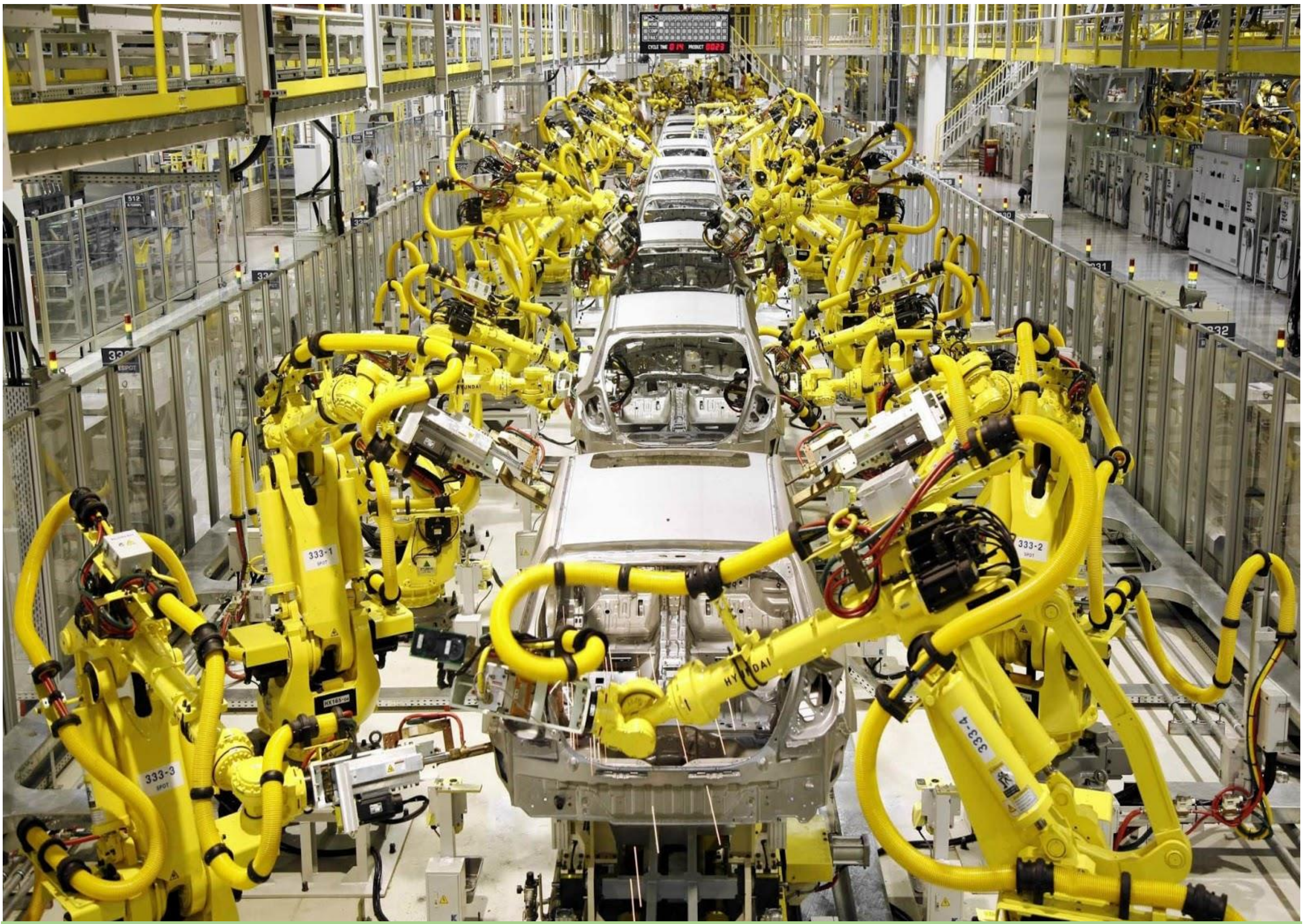

Industrial Robots in China Market Outlook

Master Thesis

June 2014

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&
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Industri Roboter i Kina
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Industrial Robots in China
Market Outlook

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Abstract

This thesis investigates the future development of industrial robots in China. It will focus on growth in robot sales toward China and try to identify which companies that are most capable of benefiting from the potential growth. A triangulation approach is applied, where both qualitative and quantitative methods is utilized. SWOT, discrete data and panel data analysis supports our conclusion about a strong growth in China. Porter`s Five Forces and financial analysis have pointed out interesting companies relative to China, such as the German based company KUKA. The thesis uses interviews as a source to qualitative information, adding firsthand business knowledge about the subject. In addition, quantitative data have been collected from The International Federation of Robotics and Morgan Stanley research department.

From 2005-2013 the robot sale in China has increased with a compounded annual growth rate of 30%. The key result suggests that the current situation in China indicates a promising future growth of industrial robots. The growth potential in China is a direct consequence of the small robot density in the country, compared to other industrialized countries. China is a manufacturing –based and export-oriented economy. Modernization of the manufacturing sector in China needs flexibility and effectivity upgrades. The aging population together with rising wages are necessitating automation of production processes. The tremendous growth experienced in the automobile industry intensifying the opportunity to robotize. The automotive industry has the highest density of industrial robots.

The thesis also concludes that domestic robot producers and the foreign company KUKA should experience a rapid growth in sales as a consequence of the growth in the Chinese market. Further analysis on domestic companies is required to explore potential domestic investment objects.

Key words: Industrial robots, robot density, China, ageing population, rising wages, motor vehicle production, KUKA, SWOT, Panel Data, Porter`s Five Forces

Acknowledgments

Several people have one way or another been involved in the completion of the thesis, whether it has been interviews, data or guidance. We have established relationship with useful contacts and we are grateful for all the support and rewarding conversations during the progress.

First, we would like to thank our advisor, Associate Professor Randi Næs, for her useful guidance under the process of writing the thesis.

We would also like to thank Ole Søeberg and Henning Warner at Skagen Funds, who introduced us to the topic, provided exclusive and helpful papers and served very tasty coffee.

The following attention goes to our interviewees:

- Thank you Steinar Olsen-Sund and Ivar Storesund from Solstad Shipping
- Thank you Jean March Launay from RobotNorge AS
- Thank you Jostein Alendal from Reach Subsea
- Thanks you Christian Kerlefsen and Steinar Riveland from ABB Robotics Bryne

Others:

- Thank you assistant Professor Morten Mossige for introduced us to ABB Robotics Bryne and RobotNorge AS
- Thank you William Gjelde for your assistance with the panel data analysis
- Thank you Inger Gåsemyr from the library at University in Stavanger for approving the purchase of the IFR Statistics

«I think there is a world market for maybe five computers. »

Thomas Watson, chairman of IBM, 1943

Foreword

Ole Søeberg
(Skagen Funds, 2014)

By: Ole Søeberg, portfolio manager in Skagen Funds

Dear reader, since the invention of the wheel humans have strived to become more and more productive in the quest of survival. It has certainly not been a straight line forward as nature and human conflicts has made progress cumbersome from time to time.

However, looking at the past 2-300 years then the Cultural Revolution in Western Hemisphere has created a background, which has made it possible for business and innovation to create a huge increase in affluence and general welfare. Trivial jobs got automated and hence much more productive. A few obvious illustrations of this are steam trains, car factories, flying machines and computers. Just image today`s society without these machines – that would most likely be a less productive and less affluent society.

Robotics as idea was introduced in 1920, however the complexity of making reliable robots in even simple production processes have proved to be more difficult that hoped for in the early days.

Faster processing in computers and software has improved the robotics outlook significantly in the past 10-20 years. The automotive industry is prime example due to lots of routine processes. However, thanks to much improved processing power, the robotics industry is likely to break into new grounds.

In Skagen Funds we monitor many new trends and how this can impact old industries and businesses and potentially create new industries and businesses. The robotics industry stands out as one of the most promising and yet disruptive technology land wins yet to be seen. The big hurdle is however to get the unit cost down as advanced robotics are not commercially competitive with humans as soon as the movements and processes are a bit more sophisticated.

Automated driving will make bus, taxi and truck drivers obsolete in due course, hence releasing their workforce to other and more productive uses. While the automotive industry is moving fast towards self-drive vehicles, the industrial and service robots at low unit costs are still years out in the future.

When Hans Kristian and Joachim approached Skagen for input for their thesis on robotics, I welcomed this a lot. It provides a good opportunity to get some ‘deep dive’ analysis of industry structure, prospects and status. Also, I think it is valuable for the students to take a look at robotics with ‘new eyes’ and bring the technological and commercial findings to the robotics opportunity.

When the steam train and flying machine was invented many doomsday predictors foresaw massive unemployment of people in the horse industry, canal transports and sailors as such, but history shows that humans have formidable mindset to adjust to new technology and get to next level of affluence. Let us see if robotics is not just another leap forward on the human innovation ladder.

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1 Preface

Skagen Funds announced an exclusive offer for all graduate business students at the University of Stavanger, namely a collaboration opportunity with the thesis. The core mission portrayed in the first place: the market outlook for industrial robots. No doubt that this this was an incredibly exciting subject. We had approximately zero prior knowledge of the topic and that was our incentive to learn more about robotics. We also considered it a valuable experience writhing the thesis in consultation with Skagen Funds.

The industrial revolution, which was born in the late 1700s, together with the modern capitalist economy, was a transition to new manufacturing processes. The direct consequence, increased productivity, laid the foundation for a new overall economic growth. Due to structural social changes, such as standard of living and labor conditions, the daily life turned upside down. The population growth began to gain momentum.

This lesson is important to keep in mind when exploring the future of robotics. Robotics is obviously a wide field. Robots have the feature to change society "again", as we know it. As of today, industrial robots are of a relatively minor economic scale, but steadily growing. However, there is no doubt that the emerging technology of 21st century robots holds a major potential.

Our journey through the robot world has been educational, not to mention fascinating. We will closely monitor the future development of robots. And both of the authors have definitely made a new area of interest. We hope to wake up your interest as well!

Hans Kristian Tjemsland

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Joachim Storm Johansen

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2 Introduction

Although the first Industrial robot was implemented 53 years ago (Aurivian`s R`search, 2011), the potential for growth is still enormous. Industrial robots has become standardized for certain segments, but are not even close to fulfil its potential in other segments. Industrial robots can perform trivial, complex, dangerous and demanding tasks. Robots feature the ability to revolutionize production possibilities and might be the world`s next big evolvement towards efficiency and flexibility.

Financial times first of June 2014:

> China becomes largest buyer of industrial robots. As rising wage costs and growing competition from emerging economies have forced manufacturers to turn to technology. The country bought one in five robots sold globally in 2013, in its attempt to drive productivity gains (Powley, 2014)

This thesis will focus on the demand for industrial robots in China and what company benefiting a potential growth. The goal of this thesis is to explore, analyze, validate and provide arguments for why the Chinese market has, and still should experience a rapid growth of robot sales the coming years. The purpose of the research is to establish a foundation for studying an outlook for this market. What is an industrial robot? Why are robots important to the manufacturing industry? Which external and internal factors are affecting the sales of industrial robots? What companies are dominating the robot market in China? How might the potential growth profit stockholders?

The reader of this thesis will gain knowledge about robots strength, weaknesses, opportunities and threats. In addition, an analysis of how macroeconomic factors affects the robot sale will be provide, such that future prognoses can be estimated. This will empower the interested person to make improved investment decisions. The mission of this thesis is considered as a meaningful and necessary piece of work, as we talk about a relatively new and decisive market. As of 2014, China is the world largest market for industrial robot sales (Powley, 2014).

The research question is supported by literature provided by Morgan Stanley research department (Uglow, Carrier, Ibara, Yoshida, & Davies, 2012), International Federation of Robotics (International Federation of Robotics, 2013), Maquire Research department (Maguire, 2014) and Aurivian`s R`search department (Aurivian`s R`search, 2011) .

3 Theoretical review

3.1 Classification of Industrial robots

In this section, the paper will first define Industrial Robotics and then discuss different theories used to justify arguments provided in the text. The last part of the theoretical review will cover financial theory that will support discussions the paper will provide.

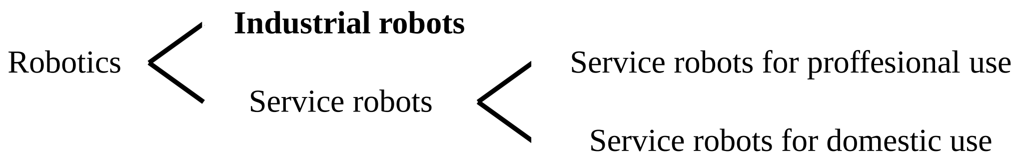


Figure 1 Main classification of robotics

There is a collection of different definitions on industrial robots. The International Organization for Standardization has developed a specific definition of a general manipulating *industrial robot* operated in a manufacturing environment.

Industrial robot, by ISO 8373
“an automatically controlled, **reprogrammable**, **multipurpose** manipulator programmable in three or more **axes**, which may be either fixed in place or mobile for use in industrial automation

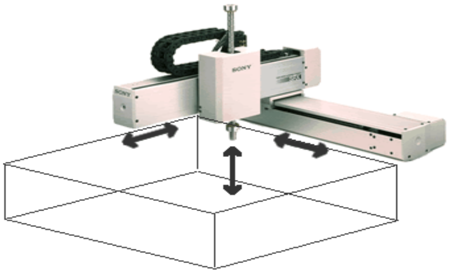
Figure 2 Source: (International Organization for Standardization, 2014)

The terms used in the definition above is explained below:

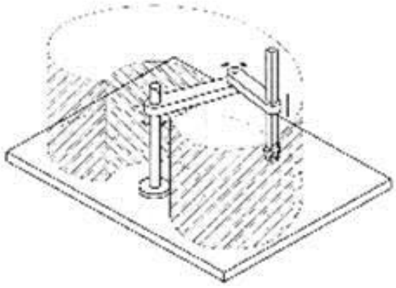
- **Reprogrammable**: programmed motions or auxiliary functions may be changed without physical alterations
- **Multipurpose**: capable of being adapted to a different application with physical alterations
- **Axis**: direction used to specify the robot motion in a linear or rotary mod

(International Federation of Robotics, 2013)

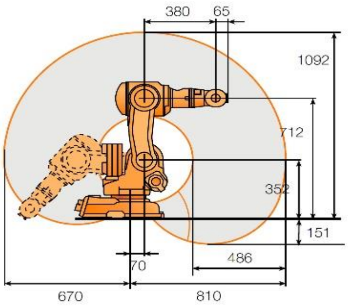
Principle and kinematic structure	Photo



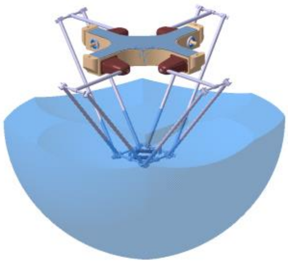
Linear robots (including Cartesian and gantry robots)



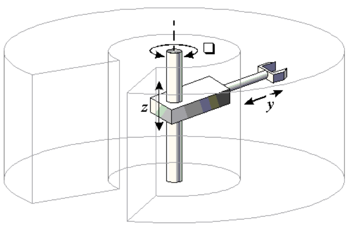
SCARA robots



Articulated robots



Parallel robots (delta)



Cylindrical robots

Figure 3 Source: (Google, 2014)

Classification of types of industrial robots by mechanical

Linear robots inc cartesian and gantry robots	A robot, whose arm has three prismatic joints and whose axes are coincident with a cartesian coordinate system
SCARA robots	A robot, which has two parallel rotary joints to provide compliance in a plane
Parallel robots (delta)	A robot whose arm has at least three rotary joints
Articulated robots	A robot whose arm has at least three rotary joints
Cylindrical robtos	A robot whose axes from a cylindrical coordinate system

Figure 4 Source: (International Federation of Robotics, 2013)

Examples of applications of different types of industrial robots (Google, 2014)

Figure 5 Articulated robot – Packaging

Figure 6 Articulated robot – Painting

Figure 7 Linear robot - Handling for plastic moulding

Figure 8 SCARA Robot – Assembly

Figure 9 Parallel robot – Picking and placing

Figure 10 Articulated robot – Palletizing

3.2 Market overview

The market of industrial robotics consist of several chains. The figure below presents a simple example of the supply chain for a robot producer.

3.2.1 Supply Chain

Figure 11 Supply Chain Robot Producers

E.g. of raw suppliers:	E.g. of robot producers:	E.g. of sale offices:	E.g. of end customers:
Siemens (systems)	ABB	RobotNorge (ABB)	BMW
ROS industrial (systems)	Yaskawa	Scala (Yaskawa)	NorDan
Alcoa (aluminum)	Fanuc	Intec (KUKA)	Daimler
	KUKA		
	Siasun		

3.2.1.1 Raw suppliers

Raw suppliers are companies that support the robot producers with raw material like copper, aluminum, carbon steel, mineral oils and various plastics. In addition, raw suppliers will often supply robot producers with fabricated products, electrical components and in some cases the robot system (software) that will control the robots maneuvers. This depends on how vertical integrated supply chains the robot producers are.

3.2.1.2 Robot producers

The robot suppliers/producers are the companies that creates, develop and produce the hardware of a robot (functional shape). It is normal that robot producers develop its own software and system. Some of the robot producing companies will focus purely on a one hundred percent robot solutions (like KUKA), while other companies produce fully automated solutions containing robots, machine tools or other automated solutions (like Yaskawa, ABB and Fanuc).

3.2.1.3 Sales offices

Sales offices are the departments that are in contact with the end customers. Sales offices distribute the robots and other automated solutions from the robot producers to the specific customer. Sales offices administer the customization and implementation phase to the end customer. Sales offices could be independent parties or vertical integrated into the robot producer inner supply chain. This vary from company to company, but also between the countries a robot producer operate within.

3.2.1.4 End customers

End customers are manufacturers that use industrial robots to automate their plant. End customers are typical mass producing manufacturers that produce products like mobile phones, cars or computers. Industrial robots can be used to produce all sort of different goods. However, the car market remains their most important customer.

3.2.2 Market value

The worldwide value of the robot market:

Year	Estimated market value in millions of USD	% growth
2010 (IFR estimate)	5,832	52,6
2011 (IFR estimate)	8,497	45,7
2012 (IFR estimate)	8,684	2,2
2013 (own estimate)	9,755	12,33 (increase in worldwide robot sales)

Table 1 Source: (International Federation of Robotics, 2013)

IFR estimated the value of the industrial robot market in 2012 to be US$ 8.7 billion.

3.2.2.1 Average unit price

$$World\ average\ unit\ price\ per\ robot \rightarrow \frac{Total\ sales\ value}{Total\ unit\ sales} \rightarrow \frac{US\$\ 8{,}7\ billion}{159\ 346\ units} \approx US\$\ 54\ 600$$

The unit price of an industrial robot is only a part of the total robot system. Industrial robot prices differs widely due to different specifications. The price typically depends on the application area of the robot. IFR suggest that the unit price of the robot constitute 33.5 % of the total revenue, on an average basis.

According to our informants at ABB Bryne Norway, *"The unit robot price only accounts for well over 1/3 of the total price of an operational industrial robot"* (appendix 1 page… own translation)

Robot Norge, Jean Marc Launay (Appendix 2):

> When you get the robot delivered on a pallet, the robot is useless. To prepare your robot to be able to produce, you need peripheral equipment, manipulators, PLC systems, transportation systems and engineering. This means that the cost of the robots accounts for only 30-40 % of the total. If it is a simple facility, the robot can be as much as 50 % of the price. If we are talking about a complicated facility, the unit costs constitute only for 20-25 % of the total price. (p. 128)

3.2.3 Robot + system

There will often be significant costs related to the purchasing of a functional industrial robot (total package). The system cost will include cost of software and cost of peripherals/application package. In addition, cost of system engineering/physical installation constitutes to a more or less decisive effect on the total price.

Year	Estimated market value in millions of USD	% growth
2010 (IFR estimate)	17,409	52,6
2011 (IFR estimate)	25,364	45,7
2012 (IFR estimate)	25,922	2,2
2013 (own estimate)	29,119	12,33 (increase in worldwide robot sales)

Table 2 Source: (International Federation of Robotics, 2013)

3.2.3.1 Average Unit price of robots + systems

$$\begin{matrix} World\ average\ unit \\ price\ robot\ and\ system \end{matrix} \rightarrow \frac{Total\ value\ robot\ systemt}{Total\ robot\ units\ sold} \rightarrow \frac{26\ billion}{159\ 346} \approx US\$\ 163\ 000$$

3.2.4 The Chinese market value

The estimated market value of the Chinese market are estimated using Morgan Stanely report from 2011 multiplied by the growth in China the last two years. Morgan Stanley calculations are used to estimate the Chinese market value such that market shares can be compared in the financial analysis. Calculations are provided below:

The value of the Chinese robot + system market (estimated)

Morgan Stanly estimate 2011: US$ 2.56 billion

Growth factor: 1.6388 (increase in robot sales to China from 2011 to 2013)

$$US\$\ \ 2.56\text{ bilion} \times\ 1.6388\ \ \approx \text{US\$ 4.2 billion}$$

3.3 Man vs. machine – Theory about the effect on human capital

To manufacture a product, an interaction between capital goods, human capital and land is necessary. They will be complementary goods, which implies that *they are goods that "go together"* (Snyder & Nicholson, 2010, p. 172). Industrial robots, which obviously are sophisticated machines, require competent humans to program and monitors the process of creating a product, as well as keeping the robot in a working condition. Without a strong human capital in form of competence, the robotic system would become ineffective and potentially dangerous. In this context, human capital and capital goods are complement goods.

However, robots and humans are at the same time substitute goods. *"Two goods are substitute goods if one good may, as a result of changed conditions, replace the other in use"* (Snyder & Nicholson, 2010, p. 172). From the beginning of the Industrial revolution, more and more jobs have been replaced by automated processes like machine tools and robots. Author Kevin Kelly stated in January 2013 issue of Wired (Kelly, 2012) that 99% of jobs located on farms 200 years ago, are of today replaced by automation. In addition, 70 % of all Americans lived on farms, which implies that many jobs have been lost to automation. What does this mean for the unemployment rate? In the short run, people might experience job losses, consistent with a higher unemployment rate. Kevin

Kelly points out that this is a natural evolution towards a modernization of the society. Without the development within automation, we would maybe still work on farms, with outdated equipment like plough and horse. We would still work 12 – 14 hours a day. Kevin Kelly points out that the evolution works in four stages.

Existing jobs	A: Jobs today that humans do – but machines will eventually do better	B: Current jobs that humans cannot do, but machines can
New jobs	C: Jobs that only human will be able to do – first.	D: New jobs that we cannot even imagine yet
	Human	**Machine**

Figure 12

- Colum A consists of jobs that humans can do, but machine do better and often cheaper. Example of such jobs are weave cotton cloth. These are jobs that were done manually by humans in the beginning, but most countries and companies have automated this process.
- Colum B consist of jobs that humans have never been able to do. This implies that these types of jobs have been created because of improved technology, automation skills and creativity. Example of such jobs are creating computer chips, which require high degrees of precision, control and unwavering attention.
- Colum C consist of jobs that only humans are able to do. Many of these jobs exist purely because of the automation trend. Let us considered web pages as an example. Due to the increase in the number of web pages, almost every firm need at least one person to operate, validate and update the web page. For many firms this is a full-time job. Without automation and technology, there would not be any need for this person. Besides, the trend of automation has created jobs that are more attractive.
- Colum D consist of jobs that are not contemplated. They do not exist because no one has found it useful, or we do not have the proper technology to benefit from it. This is where robots get interesting. With an increasing use of robotics, other existing jobs will be created. Kevin Kelly states in this article that: *"before the*

end of this century, 70 percent of today's occupations will likewise be replaced by automation." (Kelly, 2012, p. 1) These new jobs, that robotics will create, will in many cases be high paying jobs that will create additional welfare.

3.4 Automation brings up the GDP per capita

In addition to create new jobs, automation is the essential reason why many countries has experienced a strong growth in gross domestic product, seen in a historical perspective. The industrial revolution accelerated the growth in GDP. A rise in GDP per capita tends to equal to a growth in the average efficiently of the economy, hence the productivity of a country. An increasing tendency of automation is equal to a higher GDP per capita, this implies that automation leads to higher welfare. This theory coincides with Ramsey`s growth model which says that growth in production equals: $F(K, AL)$ where K is capital, A is technology and L is labor. Improved technology (A) will multiple the effect of manual labor (L). (Duarte, 2009).

3.5 Product life cycle

Product life cycle theory applies to both industrial robots and products that might be produced by robots. Product life cycles are defined as *"a characterization of product growth, maturity, and decline over time"* (Evans & Collier, 2007, p. 269). The Operation Management book states that every product follows in some sense the same pattern, when it comes to how the value of products change over time. The traditional product life cycle consists of four phases – introduction, growth, maturity and decline and turnaround. In the introduction phase a products number of units sold will grow slowly due to lack of knowledge about the product or pure skepticism.

The first phase is followed by a period of rapid growth as the product gains acceptance and market shares.

The next phase is maturity, at which demand levels off and no new distribution channel are available. The product has fulfilled its growth potentials and are selling as many units per unit time that it can. At this stage, the product design becomes standardized and other firms tries to copy the design and sell it for a lower price.

The last phase is characterized by decline is sales as other substitute products are introduced and becomes popular. In this stage the product will eventually die out or be improved, such that it ones again experience growth. For some firms the decline implies that a complete new product must be established. For others it means shut down.

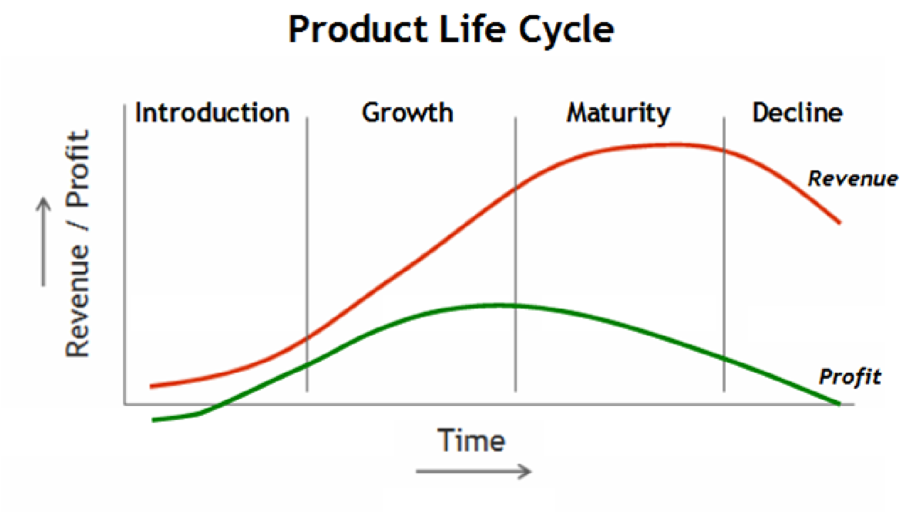


Figure 13 (Liveseysolar, 2014)

"Too reach a competitive position on the global market today, a company needs to develop appealing products in terms of cost and quality that are brought to the market in timely manner (Björkman, 2010, p. 33)*"*. When looking at a specific robot type it becomes important to take into account product life cycle cost. Life cycle cost can be explained as the different cost associated with each phase of the product life cycle. This includes both which type of cost that are included and how long they affect each phase. *"A product's life cycle cost profile determined by absolute cost values, relative distribution of the costs across the life cycle, the duration of the individual phases and the production volume"* (Björkman, 2010, p. 33). For industrial robots a product life cycle cost analysis may look like this

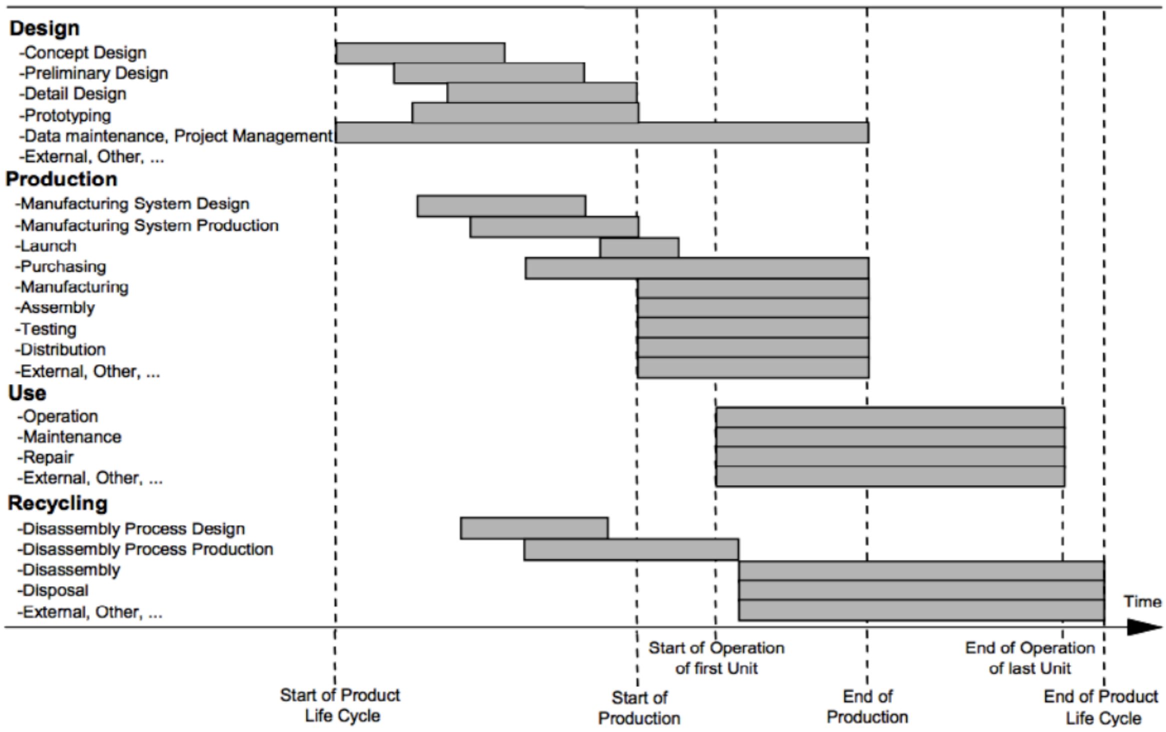


Figure 14 (Björkman, 2010, p. 34)

A demand from the market is a fundamental need. The manufacturers are the robot supplier's main customers. The demand is met with knowledge about technical possibilities, and the designing of the product can begin. (Houtum, 2010)

From the table we can see that in the start of a robot life cycle there are much cost associated with the design. In the creation phase, there are cost associated with manufacturing system design, manufacturing system production and purchasing parts to create the robot. These are costs associated with the production of the robot. Lastly, there will be some cost associated with making it possible to create the robot in the beginning phase of a robot`s life cycle.

In phase two, when the production of the robot product begins, costs related to the mass production of the product are prominent. Involving factors here will be manufacturing, assembly, testing and distribution. As soon as the first robot is sold, implementation and installation of the robot into the customer's production plant generates cost. Maintenance, upgrades and repairs are associated costs after the installation. Customers have different preferences and demands to what the robot should be able to do, they need to customize each robot to each customer. This means that they need to have people working on systems through the entire life cycle of the robot.

After end production, the most important aspect concerning cost is to keep providing customers with service of the robot. After all, one of the main strengths of robots compared with machine tools is flexibility. An industrial robot might have a life expectancy of 15 years (International Federation of Robotics, 2013). This means that a robot might operate much longer than what is expected.

3.6 A robots life cycle lengths

In Björkman's Cost analysis of robot family's products life cycle lengths is categorized into three different scales: Small scale, mid-scale and large scale.

Small scale is products that needs less than 1 year to be developed and they stay operational for less than 2 years. These are simple products that the suppliers mass-produce and sell to a big population. For small-scale products, operational cost are most prominent, as they will mass-produce the product.

A mid-scale design is one that takes 1- 5 years to develop and has 1-5 year operational lifetime. More cost associated with development has occurred to make the product work. Lifetime of these products is rarely more than 5 years, as improvements replace them (Björkman, 2010).

A product with large-scale lengths has multiple, multi-year, on-gonging development process and might stay operational for a decade. They are complex products that both takes long time to produce and requires a lot of maintenance to stay operational. Products of a large-scale lengths is often demanding to implement but can create much benefit, as it can be used to create new products and services after implementation. As they requires many years to be develop, they require high research and development costs. These products often requires extensive workforce and training as it becomes important to keep it running in an optimal and safe way. For a supplier of this product, a lot of the value created (in form of money accumulated) comes from following up a sale, with upgrades, maintenance and other type of services. (Björkman, 2010)

3.7 Categorize robotics

For Industrial robots, many products will take many years to develop, and they must often be renewed and updated. A lot of the cost accumulated for robot producers occurs because of service provided to customers. Therefore, we can classify industrial robots as large-scale to mid-scale lengths. This implies that it is of extreme importance to select right projects, as choosing the wrong ones can hurt future projects extensively, hence the entire firm. It will also be important to have the "right" customer basis. Since the process of creating a product is long and costly and providing customers with follow-ups service are crucial, it is valid to have close communication with the customer under the entire process.

3.8 Pull systems – How should robotics be introduced?

Product life cycle cost analysis and product life cycle lengths becomes important when a company studies its customers. Theory about pull systems then becomes central: *"A pull system produces only what is needed at upstream stages in the supply chain in response to customers demand signals from downstream stages."* (Evans & Collier, 2007, p. 370). Using this approach, a company do not try to "push" the product over on the customer. Instead, the customer takes the initiative to seek out a company and ask them to make a product. A push approach is driven by a demand from customer, hence the term "pull". Companies driven by a pull approach will often focus in a core competence area. Production of semi-finished products is prevalent. With this approach, it becomes easier to give the customer exactly the type of product they need. The company can make sure to provide the customer with the latest technology available.

