefer to invest in new machinery rather than moving out production as a method to save the costs of production. Nevertheless, many also mentioned that the off-shoring option remains open.

For the 12 firms that have offshored their production activities, three firms have indicated that they have subsequently moved activities back to Norway while another five mentioned that they are planning to move activities back to Norway in the near future. The motives for why this reshoring is taking place are presented in Figures 18 to 22.

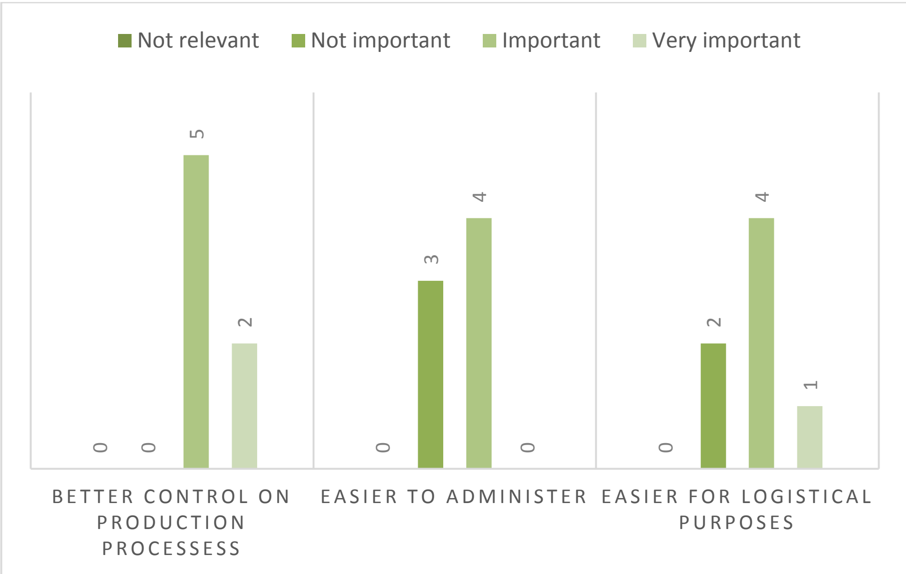
One important motive for reshoring mentioned by the respondents is proximity (see Figure 18). This involves proximity to the general production process, but also takes into consideration the fact that production might play an important role in product development (the factory as a laboratory). Other motives mentioned are in the organizational sphere, where respondents have highlighted that there is an improved control of production processes when they are located at home, as well as easier administration and logistic benefits (see Table 19).

Figure 18: Motives for Reshoring - Proximity (n=7)



Note: numbers in the graph indicate the number of observations

Figure 19: Motives for Reshoring – Organizational (n=7)



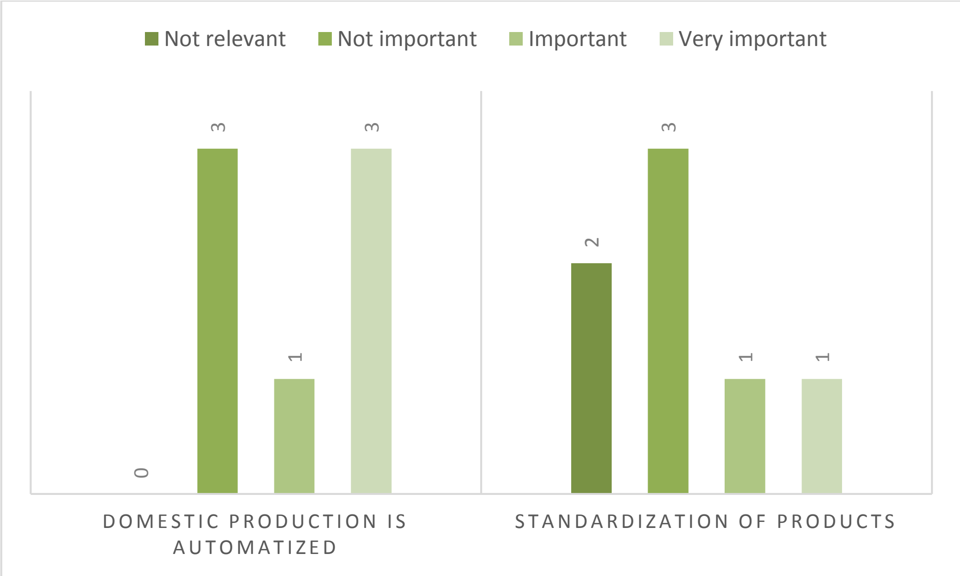
Note: numbers in the graph indicate the number of observations

Automation of production is also listed as a motive for bringing production back to Norway. Standardization of products is important for two firms in our sample. This seems, however, to contradict the accepted wisdom that offshoring in high cost markets, instead of reshoring, is associated with higher levels standardization (see Figure 20). This because lower complexity allows production to take place where it is cheapest.