3.9 Business-to-business vs business-to-consumer

Theory about pull systems brings us to how a business supply chain is composed. *"A supply chain is the portion of the value chain that focuses primarily on the physical movement of goods and materials, and supporting flows of information and financial transactions, through the supply, production, and distribution processes"* (Evans & Collier, 2007, p. 47). A firm's supply chain is different concerning what type of product or service they produce. Two main directions are described in economics literature: Business-to-business companies and business-to-consumer companies: *"A Business-to-business company manufactures products for other businesses. They typically manufacture on order and the product is either quite expensive or in large quantities."* (Tjemsland & Wigestrand, 2012, p. 1). Business to business companies have become increasingly important in today's society. While traditional companies often produce every single part of a supply chain themselves (raw material, screws, etc.), modern companies are often a part of a longer chain of companies. In modern business models, companies focuses on their core competence and outsource other processes.

Business-to-consumer are the opposite. These companies confronts the private consumer directly. At the end of several supply-chains, there will be a business-to-consumer company.

Most industrial robots producers are business-to-business companies. They are a part of a larger whole whose ultimate objective is to create products. The robot ease the process of creating a variety of products.

3.10 Mass customization

"Since the 1990s, the production enterprises are going through a strong global change in terms of shorter product life cycles, fluctuations in the order income and increased demand of customized products" (Björkman, 2010, p. 19). Customers demand higher differentiate products, as cheap as possible. To keep up with this trend, companies needs to focus on effectivity and flexibility when producing products and services.

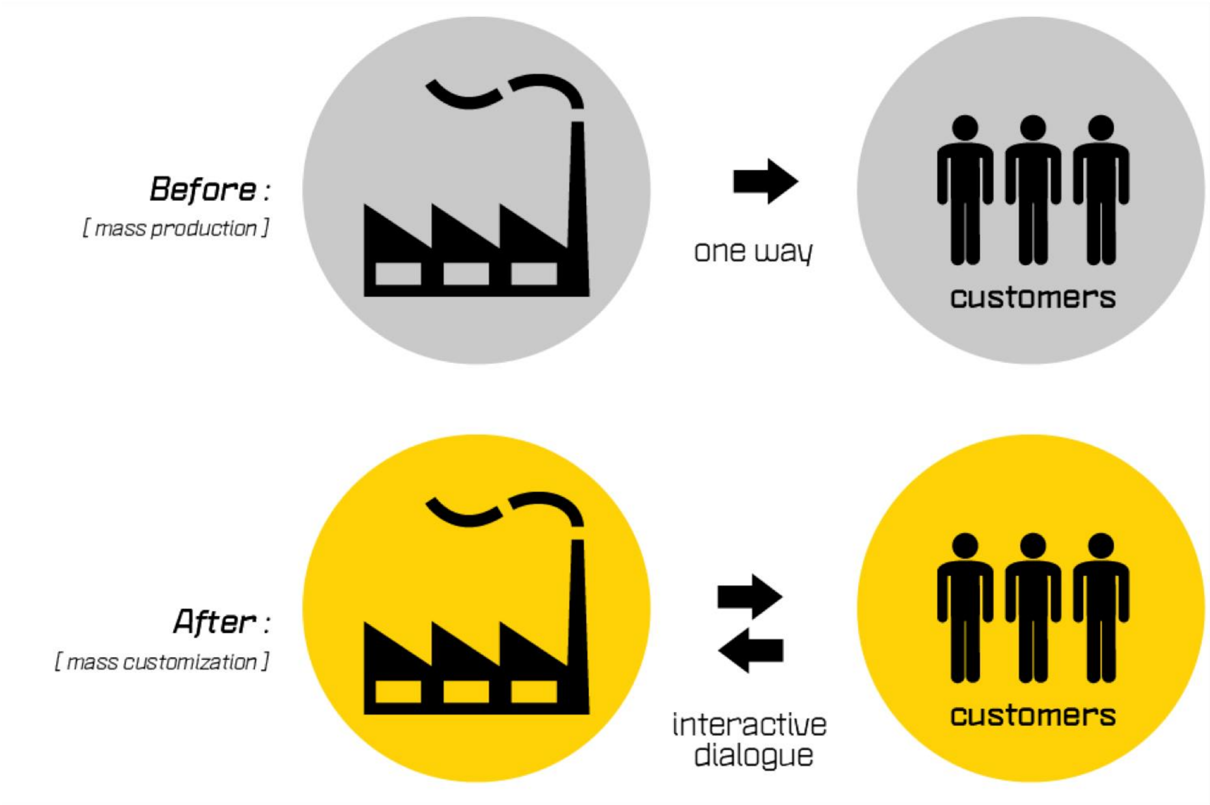


Figure 15 (Brown, 2013)

This leads to theory about mass customization. *"Mass customization is being able to make whatever goods and services the customer wants, at any volume, at any time for anybody, and for a global organization, from any place in the world."* (Evans & Collier, 2007, p. 129). Mass customization is a hybrid strategy *"which supports the production of* *individual products to fulfill specific customer needs at the same time as doing it within the principles of mass production at reasonable cost"* (Björkman, 2010, p. 19).

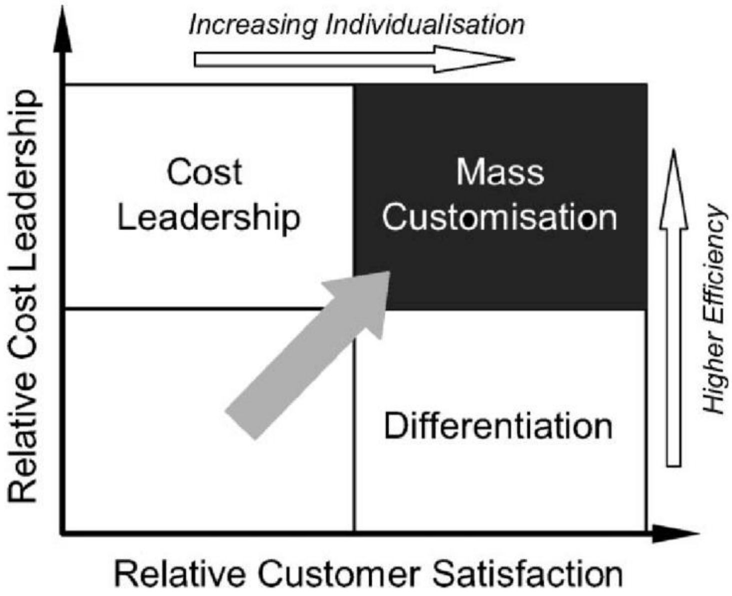


Figure 16 (Björkman, 2010, p. 19)

As more and more companies aim for mass customization, finding new more effective, more flexible and cost minimizing processes becomes crucial. As technology becomes more sophisticated, the value of implementing a robotic system might increase. Modern manufactures has increased efficiency by automating processes, such as use of machine tools. At some point in the future there will not be any room for more improvements by using basic operational management theory. There must be a new change in technology and in the mindset of companies. This mindset can be industrial robotics. If manufactures can develop a positive impression towards industrial robotics, they may be willing and wanting to implement industrial robots.

3.11 The financial perspective

This thesis will in addition to a strategic/ operations management approach and econometric approach consist of a financial approach. The text will provide a market overview where the most important companies toward the Chinese market are analyzed.

3.11.1 Payback period

Statement of the pay back period (Berk & DeMarzo, 2011):

> The payback period investment rule, states that you should only accept a project if its cash flows pay back its initial investment within a pre specified period. To apply the payback rule, you first calculate the amount of time it takes to pay back the initial investment, called the payback period. Then you accept the project if the payback period is less than a pre specified length of time – usually a few years. Otherwise, you reject the project (p. 164)

In practical use of the pay back formula, one will in addition to calculate investments costs payback time, often look at how an investment can save costs (with projects that replace an existing process design). Such costs can be reduce of salary costs, reduce of safety costs, reduced injury costs and increase effects such that a revenue might be reached in shorter notice. This implies that the simple pay back rule might elude important aspects that would reduce payback time. This becomes important factors when we talk about Industrial robotics. As industrial robotics is substitute goods to other already existing products, one need to account for these factors.

Payback formula for robotics:

(Robots+Systems)/ (net change in wages from old and new employees + savings + robot depreciation – maintenance) = (number of years before the investment is paid back)

(Uglow, Carrier, Ibara, Yoshida, & Davies, 2012)

The payback rule becomes important for this thesis because it is widely used as investments rule for end customers. Later on, the conservative demands on payback period are expressed. Companies are known for using the pay back rule, while applying the present value formula would provide better investment decisions. (Berk & DeMarzo, 2011).

3.11.2 Business cycles

Business cycle is the theory that all economics experience periods of expansion and contraction. These business cycles might vary in the length and depth, but all economics, will to some degree, follow the same pattern. All economics will suffer from peaks and troughs, corresponding to recoveries and recessions.

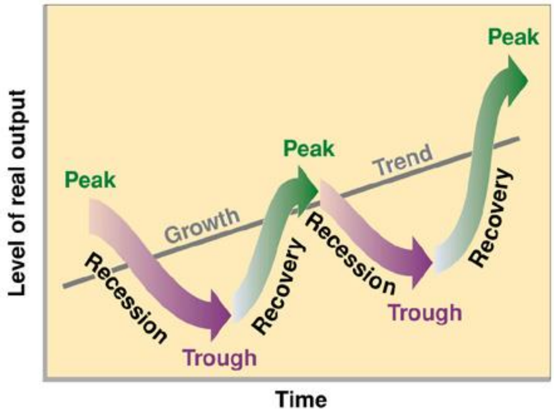


Figure 17 (Decline of the Empire, 2014)

So why is this relevant for this paper? Industrial robot are sensitive to fluctuations in the economy, especially due to business investments and corporate profits. How this business perform is deeply dependent of how the automobile industry perform.

From the book (Investments and Portfolio Management, 2011):

> Example of cyclical industries are producers of durable goods such as automobile. Because purchases of these goods can be deferred during a recession, sales are particular sensitive to macroeconomic conditions. Other cyclical industries are producers of capital goods…Therefore, the capital goods industry bears the brunt of a slowdown but does well in expansion (p. 737).

4 Methodology

In this section, the paper will explain the methodology use to obtain information and data. A validation of sources consistency, stability and preciseness is also presented. The methodology is applied using principles in the book Research methods in the Social Sciences (Frankfort-Nachimas & Nachmias, 2008).

4.1 Design

The approach used to answer the problem definition consists of three phases: to identify China robot markets. Perform strategic, statistical and financial analysis. Discuss the future growth in China and which companies that might benefit this scenario.

4.1.1 Identify robot market

Identify the robot market consist of three steps:

- Collecting data: collecting of information about robot sales, operation stock, accumulated sales and the historical growth for robotic in general. Since robotic was completely new for the writers, an open approach was used to obtain knowledge and expertise about robotics in general. This means that the writers obtained knowledge about industrial robots and service robots for every country and every application in the world.
- Identify markets: consist of understanding applications for robotics and in which markets different types of robots have their dominance. This made sure that the writers could be able to select markets and hence applications that where most interesting to analyze.
- Identifying potential: in different markets using robot density, historical growth and prognoses provided by different sources.

4.1.2 Choose narrowing

As a result of the complexity analyzing the global robot market as a whole, this paper gradually narrows the problem definition down to a specific country. A narrowing against China is chosen because of the recent world largest growth rate in terms of robot sales and its manufacture-orientated economy. Some of the findings will apply to industrial robots in general, such as the SWOT-analysis.

4.1.3 Applied analysis

The analysis, both strategic and statistic, should provide arguments for why the selected country is "growth candidate" and which companies that should benefit from potential growth. Five different analysis are conducted:

- SWOT analysis: is conducted in order to give the reader knowledge about what are the main criteria for and against industrial robotics. The SWOT analysis will serve as a tool in order to understand why industrial robotic solutions is interesting.
- Descriptive statistics: consist of an analyze of China`s annual sales of robots, robot density and operational stock compared to other countries with large robot density. The main goal of this analyze is to clarify potential in the Chinese robot market and how it looks compared to other selected countries.
- Panel data analysis: consist of a regression model using both cross sectional and time series data. The analysis will try to estimate relationships between annual robot sales and different macroeconomic variables, where both time and the number of countries are relevant information. The analysis is used as a tool to understand how much different factors influence the robot sale in countries and if it is significant. The analysis will help support hypotheses provided about relationships between macroeconomic factors and robot sales and will serve as an estimate to predict future growth in China.
- Porter`s five forces analysis: is conducted to understand the rivalry inside the Chinese robotic market. The analysis is used as a tool to understand what criteria that counts, what strategically is important to succeed in the market and how the competition is structured. The analysis is used as a tool to understand which companies that will benefit from a growth in robot sales.
- Financial analysis: consist of an analysis of selected companies revenues, P/E ratio, stock indexes and other important data. The analysis is used as a tool to understand which companies that will benefit from a growth in robot sales in China.

4.1.4 Discussion

Discussion consist of two phases. First, the text will discuss why we decided to focus on China robot market. Arguments, essential estimates and forecasts will be collected from SWOT analysis, statistical analysis and the regression analysis. In addition, some arguments will be collected directly from qualitative interviews. Second, the paper will discuss which company that is in a position of benefit from the potential growth in China. Arguments will be collected from porter`s five forces analysis and financial analysis.

4.2 Collection of data and information

The data was obtained using several sources. For the statistical analysis and the regression analysis, data containing annual robot sales, operational stock, robot density and accumulated sales where obtained from World Robotics: Industrial robots, 2013, IFR statistical department. Other depended variables used in the regression analysis was obtained using World Databank (open for public access), OICA (open for public access) and DataStream/Thomson Reuters. Qualitative information where obtained by conducting interviews with professionals working in ABB Robotics research department and RobotNorge AS. In addition, financial data where obtained using Morgan Stanley research, Maquarie research and Aurivian`s R`search.

4.2.1 Reliability of data used in regression analysis and statistical analysis

4.2.1.1 IFR (International Federation of Robotics, 2013)

The data collected from IFR statistical department are measured on ratio levels. This means that the variables have natural, absolute, and fixed zero points that makes them useful in statistical manipulation. This makes sure that the data are consistent as the data are measured down to each single robot.

The stability in the statistics will vary between countries and how many years back in time they were collected. IFR states that the data "*are based on consolidated data provided by nearly all industrial robot suppliers worldwide.*" (International Federation of Robotics, 2013, p. 22). There were probably more measurement errors in the early collections of statistics. In addition, countries like Russia have experience major changes in geographic extent that might create measurement errors. A positive point with the data are that they represent actual events. Robot suppliers should have good data on how much they have sold and there are no estimate calculations when concerning annual sales and accumulated sales that would yield room for measurement errors. This means that measurement errors would most likely occur because of underestimation, because some robot producing companies might have been excluded from the sample.

Jean Marc Launay, the Managing Director of RobotNorge AS, made some comments about IFR statistics towards Norway. For operational stocks, he said that it seems like the data is marginally underestimated. They predict to generate money from approximately 1000 different robots in operation. IFR has estimated the total amount to be 1019 in 2012. Launay thinks that this must be an underestimation as there are other suppliers on the market, although much smaller and newer to the game than RobotNorge AS (appendix 2).

RobotNorge AS have estimated that 100-150 robots where sold in 2012 in Norway. IFR states that the total number was 91. Mr. Launay thinks that this is an underestimation (appendix 2).

For Norway, it seems like the data consist of minor underestimations. However, Launay proves that the data collected are relatively precise and not overestimated. As the data will be used to predict relationships between robot sale and macroeconomic variables, an overestimation would be a much bigger problem as this will overestimate the growth potential.

When validating IFR as a source is that most articles, scientific journals and magazines use IFR as a source when talking about robotics. This includes both Morgan Stanley research and Macquarie research. It seems that almost every scientific paper that mention robots has used IFR data directly or through other research departments.

4.2.1.2 World Data bank, DataStream and OICA:

The World Data Bank collects their data from expert informants, mostly lawyers. Independent Evaluation Group (IEG) points out the vulnerabilities of World Data Bank:

- Few informants provide the data from each country. This means that it becomes difficult to provide securing validation by comparing data from different sources. In addition, you might experience a self-selection bias.
- As World Data Bank delivers data on very different topics, it becomes difficult to validate the reliability for each topic separated. It would simply be too demanding for World Data Bank to present a detail validation for each subject.
  (The Independed Evaluation Group, 2014)

DataStream is a financial database that contains company and market information. As it is a license product, it need to be subscribed on in order to be used, which always creates reliability. The Library at University in Stavanger are validating the reliability of all information that is made accessible for their students. DataStream should therefore be a reliable source. However, some of the same problems as with World Data Bank might be the case with DataStream. As the data collected from DataStream are of macroeconomic levels, one need to understand that there is a possibility for measurement errors. These measurement errors will be present no matter how reliable the sources are as a big sample mean always creates measurement errors.

OICA (Organisation Internationale des Constructeurs d'Automobiles, 2014) is the leading organization when it comes to collection of automobile statistics. It was founded 1919 and are a respected organization.

4.2.1.3 Qualitative interviews

The interviewees are experienced players within industrial robotics. The interview with ABB Robotics Bryne was conducted with their Local Business Units Manager (CEO local) and their Global Product Manager. The interview with RobotNorge AS was conducted with their Managing Director (CEO). All three has long experience with research and development. In addition, the Managing Director at RobotNorge AS has experience with implementation of robotic solutions (multi-applications purpose robots) to end customers. A non-schedule-structure or focused personal interview were used in the interviews. This means that the context of the interview were pre-established (they had been sent a questionnaire), but the interviewees were allowed to talk freely about what they find most interesting while the interviewers provided follow-up questions when necessary. The reason for choosing personal focused interviews was that the interviewees had more experience concerning the research question than the interviewers. By choosing this interviewing form, the interviewers could gain knowledge about important topics, without putting restrictions on their source to information. With a structured interview, it was not be possible to deepen topics that turned out to be interesting.

A weakness with this type of interview is that the interviewees gets the opportunity to express personal opinions. Other professionals might not share these opinions, which may mislead the interviewers. A personal interview requires non-anonymity. The interviewees might respond differently than what they truly believes, because they do not want sensitive information to be revealed.

For the interview with ABB Robotics the presence of personal opinions were reduced by the fact that they were two interviewees. This means that if one of the interviewees draws the interview towards misleading information, the other person may ensure and correct information.

In the interview with RobotNorge AS there was only one interviewee. Several topics debated with ABB Robotics also were debated with RobotNorge AS, making it possible to quality assure the answers given. In addition, some of the questions ask in the interview are leading question, such as "*It must be a huge potential for an increase use of robots in Norway?"* (See Appendix 2). In this situation, it would be easy for the interviewee to agree with the statement, as it promotes his agenda. However, the interviewee tuned down the potential and stated problems concerning growth in Norway. This proves that the interviewers are not able to manipulate the interviewee.

This thesis is written in English, but the interviews are conducted in Norwegian. As Norwegian is the domestic language for four of five participants, it was natural to conduct them in Norwegian. The interviews are translated from Norwegian to English by the authors.

4.2.1.4 Morgan Stanley, Maquire research and Aurivian`s R`search:

Morgan Stanley and Maquire research are well-respected research departments. Skagen Funds has provided these papers, which implies that the sources should be rated as reliable.

Aurivian`s R`search paper is collected through Report Linker. They collect there statistic from both public and private sources and are considered a trusted source. Report Linker is a subscribing source.

5 SWOT analysis for Industrial robots

This part covers the key arguments such as what strengths, weaknesses, opportunities and threats industrial robots faces today. The arguments will be backed-up in theory, qualitative interviews or articles concerning robotics. Generally, we can summarize the findings in the table below. The most important findings are cost savings arguments, drastically improved quality, performance and flexibility arguments, external changes and internal changes that will make industrial robots more favored.

	Strengths	
Cost savings	**Quality**	**Performance and flexibility**
○ Reducing costs	○ Precise, consistent and reliable	○ Can work 24/7. ○ Increasing production output rates
○ Save time	○ High quality	○ Can be reprogrammable ○ Flexible production
○ Save space	○ Perform extremely complex tasks	○ Can do jobs that humans never have been able to do
	Weaknesses	
Costs:	**Profitable**:	**Performance problems**
○ Substantial initial investments ○ Need maintenance ○ Require service engineering ○ Clean-up costs ○ Training of employees	○ Need to a certain production volume to be profitable	○ Potentially dangerous ○ Safety requirements ○ Technically failure ○ Need solid ground

Opportunities	
External factors:	**Internal factors:**
○ Replacing humans in hazard, tedious and dirty work ○ Ageing population ○ Limited access to manufacturing employees ○ Growing consumer markets ○ Improved working conditions ○ Creating new jobs ○ Rising wages	○ Collaboration and interaction with human workers ○ More "Easy to use" and flexible automation ○ Improved vision and sensor system ○ Increasing integration of robots in machine tools ○ Deep automation ○ Trained and qualified sales team

Threats		
Substitute goods	**Mental threats**	**Investments Threat**
○ Other automated production solutions ○ Low-cost country sourcing	○ Job losses in the short run ○ Sensitive to economic fluctuations ○ Overuse of robotics ○ A restrictiveness towards robotic solutions	○ Unrealistic payback period

Table 3 SWOT

There are numerous of applications for industrial robots. However, what are their strengths, weaknesses, opportunities and threats, will roughly be the same for all types of industrial robots. Some of the aspects of a robot listed above is easy to understand, without further explaining, while others need to be explained broadly. The following text explains important arguments for all four aspects.

5.1 Strengths for Industrial robots

Identifying the strengths of industrial robots in a transparent manner is a simple, but essential method to expand the understanding of robots. Why should one choose robots? Strengths concerns savings in terms of time, money and space. Increased product quality is also an essential strength.

5.1.1 Cost savings

Cost saving argument is the main argument for implementing robots into manufacturing. As wages are increasing in most parts of the world, industrial robots becomes more and more profitable as an automated solution. There are many costs associated with having employees.

People are likely to get sick. For well-developed countries, like Norway, this means that not only does the company need to pay the sick person, they also need to pay for a replacement. These are cost that are not easy to calculate for companies in advance, but that does not make them less important. A robot does not get sick, at least not in the same way. There is always a possibility that they break down, but with sufficient maintenance, a robot should endure 99 % of the time (appendix 2 p.127). That is much less “sickness” than even the best, healthiest and disciplined manual worker would ever be able to achieve.

Accidents involving human injury is a risk faced every day in the manufacturing industry due to physical and manual operations in dangerous surroundings. When an accident occur, within a given probability distribution, the involved companies can experience significant costs in terms of redress payments, lawsuits, loss of reputation and riots.

Work-related accidents are strongly unwanted incidents due to the negative effects it may cause the company. The news are monitoring the world, such as conditions regarding outsourcing of production of goods. People are more alert on how the products are manufactured in terms of working conditions and pollution. Imbalance in labor rights across national borders can create precarious situations, especially when talking about international production cooperation. One example from China is the Foxconn-case from 2010, where 14 workers committed suicide in a pure demonstration of insufficient working conditions. Foxconn produces smartphones and tablets that are sold by Samsung, Sony, Apple or Dell and end up in American homes among others. (Chakrabortty, 2014). Robots increase the safety of the workplace. Manual workers are moved to supervisory roles where they no longer have to perform dangerous applications in hazardous environment.

For most western countries, human rights are considered important. Therefore, it becomes even more important for companies to keep workers away from dangerous environments and tasks that potentially might hurt the worker. As Steinar Riveland from ABB Bryne said in the interview: *"One can calculate costs associated with losing a robot to dangerous tasks, but never a human"* (appendix 1 p.118 own translation). This implies that when calculating costs, it is easier to deal with a robot compared to a worker.

One can reduce other costs as well. For fully automated plants, cost ranging from lightning, air conditioning and heating can be reduced. The Japanese robot company Fanuc has used the "lights out" principle of Roger Smith to create their own facility, which are fully automated an do not require any workers. Since no workers are required, there are no one to complain about the temperature or the brightness of the plant. This means that they have created a plant that can work 30 days in a row without having the "taken for granted" costs. The only reason why they cannot work longer is that there is no more space left for finished products. This is the only time when workers needs to interact with the plant, by receiving finished products. (Null & Caulfield, 2014)

There are other social and operational costs to take into account as well. Workers may demand benefits such as lunch, breaks, cafeteria, dressing room, personal equipment, showers, holiday pay, sick leave, team leader, severance package, and pension savings. Robots do not require any of the benefits above.

The next saving argument is space savings. A robot will require less space than workers do. There are several reasons why this is true. First, one need more workers to do the same task as a robot. Second, robots are predictable and coordinated; consequently, less safety margin in terms of space. Third, some objects might be so heavy that a worker needs additional equipment and tools to do the same task a robot could have done, and the equipment need additional space. A concrete example is NorDan, where they use workers combined with trucks to maneuver pallets of glass from storage to production. As they need to sort which pallets that supposed to go first into production, they need eight different stages to make it work. This means that they need to move pallets of glass back and forth several times. In addition, they need to move stored pallets just to get to the pallet they are supposed to move. It is not difficult to see how this takes up space. How does space cause greater cost? Because additional land or floors must be bought to increase production, perhaps in a highly valuable manufacturing area. An ineffective process design is more time-consuming and more space occupying. This leads to another problem, companies will often experience that there is not any more land left near the original plant. This means that they need to move parts of the production away from their original plant and face the challenges this entails.

Automation of manufacturing process can create competitive advantages in terms of cost efficiency, quality and productivity. Manufactures that are robot operational can produce products in shorter notice. When a product takes less time to produce, it becomes easier to plan the production. This in itself can reduce costs. When a customer makes an order, the company starts a process to create the product. If it takes 3 weeks to produce, there will be costs associated with information flow, communication and people in work in this period. If however the product where made in 1 week, with same quality, precision and price (using robots which is more effective). This means that the cost associated with creating each product would be smaller. The workers would still be paid the same salary per hour, dealing with information would become easier as product sold will disappear quicker and the company would have less costs associated with keeping the plant running per sold unit. If robots is the ultimate form of automation, it will be important to consider these costs.

What about other ways to automate production? If one need a flexible and forward-looking automation system, robot might reduce costs more than other solutions. With other automations, it will be more time consuming and costly to change the process design after installation. A robot are able to do a numerous of tasks, it is just a matter of the programming. If manufacture want to make change or small adjustment to the products, this can be done in a hurry by reprogramming the software of the robot. In most cases, this might be less expensive than make substantial physical changes in the layout of the plant.

5.1.2 Quality

The concept of quality is a major advantage of robotized manufacturing solutions. Robot automations are superior in precision, perfectionism and repeatability. This level of consistency can dramatically improve product quality. This benefit is hard to achieve any other way then the use of robots. With robots, throughput speeds increase, which directly impacts production. Robot has the ability to work at a constant speed in contrast to humans. A robot is capable of producing the exact same product or shape every time. Human is not able to do this within the same time interval. More precise means more reliable. You can trust a robot to do exactly what it is supposed to do.

The robot are also persistent. This gives two advantages. First, you truly know how much you will be able to deliver. Second, you can keep the robots running twenty-four hours per day. This gives a manufacturing greater capacity, which means that they have better time to achieve the desired quality.

The fact that a robot can be reprogrammable, and the implied “ease of use”, are a quality strength. The level of adaptability and flexibility is a matter of survival in the market today. As smaller and larger changes arises in society, market or demand. Manufacturers who are empowered with production technology needed to react to these ongoing changes, fastest and cheapest, will hold an ultimate advantage. There may be a case of new product introductions or changes in quantity produced. Industries must adapt such that they are capable of deliver the “newest” product. The growing consumerism is forcing an exponential increasing turnover in new products with continually technological and cosmetic modifications.

For industries with a high density of manual workers in combination with machine tools, need an ongoing training program to keep employees flexible. This is time consuming and costly. A robot only needs to be told what to do one time and it never forgets.

Some tasks are too complex for humans to perform. Thereby, robot production opening the possibility to make products that the world have not been able to make before. (3.3 Man vs. machine – Theory about the effect on human capital column b). Robot technology creates new production possibilities for products to be sold in the future.

The demand for customization and personalization of products is increasing (mass customization). The automobile industry is a splendid example of the practice of this detail-focused culture. The customer often has several ideas about different features and characteristics. In order to be able to mass customize their needs, sophisticated automations is required. The automobile industry has the highest robot density in the world. In addition, a car manufacture is constantly developing new models and produce a range of different models at the same time

Jean Marc Launay said in the interview (appendix 2):

> BMWs new ultra-green i3 factory was built on the concept of a 100% robotized manufacturing solution. Assembling lines do not exist. The production is based on lightweight handling that do not required strong robots. There is a positive correlation between the lifting capacity of the robots and the price of the robot (appendix 2 p. 132 own translation).

5.1.3 Ease of use

The usability or ease of use is a strength of industrial robots. Recruitment of human workers in the manufacturing creates more challenges today. The challenges are rooted in both from worker perspective and from employer’s perspective. From the workers perspective, declining popularity of jobs related to manufacturing and industry due to dangerous and dirty environment. The tasks are often monotone, physical and repetitive. There are limited opportunities of personal development. This situation is perceived as boring and gratuitous among candidates, compared to other job options. From the employer’s perspective, challenges may be rooted in organizational and administrative areas or costly safety requirements.

This mindset define a human worker as “hard of use” unlike industrial robots. A robot do not complain or revolt. A robot does not get hurt, sick or bored. This means that a robot are simple to deal with. After a robot has been bought and installed, only maintenance, updating of software and regular supervision is needed. The rest is simply on/off.

5.2 Weaknesses of Industrial Robots

It is at least as important to identifying the negative aspects associated with robots. The following points are in some cases permanent weaknesses, and in other cases improvement possibilities.

5.2.1 Costs

Choosing a robot solution can lead to reduced cost and increased profitability for a manufacturer in the long-term. However, robot investments are substantial. Steinar

Riveland in ABB robotics Bryne confirmed in the interview that a painting robot could cost everything between 30 000 dollars to 400 000 dollars implemented to a manufacture (the total package) (appendix 2 p.120). This means that in order to even considering a robotic solution, one need capital and liquidity. It can take years to benefit from the investment.

Robots require periodically maintenance. This include replacement parts, service and upgrades of hardware and software, which means fixed costs. The robot relies on competent personnel to be responsible for this necessity. Personnel who monitor the robots in action are also needed.

A robot consumes energy, which implies accumulation of energy costs. This means that manufactures needs access to electricity to implement robots.

5.2.2 Profitability concerns

In order for a robotized manufacturing solution to be profitable, a steady and large production volume is vital. Higher mass-producing rates forces robots to be working around the clock, which should result in shorter payback periods and higher return on investment. Large companies with economies of scale often represent this type of manufacturers. On the other hand, SMEs (small, medium enterprises) are generally less consistent with profitable investment done in robots.

Another problem is manufactures that produce in the short-run (tend to be conservative toward long term investments). Based on robot prices today, robots should be seen as a long-term investment.

5.2.3 Performance problems

A “deadly” weakness with robots is that it can be dangerous for humans. As Jean Marc Launay said in the interview: *“if a robot in full motion hits you, it will not even hurt. You will be as dead as a rock”* (appendix 2 p.135 own translation). Because of the danger zone surrounding the robots workspace, the user need to follow-up safety requirement to reduce risk. The typical safety measure is to create restricted zones where the robot shutdown, if a human enters the door. This means that direct interaction between robot and human is impossible. For some processes, like controlling the painting job performed by a robot, regular interaction is needed. With today`s solutions to the problem, temporary shutdown of production, is not optimal.

Another important flexibility problem is that software and "instructions given" needs to be integrated to make the robot functional. Programming the robot to adapt to tiny changes (millimeters) is equally demanding as instructing the robot to act in a completely different pattern.

The positioning and location of the robot installation is dependent on solid and horizontal surface.

Robots are exposed to system failure and manufacturing defects. There may be serious negative consequences if an unrecoverable error propagates in the assembly line. This is a reason for having quality control and monitoring and maintenance processes. Industrial robots are not problem solvers and do not react on suspicious situations. They need competent human capital in order to work probably. If emergency is about to happen, they cannot prevent them.

5.3 Opportunities for industrial robots

The mapping of the opportunities is divided into two subgroups: External factors and internal factors.

Internal factors is all about the performance of the very robot. External factors represents how the robot-usage can be intensified by changing circumstances in the world and in the society.

5.3.1 External factors

As robots replaces humans in hazard environment, serious injury can be reduced. It is increasingly focus on human rights such as safety, pollution and development of diseases. This mindset can be justified by the rising value of a human as the overall economy increase. That is why different types of jobs, especially within manufacturing and industry sector, become outdated. In the process of protecting human workers, robots are growing into a natural alternative.

Robots can also replace humans in boring tasks. Boring tasks are unpopular. When robots replace humans in dangerous and boring tasks, new kinds of jobs occurs. These jobs are enriching and better paid, but at the same time reduce the total salary costs for a manufacture (3.3 Man vs. machine – Theory about the effect on human capital).

In many countries, the consumer markets are increasing. In addition, more and more people are choosing to work within the service sector. Manufactures will experience a decreasing access to manufacturing workers and increase in demand for consumer goods. This yields potential towards robots. If the necessary workforce is shrinking, for various reasons, the minimum wage goes up. Wage can be a crucial incentive to choose industrial robots.

Many parts of the world today are experiencing aging population. Birth rate is decreasing on average and the median age is rising. Manufacture jobs are meant for the younger part of the workforce. Choosing a robot solution to handle the aging challenge, might be a way to remain productive.

Trained and qualified sales team play an important role in marketing and an eventually transaction. This is a demanding job. You must have knowledge of all industry and factory areas, in addition to having a unique understanding of process designs. Implementing robots can be a demanding process and there are always many configuration options. Jean Marc Launay has confirmed the importunacy of a developed sales team (appendix 2).

5.3.2 Internal factors

One of the major weaknesses with industrial robots today is the fact that they cannot interact with humans. New technology hence improved ability and performance will make robotic solutions more attractive. Today there do not exists a system/technology that insure that robot human interaction can be done in a safe way. However, as Jean Marc Launay said in the interview there are many suppliers trying to develop a system where this is possible (appendix 2) like Universal Robots. Jan Christian Kerlsefsen and Steinar Riveland, working with technology improvement for ABB (Appendix 1), are also pointing out that they are trying to create a closer interaction between humans and robots. In order to make collaboration of robots with human workers a reality the robots have to be capable of understanding human-like instructions (by voice, gesture, graphics) and they have to be safe, human-aware and space sharing. This requires integrated vision guidance and improved sensor integration.

To make it possible for different industry branches to reach higher robot penetration a new kind of robot generation should be introduced: easy to use, limited application, short life cycle and low price.

These technological features opens a large potential in SMEs. Small and medium size companies could implement robots, without having to fire a big amount of workers at the same time and without a large investments cost immediately. The transition between human and robots would become smoother and easier to achieve.

Steinar Riveland told us in the interview that they often see humans that walk inside the restricted zone to validate and paint though areas that the robot are not been able to paint (Appendix 1). With today`s technology this means that the whole painting process is shut down in the meantime. With human- robot interaction, the robot could continue working (probably with reduced speed tough) instead of full stop. Having the possibility to interact with robots means that new ideas can be implemented to a process design. This could create new jobs, better solutions and a more efficient plant, which is supported in theory about man vs machine.

Human - robot interactions has its sources from deep automation. Deep automation is the system and the brain of an industrial robot. In order to make many of the emerging ideas, including human- robot interaction possible to function, engineers needs to improve the level of automation in a robot. Deep automation is about making robots "smarter", about making robots that can fulfill a task more or less completely independent of an operator.

Another important deep automation that creates opportunities is machine vision. Machine vision is a crucial step towards intelligent robotics. Automated 3D measurement systems are replacing manually operated systems. Industrial robots without machine vision are essentially blind, repeating automated processes in a specific pattern, length and time. This implies that an industrial robot without machine vision can only do a specific task, as long as it is completely similar as before. In a manufacture, this means that if a metal plate is bigger than those treated prior, it will not be able to grip the metal plate and hence not treat it. With machine vision, the idea is that the robot will be able to see, react, analyze and decide by itself. Sensors combined with a system will make the robot able to scan each metal plate and adapt its grip continuous to the appropriate size. (Maguire, 2014).

Machine vision has been around for a long time, so it is not an emerging technology. However, it is an evolving technology. Jan Christian Kerlefsen and Steinar Riveland comments on machine vision: Jan Christian Kerlefsen (Appendix 1):

> Machine vision are something that we follow closely, and we know that our competitors are doing the same. There are many solutions for this and we are continuous developing new solutions. We believe that machine vision can become increasingly important inside

> some applications. There are new and existing camera technologies (e.g. point cloud) that can create new solutions (p.122 own translation)

Steinar Riveland (Appendix 2):

> ABB has an integrated machine vision and we are looking at several applications. One can imagine in the future, point- cloud cameras are used to scan an object, such that a simulation software and robot software can identify which objects the robot should pay attention to, and which one it should discard. (E.g. if one have an object that should be painted that is placed on a table, the robot should identify the object and pay attention to the limitations the table provides concerning freedom of movement.) The technology has come far since the 90`s. However, it will keep on growing (p.123 own translation)

Deep automation is process optimization. There is a version of deep-automation called plant-wide automation. Plant-wide automation is a way of thinking about the process design of an automated plant. The basic idea is; instead of having separate departments in a factory where each department more or less are managing their own progress, a main control room are operating each part of the chain interdependent. This system monitoring automated robots from a centralized system. The “head quarter” can control, manage and override all parts and every single robot of an automated production line. (Siemens, 2014)

There is no doubt that flexible production facility become essential for surviving in the future. The foundation of the increased competition in the market is entrenched in product variation and customization. It becomes increasingly costly to use humans as input to manufacturing. Smarter robots of the future that can create a variety of products. It could simply be a matter of programming your production facility instead of rebuilding it, when new products are put into production.

The trend has followed the developed countries outsourcing mass production to low-cost countries. Jan Frick, an operations management professor at UiS, said that a recent trend is that some companies has moved their production back home instead of outsourcing it overseas. The reason for this is that they have realized that it turn out to be difficulties related to coordination of the production when the distances are so far. For robots, this creates opportunities. Bringing production back may perhaps mean robotic solutions.

5.4 Threats for industrial robotics

5.4.1 Substitute goods:

The most obvious threats will of course be other substitute goods. Humans, machine tools, CNC *(“A Computer Numerical Control (CNC) uses a stream of digital information (codes) from a computer to control the functions and motions of a machine”* (Uglow, Carrier, Ibara, Yoshida, & Davies, 2012, s. 56)) and other type of automation systems. If other solutions are considered better or cheaper a manufacture would choose this over a robot. The substitute goods can also work as complement goods. Jean Marc Launay about substitute goods as the major threat for robots (Appendix 2):

> You could say that substitute goods are a threat. However, often the facilities we creates will consist of a combination. One can use simple forms of automation one place in the plant and a robotized solution somewhere else. It is not necessarily one way or another. Some processes will simply be better using hard automation (not robotize). Nevertheless, we see examples of fully robotized solutions (p.132 own translation).

Low-cost country sourcing is a direct threat of substitution. The choice is domestic production vs. outsourcing of production to countries with skilled and cheap labor. It is then a matter of robot price relative to wages.

5.4.2 Mental threats:

This argument concerns an overuse of robots. Steinar Riveland where quite concerned with the mistake of trying to robotize everything (Appendix 1):

> I believe that the problem today is that too many (robot producers) are looking towards too many applications at the same time. We see synergies and possibilities between different applications, but there are issues of concern. Take for an instance a car. If one is able to create a car (normal car) with the use of robots, then it becomes easy to create a pick up (bigger car) because there are synergies between different platforms. Then one can quickly walk into a trap, more or less unconsciously. We try to navigate applications towards something we want to focus on, but where we lack what we call the FrontEnd, which are the people that implements the robots to customers (E.g. RobotNorge), who needs the necessary competence and tools. It is of no use to develop a product, without having any one that can sell it, no one that can promote it, no one that can back it up. So it becomes important to choose a clear strategy. Where do one wish to go? Which direction do we believe is the right one to go? One cannot have an arsenal which is too large, that

> brings along too high costs. Even though there is a possibility for easy sales, one is lacking a sales team that is specialized (p.114 own translation).

Overuse of robots might lead to a restrictiveness and bad reputation toward robotic solutions. Bad experience will always make customer skeptical. If the robot producers gets a reputation of providing robot solution, where robot solutions are not required, the customers will stop choosing robotic solution.

This restrictiveness can be further amplified by the fact that people thinks that robotic solutions leads to job losses. Often when manufactures tries to implement industrial robots, they will meet resistance from labor movement. This resistance makes it difficult and more costly to implement robots. Therefore, a threat against robot can be that a manufacture, market or even countries have a restrictiveness towards robotic solutions.

Restrictive markets and manufactures, may lead to an unrealistic pay back demands. Jean Marc Launay said in the interview that (appendix 2):

> A payback period of 2-3 years is often the threshold for when customer are willing to invest in robotics. When we talk about a payback period of 1 year most customers want to invest. With a payback period over 2 years, the customers will often wait and see if there revenue are increasing or decreasing before they decide whether to invest. If the payback period surpasses 3 years, the investment is rarely carried out (p.129 own translation).

The point here is that customers are unwilling to invest in projects that would have been good projects, simply because they are afraid of investing in long term projects. The threat is that only projects with unrealistic short payback period are realized (in restrictive markets).

5.4.3 Investments threats

Industrial robots are capital goods, valuable inputs in production. The robot customers are various manufacturers and industries. Robots constitute substantial and long-term investments. Robot Market is sensitive to fluctuations in the underlying economy and it can mean serious consequences if recession is lurking, especially for a company that is 100% engaged in industrial robots. If companies start reducing investments, robot companies are the first one to be affected. The financial crisis played a nasty trick on all robot-producing companies.

6 Discrete data analysis and variable explanation (panel data)

This section will deal with the global market of industrial robots. The worldview 2013 is briefly presented before a gradually zooming into the Chinese market. Relevant market drivers and data are explained using descriptive statistics and CAGR –calculations (Compounded annual growth rate). The data is designed to compare China with highly automated and robotized countries like Japan, USA, South Korea and Germany. At the end of the section the examined variables is used in a panel data analysis. The goal is to identifying changes and impacts the variables might have on the yearly sale of industrial robots.

6.1 Worldwide sales

The worldwide sales of industrial multipurpose robots are summarized in the figure below, notice that the 2013 number was obtained fourth of June 2014:

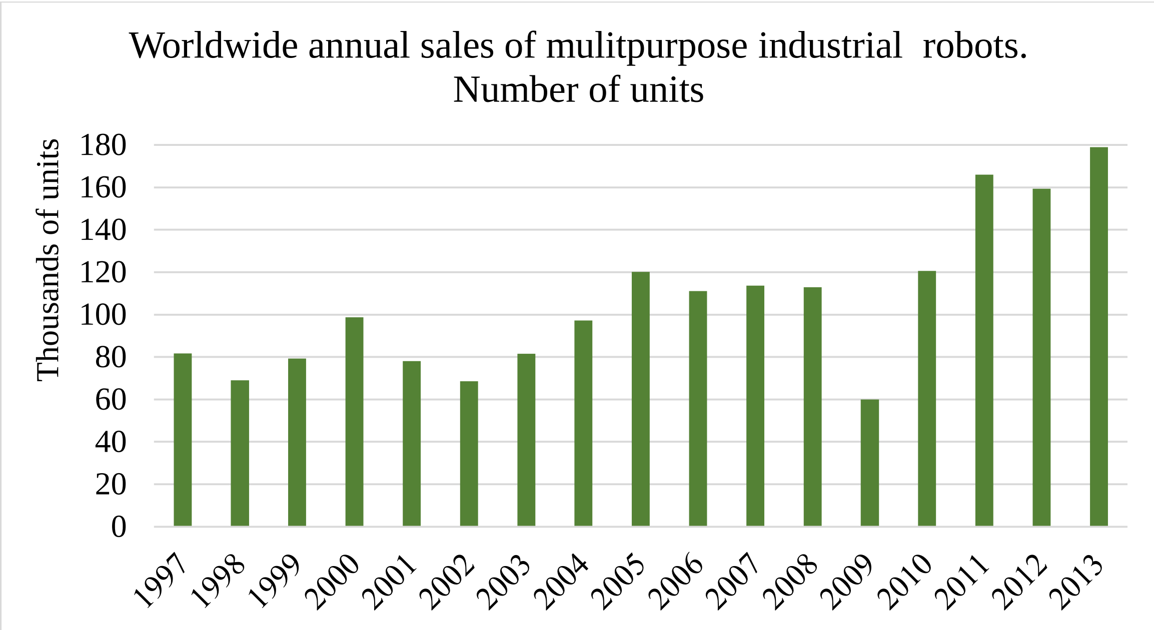


Figure 18 Source: (International Federation of Robotics, 2013)

Munich, 04 June 2014 - *"In 2013, about 179,000 industrial robots were sold worldwide, again an all-time high and 12 percent more than in 2012"* announced Arturo Baroncelli, IFR President. *"Incoming orders in the first four months of 2014 increased remarkably and requests from all customer industries are on the rise. Therefore, we expect that in 2014 growth of unit sales will continue with the same pace like in 2013,"* stated Baroncelli. (Baroncelli, 2014)

The table below shows how the sales is divided among different world regions.

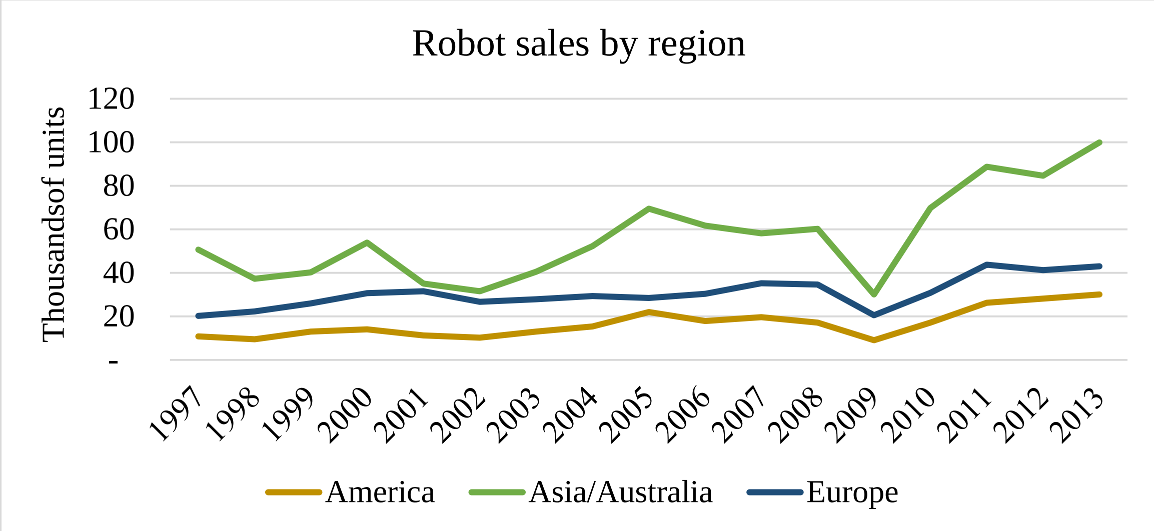


Figure 19 Source: (International Federation of Robotics, 2013)

As we can see on the figure above the Asia dominate the robot market in terms of robot sales. The Asian market had a considerable growth in sales after the Global Financial Crisis due to strong demand from China.

REGION / TIME HORIZON	**CAGR 1997-2013**	**CAGR 2002-2013**	**2013/2012**
ASIA/AUSTRALIA	4,3%	10,6%	18,1%
EUROPE	4,9%	4,4%	4,3%
AMERICAS	6,6%	11,8%	6,6%
THE WORLD	**5,0%**	**9,6%**	**12,3%**

Tabel 4 Source: (International Federation of Robotics, 2013)

6.2 Total accumulated sales and operational stock

The total worldwide **accumulated sales** of industrial robots was about **2 470 000 units** by the end of 2012. IFR measures this estimate from the end of the 1960s.

Like any other capital goods, industrial robots have an expected service life. Using accumulated sales to describe the operating robot population will lead to an overvalued inventory of robots. There is no doubt that several of the early robots are taken out of service. To measure the size of the operational stock, an average **service life of 12 years** has been assumed, in accordance to IFR.

6.3 Worldwide operational stock

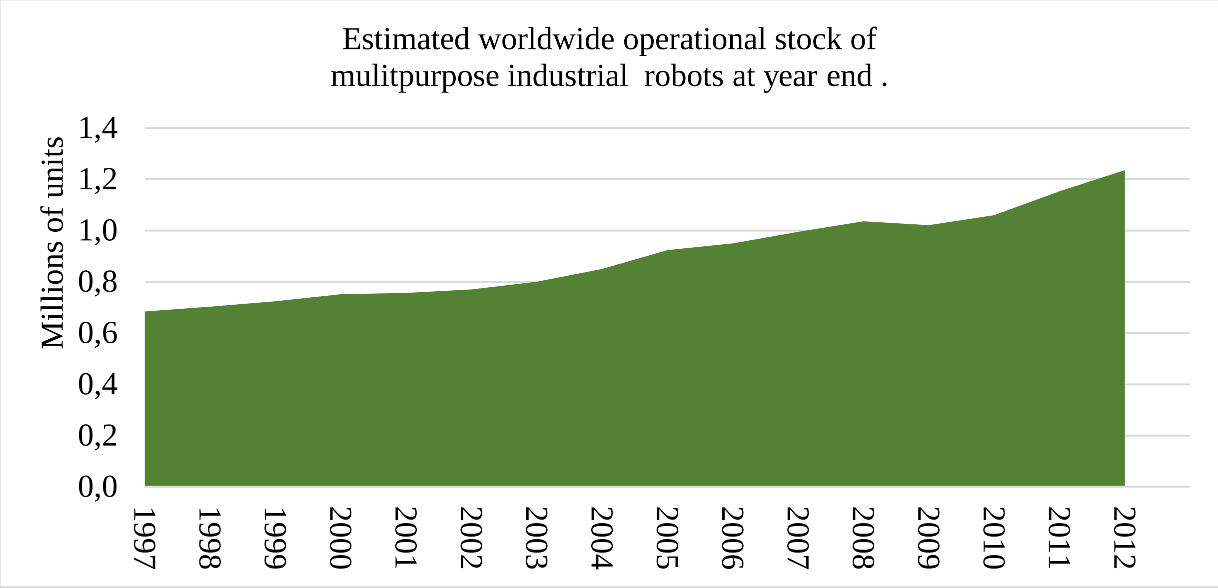


Figure 20 (International Federation of Robotics, 2013)

6.3.1 Who are your best customers?

In 2012, about 70% of the total robot sales went to Japan, China, the United States, South Korea and Germany. China is the fastest growing market in the world. During the period from 2008 to 2013, sales of industrial robots to China reached an average annual growth rate of over 36%. From 2012 to 2013 the robot demand in China increased with 61%! A report from Morgan Stanley claims that this growth will continue and possibly accelerate in the near future. (Uglow, Carrier, Ibara, Yoshida, & Davies, 2012)

6.3.2 Leading robot-using branch

The largest consumer of robots is the automotive industry, which has been a major driver of robot penetration in manufacturing. Robots are used in metals industry, electronics, food and beverages, logistics and aerospace.

6.4 Analysis of robot density

Comparing country in terms of units can be misleading. Robot density is a measure that accounts for the difference in size of the manufacturing industry. The measure is defined as: number of multipurpose industrial robots per 10 000 employees in manufacturing industry. (International Federation of Robotics, 2013)

Countries above the world average robot density:

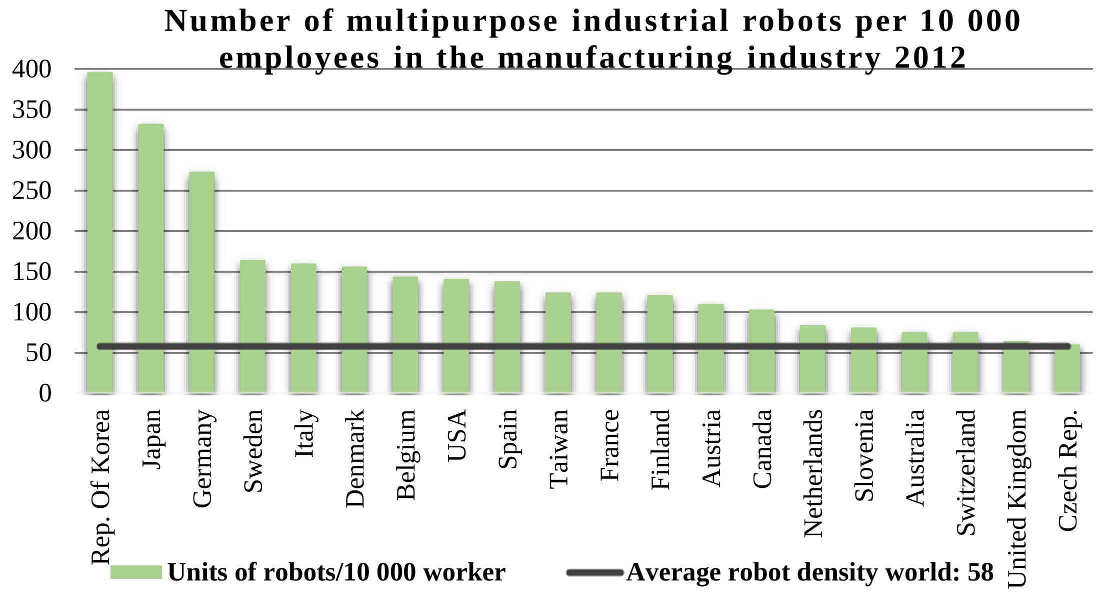


Figure 21 Source: (International Federation of Robotics, 2013)

Countries below the world average robot density:

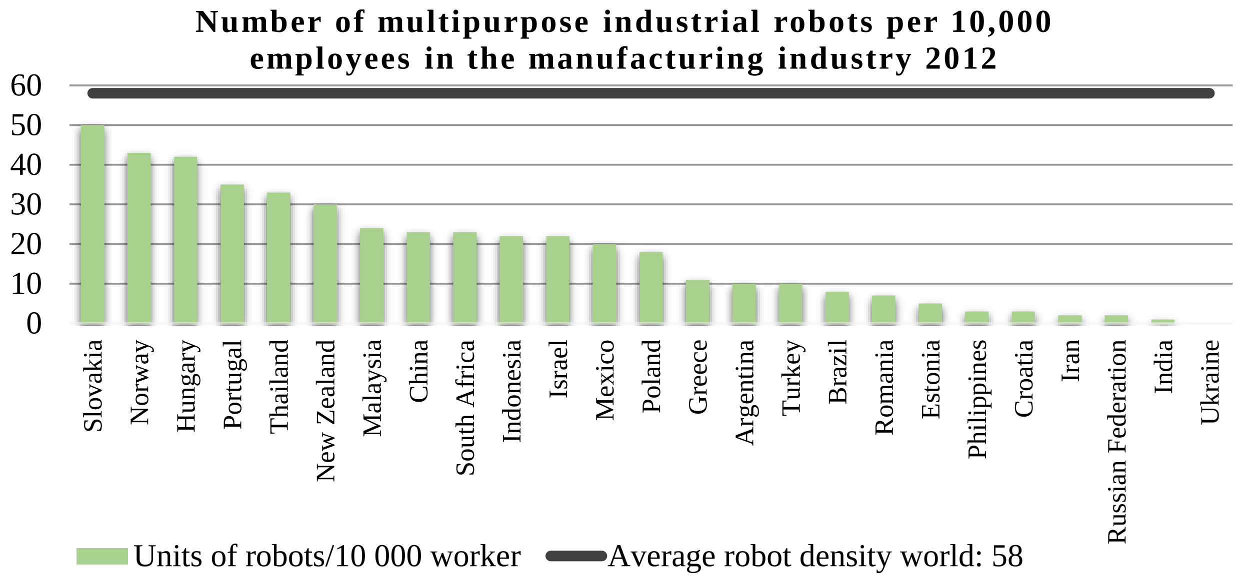


Figure 22 Source: (International Federation of Robotics, 2013)

In the global context, China contributes greatly to both the purchase and the operational stock of robots. China also has a small density of robots, only 23 robots/ 10 000 workers employed in the manufacturing industry in 2012. Chinas density is below the world average of 58 robots/ 10 000 workers. This fact is indicating the potential of substantially investments in industrial robots in China. If China was to obtain the same robot density as the most automated/robotized countries like South Korea (396 robots/ 10 000 worker), Japan (332 robots/ 10 000 worker) and Germany (273 robots/ 10 000 worker), a considerably amount of robots would have to be installed into Chinese manufacturing facilities the coming years. About 1 million units of robots would be required today, with a market value (robot + system) of roughly 100 billion US$ today, everything else held constant.

6.5 Why is automotive an important driver?

There is another reason that amplifies the potential for industrial robotics in China. Namely the motor vehicle production. There is a strong positive correlation between motor vehicle production and industrial robots. The next chart will show the robot density in the automotive y in comparison with all other industries. The selected countries are all major motor vehicles producers. The automotive industries is the most robotized industries, with the highest rate of automation.

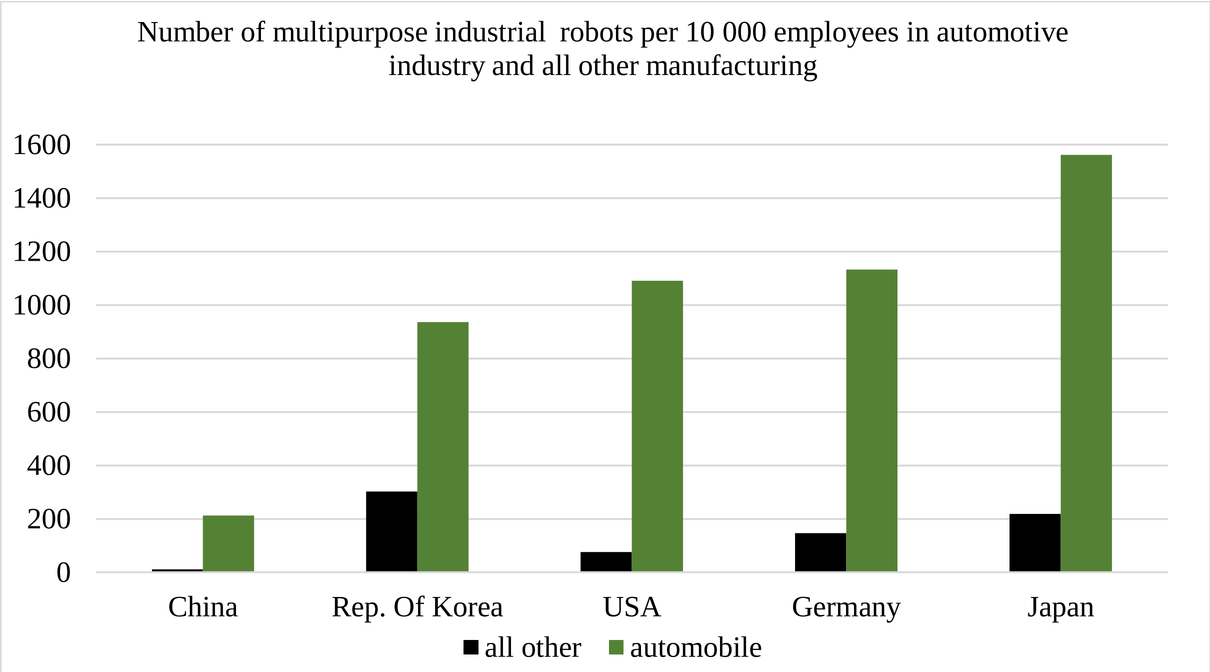


Figure 23 Source: (International Federation of Robotics, 2013)

The figure is implying the potential of implementing a tremendous number of robots into the automobile industry in China. It may be pointed out that China has become world largest motor vehicle producer.

The table below shows the aspect of the specific per capita share of industrial robot in automotive industry and all other industries, in 2012:

	Automotive	All other industry
Japan	1 562	219
Germany	1 133	147
USA	1 091	76
Rep. of Korea	936	302
China	213	11

Table 5

Based on the annual average over 2007-2012, the global manufacturing industry accounts for at least 85% of the worldwide sales of industrial robots. The rest is defined as unspecified branch in the sales statistics. Hereby, on the same annual average the automotive sector accounts for about 42% of the manufacturing sector, followed by electrical/electronics sector with a 23% share of sales in the manufacturing industry.

Other key industry branches for the robot suppliers are plastic/chemical products and the metal industry, both having a roughly 12% share of the robot shipments. The food and beverage industry accounts for about 4% of the worldwide sale.

6.5.1 China is a world leading motor vehicle producer

In 2009, China became the world biggest producer of motor vehicles. In 2013, China produced about 22.1 million motor vehicles, an increase of almost 15 % from the year before. China vehicles production accounting for slightly over quarter of the world total production in 2013. (Organisation Internationale des Constructeurs d'Automobiles, 2014)

The world production of motor vehicle together with the top five motor vehicle producing countries in 2005:

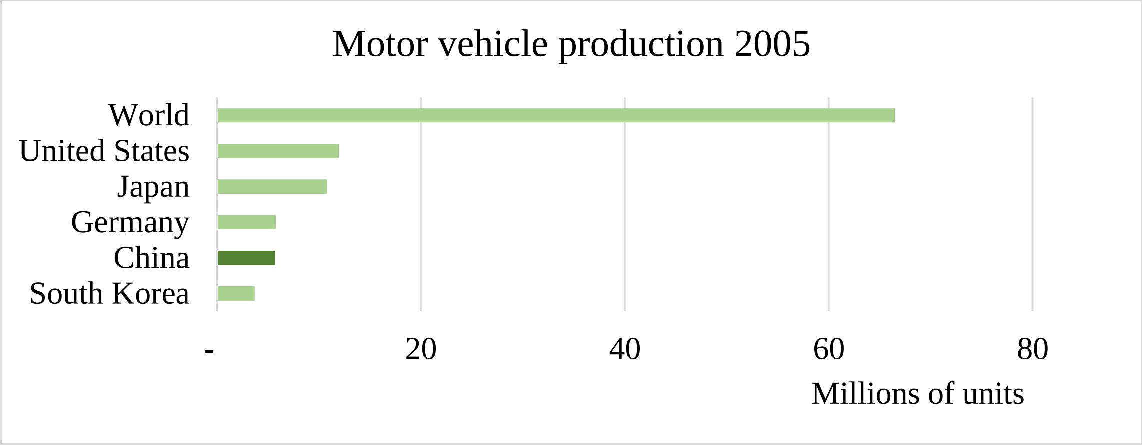


Figure 24 Source: (Organisation Internationale des Constructeurs d'Automobiles, 2014)

In 2013, the situation was quite different for Chinese motor vehicle production. China accounts for a quarter of the world output of motor vehicles:

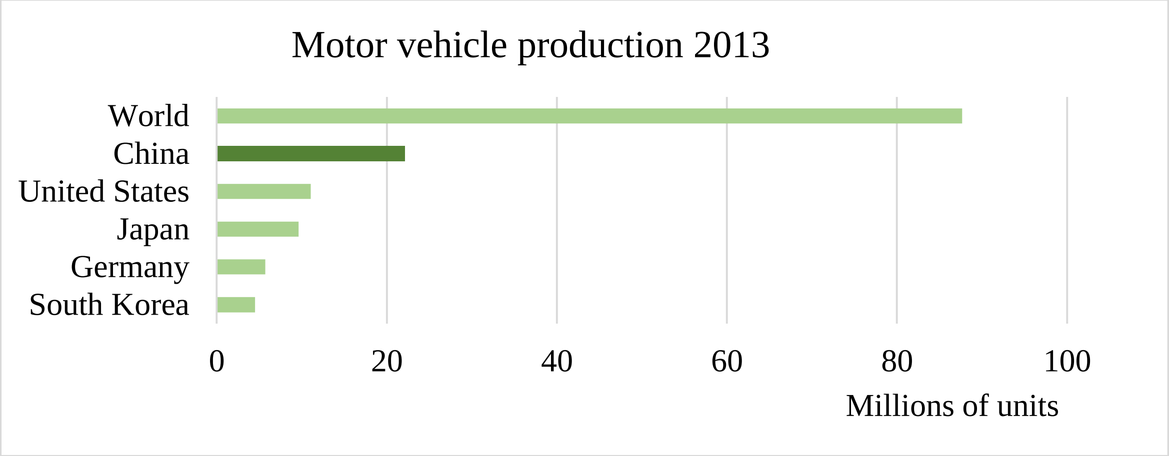


Figure 25 Source: (Organisation Internationale des Constructeurs d'Automobiles, 2014)

	Compounded annual growth rate			
	Motor vehicle production **2005 - 2013**	Sales new motor vehicles **2005 - 2013**	Total motor vehicles in use **2005 - 2012**	Motorization rate (vehicles/1000 inh.) **2012**
World	*3,5 %*	*3,3 %*	*3,62 %*	*170*
China	*18,4 %*	*18,2 %*	*19,39 %*	***79***
United States	*-1,0 %*	*-1,2 %*	*0,81 %*	*791*
Japan	*-1,4 %*	*-1,1 %*	*0,08 %*	*599*
Germany	*-0,1 %*	*-1,3 %*	*-0,80 %*	*562*
South Korea	*2,5 %*	*3,5 %*	*2,95 %*	*386*

Table 6 Source: (Organisation Internationale des Constructeurs d'Automobiles, 2014)

It is necessary to specify the substantial change in the production dominance, because of the strong connection between the applications of industrial robots in the decisive industry of motor vehicle production. There has been an overwhelming growth in both production and domestic demand for automobiles in China. If China as of today had a motorization rate (The motorization rate is defined as the number of passenger cars per 1,000 inhabitants (Organisation Internationale des Constructeurs d'Automobiles, 2014)) equal to the world average, approximately 100 000 000 vehicles would have to be produced, all else held constant.

Motor vehicle production will be incorporated as an explanatory variable in the panel data analysis.

6.6 Rising wages

At present, China is in the process of development from labor-intensive mode to modern and automated manufacturing industry. This next step in the industrialization is an important task in the economic development of China.

With increasing economic growth and access to capital, the labor supply in China is gradually decreasing. The contradiction between labor and capital has escalated, and this fact has driven the labor costs to rise rapidly (International Federation of Robotics, 2013), (Uglow, Carrier, Ibara, Yoshida, & Davies, 2012).

The changing factors are compelling to structural change in China, both within manufacturing sector as well as social long-term shifts. Improving the production efficiency by using robots can effectively promote the transformation and upgrading of traditional industries.

From 2000 to 2012, per capita pay of employees in the manufacturing industry increased from 8750 Yuan to 41 650 Yuan with an average annual nominal growth rate of 13.9 % and an average annual real growth rate of 11.6 %.