The availability of skills and knowledge in the region (and lack of these skills and competences in the offshore location) is also an important motive for firms to relocate domestically. Conversely, improving the quality of the product and the introduction of new products seems to play a less important role in the reshoring decisions (see Figure 21).

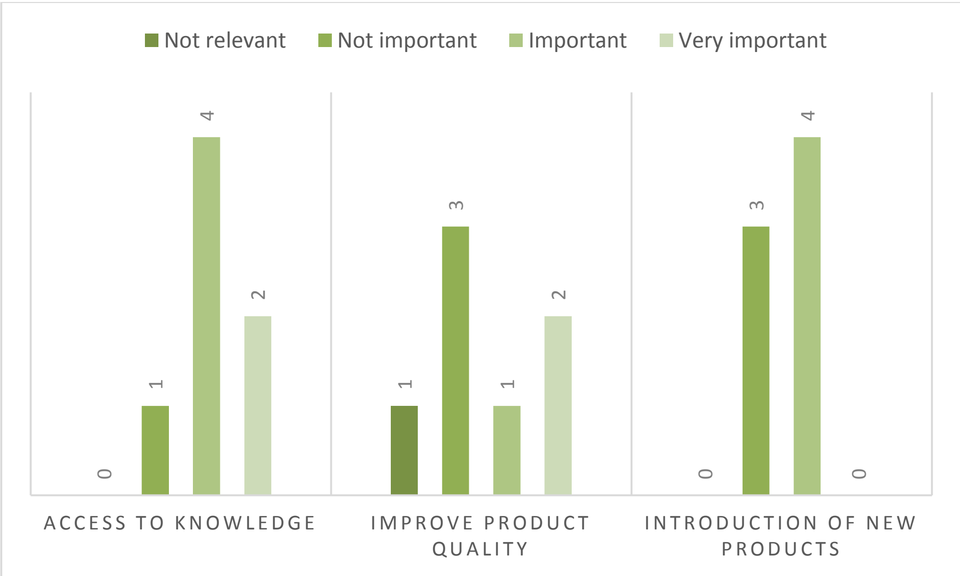
Figure 22 illustrates that the main motivation for reshoring or wanting to reshore by respondents is associated with the cost associate with production abroad compared to production at home. More in depth analysis among these firms might shed more light on which cost dimension are at play. A more relaxed legislative environment and better tax conditions hardly plays any role in the reshoring decision, whereas strategic decisions by management plays a role to some degree.

Figure 20: Motives for Reshoring - Automation and Standardization (n=7)



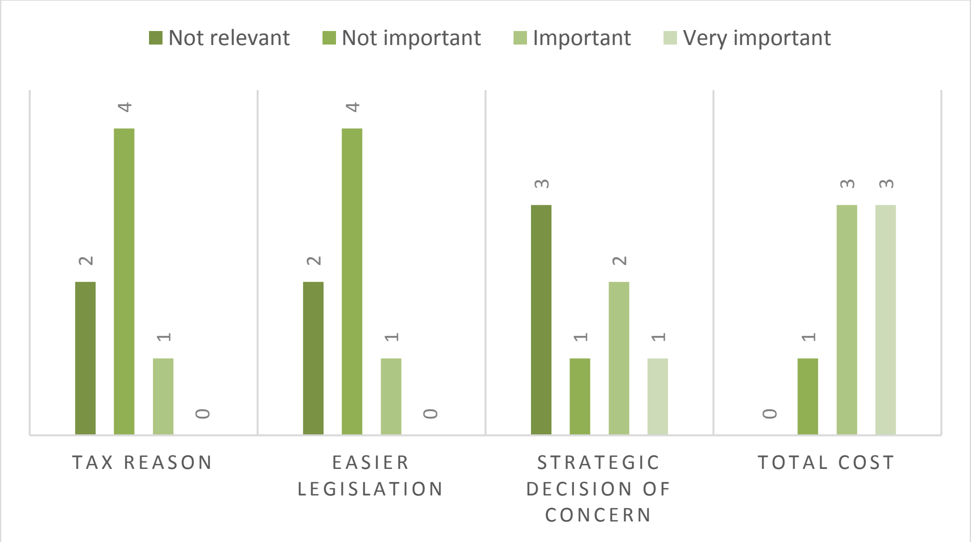
Note: numbers in the graph indicate the number of observations