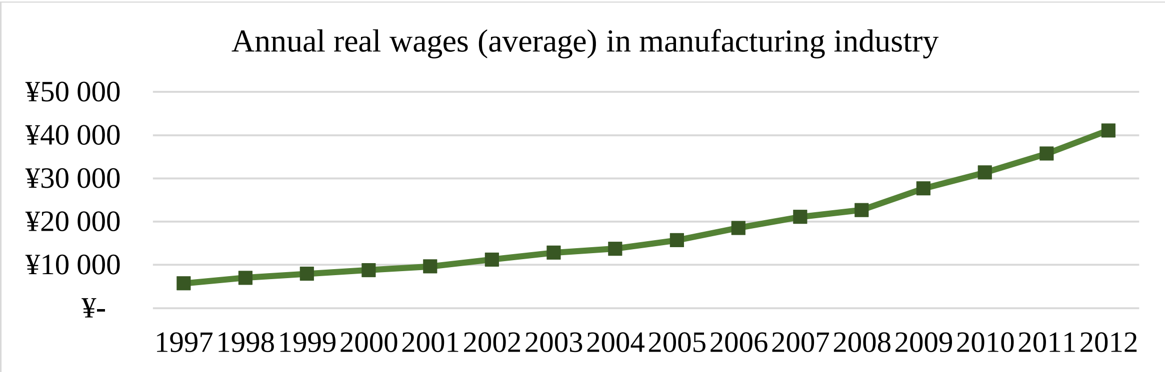


Figure 26 Source: (Thomson Reuters, 2014)

Wages in manufacturing will also be included as a variable in the panel data

6.7 Chinas aging time

“Made in China” which boosted the advantage of cheap labor is facing more and more challenges .A contributing reason to pressure on the wages is caused by the fact that China is gradually entering the aging time. China’s working-age population is now showing a trend of decreasing. The trend is summarized in the table below:

	2000	**2012**
Total population	1 262 645 000	1 350 695 000
Population ages **0-14**	**25,6 %**	**18,0 %**
Population ages **15-64** (working-age)	**67,5 %**	**73,3 %**
Labor force participation rate (% of total working-age population)	*82,4 %*	*77,0 %*
Population ages **65 and above**	**6,9 %**	**8,7 %**

Table 7 Source: (World Data Bank, 2014)

The proportion of people above 65 in China will surpass that of Japan in 2030, which will make China the world's most aged society, according to a report by Chinese Academy of Social Sciences (Chinese Academy of Social Sciences, 2014). From 2000 to 2012, the annual average population growth was 0.58 % due to family planning policy. China has a large population, and after aging of population, it could encounter the Lewis turning point by installing industrial robots. Lewis turning point is describe in The Economist 31.01.2013 (A.C.S, 2014):

> When an economy first becomes industrialized it grows very fast by importing foreign technology and employing capital and plentiful, cheap, unskilled labor from the farm. However, after a while the extra agricultural labor is put to work and wages start to rise. This makes firms less profitable and they have to come up with their own technology to keep growing. This shift is known as the Lewis Turning Point.

The growth in the Chinas working age (15-64) has slowed down.

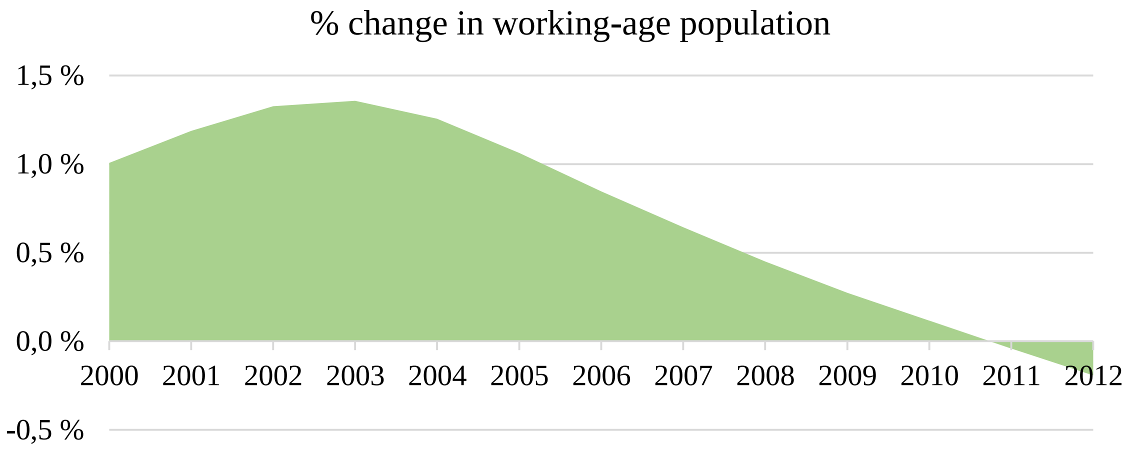


Figure 27 Source: (World Data Bank, 2014)

7 Panel data

The objective is to find an explanation to how the different variables affecting the change in sales of industrial robots. To which extent can the selected variables explain the change in annual sales?

In this section, the reviewed variables are tested in a panel data analysis with respect to the annual robot sales. Panel analysis, also called longitudinal data or cross-sectional time series data, are data where multiple cases were observed at two or more time periods.

Due to lack of observations necessary to conduct an adequate regression analyses on China alone, the panel data method comes in handy. Using additional countries within the same time horizon compensate for insufficient observations. The fixed effect model is applied. Fixed effects means that the regression model only measures the relationships between explanatory variables across time inside a country, not between countries.

The data set is characterized as unbalanced panel due to missing data in some years for certain variables in some countries. This weakens the analysis, but it is still valid.

The statistical software package, STATA, is used to run the panel data.

The data is transformed to percentage change per year to establish a common measurement among the variables (stationarity).

The panel data regression with fixed effect (cluster robust estimator) is a strict model; hence, it is difficult to obtain significant observations. As the depended variable of interested is annual robot sales, the model included the 18 countries with the highest robot density. (Appendix 4)

7.1 Correlation matrix

	Annual supplies	GDP per capita (constant)	Age dependency (old)	Employment in manufacturing	Export of goods and services	Manufacturing	Unemployment rate	Motor vehicle production	Wages in manufacturing	Capacity utilization	Inflation (CPI)
Annual supplies	1.0000										
GDP per capita (constant)	0.2806	1.0000									
Age dependency (old)	0.0067	-0.0483	1.0000								
Employment in manufacturing	0.0830	0.1856	-0.0909	1.0000							
Export of goods and services	0.2397	0.7636	0.1229	0.1012	1.0000						
Manufacturing	0.2721	0.8614	0.0770	0.1335	0.8432	1.0000					
Unemployment rate	-0.1534	-0.6522	0.1072	-0.1647	-0.3225	-0.4473	1.0000				
Motor vehicle production	0.2248	0.4522	-0.0101	0.0764	0.4748	0.5149	-0.2589	1.0000			
Wages in manufacturing	0.0432	0.0103	-0.3185	0.0797	-0.1399	-0.0355	-0.1511	0.0039	1.0000		
Capacity utilization	0.1637	0.5456	0.0958	0.0069	0.6486	0.6479	-0.2242	0.2611	-0.0514	1.0000	
Inflation (CPI)	0.0004	0.1127	-0.1264	-0.0603	0.2298	0.1050	0.0263	0.0293	-0.2893	0.1024	1.0000

Table 8

There is unfortunately a certain multicollinearity problem among the explanatory variables in the dataset. The problem applies in particular to the GDP-values, which was somewhat expected. Without considering the correlated variables, noise in panel data will occur. High correlation between two variables will yield a higher variance for both of them. Higher variance makes it more difficult to find casual relationships between the explanatory variables and the depended variable. Since we do not care about correlation between two explanatory variables, we exclude them. The problem is reduced by excluding the strongest correlated variables (Wooldridge, 2009).

7.2 Fixed-effects (within) regression, with cluster-robust estimator (1)

Annual sales of industrial robots regressed on multiple selected independent variables

Number of observation	=	233
Number of groups	=	18

	Within	0.0800	F(7,17)	23.02
R^2	Between	0.0574	Prob > F	0.0000
	overall	0.0733		
			corr(u_i, Xb)	-0.1869

	Coefficient	Standard error	T-value	P-value (95%)
Motor vehicles production	.400457	.2658235	1.51	0.150
Wages in manufacturing	-1.368885	1.342789	-1.02	0.322
GDP per capita (constant)	6.104513	2.08136	2.93	0.009
Age dependency (old)	6.86795	3.37392	2.04	0.058
Unemployment rate	-.0290434	.2176766	-0.13	0.895
Employment in manufacturing	.4151254	.5749037	0.72	0.480
Inflation (CPI	-2.460487	6.495003	-0.38	0.710
Constant	.0826233	.1312059	0.63	0.537

Table 9

Explanation of the model

The first model runs all explanatory variables (6) for every country included (18), except Export of goods and services, manufacturing (of GDP) and capacity utilization. They are excluded because of multicollinearity.

Interpreting the results

The model is significant, see F-value. R-squared is rather low; suggesting the model is explaining 7.33 % of change in robot sales.

GDP per capita is significant. The model suggest that a 1 % change in real GDP per capita corresponds to about 6% change in robot sold.

Wages in manufacturing is not significant. The model estimates a negative relationship between growth in wages and growth in annual sales. This contradicts with theory, which states that robot sale will go up when wages increases. It is likely that the model suffers from spurious regression problem (it seems like there is a negative relationship between them, but in truth there are omitted explanatory variables that make them behave different than expected). Another explanation is that wages lags relative to sales of robots. A third explanation to the problem might be that robot sales constitute only for a small portion of the manufactures that have been included in the explanatory variable wages. This means that wages are not able to effect robot sales as much as theory suggest, simply because too many manufactures are not considering robots at all.

Age dependency is significant with a 90 % confidence interval. The model suggest that a 1 % change in Age dependency corresponds to a 6.8 % change in robot sale. When age dependency goes up the general population of a country is getting older. This finding corresponds to theory, which states that manufactures will buy more robots, when the general population are getting older.

Unemployment is highly insignificant. The model finds very little relationships between robot sale and unemployment. However, theory says that whenever unemployment is low, the need and willingness to buy robots increase. The estimated negative correlation coincides with theory.

Motor vehicles production are insignificant. However, robot industry tend to be heavily depend on the automobile industry. Theory states that this is an important factor for the growth in annual robot sales. Reasons why it is not significant might be that too many of the included countries have none or too small car production.

7.3 Fixed-effects (within) regression, with cluster-robust estimator (2)

- Annual sales of industrial robots regressed on multiple independent variables

Number of observation	=	264
Number of groups	=	18

	Within	0.0725	F(3,17)	24.20
R^2	Between	0.2074	Prob > F	0.0000
	Overall	0.0802		
			corr(u_i, Xb)	0.1660

	Coefficient	Standard error	T-value	P-value (95%)
Motor vehicles production	.4202938	.2240068	1.88	0.078
GDP per capita (constant)	6.121193	2.650032	1.96	0.067
Age dependency (old)	5.186181	1.168149	5.24	0.000
Constant	.0191845	.0377597	0.51	0.618

Table 10

Explanation of the model

In model 2, a panel data is conducted applying only variables that theory have pointed out to be most important for robot sales. The model use the same number of countries in the estimation as in model 1.

Interpreting the results

The model is significant, see F-value. R-squared is still low; suggesting the model is explaining 8% of change in robot sales, marginally higher then model (1).

Except for the constant term and GDP per capita, all the explanatory variables are more significant in model (2).

Age dependency are highly significant. The model suggest that a 1 % change in Age dependency corresponds to about 5.19 % change in robot sold.

Motor vehicles production are now significant. The model suggest that a 1 % change in Motor vehicles production corresponds to a 0.42 % change in robot sales.

GDP per capita are still significant, suggesting that a 7 % growth in real GDP per capita for an average country within the dataset, would result in an over 40 % growth in robot sales.

7.4 Fixed-effects (within) regression, with cluster-robust estimator (3)

- Annual sales of industrial robots regressed on motor vehicle production

Number of observation	=	264
Number of groups	=	18

	Within	0,0378	F(1,17)	7.23
R^2	Between	0,3285	Prob > F	0.0156
	Overall	0,0527		
			corr(u_i, Xb)	0,1285

	Coefficient	Standard error	T-value	P-value (95%)
Motor vehicles production	.7608808	.2830606	2.69	0.016
Constant	.2127258	.0013828	153.84	0.000

Table 11

Explanation of the model

As motor vehicle production are pointed out in theory as important for robot sale growth, the analyze runs the regression with only Motor vehicles production as explanatory variable.

Interpreting the results

When using no control variables the motor vehicles production variable are significant. The coefficient are getting closer to one, which indicates an almost perfect relationship between robot sale and cars produced.

The R^2 are though lower than model 1 and model 2, suggesting the model is explaining 5,27 % of change in robot sales.

7.5 Fixed-effects (within) regression, with cluster-robust estimator (4)

- Annual sales of industrial robots regressed on GDP per capita
-

Number of observation	=	296
Number of groups	=	18

	Within	0.0611	F(1,19)	39.67
R^2	Between	0.2186	Prob > F	0.0000
	overall	0.0730		
			corr(u_i, Xb)	-0.0974

	Coefficient	Standard error	T-value	P-value (95%)
GDP per capita (constant)	7.020854	1.114717	6.30	0.000
Constant	.0744938	.0203621	3.66	0.002

Table 12

Explanation of the model

The last model (4) runs a regression using only GDP per capita (constant prices).

Interpreting the results

Not surprisingly, the model is significant. The model suggest that 7.3 % of the change are explained in the model.

GDP per capita is very significant. Model (4) suggest that a 1 % change in GDP per capita corresponds to about 7 % change in robots sold.

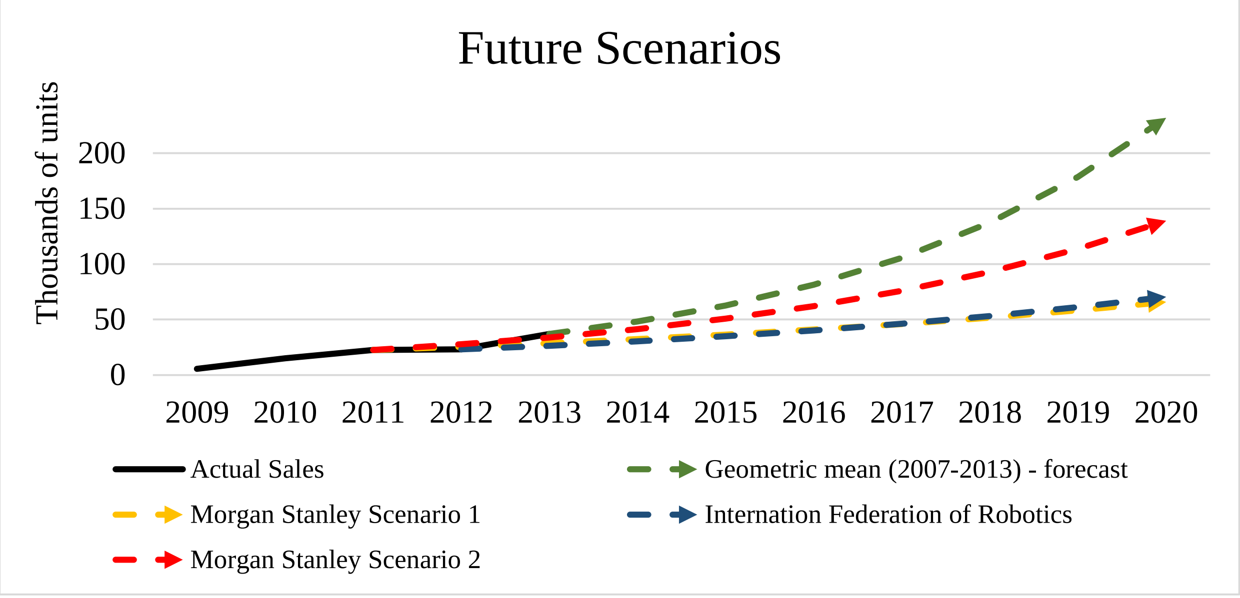
7.6 Forecast of sales in China

Morgan Stanley forecast:

- Scenario 1: 12,6 % CAGR
- Scenario 2: 22,4 % CAGR

International Federation of Robotics forecast:

- 15% CAGR



The Morgan Stanley Blue Paper started projecting from 2011. IFR's forecast was running from 2012. The 2013 actual sales were published the 4 June 2014. As seen from the figure above, all the prognoses are lagging behind the actual sales. It is reason to believe that it is a stronger growth in this market than previously expected. The CAGR in robots units sold from 1999-2013 is 35 %.

The International Monetary Fund's forecasts with a nearly 8 % annually increase in GDP per Capita towards 2018 in China. Plugging the forecast estimate into the panel data results yields an annually growth of about 55 % in robot sales to China (model 4). The paper will not apply the panel data forecast since the R-squared of the model is rather weak, > 10 %. The estimate should be interpreted as a rough indicator.

This paper will assume a **20 % annual increase towards 2020**. The estimate is based on the already existing and own calculations about the future growth of Industrial robots in China. Foreign suppliers increased sales (units) with about 20% from 2012 to 2013. (Baroncelli, 2014)

8 Porter`s Five Forces – Understanding Rivalry In The Chinese Industrial Robotic Market

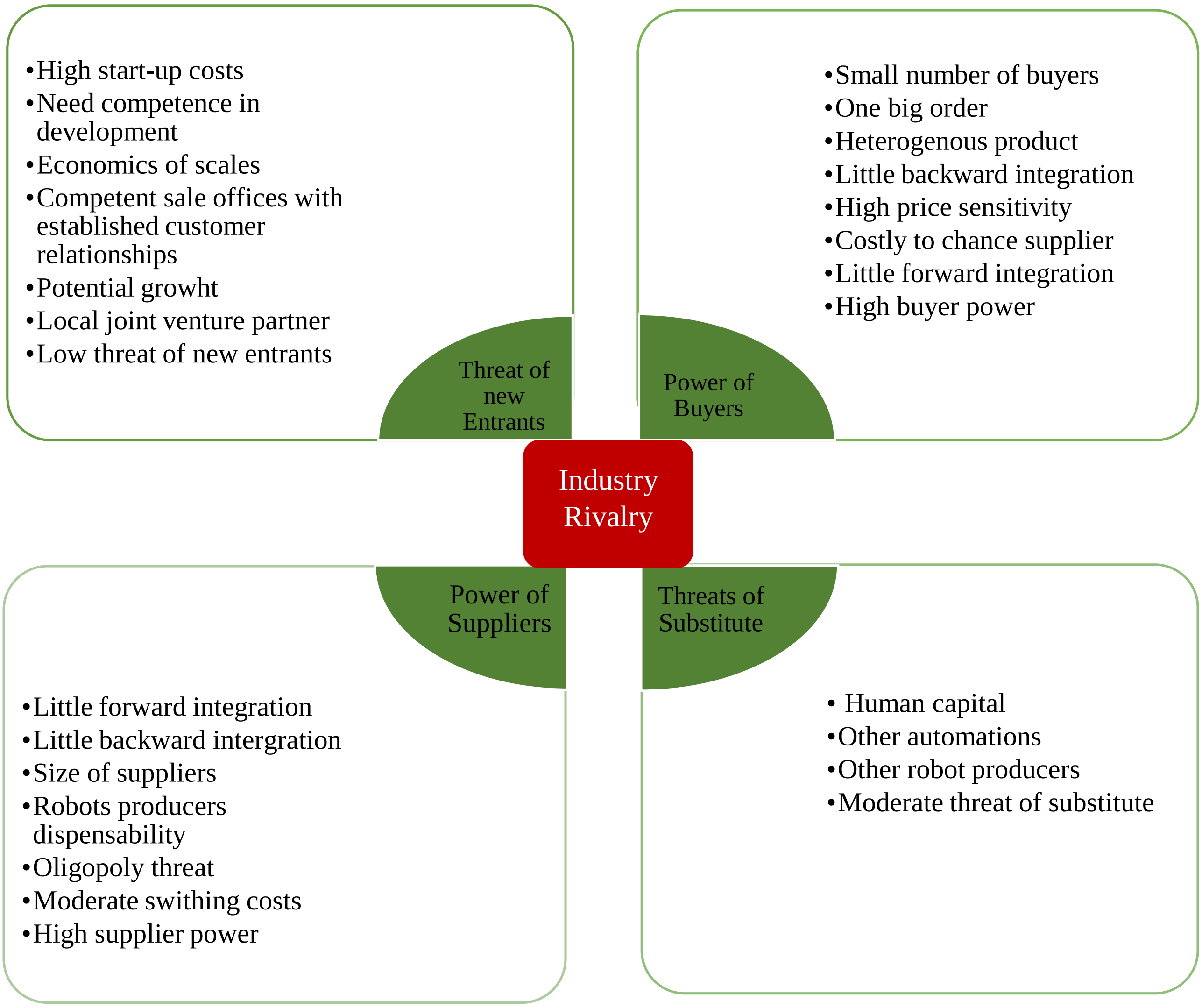


Figure 28 Porter`s Five Forces

In this section, the analyze will focus on the competitive rivalry inside industrial robotics, primarily towards the Chinese market. The analysis will use a scale from 1-5 where 1 is very low power/threat and 5 is very strong power/threat. Each factor mentioned will be rated and the average of the total will be used as a measurement for the combined competitive rivalry. Different factors are assume as equally important. The rating are based on the writers own opinions based on knowledge acquired through research and qualitative interviews. The rating system is a calculated estimate. Other writers and professional institute might rate different factors differently.

8.1 Threats of new entrants

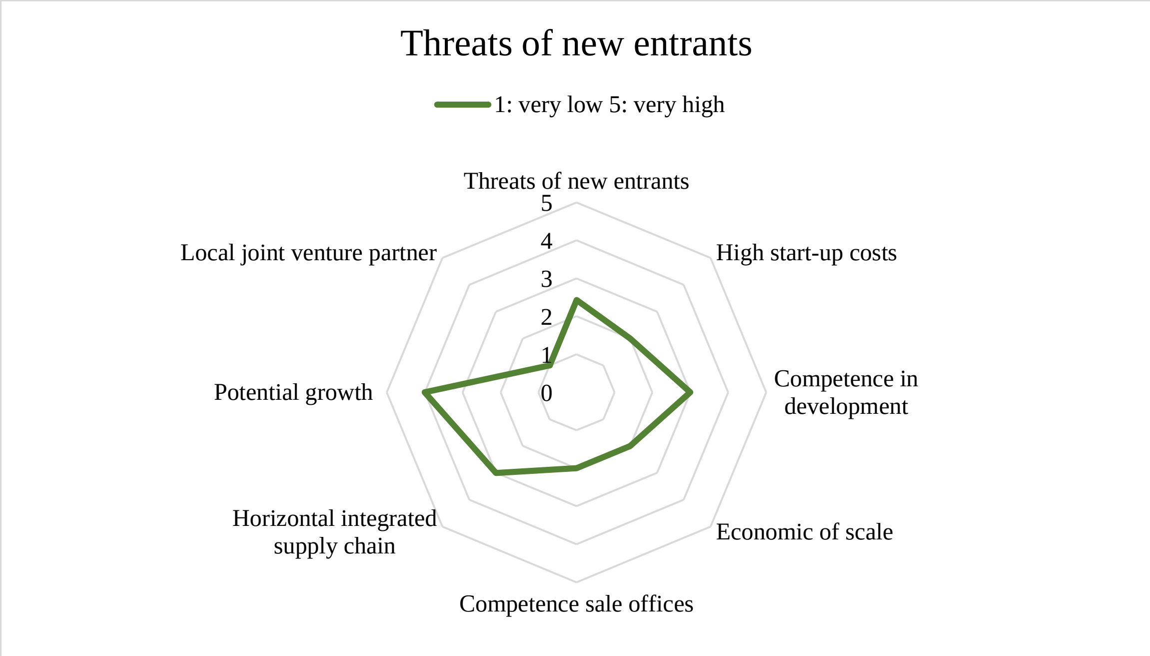


Figure 29

8.1.1 High startup costs (2: low)

There are high start-up costs in the Chinese industrial robot markets (mention in SWOT). This means that new companies will need to invest much money before they can even consider entering the market. This favor the existing companies. New entrants needs to be wealthy, which of course benefits the big existing robot companies, compared to completely new companies.

8.1.2 Competence in development (3: moderate)

There are high costs associated with development (product life cycle cost theory). This also favors big existing companies as they have been in the robot industry for many years and should have developed a company with competence and innovation potentials.

However, there are some drawbacks. First, as the big companies where the first to enter the Chinese robot industry (roughly) they have used much money on research. In their path towards perfection, many failed project might have happen, much technology research has never led to better solutions and competent human capital, which the company have used money to train, has changed jobs. This means that many costs are associated with the process of becoming leading in industrial robotics. In order to justify these costs, they need to earn them back on robot sales. As new companies can benchmark, they can skip the entire try and failed process and go straight to the process of creating a robot similar to those delivered by the existing companies. As much research costs are avoided, they might be able to deliver the same robot (at least the hardware) for a smaller price. The existing companies might have patents that will protect them against this though.

In addition, well-established companies tend to be conservative. Years of experience coping with standards and regulations might have made them blind towards better solutions. A startup firm will probably consist of younger and more inexperienced workers. They will not have the same pessimistically trend towards thinking in new manners. This is what Jean Marc Launay had to say about new entrants (appendix 2):

> New robot producers struggles to establish themselves in the market. However, we see that a Danish producer (Universal Robots) has become interesting lately. It will be interesting to see if they are still here in 3 years and how large they possible have come. They are introducing new ideas that gives them growth potential. Can they become as big as ABB, KUKA or the other big companies (Yaskawa and Fanuc)? They are developing robots that do not require safety, hence fences and stuff. The idea is that a human should be able to work beside the robot and if they collide the robot stops. This is new thinking and challenging to us that have work for ABB for many years and follows specific standards. Of course, it will be difficult for them to enter the market and in order to be able to, they need to bring something new. It will not be enough to copy an ABB robot. However, it seems like Universal Robots are bringing something new that will bring robot and humans closer together (appendix 2 p.135 own translation)

Jean Marc makes a great point that although new producers can skip many costs associated with introduction phase, but this is not sufficient to establish themselves in a robot market. A new enter will need to be innovative. This point are favoring established companies, as bringing new ideas to the market is difficult and costly to develop.

8.1.3 Economic of scale (2: low)

As there are high-startup costs, high-to-moderate development costs (product life cycle cost analysis theory) and competent human capital is important, this means that the market favors companies that can fully exploit economics of scale.

8.1.4 Competence sale offices with established relationships (2: low)

Exploiting economics of scale means robot producers needs to sell as many robotic solutions as possible. They need to have competent sales offices that have established good customer relationships. Introducing robotic solutions to customers are time consuming, costly and associated with risk. One would therefore expect customers to choose suppliers they have used before and trust. Jean Marc Launay said in the interview: *"We experience that 95 % of our customers are satisfied. There are of course always a few, which for some reason are not satisfied with us or the robot… Most customers are happy and will buy from us again"* (appendix 2 p.134 own translation). A new robot producer that does not have established customer relationships, will have a disadvantage.

8.1.5 Horizontal vs. vertical integrated supply chains (3: moderate)

Robot producer might have vertical or horizontal integrated supply chains. An established robot producer with an integrated sales office will have the strongest position when it comes to market entry. They do not suffer from pressure from independent sales offices that want to press the price down such that they can benefit from the margins. A robot supplier that have a horizontal integrated supply chain will have a looser relationship to their sales offices. Contracts, established relationship and mutual understanding often implies that large companies with horizontal integrated supply chains have strong relationship to their sales offices, but at the same time having a weaker position.

8.1.6 Potential growth (4: high)

There are potential for growth of robotic towards China. As the Chinese robot market is increasing more than the world average, new enters can attain a customer base, without "stealing" customers from established companies. This will benefit new enters as new customers do not have relationship to robot suppliers. In addition, the rapidly increasing demand from Chinese markets can make it difficult for the established companies to deliver on time.

8.1.7 Local joint venture partner (1: very low)

China is governmental regulated. This means that foreign robot producers are only allow to sell robots in China through a local joint venture partner. This means that new foreign robot producers has a disadvantage entering the market. It gives the existing companies a major benefit. (International Federation of Robotics, 2013)

8.1.8 Threat of new enters (2.43: moderate)

The threat of new enters towards the Chinese robot market are low to moderate.

8.2 Power of buyers

Who are your buyers, becomes a question about definition. Markets where the robot supplier are operating through independent companies (horizontal integrated supply chain), such as ABB cooperates with RobotNorge in Norway, where RobotNorge is the buyer.

8.2.1 Independent sale offices power

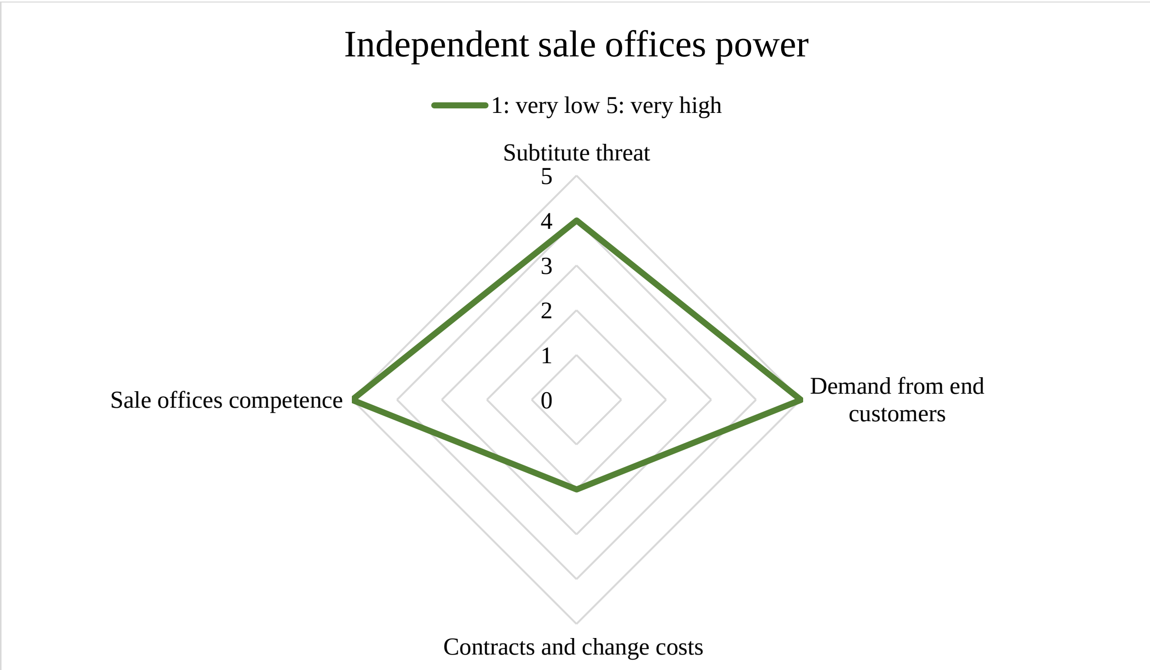


Figure 30

8.2.1.1 Demand from end customers (5: very high)

Sales offices have to some extent power to affect the robot producer's decision-making, given that the sales offices is the buyer. It becomes important to take into account what the sales offices need, in terms of robot solutions, in order to make them capable of deliver optimal solutions to their customers (end users).

8.2.1.2 Contracts and change costs (1: very low)

Independent companies that has well-established relationships to the robot producer will have more power compared to a dependent company (vertical integrated), as they have the possibility to change from one robot producer to another. If an independent company like RobotNorge AS wants to focus on an innovative idea, for example closer human-robot interaction, ABB may find this little tempting to invest in. They could put pressure on ABB by announcing that they will start buying from other companies.

8.2.1.3 Sale offices competence (5: very high)

As the sale offices are the one that actually creates accumulated sales, it will always be important to take into account what they need to provide the market. Robot producers can produce products they find attractive, but as long as none of their sales offices do not know how to implement the product or do not believe in it, it will not create competitive advantages.

8.2.1.4 Sales offices power (4: high)

Sale offices has high power, as they are the most important factor in order to create accumulated sales. This power is reduced by contracts and change costs, but they will still have a high power.

8.2.2 End customers as buyers

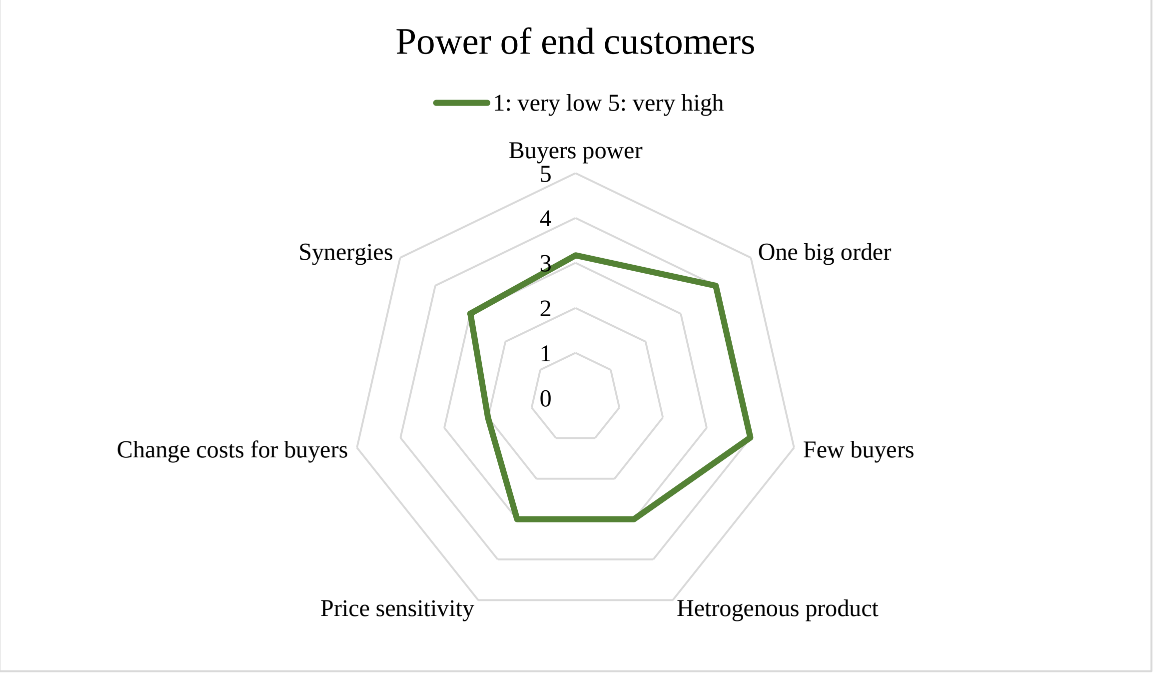


Figure 31

If we instead define the end users as buyers, the situation becomes different. End users are different type of manufactures that use industrial robots to create products. As most shipments of robots to the end user will consist of one large shipment, containing robot(s), assembling lines, training of staff and other equipment required to make the robots work properly, the sales offices need to involve the customer under the entire process of implementing robots. The customer's opinion, knowledge, practice and culture becomes important.

8.2.2.1 One big order and few buyers (4: high)

As end users buy a total package, a natural consequence is that most customer are mid to large sized companies. This means that each sale offices will consist of few to a moderate number of buyers depending on which market they are operating in (which country and which specialization). As new projects generates sales in lags (not a continuous float of revenue), it becomes important to deliver service to their customers during the entire product life cycle.

8.2.2.2 Heterogeneous products (3: moderate)

The robot companies must deliver heterogeneous products, meaning that developing products customers wants becomes essential (Pull approach).

8.2.2.3 Price sensitivity (3: moderate)

Convincing new customers to implement robots is important, results in price sensitivity in the market. The robot companies need to compete on price- performance. This gives buyer's power as they can negotiate the price about the package price.

8.2.2.4 Change costs for buyers (2: low)

When deciding which robot producer to use, the customer has high power. However, after choosing to implement a robotic solution, it becomes costly for customers to change supplier, as this would require dissembling of existing solution. This means that buyers loose much of their power after completed negotiations.

8.2.2.5 Synergies (3: moderate)

Service is an important part of robot supplier's revenue and it is vital for suppliers to keep customer satisfied. If the robot suppliers are able to give the customer a satisfying solution, this might create synergies. Jean Marc Launay about synergies (appendix 2):

> …the car industry tends to be the driving force behind robotizing in other industries. Suppliers of different products, raw material and service to the car industry see that the car industry have good experience with implementing robots. This leads to synergies that we have seen in lesser degree in Norway, because of small car industry. (p.127-128 own translation).

As synergies are an important way of introducing robots to new customers, a robot supplier needs to keep customers satisfy. This amplify power of buyers.

8.2.2.6 Power of end costumers (3.17: moderate)

Power of buyers toward the Chinese market will be moderate. The market will consist of few large companies, but buyers have high changing costs, which reduce their power.

8.2.2.7 Power of buyers (3.6: high)

Summarized together (power of sale offices and power of end costumer), the power of buyers are high.

8.3 Power of suppliers

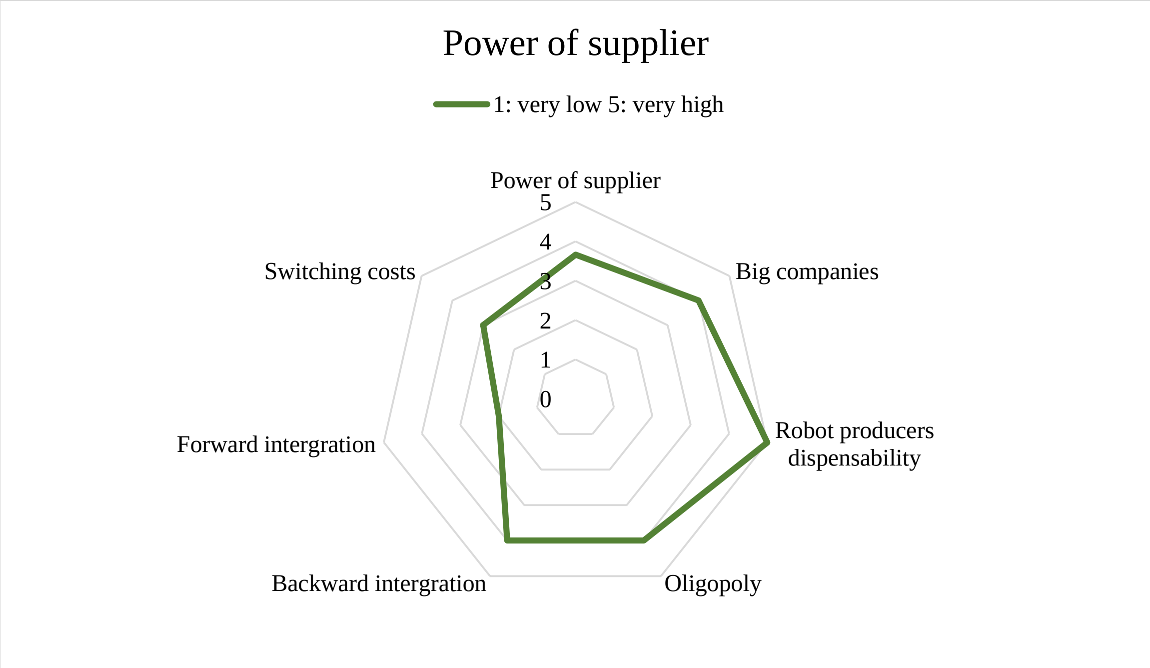


Figure 32

Power of suppliers concern companies that support the robot producing industries with raw material, components and systems. They are important to consider because the robot producers are completely depended on suppliers to deliver on time.

8.3.1 Big companies (4: high)

The first important notice is that suppliers to the robot industry tends to be large companies. These companies delivers material to many type of industries, hence their financial situation, size and power completely outmatch most robot companies (at least if you considers the robotic division of a robot producing company).

8.3.2 Robot producer dispensability (5: very high)

Most suppliers operate in many type of industries, completely different from robotics. They are not reliant on robot producers to buy from them. The value of industrial robotics is estimated to be about US$ 28 billion (see discrete analysis…) the robot industry becomes quite small compared to other industries..

8.3.3 Threat of oligopoly (4: high)

As economic of scale is important for mass-producing companies, like metal manufactures. Suppliers to the robot producing industry tends to lean towards oligopoly, where the opportunity to change suppliers is small.

8.3.4 Backward integration (4: high)

There are little possibility of backward integration (robot producer starts to create their own raw material). Robot producers are in a position where they have no possibility to strategically challenge suppliers on price by choosing to include raw material production into their inner supply chain (part of the company). This makes suppliers powerful.

8.3.5 Forward integration (2: low)

Robot products can be complex products that requires completely different properties than raw material production. There will be few chances of forward integration as well (suppliers implementing robot production to their inner supply chain). This inhibition for suppliers are a positive factor for the robot producers. The threat concerning that suppliers decides to become the robot producers rivals, are low.

8.3.6 Switching costs (3: moderate)

Switching between suppliers cause moderate costs for robot suppliers. Although robots might look different between robot producers, they use more or less the same metal, components and systems. Metal and components cost will often be moderate. System costs might be higher as they require good cooperation between companies. However, most robot producers have system developing integrated as a part of their inner supply chain.

8.3.7 Power of suppliers (3, 66: high)

The power of supplier are combined high for industrial robotics in the Chinese robot market.

8.4 Threat of substitute

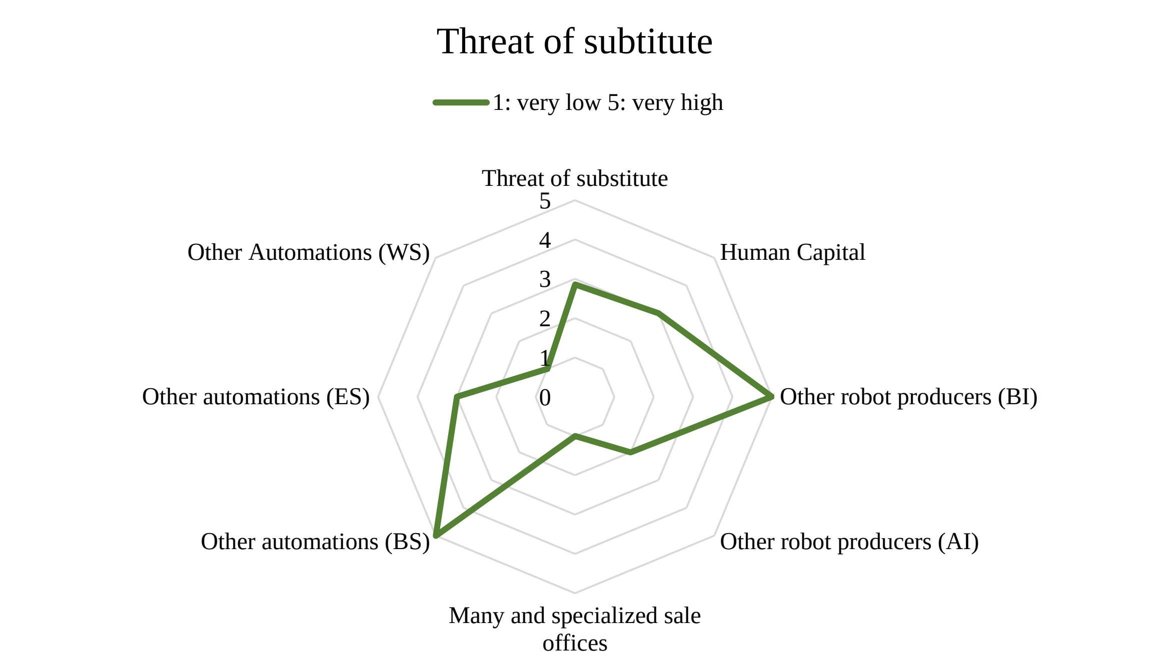


Figure 33

As analyzed in SWOT there are substitute companies. These companies would either sell other type of automations or be other robot selling companies. In addition, end customers can choose to use strictly human capital, which must be viewed as an "invisible" rival.

8.4.1 Human capital (3: moderate)

Towards new potential manufactures and industries, the challenge will be to convince them that a robotic solution is better than human labor. However, it is more likely to be the case for manufacturers and industries that do not use robots. For most robot using manufacturers (like in the car industry), there are low threats that the manufactures decide to return to old solution using only human labor.

8.4.2 Other robot producers (Before Implementation 5: very high)

Before implementing a robotic solution, the power of substitute robot companies will be severe. They can negotiate on price, quality of system and implementation time. It all depends on selling your solution as the best implementation.

8.4.3 Other robot producers (After Implementation 2: low)

After the contract is signed, other robot producers will have little power to get customers to change robot supplier, mainly because of the costs of changing supplier.

8.4.4 Many and specialized sale offices (1: very low)

For robot producers it becomes important to have competent sale offices, hence as many sales offices as possible. This requirement concerns both geographic location and specialized competence. A robot producer will have a competitive edge if they are located near the customer and are truly specialized in their area of interest (E.g. automobile industry wants sales offices that are specialized in wielding). Therefore, much of the competitive rivalry in a market will be determined by which robot producer that have the best sale offices.

8.4.5 Other automations (Better solution 5: very high, equal solution 3: moderate and worse solution: 1 very low)

End customers may decide to use other type of automations, which is a threat. Companies using other type of automations will have **moderate power** in situations where a robotic solution is not necessary and **very high power** in situations where robotic solutions is less efficient. Substitute threats will be very low in segments which truly favors robots.

8.4.6 Threat of substitute (2.86: moderate)

The threat of substitute are combined moderate.

8.5 Competitive Rivalry

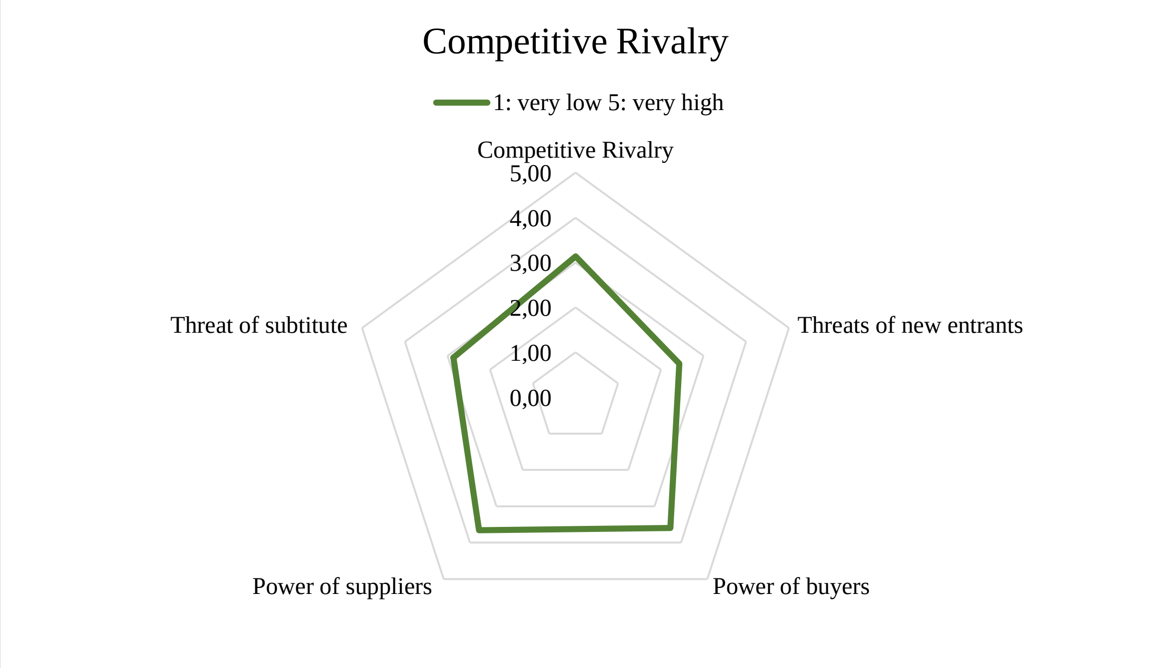


Figure 34

8.5.1 Threats of new entrants (2.43: low)

As the Chinese robot market consist of few large companies and government regulates the market, meaning that the threat of new entrants is low. This favor existing companies that will be able to fully explore their economics of scale. Any attempt to become a market player can be met by acquisitions or price competition. The degree of threat is slightly higher than 2 because of the growth potential of the Chinese robot industry. This makes it possible for new entrants to become established, simply because it becomes difficult for existing robot producers to satisfy the increasing demand in time.

8.5.2 Power of buyers (3.60: high)

Power of buyers are high in the robot market in China. As buyers are important under the entire process of creating a robotic solution and sales offices competence and ability to come up with the best solution is important. This implies that robot producers are completely dependent on solid relationships with both sales offices and end customers.

8.5.3 Power of suppliers (3.66: high)

As with power of buyers, the power of suppliers is also high. Suppliers are often a larger company than the robot producer company. Suppliers are often diversified in different markets. This means that the robot producing companies have little possibility to influence, negotiate or pressure their suppliers. In addition, little possibility of backward integration make them very depended of suppliers. For suppliers it is small possibilities for forward integration as well, which is positive for the robot producing companies.

8.5.4 Threat of substitute (2.86: moderate)

Threat of substitute is moderate. Human labor constitute a big threat in unestablished markets (little robot density), but a smaller threat in established markets. Other robot producing companies constitute a big threat before implementation of robots, but this threat are seriously reduced after the implementation of a chosen robot supplier. Other automations will constitute a small, moderate and high threat relative to if it is a worse, equal or better solution respectfully. Combined the threat of substitute will be moderate.

8.5.5 Competitive rivalry (3.14: moderate)

The four forces combined will decide the degree of competitive rivalry in Chinas industrial robotic market.

Power of buyers and power of suppliers are high such that these are increasing the competitive rivalry in the market. However, as there are low threat of new enters and the threat of substitute are moderate, the combined rivalry are set to be moderate.

9 Financial Analysis – Key Companies toward Chinese robot industry

In this section of the thesis, the paper will provide key metrics and an overlook of the most important companies when considering Chinese robot industry. The analysis will try to calculate the degree of influence each selected companies has on robotic market in China. The financial analysis will provide arguments for which companies that should benefit the most from the future growth in China. In addition, the paper will try to give a formal statement as of why we choose to pursue specific companies.

A calculation of the selected company's revenues is provided in order to calculate companies market shares in China. The analysis choose to look at revenues because it is interesting to see how much money each company receive from the industrial robotic market in China. Between the selected companies revenue earned on robots sales, revenue earned on systems and revenue earned on service will vary. For simplicity, the paper has chosen to calculate market shares on total revenue.

Estimations on China robotic market, Key metrics selected companies 2013.

Robotic Company	Siasun	ABB Group	KUKA AG	Yaskawa	Fanuc
Company profile					
Group revenue (000 local)	CNY 1 318 764	CHF 38 659 497	EUR 1 774 500	JPY 310 383 000	JPY 498 395 000
Group revenue (000 U$)	USD 214 742	USD 41 772 393	USD 2 361 771	USD 3 152 394	USD 5 084 471
% of revenues from robotic and system	28,00 %	3,00 %	100,00 %	34,00 %	32,6 %
Estimated revenue from robotics and systems (000 U$)	**USD 60 128**	**USD 1 253 172**	**USD 2 361 771**	**USD 1 071 814**	**USD 1 657 538**
Geographic Exposure 2011					
China	95 %	20 %	11 %	25 %	30 %
Europe	0 %	50 %	58 %	10 %	10 %
North America	0 %	20 %	19 %	15 %	15 %
Other	5 %	10 %	12 %	50 %	25 %
Geographic Exposure 2013					
China	95 %	20 %	13 %	19 %	30 %
Estimated revenue from the Chinese market (000 U$)	**USD 57 121**	**USD 250 634**	**USD 307 030**	**USD 203 645**	**USD 497 261**
Key Customers	Delphi Shanghai Jiaoyun ZF Friedrichshafen	Foxconn Honda GM Toyota Volkswagen	Daimler BMW Volkswagen Foxonn	Honda Hunday Motor	Foxconn General Motors Nissan
Key Activity	Robotics	Power equipment/ Automation	Robotics	Robotics/ Automation	Robotics/ Automation

Table 13 Source: (Veldman & Alblas, 2012), (KUKA, 2014), (ABB Group, 2014), (Yaskawa, 2014), (Fanuc, 2014)

Explanations of calculations provided in appendix 3.

9.1 The industrial robotic market

In the table below four biggest companies (ABB, KUKA, Yaskawa and Fanuc) of robot systems (robots and systems combined) are provided. As threats of new entrants are low in the Chinese market, we would expect the biggest companies to benefit from a growth in robot sales. In addition, the biggest Chinese company in 2011 (Siasun) is included as it might benefit from domestic regulations (8.1 Local joint venture partners) and strong geographic exposure. The analysis is easiest to conduct keeping robot and system together as it is difficult to find estimations that separates them. In the SWOT analysis, the paper has described that robots needs system integration in order to work. This means that it is most natural to consider them together as the companies would not earn on robot sales without having an integrated system as well.

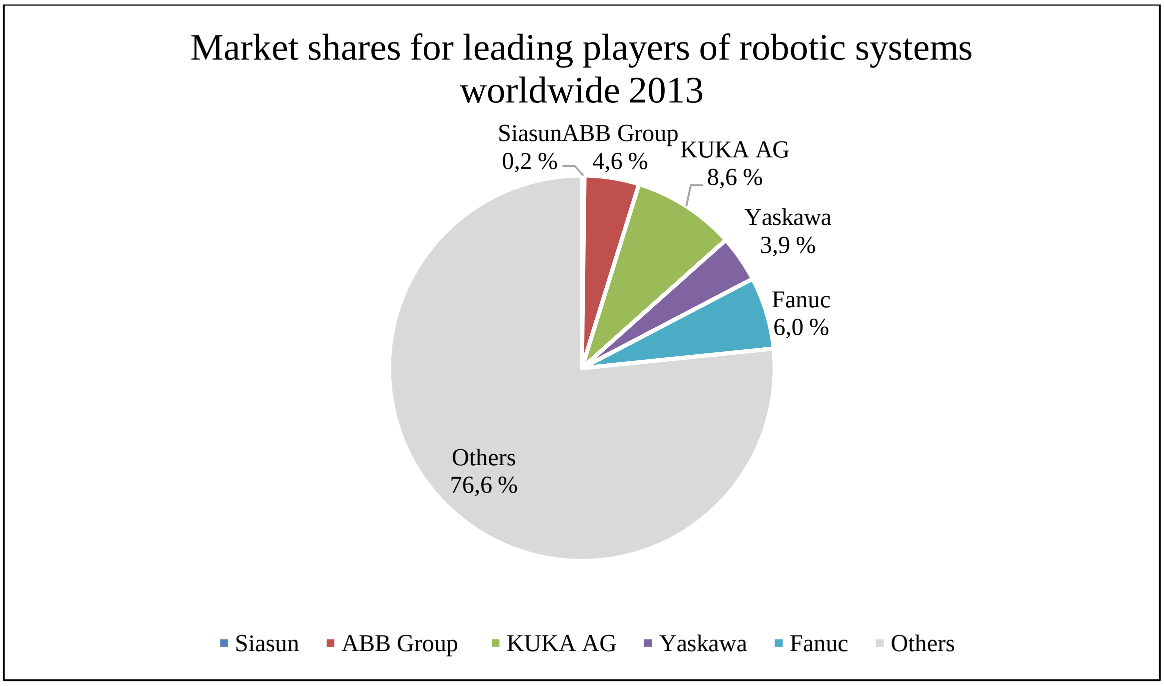


Figure 35

When considering revenue strictly from industrial robotic systems, KUKA AG seems to be the leading company worldwide with 8.6 % of the market shares followed by ABB Group (4.6 %), Yaskawa (4.4 %) and Fanuc (3.9 %). Siasun is the biggest Chinese company (2011), but has only an estimated 0.2 % of the robotic system market worldwide.

Only 3 % of ABB Group`s revenue comes from robotic sale. An increase in robotic sale will not yield a significant change in revnues as it will do for KUKA AG and Siasun. For KUKA 100 % of the revenue concerns robotics (robot and systems). Sisaun is estimated to generate 28 % of revenue from robotic systems. Therefore, Siasun would not benefit fully from increased robot sales in China. However, they have a strong presence in China (95 %) which make Siasun able to benefit from an growth in China.

9.2 China robotic market

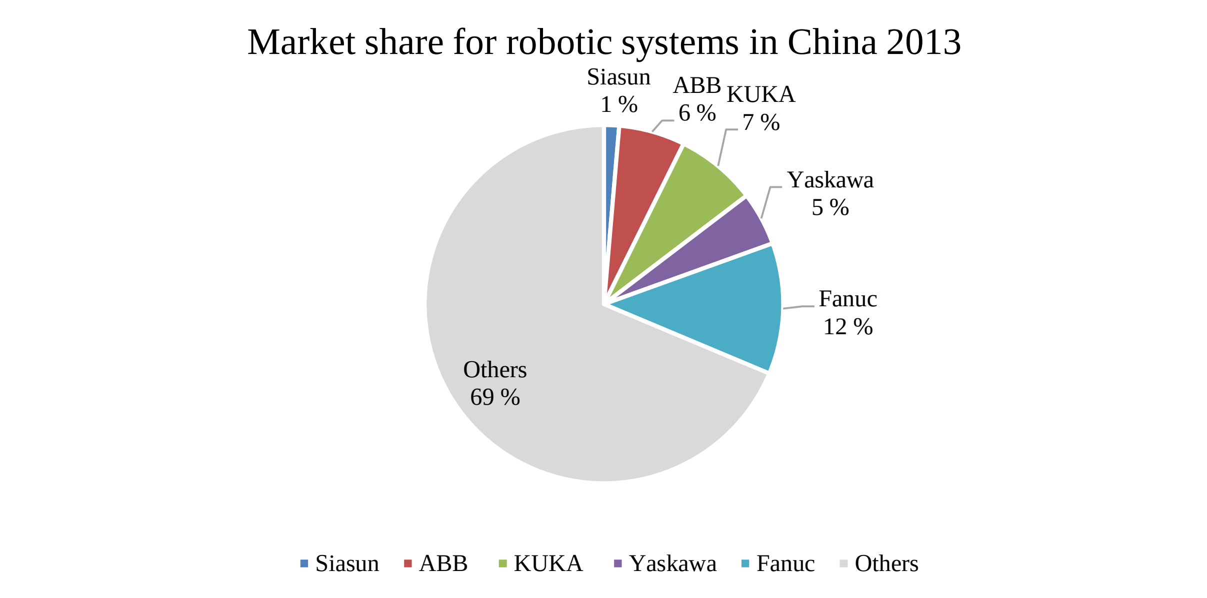


Figure 36

In contrary to worldwide market shares, Fanuc (12%) is the leading player when strictly considering China industrial robotic market. Second largest is KUKA AG (7 %), followed by ABB Group (6%) and Yaskawa (5 %) respectively. Siasun has a market share of 1 % and is the domestic company with highest market shares. However, as the Chinese industrial robotic market has increased with 61 % from 2012 to 2013 (published 04.06.2014 in IFR) and domestic companies are reported to contribute 24.4 % of the increase. This means that Siasun might not be the biggest domestic company anymore, as other domestic companies have become domestic market leaders. Morgan Stanley has estimated that the four biggest players have more than 50 % of the market share in 2011(53 %). In this analysis, it seems like they have a significant drop in 2013 (31 %). Reasons for this should be that other smaller companies has had a significant gain in shares in the time between 2011 and 2013 (especially from 2012 to 2013) by gaining new customers in a growing market. Different methods used to calculate the market share could be another reason (total value of market estimated differently), although it needs to be pointed out that the estimation has been done trying to replicate their estimation method.

If one compares this estimation with the Morgan Stanley report from 2011 it seems like KUKA AG is gaining market shares compared to the selected companies in the Chinese robot market. Morgan Stanley estimated a 10 % market share for KUKA AG in 2011 compared to 7 % in 2013. Remember as the market has grown, KUKA have lost market shares to the total market but gain compared to selected companies. Even though they cannot be compared directly it is possible to see that KUKA AG have gain revenue in the Chinese market over the last years, a view that Morgan Stanley anticipated and KUKA AG have shown in their annual report 2013.

Fanuc have been estimated to a 17 % market share in Morgan Stanley 2011 for 2011. Comparing this with this thesis estimates it seems like they have lost market shares (12 %). Fanuc has increased from 446 201 000 JPY in 2011 to 498 395 000 JPY (11.69 % increase). It is likely that some of the increase they experienced in revenue comes because of gain in market shares in China. However, as the market has grown faster than Fanuc has been able to follow, they have lost market shares. The geographic exposure estimates for China is highly uncertain for Fanuc. In Fanuc`s financial annual report from 2014 it looks like the geographic exposure has declined. It might be as low as 20 %. If this is the case Fanuc market shares are overestimated and there true market shares are even lower.

Yaskawa have been estimated to a 15 % market shares in Morgan Stanley 2011. They used a geographic exposure toward China of 25 %, while Yaskawa have estimated their geographic exposure toward China inside robotics to be 19 % in 2013. This means that Yaskawa will be estimated to have considerable lower market shares in this thesis in 2013 (5 %) than in Morgan Stanley in 2011. While Yaskawa have lost some market shares toward China (can be seen in their annual report), it can be argued that this significant different might be a combination of actual lost and an overestimation of Yaskawa`s market shares from Morgan Stanley. Lastly, it might be that this thesis is overestimating the geographic exposure of Fanuc, as there are reasons to believe that it is overestimated.

ABB group have been estimated to a market share of 11 % in Morgan Stanley report 2011. The paper believes the estimation of 6 % in 2013 is quite right for ABB group, as the total value of the Chinese market has increased much, while ABB Group generates marginal more revenue from the Chinese market than in 2011. Since ABB Group is such a large company, which generates revenue from many products. The estimates used to calculate revenue are more uncertain than for the other companies, such that a different of 5 % (11 % - 6 %) is fair, although the difference from 2011 to 2013 is probably overestimated.

Morgan Stanley has not estimated the market share of Siasun, hence it is difficult to say anything about their evolvement from 2011 to 2013.

9.3 KUKA

A supplementary analysis of the German-based company KUKA AG is done “to take the financial pulse” of a robot supplier. Here are the motives to select KUKA above other competitors:

- KUKA AG is a key robotic player and the only large robotics pure play.
- Dedicated 43,3 million euros (about 6% of robotics revenue) into R&D in 2013.
- Global leader in the automotive industry (robots and systems).
- The company is currently expanding in China, both in market share and new facilities.
- Innovative product lines and high level of customization, fully compatible with the needs of General Industry customers.
- The company has experienced strong growth in the recent years.

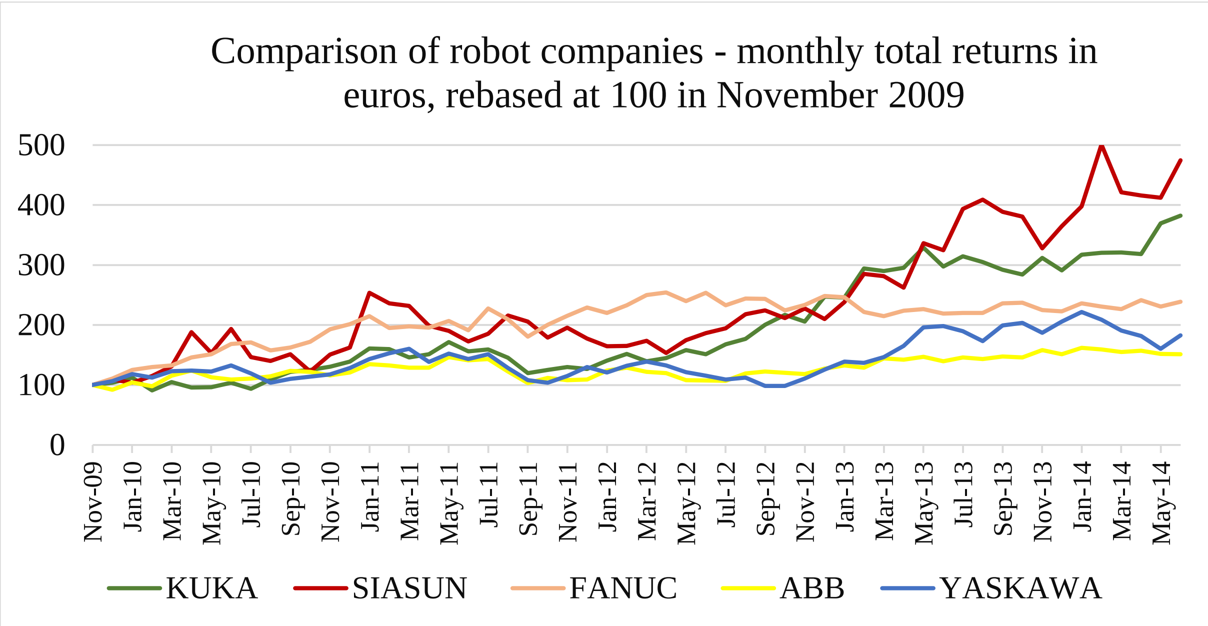


Figure 37 (Thomson Reuters, 2014)

KUKA has experienced a strong growth in total returns after the financial crisis. The smaller Chinese company, Siasun, has recorded the greatest growth since November 2009 compared to these competitors. KUKA and Siasun are the only “pure play” robot companies. The additional represented companies are more or less involved in other business segments.

9.3.1 Stock price

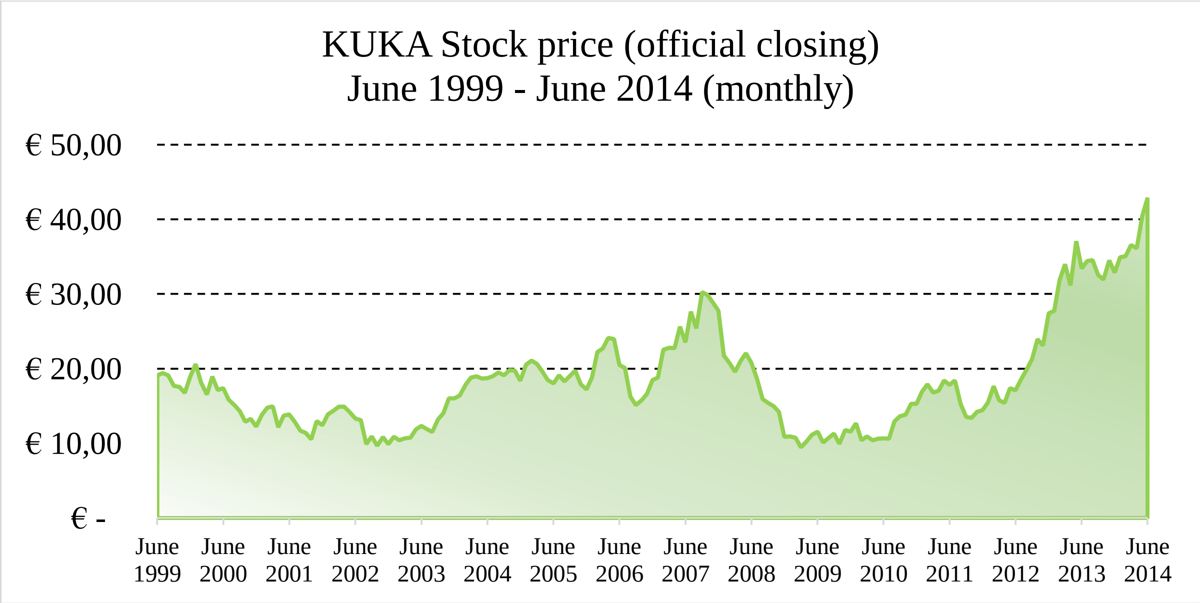


Figure 38

Range	**15 years** Jun 99 - Jun 14	**10 years** Jun 04 - Jun 14	**5 years** Jun 09 - Jun 14	**2 years** Jun 12 - Jun 14
Annual **geometric** mean (**stock price**)	*5,5 %*	*8,6 %*	*30,0 %*	*58,6 %*
Annual **arithmetic** mean (**stock price**)	*10,6 %*	*14,8 %*	*35,9 %*	*62,1 %*
Annual **geometric** mean (**total returns**)	*8,0 %*	*10,0 %*	*30,4 %*	*59,6 %*
Annual **arithmetic** mean (**total returns**)	*13,1 %*	*20,1 %*	*36,3 %*	*63,1 %*
Average stock price	*EUR 18,17*	*EUR 20,08*	*EUR 20,74*	*EUR 30,77*
Annualized standard deviation	*38,2 %*	*40,0 %*	*36,9 %*	*28,1 %*
All-time high	**5-Jun-14** EUR 43,03			
Low	**21-Sep-01** *EUR 8,65*	**25-Feb-09** *EUR 8,93*	**28-Oct-09** *EUR 9,54*	**4-Jun-12** *EUR 16,30*

Table 14

Historical performance of KUKA shown by year (June) - to - year (June) growth in KUKA AG total return index:

1999	2000	2001	2002	2003	2004	2005	2006	2007
	-6 %	-17%	1 %	-3 %	60%	3 %	13 %	15%
2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
	-8 %	-44 %	-8%	67 %	-4%	97 %	29 %	?