Figure 21: Motives for Reshoring - Knowledge and innovation (n=7)



Note: numbers in the graph indicate the number of observations

Figure 22: Motives for Reshoring – Other (n=7)



Note: numbers in the graph indicate the number of observations

5 Analysis

Based on the analysis conducted among the 37 organizations that are a member of GCE Node, Eyde Cluster, DIGIN, Lister Alliance, SINPRO and STN, we observe that it is primarily larger organizations in these clusters that employ more advanced forms of process technology in their organizations. The adoption of these technologies varies to a large extent. More advanced manufacturing technologies apparently are only used by a small number of these firms, as only a few indicated using robot technology and/or additive manufacturing (3D printing) in their production process. Furthermore, the distribution of robots (and 3D printers) among these organizations is highly skewed, meaning that only a few firms have two or more of these types of machines and thus can be regarded as advanced users. Contrary to the findings for the use of advanced machinery, organizations tend to a larger degree to use data systems and digital communication in their production process, but again this is mainly limited to larger organizations in the clusters.

The main motives for firms to consider investing in new production technologies is to decrease costs and/or improve quality of products, increase flexibility (more important) and capacity (less important) of the production process, enhance the ability to enter new markets and/or increase market share, and/or to improve the health, work environment and security of workers. Some firms also see it as means to preserve production in the region, mainly due to the decrease in cost per unit that these investments are expected to give. The main barriers for investment in these technologies relates to the overall expenses involved with introducing such type of technology in the production process and the uncertainty about the technology at large.

Nearly half of the respondents indicated that they are familiar with the concepts of Industry 4.0, Internet of Things, and/or Industrial Internet. It is mainly the companies that are members of GCE NODE and Eyde Cluster that report familiarity with these concepts. It is reasonable to posit that cluster activities might have contributed to spreading the information about, and knowledge of these concepts.

As firms in our sample are active in production, it is not surprising to see that many firms have moved some of their activities abroad (33 percent). Furthermore, the motives for doing so are not surprising either. Costs, primarily wages, are the main motivation for everyone that has moved activities abroad. Other factors commonly associated with offshoring, like lack of qualified labor (4 respondents) and proximity to markets (6 respondents), only played a minor role. More interesting, however, is that 13 (out of 37) of the respondents have considered offshoring manufacturing activities but decided not to proceed. Despite this decision, they continue to evaluate whether they should move regularly.

More recently, there has been considerable attention paid to reshoring, i.e. the return of offshored (production) activities. Among the cluster organizations that have been reshoring production, nearly half of them indicated that they have done so primarily to be located in geographic proximity to the head office. Despite the overall low number, this finding is interesting and calls for further investigation.

6 Conclusion

Small vs Large Organizations

The study has demonstrated that the organizations in our study are not unfamiliar with the introduction of advanced machinery in their production process. However, there are large differences between firms on whether and to what extent they use this technology. We emphasize again that a small set of firms account for the majority of machines used. What particularly plays a role is firm size measures in number of employees. In any population of firms, small and medium-sized enterprises are those most represented. The question that arises is whether new production processes are only of value for large organizations or whether smaller organizations can reap the benefits of these technologies as well, and if so, how. One might also speculate as to what extend smaller firms should collectively own these technologies like, for example, firms have outsourced/rented 3D printing equipment.

Cluster members vs non-cluster members

This study is confined to cluster members in the larger cluster organizations in the region of Agder. Consequently, it might not be surprising that firms in these sectors appear to have familiarity with the technologies listed in this study. Because this research is confined to cluster organizations, it raises the question about how generalizable these findings are to the population of manufacturing firms in Agder. Firms that are member of these cluster organizations are among the (regional) leaders in the industry; consequently, they might also be leading in automation and thus not representative for manufacturing in Agder as a whole. This leads us to conclude that a larger scale study might fit well in the recently launched national Industry 4.0 initiative.