Table 15

9.3.2 P/E ratio

It is helpful to look at the P/E-ratio between competitors in a given sector. Price/Earnings is the relationship between a firm's market value and net income. Changes in P/E are affected of either changes in net income or changes in the stock price. P/E-ratio may indicate the "aggregate" future beliefs about a market, a sector or a company growth relative to financial results. The beliefs in this case corresponds to the anticipated future growth of industrial robots.

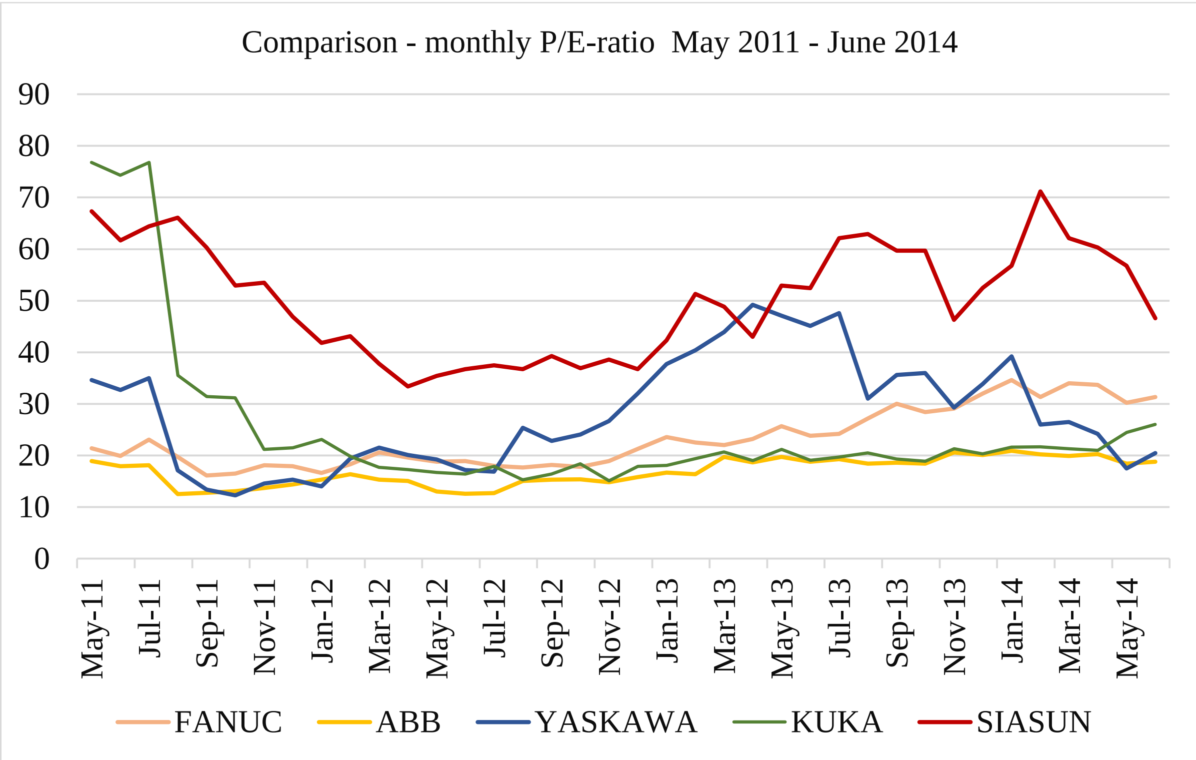


Figure 39

The presented P/E-ratios are to a certain degree positive correlated. All of the companies has had a reduction in the P/E-ratio from 2011, much of the change can be explained by improved results. The Chinese company Siasun has the highest ratio in June 2014. The rest of the companies is ranging from around 20 to 30 in price to earnings.

Let us take a closer look at KUKA and add earnings per share together with the P/E-ratio

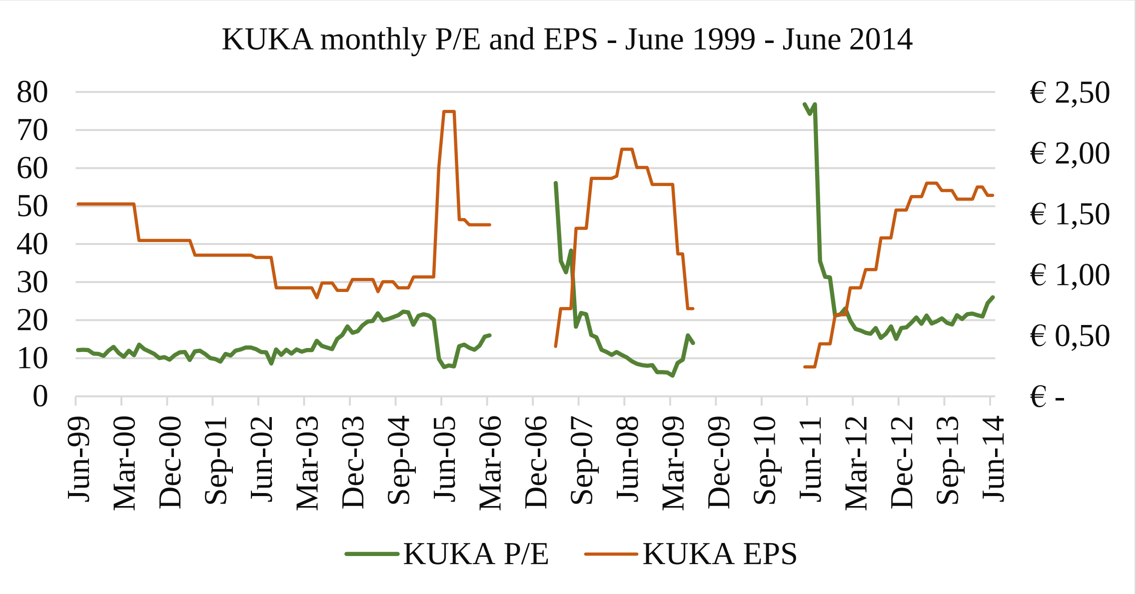


Figure 40

Net income was negative during seven quarters: August 2009 to April 2011. The period April 06 to March 2007, were also affected by negative results. The graphs suggest there is a negative correlation between P/E ratio and earnings, but a smaller effect in past couple of years. P/E increased from about 21 to 26, from beginning of 2014 until middle of June. During the same period earnings has been relatively stable. This could be a more optimistic view of the company relative to the market, where it operates. This implies that the future growth could be reflected in the stock price.

9.3.3 Beta-estimation (β)

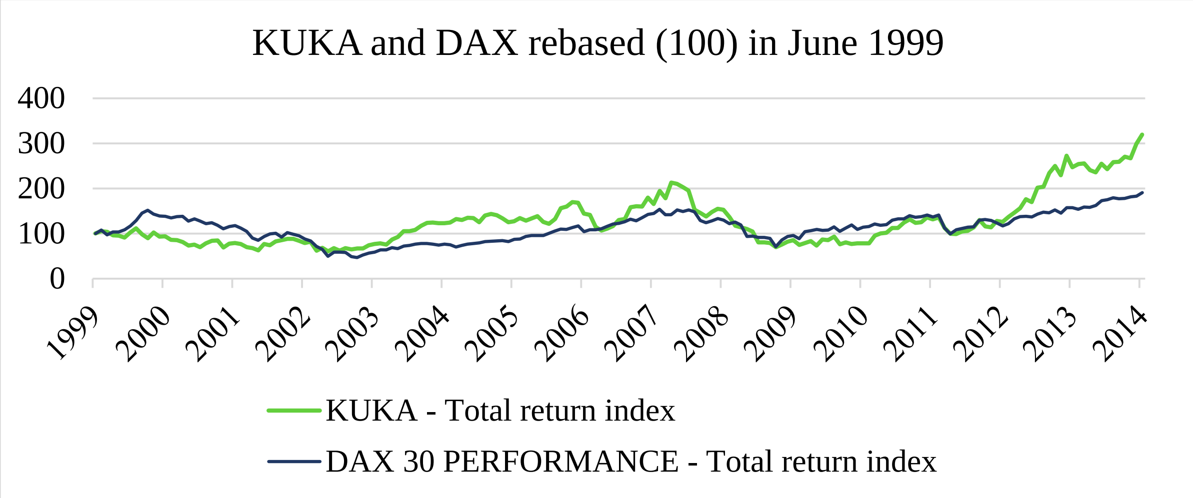


Figure 41

Regression results

The OLS results show a surprisingly large difference in estimated beta values. This indicates that selection of market index will have an excessive impact when deriving the required rate of return. The dispersion amplifies relative to shorter time series.

KUKA is a German based company, noted at Frankfurt Stock Exchange. DAX (Deutscher Aktienindex) is a blue-chip index based on companies listed on Frankfurt. The **three-year beta** compared to **DAX** is selected to represent the volatility/*systematic risk* of KUKA. This implies a **beta value of 0.887**. However, the spread in beta values shows that its reason to believe that a beta of 0.887 could be underestimated. Reuters report a beta of 0,845 (information given June 2014).

June 1999 – June 2014 (15 Y)

	DAX	MSCI Europe	MSCI World
Beta	0,618	0,825	0,742
Standard error	0,089	0,111	0,117
Adjusted R^2	0,210	0,232	0,181

June 2004 – June 2014 (10 Y)

	DAX	MSCI Europe	MSCI World
Beta	0,701	0,838	0,757
Standard error	0,119	0,136	0,117
Adjusted R^2	0,220	0,236	0,165

June 2009 – June 2014 (5 Y)

	DAX	MSCI Europe	MSCI World
Beta	0,797	1,086	1,057
Standard error	0,167	0,212	0,263
Adjusted R^2	0,265	0,295	0,202

June 2011 – June 2014 (3 Y)

	DAX	MSCI Europe	MSCI World
Beta	**0,887**	1,414	1,329
Standard error	0,197	0,645	0,340
Adjusted R^2	0,348	0,400	0,285

Table 16

9.3.4 Currency exposure and risk

KUKA is a global company listed on the Frankfurt Stock Exchange, Germany. It is necessary to point out the foreign exchange issues that applies to both the company and investors. The risk can be briefly be summarized in the following illustration:

Annual total return index rebased (100) in 1999. E.g. investment (100) done in USD yield highest return because euro has appreciated most relative to USD (or dollar depreciation relative to euro)

	Base - EUR	**USD**	**GBP**	**NOK**	**JPY**	**CNY**
June 99	100,0	100,0	100,0	100,0	100,0	100,0
June 00	94,7	85,8	91,8	96,1	77,7	85,8
June 01	78,8	63,2	74,1	76,4	65,3	63,2
June 02	81,9	73,6	80,8	74,3	78,3	73,6
June 03	78,2	87,6	84,5	78,4	87,3	87,6
June 04	124,1	142,0	125,8	125,6	132,5	142,0
June 05	127,9	147,7	131,1	122,3	135,7	147,7
June 06	144,9	174,7	152,5	137,9	168,3	169,0
June 07	173,4	220,5	180,4	171,4	227,3	204,1
June 08	150,8	223,2	183,0	147,0	201,8	186,5
June 09	86,4	115,8	112,8	94,0	96,0	95,6
June 10	86,2	99,3	109,8	82,3	77,1	82,0
June 11	129,5	177,1	175,7	124,2	120,3	138,7
June 12	126,4	150,6	156,3	116,2	101,3	115,9
June 13	252,8	319,7	329,9	237,2	262,3	236,9
June 14	320,4	413,2	396,1	317,2	356,6	310,9
Geometric mean, annual return	8,1 %	9,9 %	9,6 %	8,0 %	8,9 %	7,9 %
Arithmetic mean, annual return	12,7 %	16,6 %	14,3 %	12,8 %	17,2 %	14,2 %

Table 17

The paper will not go in depth into the currency issue. By looking at the geometric and arithmetic mean, you get an idea of how the return differs among currencies.

Applied Exchange rates

	USD to EURO	**GBP to EURO**	**NOK to EURO**	**JPY to EURO**	**CNY to EURO**		**USD to EURO**	**GBP to EURO**	**NOK to EURO**	**JPY to EURO**	**CNY to EURO**
June 99	*1,05*	*0,65*	*8,20*	*123,92*	*8,69*	June 07	*1,33*	*0,68*	*8,11*	*162,45*	*10,23*
June 00	*0,95*	*0,63*	*8,31*	*101,64*	*7,87*	June 08	*1,55*	*0,79*	*8,00*	*165,90*	*10,75*
June 01	*0,84*	*0,61*	*7,94*	*102,59*	*6,97*	June 09	*1,41*	*0,85*	*8,93*	*137,78*	*9,62*
June 02	*0,94*	*0,64*	*7,43*	*118,39*	*7,80*	June 10	*1,21*	*0,83*	*7,83*	*110,86*	*8,26*
June 03	*1,18*	*0,70*	*8,22*	*138,39*	*9,73*	June 11	*1,44*	*0,88*	*7,87*	*115,14*	*9,30*
June 04	*1,20*	*0,66*	*8,30*	*132,33*	*9,94*	June 12	*1,25*	*0,81*	*7,54*	*99,36*	*7,97*
June 05	*1,21*	*0,67*	*7,84*	*131,47*	*10,03*	June 13	*1,33*	*0,85*	*7,70*	*128,58*	*8,14*
June 06	*1,26*	*0,69*	*7,80*	*143,91*	*10,13*	June 14	*1,35*	*0,81*	*8,12*	*137,92*	*8,43*

Table 18

9.4 Estimating fair P/E ratio

Based on the prognoses delivered by IFR an estimation of fair P/E ratio is calculated for KUKA. The calculation will support whether KUKA is over- or underestimated assuming that they will experience a growth at least as good as maintained in 2013 for different regions. The estimation use net income 2013 in euro and calculate weighted expected value 2020.

9.4.1 Estimating KUKA figures

Geographic Exposure KUKA 2013	Revenue in € millions	Geographic Exposure
Germany	582,5	32,83 %
Europe (Excluding Germany)	412,2	23,23 %
North America	492,2	27,74 %
China (estimated)	230,7	13 %
Asia/other regions (excluding China)	56,96	3,21 %
Total	1774,5	100,00 %

Table 19 Source: (KUKA, 2014), (Uglow, Carrier, Ibara, Yoshida, & Davies, 2012)

The geographic exposure towards China are estimated using Morgan Stanley estimate from 2011 (11 %) plus a 1 % growth each year. Based on KUKA`s annual report this estimation should be moderate.

Growth prognoses by region/country based on 2013 growth	
Germany	5,00 %
Europe (excluding Germany)	5,00 %
North America	8,00 %
Asia/other regions (excluding China)	18,00 %
China	20,00 %

Table 20 Source: (International Federation of Robotics, 2013)

Future net income are calculated using growth prognoses from IFR for different regions weighted for KUKA`s geographic exposures. The estimation assumes that KUKA will have the same growth as expected for the whole market. This can be viewed as a moderate prognoses, as KUKA should experience at least as high growth as other companies according to market share analysis provide above. The weighted overall growth for KUKA is estimated to be 8.20 % a year. The estimation assumes that net income will be perfectly correlated with growth in robot sales. This assumption is simplified as other factors like changes in costs, changes in prices and repayment of expensive loans will make the net income change differently than robot sales. Realistically KUKA will experience a lesser growth in net income than is anticipated the first years (as they are getting rid of expensive loans (KUKA, 2014)) and more growth in net income later. As the prognoses uses a moderate estimate, this factor are accounted for.

Estimation of future growth								
Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Net income (000s)	58 300	63 080*	68 252*	73 848*	79 903*	86 454*	93 543*	101 212*

Table 21

Estimated net income is used to calculate the stock price:

$$Unit\ stock\ price = \frac{P/E\ ratio \times Net\ income}{Shares\ issued}$$

The calculation assumes that P/E ratio for 2013 is constant and applies for every year. In scenario 1 stock price 31.12.2013 is used and the corresponding P/E ratio. The future stock prices are provided in table below.

Scenario 1								
Year	2013	2014	2015	2016	2017	2018	2019	2020
P/E ratio	19,84	19,84	19,84	19,84	19,84	19,84	19,84	19,84
Stock Price	34,10	36,90*	39,92*	43,19*	46,74*	50,57*	54,72*	59,20*

Estimating CAPM					
Country	Germany	Europe (excluding Germany)	North America	Asia/other regions (excluding China)	China
Market risk premiums	5,50 %	4,50 %	5,55 %	4,50 %	7,70 %
Risk free rates	1,90 %	2,50 %	2,20 %	3,00 %	3,80 %

Table 22 Source: (Duff & Phelps, 2014), (Fernandez , Aguirreamalloa, & Linares, 2013).

The required return are estimated using market risk premiums and risk free rates from different regions weighted for geographic exposure for KUKA. The result are provided in the table below.

Estimated CAPM	
Estimated market premium	5,54 %
Estimated risk free rate	2,40 %
Beta KUKA (3 years beta, DAX)	0,887
CAPM	7,31 %

Table 23

Stock price 2020 discounted back to present value using a 7.31 % rate of return with the formula:

$$p_0 = \frac{59,2}{1,0731^7}$$

Discounting stock price 2020	2013
Present value of estimated stock price	36,12*
Market value of estimated stock price	1 225 020 *
Fair P/E ratio	21,01*
P/E ratio (31.12.2013)	19,84

Table 24

From the calculations, one can see that with the estimated future net income and a rate of return of 7.31 % the Fair P/E ratio is higher than the current (31.12.2013). The KUKA stock price is underestimated according to scenario 1.

Since the stock price of KUKA has drastically increased between 31.12.2013 and current date (02.06.2014) a second scenario is constructed using updated stock price.

Scenario 2							
Year	30.05.2014	2015	2016	2017	2018	2019	2020
P/E ratio (04.06.2014)	22,26	22,26	22,26	22,26	22,26	22,26	22,26
Stock price (04.06.2014)	41,40	44,80*	48,47*	52,44*	56,74*	61,40*	66,43*

Table 25

Discounting stock price	
Present value of estimated stock price	43,49*
Market value of estimated stock price	1 475 118 *
Fair P/E ratio	23,38*
P/E ratio (04.06.2014)	22,26

Table 26

The fair P/E ratio is higher than current. KUKA stock price is underestimated according to scenario 2.

10 Discussion

It is finally time for debate. Let us roll back to the problem statement(s) presented in the introduction. Is there a potential for industrial robots in China? If so, will there be a promising growth?

10.1 Growth in China

Let us summarize what we find to be central drivers concerning robotizing of China:

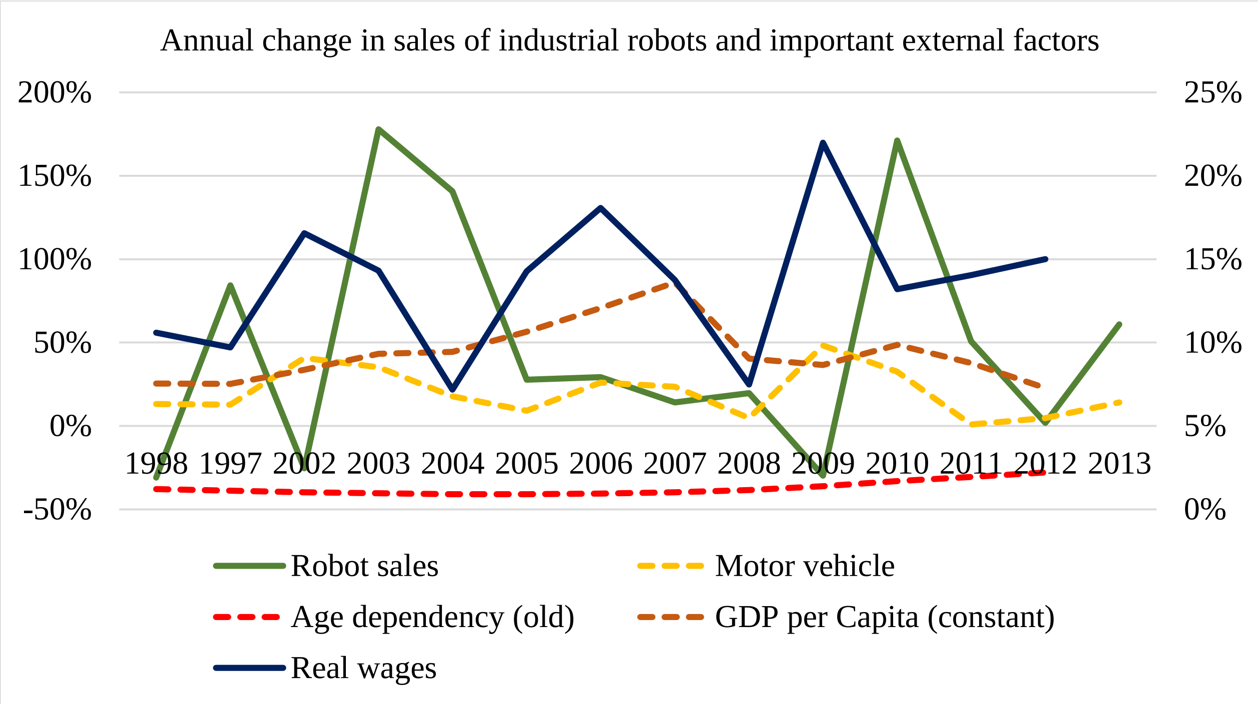


Figure 42

The percentage change on the left side of the figure belongs to the solid lines. The right side scale represents dotted lines. The figure above suggest a certain positive relationship between the variables. It seems like real wages are lagging (one year behind) relative to robot sales.

China is the biggest and fastest growing robot market regarding annual sales (units) of industrial robots. The rise of China brings on many business opportunities. Among them is modernization of the industry and manufacturing sector. China is the world's largest manufacturer and exporter (United Nations). Cheap labor, which opened for "Made in China, has been the foundation for adventurous growth. The economic size of the country, and the high activity in manufacturing, implies that small changes in the underlying economy can lead to solid changes in demand for certain goods and services (e.g. robots).

Chinese industries are characterized by high production volume facilities. In 2012, the robot density in China is in 23 robots/10 000 manufacturer worker, versus 396 robot/10 000 manufacturing worker in Republic of Korea and 332 robot/10 000 manufacturing worker in Japan. Reforming the manufacturing sector in China to be as "modern" as their overseas neighbor, about 1 000 000 robots (IFR) would have to be installed today. This is equivalent to US$ 150 billion, assuming the current dollar value and given robot prices.

It is absurd to imagine that robotized automobile factories will ever return to manual workers-based production, which implies that robots are here to stay. The automotive industry has been the main area of application of industrial robots from the beginning. The electric/electronics industry has increased robot usage into their processes. There are several industry branches with small robot densities. The automotive industry is the key customer to the robot suppliers. China has a tiny robot density in automobile industry compared to other "car producing countries". The robot potential in the automotive industry is a particularly exciting area in China. China has become the world largest motor vehicles producer. It is many opportunities (e.g. self-driving cars and electric cars) in the automobile industry today. China has access to capital. Robots produce high quality cars in high volume. In addition, automation of the automobile sector creates synergies to robotize other industries branches.

The real wages in manufacturing are increasing exponentially, and the average Chinese people are getting richer. The aggregate demand in the domestic and the international consumer markets are growing. This growth requires expansion of production capacities, in addition to increased product quality. Life cycles of products decreases, while product variety increases. The solution to this problem is flexible automation.

China is on the eve of a demographic shift due to aging population and one child policy. IMF Working Paper 2013, concludes that the Lewis Turning Point will develop between 2020 and 2025 in China. The supply of low-cost workers is shrinking, and a labor shortage will occur. (Das & N'Diaye, 2013).

China has to face economic and social challenges that would affect the rest of the world. The Chinese workforce is about to reach a historical peak. Particularly the shrinking access to young workers to manufacturing purposes, amplifies the opportunity to robotize. The generation of young people (born after 80s) would rather pursue other types of jobs (such as service) than "still underpaid" industry or manufacturing based jobs. The problem is reflected in the high turnover among workers in these sectors (Appendix 1). This trend corresponds to higher costs and less skilled workers in a company. Robots can take over dangerous, tedious and dirty jobs that are not possible or safe to preform by human labor. The aging population is an emergent problem in China. As more and more of the population is getting older, there will be a shortage of young workers. Age dependency (old) became the most significant variable in our panel data model. Robots can play a key role in sustaining the present production levels in the country. Japan is in the aged situation today. Japan has the highest inventory of active industrial robots in the world. Japanese manufacturer started investing in manufacturing of industrial robots in the 1980s. Today in Japan, adult diapers sell better than baby nappies (The Tokyo Times). A lot of export goods are made by robots in Japan (the third biggest economy).

Another scenario is that countries are taking production back home (e.g. USA). This is a recent trend according to Jan Frick. Due to the coordination problems because of large distance, weakens the competitive advantage. Investing in robotized domestic factories opens many possibilities ta. Additional outsourcing to "new" low-cost countries could also be a response to higher costs and shortage of labor in China.

Regarding the projections about future growth, this depends of method, probability distribution and knowledge of the market. Our task was not to estimate a “most correct” growth factor. The analysis carried out has never accounted for any future financial crisis, likely to affect robot manufacturers hard. Forecasting industrial robot sales, which is not a “common good” (as of today), in relation to considerable macroeconomic variables. Nevertheless, the analysis showed that age-dependency and real GDP were significant, with reasonably high positive coefficients, meaning small changes in these variables suggest major changes in robot sales.

Several assumptions and simplifications has been made through-out the entire work. Our future projections contains uncertainty. However, our goal has been to make a comprehensive, informative and “revealing” outlook of this relatively new and emerging technology.

10.2 Benefiting from growth in China

As discussed above there are several arguments favoring a China growth. However, a question remaining is which company that will benefit most from this growth. As analyzed in Porters five forces it might look like that the fact that a company already is established in the market is a fundamental requirement. This will imply especially for foreign companies.

In addition, domestic companies will have competitive advantages over foreign companies, because they do not require local venture partners. In China, the highly restricted market makes the actual growth lower than its potential growth. It is restrained by regulations. Regulations benefits domestic companies that will have an easier time established themselves in the market. Foreign established companies like ABB, KUKA, Yaskawa and Fanuc are also benefitting from this, as they already are established.

10.2.1 Domestic companies as investment objects

The selected companies have their dominance in market shares much because they were the first to enter the market. All the selected companies (except Siasun) entered a market where it did not existed domestic players big or strong enough to compete. If they had entered the market today, they would probably have struggled more against domestic companies.

This statement is backed up in the financial analysis, where one can clearly see that the leading player has lost much of its market shares from 2011 to 2013. The announcement of 2013 figures provided by IFR (published 04.06.2014) proved to us that the potential growth where higher than anticipated for 2013. We did expect that domestic companies would gain market shares, as a consequence of local venture partners and potential growth, but we did not expect it to happen this quickly. From the analyze it is possible to see that Siasun have experience a rapid growth and should continue to do so, which seems to be accounted for in the stock price. However, there must be other domestic companies benefitting from the growth. Some of these companies might be underestimated in the stock market. It would be interesting to analyze more companies that are domestic. Unfortunately, the information was published close to our deadline. We therefore would recommend the reader to take a closer look on domestic industrial robot producing companies in China. Our reasons are based on the arguments that the market is growing and the leading players are losing market shares, hence someone must be gaining market shares.

An important thing to elaborate is that the financial analyze is based on Morgan Stanley report, where they point out ABB, KUKA, Yaskawa and Fanuc as the important players. In the financial analyze conducted in this thesis, it is assumed that this is true and that other players in the markets (others in charts) are mostly domestic companies or insignificant players concerning size. If however, this statement is false, and other foreign companies are gaining in the market compared to domestic companies, then these foreign companies should have been included in the analysis, as they represents interesting investments objects.

10.2.2 KUKA as an investment object

In addition to domestic companies, we would recommend KUKA as an investment object. They are one of the leading players in the market. They are gaining on other leading players in term of market shares. They have an increasing revenue, which are increasing their margins and eventually will increase the dividends paid to stockholders. All these factors should increase the stock price of KUKA, which is underestimated according to scenario 1 and 2 using 2013 figures as prognoses for the future (9.4 Estimating fair P/E ratio).

Beyond arguments provided in the analysis, there are other arguments favoring KUKA. As systems becomes more and more important part of a robot producer’s revenue, it is important to be adept in system integration. KUKA together with Fanuc is considered to be leading inside systems. As the hardware of robotics becomes standardized, where all the robot companies use the same superficial structure, system improvements along with robotic integration to end customers becomes important competitive edges. KUKA know how important system integration is, and have announced cooperation with Siemens the 17th of September2013 (Siemens, 2014). Siemens is working with system integration and is developing the plant- wide automation mention in SWOT. They will make KUKA even better in system integration, as they introduce a dimension that KUKA has been lacking. Since KUKA is a pure robotic producer, they have not been able to provide the best machine tool solutions. As mention in SWOT, sometimes a robotic solution is inferior compared to machine tool solution. This means that, by cooperating with Siemens, KUKA can create solutions that are even more effective, mixing robots and machine tools. Inside the car industry, pure robotic solutions can be justify, but for general industry a mix will most often be more suitable. This implies that this cooperation should make KUKA able to deliver better solutions toward the general industry. According to Morgan Stanley (Uglow, Carrier, Ibara, Yoshida, & Davies, 2012) Fanuc and Siemens holds up to 80 % of the market shares inside CNC. CNC is a sophisticated machine tool. By cooperating with Siemens, KUKA can include CNC in their implementations. Introducing plant wide automation to KUKA`s well develop research teams should give KUKA robots an extra dimension as well.

Figure 43 (Siemens, 2014)

KUKA is focusing on China. They recently open a new manufacture in Shanghai in order to be able to supply the increasing demand from Chinese companies in timely manner. As the growth in China in 2013 has been beyond any anticipation, we believe that the leading players have lost some of the market shares simply because they have not been able to deliver on time. Customers might have favored using ABB, KUKA, Yaskawa or Fanuc for robotic integrations, but have been forced to use domestic companies. They might have been able to deliver faster because they have production closer to customer and they do not need to priorities existing customers as much as the leading players do. With the opening of the new manufacture, KUKA will be able to deliver 5000 new robots every year to the Chinese market (KUKA, 2014).

Is not just inside Industrial Robotics KUKA are making progress. On the October 5th 2011 (KUKA, 2014), they open a new division (KUKA Laboratories) which has been developing surgical robots and professional service robots. As this thesis has focus on industrial robots, these markets have not been analyzed. However, from 2014 KUKA will begin receiving revenue from service and surgical robots as well. IFR anticipate that these markets will increase drastically in the future. KUKA can become a dominate player here, as well.

A last point when argue for KUKA as an investment object, is that we have focused at China growth as measurement. This means that when we discuss which company to invest in, the significance of a growth in China should matter for the company's stock price. As KUKA is a pure robotic player, a growth in units sold of robotics should increase the stock price significantly, as this generate larger revenues for both the robotic and system division (which contributes 100 % of their revenue in 2013). It will also become important that the geographic exposure toward China is significantly large. For KUKA we have assumed that the geographic exposure is approximately 13 % (using Morgan Stanley estimate and assuming a 1-percentage point increase yearly form 2011 to 2013). This is a quiet low geographic exposure, which obviously reduces the effect on stock price. However, as more and more robots will be sold in China, the geographic exposure will become larger and larger. We believe that China will become a huge part of KUKA`s revenue which ultimately will lead to increase in stock price.

The reader of this thesis might think that we believe that ABB, Yaskawa and Fanuc will not be able to participate in the growth in China. This is not the case. We believe that all the four leading players should experience a growth. Nevertheless, there are reasons to believe that KUKA might gain slightly more as they seems to gain market shares compared to other selected companies. KUKA are the only “pure play” robot company studied in the thesis. The growth in revenues resulting from increased robot sales in China will affect KUKA in a higher degree than its selected competitors. The other competitors are diversified in other business segments, ranging from 3% (ABB) - 30% (FANUC) focus on robotics. The impact from robot growth will have less effect on these companies overall profitability.

11 Conclusion

The following conclusions can be drawn within the framework of the thesis:

There are good reasons to believe that the strong growth in robot sales to/in China will continue. The most important findings supporting this conclusion are the following:

- small robot density in China implies high potential
- manufacturing –based and export-oriented economy
- constantly improved functionality of industrial robots
- aging population and shrinking workforce (especially young)
- rising wages
- increase motor vehicle production
- increased domestic demand for cars

Industrial robots have several strengths and opportunities

- ability to penetrate new applications areas and industry branches
- contributes to increased profits in the manufacturing industry
- substitute hazard, repetitive and dirty work tasks

KUKA is a strong pure play robotic candidate in the growing market of China

- dominant industrial robot suppliers in China
- gaining marked shares compared to other dominant companies
- the company's equity value reflect part of the anticipated growth
- the stock price seems slight underestimated according to our growth estimate

Increasing competition in the Chinese market.

- domestic robot suppliers beginning to gain market shares
- leading market players are losing market shares
- emergence of new companies

12 Suggestions for further work

The work carried out in this thesis has revealed many promising areas of further research of robots in economic and financial terms. Some areas worthy of further investigations can be briefly summarized as follow:

- Profitability of industrial robot in different industry branches
- How are investment decisions of robotics solutions made
- Do companies lose profits by choosing not to invest in industrial robots
- Study the emergence of service robots, both professional (e.g. medical/surgery and subsea) and household/entertainment (humanoids) robots
- The effect of robot installation versus unemployment
- The demand and potential for robots in the oil and gas industry (particularly subsea). This could apply to Brazil due to deep-water challenges
- Study the market for self-driving cars
- How are the industrial robots priced? What characterizes the price trend? How are costs divided through its service life?
- Exploring Chinese robot suppliers companies (e.g. Siasun)
- Exploring key companies engaged in revolutionary robot technology (E.g. Universal Robots, Denmark)

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14 Appendix

14.1 Appendix 1: Interview with ABB Robotics

Fredag 28.mars 2014 var vi så heldige at vi fikk komme å intervjue Jan Christian Kerlefsen og Steinar Riveland som jobber ved ABB Robotics Bryne. Intervjuet ble utført i konferanserommet til ABB Brynes hovedkvarter i Nordlysvegen 3, 4340 Bryne (Google, 2014). Vi ble møtt av Jan Christian Kerlefsen kl. 11.30, ved inngangen til bygget, hvor turen gikk direkte til deres kantine. Etter å ha valgt noe å spise, gikk turen videre inn i deres lab, hvor en rask introduksjon av robotene som stod der ble gjort. På grunn av tidsklammeri gikk vi hurtig inn til deres konferanserom lokalisert i deres lab. Her ble intervjuet utført.

Varighet: ca. 45 min.

14.1.1 Intervjuobjektene

Jan Christian Kerlefsen er LBU manager ved ABB Norge (direktør) og har jobbet som dette siden oktober 2012. Han har er også R&D Manager (Research and Development Manager) og har vært det siden Januar 2005. Startet å jobbe for ABB Norge oktober 2002 (Linkedin, 2014).

Steinar Riveland er Global Product Manager - Paint robot development ved ABB Norge og har jobbet som dette siden mars 2007. Steinar Riveland har jobbet i ABB Norge siden oktober 1999 (Linkedin, 2014).

14.1.2 Om ABB Norge

Fra ABB sin nettside (ABB Group, 2014):

> ABB i Norge er en del av den verdensomspennende ABB-gruppen som har hovedkontor i Sveits. ABB har virksomhet over hele landet med ca. 2200 ansatte og en årlig omsetning på rundt 9,6 milliarder kroner. ABB har en over 100 år lang tradisjon innen kraft- og automasjonsteknologi og satser hvert år store ressurser på forskning og utvikling. Teknologi, produkter og systemer fra ABB er i bruk over hele verden. Deres produkter og systemer gir en mer stabil strømforsyning og bedre utnyttelse av eksisterende energi. Høyere energieffektivitet er siktemålet for alt de gjør. Deres løsninger skal bidrar til økt produktivitet og dermed økt lønnsomhet for deres kunder. ABB er i dag verdens største leverandør av industrielle motorer og frekvensomformere, generatorer til vindkraftindustrien og av produkter og systemer til strømnett.

14.1.3 Intervju

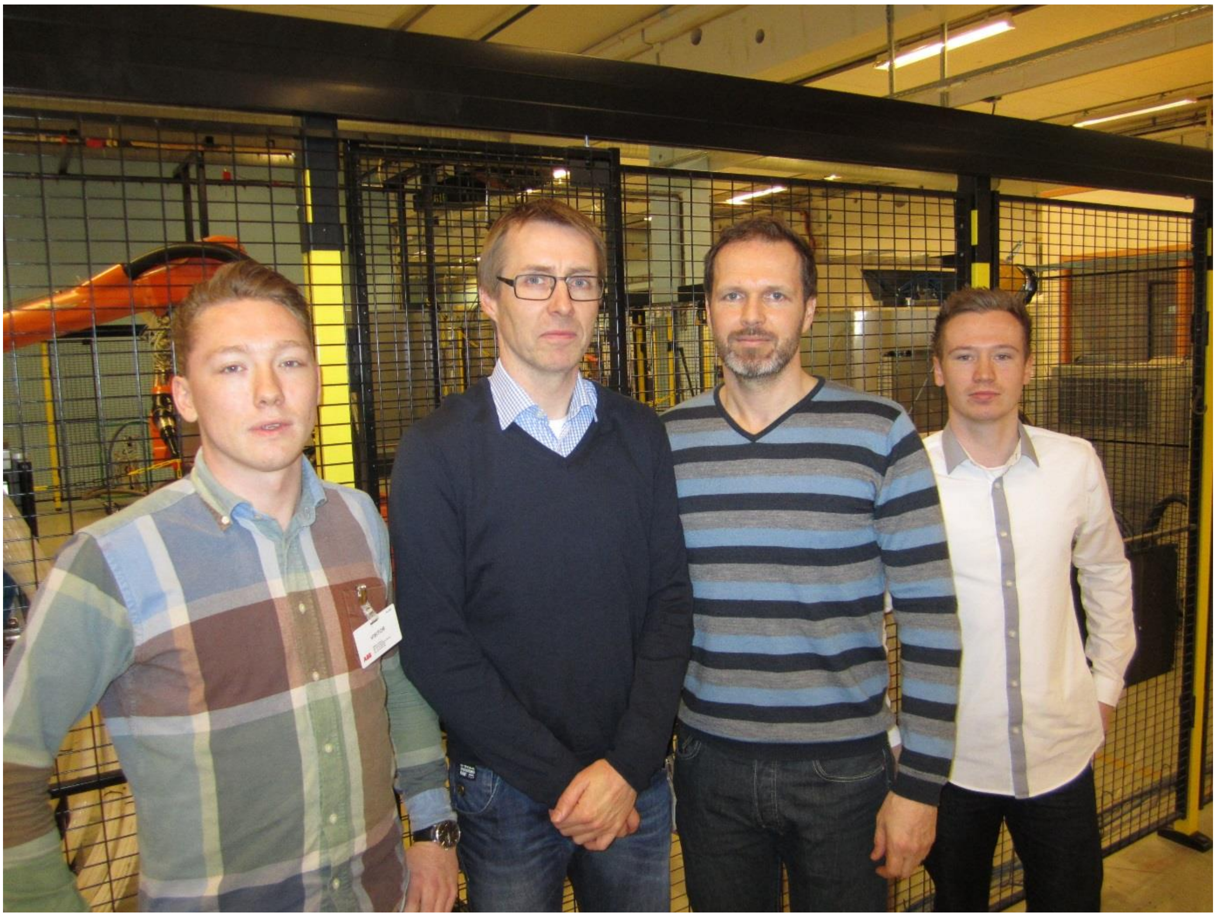

Figure 44 Bilde: Fra venstre Joachim Storm Johansen, Jan- Christian Kerlefsen, Steinar Riveland og Hans Kristian Tjemsland. Fotograf: Hyggelig ansatt hos ABB Bryne.

Vi er totalt 4 i konferanserommet. Disse er Jan Christian Kerlefsen, Steinar Riveland, Hans Kristian Tjemsland og Joachim Storm Johansen. Da vi ankommer konferanserommet med Jan Christian Kerlefsen er Steinar Riveland allerede ankommet. Noen uker tilbake har vi sendt over spørsmålene som vi ønsker å stille dem, ergo så har intervjuobjektene allerede fått disse opp på overheaden. Det er tydelig at intervjuobjektene har forberedt seg, så vi anvender av naturlige grunner et mindre formelt intervju, hvor Steinar Riveland og Jan Christian Kerlefsen snakker nokså uavbrutt og selv velger hvilke spørsmål dem ønsker å svare på.

- ***Steinar Riveland**: Vi kan begynne med å fortelle litt generelt om hvordan Robotics ser ut.*

Jeg er produkt sjef så jeg kan mest om hva som har med produktene å gjøre. Spesifikt lakk produkter. Mitt felt er lakkerings roboter, lakkerings kontroller, styrespak, software, applications utrustningen og selve sprøyteholderen. Vi har flere personer som har samme ansvaret som meg i ABB Systemet. Men i all hovedsak sitter de i Kina, som er et av hovedkontorene våre, eller i Sverige som er et annet av hovedkontorene våre for industri roboter. Jeg sier ofte at de er (Sverige og Kina) industri roboter og vi er paint roboter, det skiller oss fra dem. Men vi er egentlig alle industri roboter. Det finnes med andre ord utrolig mange segmenter innenfor ABB allerede.

- ***Steinar Riveland****: Om vi (ABB Group) vil vokse til nye segmenter i framtiden.*

Det kan vi komme litt tilbake til, men problemet tror jeg er at mange i dag ser på alt for mange segmenter på en gang. Vi ser synergi effektene og mulighetene mellom ulike segmenter, men det finnes problemer vi må ta hensyn til. La oss ta et eksempel med når man lager en bil. Er man i stand til å lage en bil med hjelp av roboter, da blir det også lett å lage en pick up fordi det er synergi mellom de forskjellige plattformene. Da kan man fort gå i en felle, mer eller mindre ubevisst. Vi prøver å styre segmentene inn på noe som vi virkelig vil fokusere på, men hvor vi har mangler det som vi kaller for en FrontEnd, dem som er på salgssiden (salgskontorene), som trenger den nødvendig kompetansen og de nødvendige verktøyene. Det nytter ikke å komme opp med et nytt produkt, uten å ha noen som kan selge det, ingen som kan promotere det, ingen som kan «back-e det opp». Så det er viktig å begynne med en tydelig strategi. Hvor ønsker man å gå? Hvilken retning tror vi er den riktige å gå? Da må man ikke ha en ball- last med seg som er for stor, og drar for høye kostnader med seg. Selv om det er muligheter for enkle salg, så mangler man salgsteam som er spesialiserte. Man mangler salgsteam som kan selge det som man har som løsninger. Man har for mye i verktøykassen. Vi prøver å skarpe opp verktøykassen til der den skal være og ha hele verdikjeden innenfor den spesialiserte verktøykassen godt dekket.

- ***Steinar Riveland****: Litt om roboter globalt sett (ikke bare ABB).*

Slutten av 2000- tallet var der solgt cirka 100 000 roboter per år, alle roboter inkludert. Vi har sett at det har vokst, det har kommet opp imot 170 – 180 000 roboter per år i 2014 tror jeg, alle roboter inkludert. Dette er litt spekulativt, for vi laget denne prognoses i 2012 – 2013. Det som er interessant å se er fordelingen mellom USA, Europa og Asia. Det er helt klart at det er mest roboter i Asia. Mye av grunnen til at det er mest roboter i Asia er naturlig nok fordi det er mye produksjon som flyttes til Asia. Volum produktene kommer fra Asia. Allikevel ser vi at mye av de tunge produksjons industriene, som krever høy robot teknologi og høy robot nøyaktighet, fortsatt ligger i Europa og USA. Så det er en stor installert base, og om vi ser litt lengre tilbake i tid så var basen faktisk enda større i de store viktige regionene som Europa og

USA. Kina er kommet i seinere tid, men vi ser at det er forholdvis harmoni fra 2010 til 2014, der det vokser litt i alle områder.

- ***Jan Christian Kerlefsen**: Bare en liten kommentar til dette temaet.*

Det er litt paradoksalt at robottettheten vokser så mye i lavkostland, der arbeidskraft er billig. Der er blitt utført en analyse på dette. Her skiver han at det ikke bare er kostnader som timebetaling til ansatte som er med å styre, men også personell turnover. I Kina skifter personelle ofte jobb og da får man ikke bygget opp en god kompetanse hos dem som jobber der, som for eksempel hos de som produserer biler. Og det i seg selv er en egen driver til å velge roboter. For robotene slutter ikke og når de lærer noe så kan de det.

- ***Joachim Storm**: Bilindustrien er veldig interessant. Det er svært høy tetthet på roboter i bilindustrien. Når vi ser på antall roboter per 10000 arbeider. Betyr ikke dette at det er vanvittig potensialet for en høyere robottetthet i andre markeder, andre segmenter?*

Steinar Riveland: Det er et godt poeng. Vi har sitt litt på et nytt segment, som er leketøy. Først og fremst barbiedokker. Hvor mange barbiedokker tror du produserer hver dag? Jeg har hørt at det produseres 25 millioner barbiedokker hver dag. Som hovedsakelig blir produsert på 8 forskjellige fabrikker. På disse fabrikkene jobber det tusenvis av arbeidere. Det er ikke nødvendigvis slik at de vil ha vekk arbeiderne, men arbeidere har en tendens til å skifte jobb ofte. Fordi de ønsker å drive med noe annet. Det er rett og slett for tungt å jobbe der. Litt som Jan- Christian sier. For å få den kontinuerligteten man trenger, er det en stor utfordring for disse fabrikkene å greie å holde folk i arbeid. Noen har derfor blitt trigget av tanken om dette segmentet som en robot applikasjon. Jeg er nok litt mer moderert innenfor dette temaet, fordi jeg mener at alt ikke kan robotiseres. Det er mange segmenter som lar seg løse bedre på andre måter enn med robotisering, for eksempel ved å lage til enkle lineærmaskiner. Vi har en tendens til å tenke alle løsninger i robotformat, det må vi prøve å unngå. Ta for eksempel det å flytta en skrue fra a til b. Det kan enklere gjøres med bruk av en sylinder, enn ved en robot. Man trenger ikke en robot med seks frihetsgrader for å gjøre den jobben. Så vi må fokusere på de segmentene der det trengs roboter. Problemet er at hvis vi går inn i leketøysbransjen og begynner å sette sammen barbiedokker, som vi mener muligens kunne vært en applikasjon. Da ved lakkering av øyenvipper. Da snakker vi om et helt annet segment, enn det å lakkere biler. I dag blir barbiedokker lakkert med et enkel sveip av en ansatt. Da vil det være mye billigere å gjøre det med en enkel lineærmaskin, enn ved en robot. Problemet vårt kan være at hvis vi blir for giret på dette segmentet så utvikler vi muligens en robot. Denne roboten har kostnader forbudne til seg, i tillegg til de forventingene vi har til produktet. I neste periode får vi ikke solgt det nye produktet, det kommer bedre løsninger på markedet og vi ender opp med å ødelegge for oss selv. Vi har da kanskje brukt to år på å forme et marked som ikke er gangbart og levedyktig.

- ***Steinar Riveland****: Litt tilbake til det jeg begynte med.*

Vi som ABB leverte i fjor cirka 25 000 roboter av 170 – 180 000 roboter. Vår markedsandel ligger med forholdvis stabilt. Innenfor industrirobot sektoren inklusivt lakkering så er det cirka 10 veletablerte robotprodusenter. I lakkering alene er det færre veletablerte. Her er det cirka 3- 4 veletablerte selskaper og en 3 – 4 som er små nisje selskaper, spesialisert innenfor stoler og andre små ting, og i mindre grad bilindustrien.

Vi har i utgangspunktet 2- 3 segmenter vi opererer innenfor. Vi har levert fra cirka 400 i 1998 opp til 740 de siste årene og vi ligger faktisk rundt en 700 – 750 jevnt. Målsettingen i år er det samme antallet. Vi har en visjon om å vokse til cirka 1500 roboter i løpet av 2017. Vi henger litt etter på dette fordi vi ikke har funnet den FrontEnd «driver-en», jeg snakket om tidligere. Vi må sørge for at vi vet hva strategi vi skal følge. Hva er målsetningen? Hva er retningen vi vil gå i? Så må vi også sørge for at produktene våre back- er opp den strategien.

2009 var et spesielt år fordi det var nokså mange måneder der vi ikke hadde solgt noe som helst. I 2009 solgte vi nesten halvparten av året før. Det er tydelig at finanskrisen preget oss slik som mange andre.

Vi har en portefølje i dag som i utgangspunktet består av 4 produktfamilier. Når vi snakker om bilindustrien så snakker vi om to av robotmodellene. Vi har to roboter ute på laben nå. En av de metter 2/3 av markedet, som er bilindustrien. Produktet som består av 1/3 av markedet er en samlerobot som lakkerer alt fra plastikk, elektronikk komponenter, møbler og mye annet. I 2009 ser vi at bilindustrien fikk seg et seriøst krakk. Dette førte til en slutt på investeringer i en periode, for de visste ikke hvor lenge finanskrisen vill vare. Derfor trakk bilindustrien oss kraftig ned i 2009. Den minste roboten vi solgte faktisk, på tross av finanskrisen like godt som den hadde gjort, nesten bare bedre. Grunnen til dette er mest sannsynlig fordi industriene som bruker denne roboten hang etter på robot fronten. Meget inntresant å se slike tall.

- ***Jan Christian Kerlefsen****: Vil bare si en liten ting om visjon.*

Det er mange aktører på markedet, Google blant andre. De har kjøpt opp og gjort mange strategiske kjøp innenfor robotiserte løsninger. For oss andre er det litt uklart hva markeder Google faktisk ønsker å gå inn i. Allikevel forventer vi ikke at de kommer til å konkurrere med oss på industriroboter. Det er nok mer service roboter og den type ting de ønsker å gå inn i som underholdningsroboter. Så er der også noe som heter universal robots som er en relativt ny aktør, med helt nye enkle konsepter som er enkle å programmere som er en del under det nivået vi driver med. Det kan være at Googles oppkjøp av robot selskaper og en slik forenklet tankegang mot systemer kommer til å drive fram revolusjoner innenfor robotics.

- ***Hans Kristian Tjemsland**: Dette argumentet om at verden opplever en aldrende befolkning, er dette med å driver fram en høyere robotisering?*

Steinar Riveland: Vi har sett en økende antall humanoid-er på de seneste messende. Altså roboter som ser ut som mennesker. Det er mye forskning og mange universiteter da spesielt i Japan som forsker på programmer som er relatert til humanoid-er. I starten var de veldig stakkato (hakkete bevegelser), det var mer det visuelle som gjaldt der roboten ikke kunne gjøre så mye. Hvis den kunne gjøre noe så var det utrolig vanskelig å programmere den. Et eksempel er en som hadde laget til en bevegelse der roboten bare flyttet en ting i fra a til b. Det tok han 14 dager å programmere bevegelsen. Utrolig komplisert. Dette er en av de store barrierene som må brytes … **Jan- Christian Kerlefsen** (bryter inn): bryte de teknologiske utfordringer, det som jeg kaller ease of use, mann – maskin grensesnittet må forbedres. Innenfor disse tingene må det skje noe revolusjonærene som gjør det lettere å anvende slike roboter. **Steinar Riveland**: For to år siden så vi at de var kommet lengre. De begynner å nærme seg noe som kan virke interessant for forbrukerne.

- ***Joachim Storm Johansen**: Hvordan er det med oljebransjen, og for eksempel robotiserte ubåter, er det et marked dere kunne ha tenkt dere å gå inn i?*

Steinar Riveland: Det er et marked som vi har snus på i denne organisasjonen de siste 3- 4 årene. Men det er en nokså konservativ bransje, en nokså spesiell bransje. Jeg skal ikke si at andre bransjer er mindre kravstor, men vi har levert roboter innenfor bilbransjen i mer enn 40 år. Så det er innforstått at man bruker roboter i den bransjen. I olje og oljeservice sammenheng så er der et fåtall roboter, så det er et helt nytt marked. Men det er et godt poeng at robottettheten i oljebransjen og Norge som sådan er veldig lav. Vi er som et u-land på roboter. Det har nok mye med at vi ikke har begynt tidligere med robotisering. Den industrielle produksjonen vi har er ofte lav skala, på grunn av kostnivå og eksportulemper vi eventuelt har.

- ***Hans Kristian Tjemsland**: Rent teknologisk, er det en utfordringer å robotisere plattformer i forhold til andre segmenter.*

Steinar Riveland: Hvis vi virkelig gikk inn for det så er det ikke vanskeligere å automatisere en oljeplattform enn noen annet segment. Så lenge man har repetitive prosess. Skal man ha noe autonome løsninger hvor roboter erstatter operatører, da begynner man å snakke mer komplisert, fordi da må roboten selv finne ut hva de må gjøre. I oljebransjen har man ikke en repetitive prosess. Man har ikke en prosess hvor noe skal flyttes på, eller at en spesiell oppgave skal løses likt hele dagen. Her er oppgavene ofte slik at man skal overvåke ulike prosesser. Overvåkningsroboter er det ikke så mange som har levert. Da finnes det masse andre løsninger, som for eksempel kamera og styrte ventiler og andre gode løsninger som vil fungere bedre. Robot i seg selv kan ikke bidra med så mye. **Jan Christian Kerlefsen**: Men det har vært en veldig hype innenfor gassindustrien om å implementere autonome roboter som har en egen vilje, egne meininger som er i stand til å ta egne beslutninger. Men disse robotene finnes ikke fordi det er ingen som bruker slike roboter. Olje og gassindustrien ønsker å hoppe rett over til slike roboter. Men vi ser applikasjoner til roboter i olje- og gassindustrien, og jobber med flere miljøer og segmenter. **Steinar Riveland**: En ting som jeg synes er interessant. Jeg har snakket med et oljeselskap som har sett litt på roboter. En av applikasjonsområdene som de ønsket å se nærmere på er brannroboter. Altså en robot som er utstyrt med pulverapparat, med co2 og andre brannslukkingsmidler. Den kunne stått hele døgnet å overvåket et område med kamera og infrarød. Så kunne den ha gjort en nødvendig aksjon hvis det var noe som skjedde. For man kan lett ofre en robot. En robot kan koste noen hundre tusen, men en person skal man aldri kalkulere med å ofre i noen sammenheng. Så for de som driver med helse, miljø og sikkerhet, brann og brannvern kunne brannrobot vært en meget interessant applikasjon. Og brannrobot kunne blitt brukt i hvilket som helst segment får man kan ofre en robot uten problem. Men det blir viktig å lage applikasjonen før man lager produktet. Det er jeg er litt dreven av. Man må sørge for at man vet hva vei man skal. Spørre oss selv om det er noen der ute som kan ha nytte av produktet. Vi har en robot som står her ute hos oss, som har gått i et og et halvt år. Og det er egentlig bare for å vise at det er mulig å lage en robot som fungerer utendørs. **Jan Christian Kerlefsen**: Allikevel finnes det ikke purpose build utendørs roboter for kommersiell bruk i dag. Vi har en prototype, og det finnes kanskje tilpassete roboter, litt mer robuste roboter, men i all hovedsak så eksisterer det i dag ikke ordentlige utendørsroboter.

- ***Joachim Storm Johansen**: Kan disse utendørsrobotene bli i stand til å tåle minusgrader?*

Steinar Riveland: Ja. 40 minusgrader skal de være i stand til å tåle. Alt ifra 30 pluss til 40 minus skal de være i stand til å tåle. Det er det som er rekkevidden. Men vi ser at det er utfordringer. Problemet er først og fremst variasjon i temperatur. Hvis man kun har 40 minus så går det greit, men har man 50 pluss i et øyeblikk og 40 minus i et annet så har man større utfordringer. Da må man ha utrustning til begge ender av skalaen samtidig.

- ***Jan- Christian Kerlefsen**: Litt om styrker og svakheter til ABB Norge.*

Jan Christian Kerlesfen: Vi har hatt en stor svakhet med at vi ikke har vært i markedet (rent geografisk). Markedene våre er Europa, sitt vekk ifra Norge, USA og Asia. Vi er et høykostland, som antakeligvis er bakgrunnen for hvorfor vi har flyttet produksjonen til Kina. Dette er for å geografisk være i markedet og da også være mer konkurransedyktige. Vi har allikevel beholdt forskning og utvikling her, fordi vi har kompetansen. Hvis vi skulle bygget opp hele ABB Robotics fra start så hadde vi nok gjort det et annet sted enn på Bryne. Men vi har tross alt overlevd siden 1969, og vært konkurranse dyktige hele tiden. Både med produksjonen og kompetansen. Vi har argumentert for at vi må ha produksjon og forskning tett sammen, tidligere hadde vi produksjonen her (laben) og forskning i etasjen over. Derfor hadde vi veldig tett kontakt begge veier. Det mener vi var et fortinn vi hadde før. Nå har vi produksjonen på andre siden av jorda, med en 7 – 8 timer tidsforskjell, annet språk og annen kultur. Derfor må vi nå jobbe på en helt annen måte, som på mange måter er litt banebrytende. Det å ha produksjon og forskning så adskilt er utfordrende, men vi har hatt det slik siden 2009 og er fortsatt i business og klarer oss. Så det fungerer. **Steinar Riveland**: Det er helt klart at vi har mange utfordringer som ikke lot seg planlegges med den beslutningen. Som organisasjon har vi greid oss bedre enn jeg fryktet. Jeg trodde utfordringene skulle bli enda større enn de har vært, selv om det alltid finnes utfordringer. **Jan Christian Kerlefsen**: ABB har nemlig forskningsteam i Kina også. Så vi har en slags intern konkurrent til oss her på Bryne. Hadde de vært flinkere enn oss, så hadde vi ikke vært her lenger, men det er vi. Vi har et veldefinert mandat. **Steinar Riveland**: Det som har med lakk å gjøre, som er vår organisasjons viktigste applikasjon. Der sitter vi med kjernekompetansen. Veldig stor andel av den teknologien som blir anvendt i våre roboter kommer herfra, og en mindre del fra forskningssenteret i Kina. **Jan**

Christian Kerlefsen: Vi har en virkelig global forskning og utvikling i USA, på Bryne, i Sverige, India, Kina og Japan.

- ***Steinar Riveland**: Jeg ønsker å snakke litt om robotpriser.*

Steinar Riveland: Vi har nok det største spranget i pris sammenlignet med andre applikasjoner/robot modeller (sveising, håndtering, etc.), der prisen ofte varierer fra 30 000 dollar til 400 000 dollar. Så prisen varierer. Men la oss ta en robot i bilfabrikken, når den er montert og «kommuniserer» med alt perifert utstyr og har alt den trenger, da kan produktet koste opp mot 400 000 dollar. Så det er et stort sprang og ikke en spesifikk pris på roboter.

- ***Joachim Storm Johansen**: Hvordan er forholdet mellom pris på selve roboten og systemet den anvender?*

Steinar Riveland: Roboten, styringen og det som er mest basic ligger ofte på mindre 100 000 dollar, så kommer det en applikasjonspakke på toppen av det, som kan ligge mellom 50 – 100 000 dollar, til slutt har vi en software pakke på toppen som er på cellenivå. Så fra 200 000 pluss opp til 400 000 så er det ganske mye lokale kostnader, som bygging på plassen. Du skal for eksempel ha en fot som roboten står på. Denne foten skal ofte flere etasjer ned, og da begynner pakken fort å bli dyr. Derfor så kan vi si at det er flere utestående elementer som drar opp prisen. Så roboten isolert sett er som oftest ikke det dyreste elementet. Selve installasjonen kan ofte være det dyreste.

- ***Joachim Storm Johansen**: Kan man da si at det viktigste for fremtiden blir implementering av systemer og software-en og at det kan bli en viktig og problematisk faktor å implementere software-en og nye ideer i tide?*

Steinar Riveland: Ja det er helt sant. Det tar ofte lengre tid enn vi ønsker. I ABB Robotics (som er en av flere 'business units' under Divisjon «Descrete Automation and Motion») investerer vi en plass mellom … (klassifisert som konfidensiell informasjon) millioner dollar i hvert år i nyutvikling. Så man kan si at det går litt penger til utvikling, men det er klart at dette er nødvendig. Vi har en målsetning om 100 000 roboter i året i 2020 for hele ABB. Skal vi nå dette målet er vi nødt til å utvikle oss og da er … (konfidensielt) millioner dollar ikke for mye penger å bruke på utvikling, i forhold til den målsetningen vi har. Innenfor lakkering hadde vi i fjor en omsetningen på cirka 450 millioner dollar. Det beviser at dette er en seriøs business.
Jan Christian Kerlefsen: En liten kommentar til software vs. hardware. Vi går mot å utvikle en mer generell hardware, der vi fokuserer mindre på hardware og mer på software. Omtrent

samme tankegang som vi ser i telefon bransjer, der mobilen er en generisk hardware sak med mye funksjonalitet i software-en, langt mer enn tidligere. Denne retningen går også vi mot. Kontrollerskapene våre blir mer og mer tomme og inneholder mer og mer software.

- ***Joachim Storm Johansen****: Er der noe forskjell på restriksjoner mellom landene, for eksempel mellom Kina og Norge?*

Jan Christian Kerlsefsen: Nei, ABB har samme policy og restriksjonskrav i alle land (Tilleggskommentar **Steinar Riveland** etter intervju: Våre kunder kan ha forskjellige krav/restriksjoner. Det er f.eks. kunden som skal spesifisere hvilke sikkerhets kategori som skal benyttes (zone defenitions, Ex sone 1, Ex sone 2 etc.).

- ***Hans Kristian Tjemsland****: Ser dere på interaksjonene mellom maskin og mennesket, med tanke på følsomme hender og denne typen ting som gjør robotene i stand til å samarbeide mer tett med mennesker?*

Steinar Riveland: Innenfor lakkering var dette temaet lenge ikke et problem fordi lakkeringen foregikk enten helt manuelt eller helt automatisert. Innenfor andre segmenter så ser vi oftere en blanding. Noen segmenter kunne man se mennesker som bokstaveligtalt gav noe til en robot. Da kreves det mer sikkerhet. I ABB og andre selskaper er det blitt anvendt en generisk funksjon der roboten har et forhold til et mennesket. Den fungerer slik at når mennesket kommer nærmere enn 2 meter så vil robotene jobbe seinere og med redusert bevegelses energi, kommer mennesket så nærme som opp til 1 meter så jobber robotene enda seinere og med enda mindre bevegelses energi, og hvis mennesket er nærmere enn 1 meter og har muligheten til å ta på roboten så stopper den helt. Så det eksisterer slike sone definisjoner og systemer som ivaretar menneskets sikkerhet. Innenfor lakkering så driver vi å forske på systemer og teknologi som kan føre til at mennesker kan jobbe enda tettere til roboter. Slik at en gjenstand kan bli lakkert manuelt samtidig som den blir lakkert av en robot. Da må man vite hvor mennesket oppholder seg til enhver tid, for han kan finne på å bevege seg inn i banen til roboten. Vi må ha systemer som fortsatt er i stand til å ivareta sikkerheten. Teknologi som var utenkelig for 10 – 15 år siden. Teknologien og tankesettet til selskapet går mot en slik holdning.

- ***Jan Christian Kerlefsen****: Vi kan avslutte med å snakke litt om vår visjon fram til 2020 som kun er 6 år unna.*

Vår ambisjon er å øke salget fra 23 000 roboter til 100 000 roboter produsert. Det sier litt om våre ambisjoner. Vi har en strategi og plan på hvordan vi skal kunne gjennomføre dette.
Steinar Riveland: Vårt marked (lakkeringsroboter) er i dag på cirka 5500 roboter. Uansett om vi har 100 % av markedet så kan vi ikke bidra med mer enn 5500 roboter i året. I tillegg er det ikke realistisk at vi skal ha 100 % av markedet. At vi kan få rundt 20 – 25 % slik vi hadde for noen år siden er realistisk. Akkurat nå har vi gått litt ned på grunn av at markedet har vokset fortere enn vi har greid å mette.

- ***Joachim Storm Johansen**: Er der noen trusler i form av substitutt goder for roboter?*

Steinar Riveland: I noen segmenter så vil andre type løsninger være bedre enn roboter. Det har med produksjonsfleksibilitet å gjøre. I Kina for eksempel, der er det eksempler på selskaper med bare en kontrakt som investerer i ny linje. Da må han vite at han får tilbakebetalt for prosjektet fra den ene kontrakten. Han har ingen anelse om denne kontrakten kommer til å eksistere om to år fra nå. Han vet ikke en gang om fabrikken enda er der. Derfor må de investere i prosjekter de kan løse der og da. Hvis fabrikkene har en plan for framtiden, da kan roboter være mer fleksible enn andre løsninger. Det gir roboter et konkurransefortrinn. Hvis de for eksempel skal lakkere telefoner det ene året og året etter lakkere noe helt annet, så vil dette seg lettere implementeres med roboter. Så med roboter har man fleksibilitet. Med lineær maskin så kan man kun gjøre den ene jobben. Så det er en ulempe med andre løsninger.

Intervju slutt.

Oppfølgingsspørsmål til Jan Christian Kerlefsen og Steinar Riveland etter endt intervju:

- ***Hans Kristian Tjemsland**: Hva er deres holdning til Machine Vision?*

Jan Christian Kerlefsen: Når det gjelder Machine Vision er dette noe vi følger godt med på, og vet konkurrentene våre gjør det samme. De og oss har mange løsninger for dette, også egne produkter, og vi følger godt med også innen forskning og utvikling. Vi tror dette kan bli stadig viktigere innen noen typer applikasjoner. Det finnes nye og spennende kamerateknologier (f.eks. point cloud) som kan åpne for nye løsninger.