Cluster organizations as a vehicle of knowledge diffusion

What this study demonstrates is the role of cluster organizations in informing cluster members about developments in production processes. Those cluster organizations that lead have a higher share of members that are familiar with concepts like *Industry 4.0*, *Industrial Internet* and *The Internet of Things*. However, there is an information barrier for smaller organizations and the question must be asked as to how these smaller organizations can be reached and how they can internalize information about such fundamental, competitive issues.

Offshoring and reshoring

Given the often traditional-industry nature of these firms, it was expected that a large share of the organizations in the sample had engaged in offshoring (nation-wide surveys score lower on the share of firms that offshore production compared to the sample of this study). The motives for offshoring are in line with this expectation, i.e. offshoring driven by cost motives. In contrast, what is extremely interesting and definitely deserves more attention are those instances where firms have moved production back to the region. Given the context of high (wage) cost, understanding better their motives for reshoring and the type of production activities that return (are these more high-skilled production activities) should be of interest for practitioners, politicians and academics alike.

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Appendix A: Survey

SPØRREUNDERSØKELSE FOR PROSJEKTENE "FUTURE ROBOTICS" OG "RE-INDUSTRIALISERING"

Mitt første spørsmål er om du har mulighet til å delta i denne undersøkelsen:

(1) ❑ Ja

(2) ❑ Nei

Passer det at vi gjennomfører undersøkelsen nå?

(1) ❑ Ja

(2) ❑ Nei (avtal et tidspunkt) _____

SEKSJON 1: OM PRODUKSJONSPROSESS OG AUTOMATISERING OVERORDNET

S1: Hvilken bransje tilhører din bedrift?

____

S2a: Hvor mange ansatte har bedriften i Agder?

_____

S2b: Hvor mange av dem jobber i produksjon?

_____

S3: I hvilken grad vil du vurdere nivået for automasjon i deres produksjon?

(1) ❑ 1 = Enkeltstående maskiner som krever høy grad av bemanning/ interaksjon av operatør

(2) ❑ 2

(3) ❑ 3 = Medium

(4) ❑ 4

(5) ❑ 5 = Produksjonen er helautomatisert

(6) ❑ vet ikke

SEKSJON 2: TYPER AV MASKINER OG TEKNOLOGI SOM BENYTTES

S4: I din organisasjon: hvilke av de følgende maskintyper brukes i produksjonsprosessen i Agder?

	Ja (også skriv antall)	Nei	Vet ikke
Industriell robot (Industrial Robot)	(1) ❑ ____	(2) ❑	(3) ❑
Laboratorie-robot (Lab-robot)	(1) ❑ ____	(2) ❑	(3) ❑
3D printer for modeller i plast/prototyping	(1) ❑ ____	(2) ❑	(3) ❑

	Ja (også skriv antall)	Nei	Vet ikke
3D printer for deler i metall	(1) ❑ ____	(2) ❑	(3) ❑
Maskiner som kommuniserer med andre maskiner uten inngrep av operatører.	(1) ❑ ____	(2) ❑	(3) ❑
Maskiner knyttet til OPC (OPC er en kommunikasjons-protokoll)	(1) ❑ ____	(2) ❑	(3) ❑
PLS systemer (det er en type styringsenhet for et regule-ringsteknisk system)	(1) ❑ ____	(2) ❑	(3) ❑
DCS systemer (En type sty-ringsenhet for et regulerings-teknisk system)	(1) ❑ ____	(2) ❑	(3) ❑
3D-skannere/3D Vision ka-mera knyttet til automatiserte systemer	(1) ❑ ____	(2) ❑	(3) ❑

S5: Bruker dere datasystemer og digital kommunikasjon i produksjonen på følgende måter?

	Ja	Nei	Vet ikke
Er bedriftens datasystemer integrert (f.eks. Enterprise Resource Planning (ERP)-system) med eksterne bedrifter?	(1) ❑	(2) ❑	(3) ❑
Brukes automatisk innhentet data fra eksterne bedrifter til styring av produksjonen? (F.eks avrop, leveringstider el.)	(1) ❑	(2) ❑	(3) ❑
Brukes det “track-and-trace”-teknologi i produksjonsprosessene?	(1) ❑	(2) ❑	(3) ❑
Er sensorikk implementert for å styre produksjonsflyten eller	(1) ❑	(2) ❑	(3) ❑

	Ja	Nei	Vet ikke
kople systemer eller maskiner sammen?			
Gjennomføres forbedringer i produksjon gjennom online kontroll av prosesser?	(1) ❑	(2) ❑	(3) ❑
Brukes data (automatisk) inn-hentet fra produksjon til fore-byggende vedlikehold?	(1) ❑	(2) ❑	(3) ❑
Trådløse nett i produksjons-systemer	(1) ❑	(2) ❑	(3) ❑
Feltbus mot instrumenter og motorer	(1) ❑	(2) ❑	(3) ❑

SEKSJON 3: MULIGHETER OG UTFORDRINGER

S6a: I din organisasjon; hvor viktig er følgende faktorer for at dere investerer i framtidens produksjonsteknologi?

	Meget viktig	Viktig	Ikke viktig	Ikke relevant
Øke utvalget av varer eller tjenesteytelser	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Erstatte foreldede produkter, prosesser eller arbeidsmåter	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Komme inn på nye markeder	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Øke markedsandel	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Forbedre kvaliteten av varer eller tjenester	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Forbedre helse, miljø og sikkerhet til medarbeiderne	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Øke fleksibiliteten i fremstilling av varer eller tjenesteytelser	(1) ❑	(6) ❑	(7) ❑	(8) ❑

	Meget viktig	Viktig	Ikke viktig	Ikke relevant
Øke kapasiteten i fremstilling av varer eller tjenesteytelser	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Redusere omkostninger pr. produsert enhet	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Beholde produksjonen i regionen	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Ha kontroll på produktutviklingen (innovasjonsevne)	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Tilgang på ressurser (f.eks. råvare)	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Energieffektivitet	(1) ❑	(6) ❑	(7) ❑	(8) ❑

S6b: Er det andre faktorer som ikke er nevnt som dere vurderer som viktig?

____

____

S7a: Hva ser du på som hovedutfordringen og barriere mot å investere i framtidens produksjonsteknologi?

	Meget viktig	Viktig	Ikke viktig	Ikke relevant
Kostnader	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Mangel på kompetanse blant medarbeidere	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Vil medføre tap av arbeidsplasser	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Prosessen er ikke egnet	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Produktet er ikke egnet	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Lokaler er ikke egnet	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Mangel på inntjening	(1) ❑	(6) ❑	(7) ❑	(8) ❑
Usiker på hva som er fremtidens teknologi (mange konkurrerende teknologier).	(1) ❑	(6) ❑	(7) ❑	(8) ❑

S7b: Er det andre utfordringer og barrierer som ikke er nevnt som dere vurderer er viktige?

____

SEKSJON 4: INDUSTRIELL FREMTID

S8: Kjenner du til konseptet Industri 4.0 eller uttrykket den fjerde industrielle revolusjon, Industrial Internet, eller Internet of Things?

(1) ☐ Ja

(2) ☐ Nei

S9a:Hva er din forståelse av disse begrepene? Industri 4.0 eller uttrykket den fjerde industrielle revolusjon, Industrial Internet, eller Internet of Things?

____

S9b: I din organisasjon; er dere i gang med implementering av industri 4.0, Industrial Internet, eller Internet of Things?

(1) ☐ Ja

(2) ☐ Nei

S9c: I din organisasjon; kjenner du til om forretningsmodellen vurderes å endres/revideres på bakgrunn av Industri 4.0, Industrial Internet, eller Internet of Things (for eksempel tjenester knyttet til produktet)?

(1) ☐ Ja

(2) ☐ Nei

SEKSJON 5: OFFSHORING OG RESHORING

S10: I de siste 15 år har din bedrift flyttet produksjon utenlands som tidligere ble utført i Agder?

(1) ❑ Ja

(2) ❑ Nei

(3) ❑ Vet ikke

S11: Hva var de viktigste motiver for offshoring?

	Meget viktig	Viktig	Ikke viktig	Ikke relevant
Lavere lønnomkostninger	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Lavere omkostninger (utover lønnomkostninger)	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Adgang til nye markeder	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Mangel på kvalifisert arbeids-kraft i Norge/regionen	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Adgang til spesialisert kunn-skap og teknologi	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Forbedret kvalitet	(1) ❑	(2) ❑	(3) ❑	(4) ❑

	Meget viktig	Viktig	Ikke viktig	Ikke relevant
Introduksjon av nye produkter	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Fokus på virksomhetens kjer-neaktivitet	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Kortere leveringstid	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Enklere lovgivning/regulering	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Strategisk beslutning tatt av morselskapet	(1) ❑	(2) ❑	(3) ❑	(4) ❑

S12: Til hvilket land har dere flyttet produksjon?

____

S13: I hvilken grad har dere offshoret følgende:

	Ingen	Liten grad	Noen grad	Høy grad	Vet ikke
Hel produktlinje	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Delkomponenter	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

S14: I de siste 5 år har din bedrift flyttet produksjonsaktivitetene tilbake til Norge?

(1) ❑ Ja

(2) ❑ Nei

(3) ❑ Vet ikke

S15: I de neste 5 år, har din bedrift planer om å flytte tilbake produksjonsaktivitetene til Norge?

(1) ❑ Ja

(2) ❑ Nei

(3) ❑ Vet ikke

S16: I hvilken grad har følgende hatt betydning for at produksjonen ble flyttet tilbake til Norge?

	Meget viktig	Viktig	Ikke viktig	Ikke relevant
Geografisk nærhet til produksjon	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Tilgang på produksjonskompetanse viktig for innovasjon og produktutvikling	(1) ❑	(2) ❑	(3) ❑	(4) ❑

	Meget viktig	Viktig	Ikke viktig	Ikke relevant
Enklere administrasjon av bedriften	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Enklere logistikk	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Øke fleksibilitet ved endringer i produksjon	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Produksjonen hjemme opp-gradert med automatisert ut-styr	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Standardisering av produktet	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Total kostnad	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Tilgang til kunnskap og tekno-logi	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Forbedre produktkvalitet	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Introduktion af nye produkter	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Kortere leveringstid	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Bedre kontroll på produksjonsprocessen	(1) ❑	(2) ❑	(3) ❑	(4) ❑

	Meget viktig	Viktig	Ikke viktig	Ikke relevant
Enklere lovgivning/regulering	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Strategisk beslutning taget af moderselskabet	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Skatteforhold	(1) ❑	(2) ❑	(3) ❑	(4) ❑

S17a Har dere tidligere vurdert å flytte ut produksjonen men likevel ikke gjort det?

(1) ❑ Ja

(2) ❑ Nei

(3) ❑ Vet ikke

Hvorfor?

____

S17b Har dere planer om ytterligere investeringer for deres produksjonsanlegg i Agder?

(1) ❑ Ja

(2) ❑ Nei

(3) ❑ Vet ikke

AVSLUTNING

Kan vi kontakte deg for utdypende spørsmål på bakgrunn av de svar du har gitt i undersøkelsen

(1) ❑ Ja

(2) ❑ Nei

Vil du bli informert om resultatene av undersøkelsen?

(1) ❑ Ja

(2) ❑ Nei

Hvis ja, vennligst oppgi e-post adresse: ______________________________

R&D information

Title	Automatization and re-industrialization - A zero-point analysis of robotization in industrial sectors in Agder
Project no.	2162
Title of assignment	Nullpunktsanalyse Future Robotics/Re-industrialisering
Project manager	Sissel Strickert
Authors	Bram Timmermans, Sissel Strickert and Kristin Wallevik
Client	GCE NODE on behalf of the projects Future Robotics and re-industrialisering
Type of report	Project-report
Report no.	3/2016
ISSN	0808-5544
Report available on	www.agderforsking.no
List of subject terms	Industry, robotization, automation, industry 4.0, fourth industrial revolution, offshoring, reshoring

Abstract - This survey is executed on behalf of the industrial clusters in Agder represented by GCE NODE (principal), Eyde Cluster , DIGIN , Lister Alliance, SINPRO and Sørlandsporten teknologinettverk. The object of the report is to conduct a baseline analysis of industrial robots in the industry clusters.
I addition a mapping of offshoring and reshoring activities in the same businesses. It is conducted 37 interviews with representatives from member companies in the 6 clusters.