Steinar Riveland: Det er en klar retning at også "Paint" kommer til å gjøre mer nytte at Machine vision, nye typer kamera, tettere integrasjon og bedre software løsninger. Jeg kom først i kontakt med Machine vision for Paint i 1995, hvor viktige kunder benytter kamera som posisjonering av biler for lakkering. På dette tidspunkt var det også store utfordringer med type kamera, lys forhold, refleksjon fra enkelte farger (lakkerte flater) etc.

I dag kan en få 3D kamera, smarte kamera, point cloud camera etc. med mye mer støttefunksjoner; lys spekter, filter, smarte løsninger, kommunikasjon etc… og med vesentlig bedre oppløsning enn tidligere.

Alle robot leverandører har en eller flere grensesnitt mot Machine vision, enten som egne løsninger eller som tredjepart løsning. Vi som ABB har også intergrated vision, som også fungerer for Paint roboter (selv om det ikke er like standardisert som på Industrial roboter).

- ABB har integrert machine vision og vi ser på løsninger som videreutvikler disse til flere bruksområder. En kan tenke seg at en i fremtiden benytter point-cloud camera for å skanne et objekt for så å ta dette inn i simuleringssoftware og robot software, for å identifisere hvilke objekter roboten skal ta hensyn til og hvilke objekter som roboten ikke skal være i kontakt med. (F.eks. om en har et objekt som skal lakkeres plassert på et bord, skal roboten ta hensyn til objektet og kjenne begrensningene som bordet gir mhp bevegelsesfrihet, samme som gjerder, gulv, tak etc.)
- Teknologien er kommet et langt stykke videre fra 1990 tallet, men vil fortsette å vokse, tenker også på kommersielle digitale kamera og telefoner, hva disse kan gjøre for videreutviklingen av Machine vision.
- Machine vision er en industri standard i dag, og ikke noe som gjør noe videre konkurransefortrinn. Alle har dette på ett eller annet nivå, mer eller mindre sømløst integrert.

Takk til ABB Robotics Bryne!

14.2 Appendix 2: Interview with RobotNorge AS

Onsdag 23.04.2014 var det duket for et nytt intervju. Denne gangen var det Jean Marc Launay fra Robot Norge som ble intervjuet. Intervjuet ble utført ved Universitet i Stavanger. Ettersom Jean Marc bor nokså nær UiS så kom vi til enighet om at dette var lettest for begge parter. Vi møter Jean Marc Launay ved inngang vest Kjøv Egelands hus kl. 08.30, der turen går rett til vårt kontor på c-127.

14.2.1 Intervjuobjekt

Jean Marc Launay er Managing Director i RobotNorge og har jobbet som dette siden oktober 2013. Han har tidligere jobbet i ABB Robotics (fra 2002 til 2011) og har lang erfaring med roboter (Linkedin, 2014).

14.2.2 Om RobotNorge AS

Fra RobotNorges hjemmeside (RobotNorge, 2014):

> RobotNorge AS ble etablert 1. oktober 2003 og er eneforhandler i Norge for ABBs totale robotprogram. Grunnstammen av våre medarbeidere jobbet tidligere i ABB Robotics på Bryne.
>
> Vår visjon er å bidra aktivt til å skape lønnsom produksjonsindustri i Norge. Og det gjør vi gjennom mer enn 30 års erfaring innen salg, prosjektering, installasjon og service av automatiseringsløsninger for norsk industri med robot som et naturlig midtpunkt.
>
> Vi kan tilby et bredt spekter av ABB-roboter og relaterte tjenester for enhver industriell automatisering. Produktene leveres som integrerte systemløsninger prosjektert av oss eller av våre samarbeidspartnere.
>
> Foruten salg av produkter og relaterte tjenester så betjener vi en installasjonsbase på over 1100 roboter i Norge og driver et utstrakt samarbeid med kunder om oppgradering, opplæring og service.

14.2.3 Intervju

Varighet: 73 min.

Intervjuet blir utført inne på skriverienes kontor (Hans Kristian Tjemsland og Joachim Storm Johansen). Tre stykk er i rommet og i likhet med intervjuet av ABB Robotics blir et flytende system anvendt der Jean Marc Launay starter med å presenter et forberedt foredrag. Spørsmålene har skriverne sendt over noen uker tidligere så, skriverne blir fortalt at foredraget vil svare på en del av de spørsmålene som er blitt stilt.

Jean Marc Launay: *Jeg kan begynne med å snakke om meg selv.*

Jeg har nå jobbet i RobotNorge i litt over et halvt år, så det er ikke sikkert at jeg kan svare på alt. Før jeg begynte i RobotNorge jobbet jeg i Akers Solutions med operasjonelle borerigger på norsk sokkel. Før jeg starter i Akers Solutions jobbet jeg i ABB Robotics som er hvor jeg startet min norske karriere. Jeg var 11 år på Bryne (ABB Robotics Bryne). Hvor jeg har jobbet med Jan Kristian og Steinar Riveland. I ABB Bryne har jeg jobbet med produktivitet og etter-salgsmarkedet.

Før jeg flyttet til Norge jobbet jeg for ABB i Frankrike. Der jobbet jeg med prosjektering, salg og teknikk.

Første oktober i fjor startet jeg i RobotNorge som daglig leder. Så jeg kan nok ikke absolutt alt om det norske markedet, men noe har jeg plukket opp underveis.

Jean Marc Launay*: Om RobotNorge.*

RobotNorge ble etablert for cirka 10 år siden etter en overdragelse fra ABB. Før dette var RobotNorge en avdeling i ABB. RobotNorge har i dag eneansvaret som forhandleren av ABB roboter ut til det norske markedet. Før 2003 var vi en del av ABB, så de fleste ansatte i RobotNorge har 7 års erfaring innen RobotNorge. Vi er 18 ansatte, som har hatt en omsetning på 59 millioner i fjor og solgte cirka 50 – 55 roboter. Mange av våre ansatte, inkludert meg selv har altså våre røtter fra ABB Bryne. De driver med produktutvikling og forskning. Mens vår kjernevirksomhet er prosjektering, salg og etter- salg som service på operative roboter (eks. vedlikehold).

Joachim Storm Johansen*: Er vedlikehold en viktig inntektskilde for RobotNorge?*

Jean Marc Launay: Vedlikeholds biten er viktig på mange måter. Den gir oss en stabil inntektskilde. Prosjekter derimot (nye implementeringer av roboter) gir store svingninger i inntektskilder, der man kan få inn store cashflows i en periode og nesten ingenting i en annen. For økonomistyring er slike svingninger en utfordring. Servicen biten derimot. Den ruller og går hele tiden og vi har en jevn strømming av likvider gjennom service (vedlikehold, opplæring, systemoppdatering). Service inntekten vår genereres fra cirka 1000 forskjellige roboter som er i drift i Norge i dag.

(Jean Marc gir en kommentar til IFR statistikken på Norge: I 2012 har IFR estimert 1019 roboter i aktivitet i Norge. Dette mener Jean Marc er underestimert ettersom de ikke er den eneste aktøren i markedet. Det finnes også leverandører av KUKA roboter blant andre, og de må det finnes flere av dem enn kun mellom 50 til 100 stykk, helt etter feilmarginen).

***Jean Marc Launay**: Tilbake til ditt spørsmål om service.*

Service er veldig viktig. Det gir oss en 15-16 millioner i året stabilt. Nesten uansett hva som skjer. Robotene vil alltid trenge service, reservedeler og oppgraderinger. Hadde vi ikke hatt service delen ville vi ikke overlevd.

***Hans Kristian Tjemsland**: Hva med opplæring av ansatte (til kundene)? Er dette en viktig inntektskilde for dere?*

Jean Marc Launay: Vi driver med dette og det er viktig. Men det er ikke en stor del av vår virksomhet og derfor ikke blant de viktigste inntektskildene. Vi bruker cirka 12 uker i året på opplæring, så det er en mindre del av service biten. Det kan hende at dette virke lite og muligens vi burde fokusert mer på opplæring. Men i dag er dette ikke tilfellet.

***Jean Marc Launay**: Litt om RobotNorge sine prosjekter.*

Vi har en del store ting som har skjedd de siste 10 årene. Det man ser er at prosjektene omhandler bedrifter som Tine meieri, REC (Solcellepanel utvikling), NorDan (vindufabrikk), Elkem (produksjon av metallprodukter og materialet), Kongsberg Automotive (bildeler), **Benteler (bildeler)** og Renderoc (olje og gass relatert).

(Vi har et stort bytteprosjekt i gang med Benteler. For et par år siden kjøpte Benteler opp en fabrikk i Farsund, som produserer bildeler til Porsche. Det første de gjorde var å fjerne alle de eldre robotene og inn med nye. Dette er noe av grunnen til at vi har solgt så mange roboter i fjor. Benteler utgjør cirka 60- 70 prosent av salget av nye roboter, så 60 – 70 prosent gikk til Farsund i fjor.)

Dette illustrerer at vi driver med en del ulike segmenter. Vi driver med næringsmiddel, mekanisk tilvirkning, solar, bildeler og olje og gass. Dette er både kjekt og utfordrende. Det er mange ulike segmenter, med forskjellige krav og ulike type kunder. I gjennomsnitt så har vi hatt et omfattende prosjekt i året.

Jean Marc Launay: *Så hvorfor robotisere industrien?*

Driftssikkerhet er viktig styrke med roboter. Roboter er overlegne mennesker som kan drives operativt 99 % av tiden. De er ekstremt driftssikre. De er også overlegne når det gjelder nøyaktighet og repeterbar het. Man oppnår bedre produksjonsflyt, og økonomisk kan man spare veldig mye ved bruk av roboter. En motivasjon for bruk av robot er også HMS og fleksibilitet. Disse motivasjonene blir svært viktige på det norske markedet hvor kjennetegnet er bedrifter med lav volum, komplekse prosesser og små serier. Roboter kan gi et konkurranse fortrinn i forhold til mennesker og andre type maskiner og automatiserte løsninger når man tar hensyn til HMS og fleksibilitet.

Jean Marc Launay*: Våre fire viktigste segmenter/bransjer.*

De viktigste segmentene våre er næringsmiddel, mekanisk industri, byggevarer og olje og gass. Næringsmiddel segmentet er vårt største segment. Da snakker vi bortimot 40 % av det norske markedet. Det meste er da innen pakking og logistikk (eks. pakke inn flasker og sette dem på samlebånd). Nest størst er mekanisk industri, der sveising, slipe prosesser og maskinbetjening er mest fremtredende. Dette segmentet står for 25-30 % av det norske markedet. Neste segment er byggevarer, der møbelindustri og slike type ting inkludert lakkering er en del av. Dette segmentet står for 15- 20 % av det norske markedet. Det siste er olje og gass som ikke er 1 % engang av vår portefølje. Vi har den med fordi vi tror at i dette segmentet vil det skje en utvikling i framtiden. Det er blitt investert flere 100 millioner i forskjellig forskningsinstitutt for å utvikle roboter skreddersydd for olje og gass.

Disse fire segmentene utgjør cirka 80 % av det norske markedet. De resterende 20 % er type roboter som står her (Universitetet i Stavanger) på skoler, universiteter og andre forskningsinstitutt.

Joachim Storm Johansen*: Hvorfor er det så stor tetthet i bilindustrien kontra andre segmenter? Er det potensialet for like høy robottetthet i andre industrier?*

Jean Marc Launay: Nja. Antakeligvis er ikke potensialet like stort tror jeg. Mye av grunnen til dette er fordi bilindustrien har en tendens til å være drivfaktoren for andre industrier til å robotisere. Leverandører av ulike produkter, materialet og service til bilindustrien ser at deres kunder (altså bilbransjen) har gode erfaringer med å implementere roboter. Dette fører med seg synergieffekter som vi i mindre grad har sitt i Norge, nettopp fordi bilindustrien er så liten. Bilindustrien vil fortsette å være drivkraften for robotisering. Når underleverandørene robotiserer så vil det igjen gi synergieffekter ut til deres andre kunder og leverandører som kanskje operer i andre segmenter, og slik blir den samlede robottettheten i et land stor. Men vi kan ha det gøy med roboter i Norge allikevel.

***Jean Marc Launay**: Litt om volumer.*

Vi estimerer at det er en plass mellom 100 og 150 roboter solgt i året i Norge. Vi solgte 50 + roboter i fjor, og har 2-3 store konkurrenter i Norge. Vi vet ikke helt hvor mange roboter de har solgt, men vi estimerer med at de omtrent har solgt like mange som oss summert sammen. Men det finnes også andre aktøren, stort sett i Norden som leverer roboter i Norge. Disse er enten aktører som har spesialisert seg på en gitt prosess, eller det som vi kaller for maskinbyggere/ linjebyggere. Det ser vi mye av i næringsmiddel segmentet og til dels i mekanisk industri. I næringsmiddel segmentet skjer det en konsolidering. For bare 2-3 uker siden fikk vi høre at Nortua har kjøpt Prima Jæren sitt store slakteri på Jæren. Det samme skjer med Tine meieri som nå har 50 + meierier rundt i Norge. Disse selskapene har en strategi om å redusere antallet. De ønsker å åpne større fabrikker. Disse store linje byggerne kommer da med sine komplette produksjonslinjer. Der de kommer med roboter og installerer det i Norge. Så det er en god del roboter som kommer til Norge via utenlandske selskaper.

***Joachim Storm Johansen**: Hvem er deres hovedkonkurrenter?*

Jean Marc Launay: Det er Scala som er en relativt stor konkurrent av oss i næringsindustrien. ITT og Intech er andre hovedkonkurrenter. De leverer KUKA roboter i stor grad. Scala samarbeider med Motorman, som er japansk å produserer egne roboter. Til sammen utgjør vi og disse tre selskapene cirka 100 – 150 roboter i året til Norge.

(Jean Marc Launay kommenterer: IFR statistikken er nok også her litt underestimert (91 solgte roboter i 2012). Men det er nok ingen som vet nøyaktig hvor mange roboter som faktisk blir solgt.)

***Joachim Storm Johansen**: Det må være et vanvittig potensialet i Norge for økt robotisering?*

Jean Marc Launay: Nja. Jeg håper du har rett. Men problemet i Norge er at volumet til fabrikkene som produserer er for lite. Men vi ser som sagt en økt konsolidering, og dette kan føre til at flere bedrifter vil tjene på økt robotisering. Utfordringen vi ser ofte er at de kundene som kommer til oss og ønsker å robotisere ikke vil spare på det fordi de produserer i et skift (eks. ansatt fra 8- 4 og stengt etter). Da blir det vanskelig å argumentere for økonomiske grunner for å velge roboter. Hvis incentiver kun er å spare lønnskostnader, og det ikke finnes andre argumenter som HMS eller kvalitets argumenter eller andre ting da blir det vanskelig. Ofte er det også stor variasjon i produkter som blir produsert, slik at man må lage til et relativt komplisert anlegg. Når volumet som blir produsert er så lavt som det ofte er i Norge så blir pakken for dyr. Lavt volum, små serier og høy variasjon i produktet er med å skape problemer for robotisering av Norske bedrifter. Vi pleier å si at et skift blir vanskelig å robotisere, to skift da må det være muligheter for robotisering. De som produserer med tre skift uten robotisering, de hiver penger ut vinduet.

Jean Marc Launay: Vi har et prosjekt som er i begynnelses fasen, som omhandler sink og smelteverk. Der robotene håndterer sink plater. Dette viser at det finnes eksempler på nyheter og nye segmenter. Men implementeringen av roboter må forsvares økonomisk.

***Joachim Storm Johansen**: Hvordan er informasjonen i markedet? Vet de ulike aktørene om mulighetene? Er det rett og slett sånn at det er for vanskelig å få hele bedrifter med på investeringene?*

Jean Marc Launay: Muligens vi ikke er gode nok til å markedsføre oss, med å informere kunder om ulike muligheter og besøke potensielle kunder.

***Hans Kristian Tjemsland**: Vil du da si at det finnes en asymmetrisk informasjon i markedet?*

Jean Marc Launay: Det er mulig at det er det ja. Men vi ser at det er flere som kommer til oss med spørsmål om implementering. Vi har hatt flere som har kommet til oss med spørsmål om grønnsaksproduksjon. Dette kunne potensielt vært et spennende segment fordi disse ulike aktørene har ekstremt store volum. Åkrene er ikke bare små hager, men store områder (opp til 50 mål med tomatproduksjon) som tilsier at det kunne vært økonomisk riktig å implementere roboter. Selv om disse områdene er store så anvendes det ofte et skift her også. Når vi begynner å regne på dette så kommer vi fram til at det blir en 2-3 års payback tid på dette. En payback tid på 2-3 år er ofte i grenseland for om kundene ønsker å investere i prosjektet. Med en payback tid på 1 år så er det ikke noe å diskutere, da vil de fleste investere. Med en payback tid på over 2 år så vil ofte kundene vente å se om produksjonen stiger eller faller før de eventuelt gjør investeringen. Med en payback tid på over 3 år så er det veldig sjeldent at de ønsker å investere.

***Hans Kristian Tjemsland**: Hvorfor er det slik når robotene i snitt må skiftes ut etter 8 år?*

Jean Marc Launay: Nei si det. Jeg har nok ikke vært lenge nok i RobotNorge til å svare på det. Men fra min tidligere erfaring da jeg drev med oppgraderinger av eksisterende installasjoner. Da opplevde jeg aldri at selskaper investerte hvis det var en tilbakebetalingstid på mer enn 3 år.

***Joachim Storm Johansen**: Hvordan er det prisen blir satt på robotene?*

Jean Marc Launay: Om du hadde kjøpt en robot fra oss i morgen, så kunne den roboten ikke gjort noe som helst. Da får du roboten levert på en pall og roboten er ubrukelig. Får at roboten skal bli i stand til å produsere, trenger man perifer utstyr, med griper, PLS systemer og transportsystemer. Det betyr at prisen på selve robotene ofte bare er 30 – 40 % av totalen i et anlegg. Hvis det er et enkelt anlegg så kan roboten være så mye som 50% av prisen. Resten er engineering, implementering og annet utstyr man trenger for at anlegget skal fungere. Er det et komplisert anlegg så kan robotene være så lite som 20 – 25 % av total prisen. Da er roboten bare en fjerdedel av total prisen. Mellom de ulike leverandørene av roboter så er prisen omtrent den samme.

***Joachim Storm Johansen**: Så for selve roboten så er ytelsen omtrent den samme mellom de ulike selskapene?*

Jean Marc Launay: Mellom oss så kan du si det (latter). Men det er klart at ABB roboter er de beste! De er raskere og bruker mindre energi enn andre roboter. Men i det store og det hele så er det implementeringen samt systemer som er avgjørende for hvilke robotselskap som har den beste ytelsen. En ABB robot og en KUKA robot vil ha nokså lik ytelse. Det er de tekniske finessene som avgjør. Hvis vi ser på et selskap som KUKA, som leverer roboter til tysk industri. Så er det klart at de løsningene de kommer opp med vil være robuste og gode. Så sett med objektive øyne så er nok ytelsen mellom robotene veldig lik.

***Joachim Storm Johansen**: Så det er selve implementeringen som avgjør?*

Jean Marc Launay: Det er det. Og det er det som er vårt konkurransefortrinn i RobotNorge. Vi har erfaringen, kompetansen og forskningen man trenger for å skape en god robotisert løsning. Man kan få til slike løsninger med ulike robottyper (selskap), men det er avgjørende at man vet hva som må være rundt roboten, hvordan man løser en gitt oppgave best mulig, prosessforståelse og at man har de beste implementeringsordningene. Hvis man skal implementere sveise roboter, så må man forstå seg på sveising. Snakker vi om lakkering, så må man forstå lakkering. Dette er vanskelige prosesser, derfor trenger man kompetanse. Det er komplekse prosesser der man trenger å forstå alle elementene i prosessen. Det er denne forståelsen som er avgjørende for hvor godt man presterer i konkurranse med andre. Kundene er på jakt etter beste løsning, uavhengig av om det er med en ABB robot eller en KUKA robot.

Joachim Storm Johansen*: Så det er prisen på løsningen som er avgjørende?*

Jean Marc Launay: Ja det er det. Hvis man har en genial løsning som løser alle gitte problemer. Der man finner den mest optimale løsningen, med størst brukerfleksibilitet. Da vil man være den sterkeste leverandøren. Hvis man da samtidig kan løse problemet vi har i Norge med lavt volum og høy produktvariasjon, da vil man være ledende innen robotikk.

Joachim Storm Johansen*: Vil teknologi utvikling være med å gjøre dette reelt?*

Jean Marc Launay: Ja det kan man si. Men det er ofte mer fantasien til konstruktøren som er avgjørende. Det å finne den gode smarte løsningen. Det er kanskje litt rart å si, men det er ikke teknologien som er mest avgjørende.

Joachim Storm Johansen*: Men hvis en radikal endring i teknologien oppstår da vil det få en del å si?*

Jean Marc Launay: Det vil det selvsagt gjøre og spesielt for Norge og andre land der utfordringen er lavt volum og stor produktvariasjon. Det meste av volumproduksjonen i Norge er blitt flyttet til andre lavkostland. Det som gjenstår er det som ingen tør å flytte på fordi det enten er for komplisert eller det ikke er lønnsomt nok å flytte på, på grunn av for små serier og volum. Disse selskapene er de vi har i Norge.

Det som vi ser på ulike aktører i Norge er at robot markedet ikke er veldig stort. De fleste av våre konkurrenter har en eller annen gang gått konkurs. Det har vi foreløpig greid å holde oss unna i RobotNorge. Dette er på grunn av ting jeg har snakket om, som gjør det til en business som er veldig kompleks og risikofylt. Markedet krever gode, smarte ingeniører. Mange ingeniører velger heller å jobbe for Statoil og Aker fordi her er det ofte mer penger å hente. Da blir det vanskelig for oss å lokke til oss de beste ansatte.

Joachim Storm Johansen*: Er det slik at den største trusselen til robotisering er andre substitutt goder som enklere automatiseringer, CNC løsninger og machine tools?*

Jean Marc Launay: Det kan man si. Men ofte vil de anleggene vi lager bestå av en kombinasjon. Man kan ha enkle former for automasjon et sted i anlegget og robotiserte løsninger andre steder. Det er ikke nødvendigvis enten eller. Noen prosesser egner det seg mye bedre med hard automation enn roboter. Men allikevel ser vi at det finnes forsøk på full robotisering. Det finnes eksempler på youtube, der strategien har vært å bruke kun roboter. Der finnes det verken transportsystem eller noe annet enn roboter. Det er kun roboter som flytter karosserideler fra den ene stasjonen til den andre. Fabrikken som produserer BMW i3 anvender kun roboter. Her skjer alt med roboter og det er en ny måte å tenke på innenfor bilindustrien. Tradisjonelt er det blitt anvendt samlebånd som transportmiddel. Så det er mye nytt som skjer.

***Joachim Storm Johansen**: Har de vært konservative i Norge i forhold til automatisering? Hvis vi ser på Benteler, som holdt på å gå konkurs, så ble de kjøpt opp av en amerikaner, og da ble det plutselig robotisert med en gang og bedriften gikk mye bedre. Da kunne han selge det videre med god profitt. Det er vel kun ABB roboter som står der?*

Jean Marc Launay: Ja det er kun ABB roboter som står der. Og ja det er riktig som du sier at Benteler holdt på å gå konkurs. Det som reddet dem var at de produserte understell til Porsche. Hadde Benteler stoppet produksjonen så ville dette gått kraftig ut over Porsche. Derfor gikk Porsche til Benteler og sa at de fikk bruke 100 millioner til å få bedriften på beinene. De var helt avhengige av Benteler for å produsere bilene sine. Dette er et positivt eksempel på hvor kunde og leverandør har reddet en vanskelig situasjon med hjelp av robotisering.

Jean Marc Launay: Jeg ønsker å vise en film om et nytt anlegg vi har, der vi har implementert industri roboter til olje og gass seksjonen. Anlegget er solgt til (mac seize?). Det er et relativt nytt etablert selskap som driver med olje og gass.

(Viser oss en film om industri roboter som bytter batteri på linjer som skal legges på bunnen av sjøen, fra et skip. Batteriene ble tidligere byttet av mennesker, men er nå fult automatisert der industri robotene er implementert på skipet uten uhell.)

Jean Marc Launay: Dette anlegget er det største prosjektet som RobotNorge har håndtert. Det er i tillegg det første robot anlegget som er implementert på et skip. Vi håper at dette prosjektet kan være med å åpne dører til andre interessante prosjekter her i nabolaget, i distriktet og innenfor olje og gass.

***Jean Marc Launay**: Jeg ønsker å snakke litt om tall.*

Det har vært en utvikling for RobotNorge de ti siste årene. Det har også vært en utvikling for andre bedrifter som driver med det samme. Vendepunktet har vært finanskrisen som befestet seg i 2008. Som har ført til en utfordrende markedssituasjon fram til 2012. Den kurven har vært lik for andre aktører i robot bransjen. Dette gjelder både for Norge og Norden. Dette har gjort at viktigheten av etter salg bare har økt. Det vi ser er at hele variasjonen i salg har vært i prosjektsalgene (nysalg av roboter). Etter- salg har forholdt seg mer eller mindre stabilt under hele finanskrisen. Dette illustrer, som nevnt tidligere, at service er en veldig viktig bærebjelke for oss.

***Joachim Storm Johansen**: Hvor lenge varer kundeforholdet mellom dere og kunden i gjennomsnitt?*

Jean Marc Launay: Livstiden på en robot er cirka 10 år. Dette tilsvarer 40 000 timer i drift hvis man produserer i to skift. Men vi har også roboter som har vært i produksjon i 15 år. Gjennom hele levetiden til roboten så vil vi ha et forhold til kunden. Det er gjennom service, salg av reserve deler, oppgraderinger (både software og hardware) og sånne ting. Som regel så produserer ikke kunden de samme produktene under hele levetiden. Derfor må vi tilpasse og oppgradere anlegget etter kundens ønske. Denne businessen er svært viktig for oss. Uten den hadde vi ikke vært her i dag.

***Joachim Storm Johansen**: Man kan nesten si at salgsteamet blir som prosess konsulenter?*

Jean Marc Launay: Det kan man si. Vi blir som konsulenter som må fortelle kunden hvordan prosesser best lar seg løse, hjelpe til med effektivisering av prosessene og utforske potensialer.

Jean Marc launay: Vi har et søsterselskap i Sverige. Som driver, i motsetning til oss, med kun en applikasjon. Som er lakkering. Alle der er gamle ABB folk som har veldig lang erfaring med lakk prosesser. Det er det de jobber med. Vi jobber litt med alt mulig. De kommer nå til å gå inn i land som Finland og Danmark. I Norge er det ikke så stort potensialet for lakkering. De gjør det veldig bra. Det jeg vil si er at måten de jobber på er interessant å se. De har spesialisert seg på et området mens vi er mer differensierte.

***Joachim Storm Johansen**: Er det slik at man faktisk bør spesialisere seg innenfor et felt?*

Jean Marc Launay: Det er vertfall en interessant strategi. Vi har hatt en strategi om å gjøre mest mulig selv. Det vi ser på nå er å i større grad å alliere oss med andre ABB partnere, som har spesialisert seg på et område. Da kan disse være salgskanalen til de ulike markedene. Vi ser at vi ikke har mulighet til å være mestere på alt og da kan det lønne seg å spesialisere seg i større grad enn vi har gjort. Så vi jobber mot en slik strategi, der vi prøver å finne vår kjernekompetanse og la andre ta seg av andre ting. Men vi ønsker at våre samarbeidspartnere skal bruke ABB roboter. Så vi ønsker å anvende to veier til markedet. Via partnere og via oss selv. Dette er den samme strategien som ABB konsernet har satset på globalt.

***Joachim Storm Johansen**: Blir kundene og leverandørene hos dere? Opplever dere at kundene er misfornøyde med implementeringen av roboter?*

Jean Marc Launay: Vi opplever at 95 % av kundene er fornøyde. Vi har selvsagt noen få, som av en eller annen grunn, ikke blir fornøyd med oss eller roboten. Ofte skjer dette når kunden har håndtert en vanskelig situasjon på en dårlig måte. De har et problem med roboten og synes ikke at vi har håndtert problemet på en god måte, og det er nok til at kunden kutter ut roboter, eller velger annen leverandør. Det er veldig sjeldent det skjer men av og til så skjer det. De fleste er fornøyde og kjøper fra oss igjen. Når unntakene skjer, så er det ofte en isolert ting som har skjedd, som kanskje var uheldig eller unngåelig, som fører til at kunden ikke ønsker videre samarbeid. Det tar lang tid å bygge opp et forhold til kundene, men kort tid å ødelegge det. Gjør man en god jobb, spesielt på service biten, da kjøper kunden av deg igjen.

***Joachim Storm Johansen**: Er det vanskelig for nye aktører å etablere seg i markedet?*

Jean Marc Launay: Nye aktører har store utfordringer med å etablere seg i markedet. Men vi ser at det er en dansk leverandør (Universal robots), som nå i det siste har blitt interessante. Mange spørsmål rundt hva de driver med og kommer til å finne på. Blir interessant å se om de fortsatt er her om 3 år og hvor store de eventuelt har blitt. De kommer med nye ideer som gir dem potensialet til å vokse. Kan de bli like store som ABB, KUKA og kompani? De driver for eksempel med roboter som ikke trenger tilleggs sikkerhet, altså ikke gjerder og slik. Disse kan man jobbe ved siden av og hvis man kommer borti den så stopper den opp. Dette er nytekning og utfordrende for oss som har jobbet i ABB i alle år og har standarder vi følger. Det er klart at det vil være utfordrende for dem å komme i markedet og da må de komme med noe nytt. Det nytter ikke å lage en kopi av ABB roboter. Men det virker som Universal Robots Kommer med noe som er nytt som omhandler tettere samarbeid mellom robot og menneske.

***Joachim Storm Johansen**: Har et mennesket noen gang blitt drept av en robot?*

Jean Marc Launay: Det har nok skjedd ja. En robot som kan løfte 500 kg og vel så det, i to meter i sekundet. Vis den da treffer et mennesket så blir det ikke vondt en gang. Da er man stein død. Men det er veldig sjeldent at det forekommer dødsfall på grunn av roboter. Dette er fordi det er veldig strenge regler på sikkerhet. Det er derfor vi stusser når Universal Robots kommer med roboter som visstnok ikke trenger noen form for sikkerhet. Men om det skulle fungere så tror jeg det er en ting for framtiden. Dem som greier å lage et system, ikke bare med små roboter som er svake, men med store roboter som ser hva som skjer og kan forholdet seg til et mennesket, de ville kunne tjene mye i framtiden. Men jeg tror ikke det er rett rundt hjørnet.

***Joachim Storm Johansen**: Hvorfor vil denne type teknologi gi konkurransefortrinn?*

Jean Marc Launay: Med kvalitetssikring av arbeidet eller arbeid som skal bli gjort ved siden av roboten. Med dagens løsning så må personen skru av roboten før den kan bevege seg inn på området og da mister man effektiviteten. Man kan ikke bevege se inn i en robotcelle uten å skru av roboten først. Hvis det var mulig å ha en person inne i en celle, så kan dette åpne for nye måter å løse oppgaver på som kan være mer effektiv og kostnadsbesparende. Hadde det vært mulig og lovlig så kunne man funnet masse nye applikasjoner for industri roboter.

Intervju slutt.

Takk til RobotNorge!

14.3 Appendix 3: Explanation of estimations of the robotic market

Currency calculations	Average Stock price 2013 (U$)	Average stock price 2013 (local)	Currency ratio 2013
Siasun	6,464166667	39,6975	6,141162821
ABB Group	23,06191667	21,34333333	0,925479597
KUKA AG	44,61533333	33,52141667	0,751342961
Yaskawa	12,225	1203,666667	98,45944104
Fanuc	161,0166667	15783,33333	98,02297899

14.3.1 Explanations of currency calculation

The currency ratio 2013 are estimated using average stock price 2013 listed in (local) currency divided by average stock price 2013 listed in USD. With perfect estimates the currency ratio of Yaskawa and Fanuc should be equal (as they operate with same currency), hence measurement errors exists. Since this is an estimate, other calculation methods would also provide measurement errors hence the calculation are assumed as valid.

14.3.2 Estimated revenue from robotics and systems

The revenues are estimated using financial data (Net sales or Revenue see appendix 3 -7) from DataStream Thomson Reuters and % estimated from robotic and system provided by annual reports or a Morgan Stanley report. The revenue are transformed into USD for every country such that they can be compared. The currency ratio are estimated using stock prices provided by DataStream Thomson Reuters (yearly average 2013).

14.3.3 Comparing company's revenue

In table 13 a comparison of the company's market share are estimated using net revenue. The table tries to excrete robot and system revenue from the revenue provided by other products for each company, such that the estimation only concern robot usage. There are some problems with this analysis that needs to be elaborated. First, the percentage used to calculate revenue strictly from robots and systems are uncertain estimations (% of revenues from robotic and system). For ABB and Siasun the estimate is collected from Morgan Stanley report from 2011. This means that the estimate could have changed the last 2 years. For ABB a small percentage change in estimated revenue from robot and system would yield a much higher or lower total revenue. This means that the analysis might underestimate or overestimate the market shares of ABB Group. Siasun is small compared to the other companies, such that measurement errors will not change the revenue too much hence not affect market share too much. KUKA AG are only concerned with robot and systems and should be a good estimate. Yaskawa and Fanuc estimates are provided from their annual report from 2013 and should also be good estimates. Another problem with the analysis is that the revenue concerning robotic and system will be generated from both new robot system sales and service on existing. Some companies might have vertical integrated supply chains hence a bigger part of the revenue concerns service. If companies have outsourced service, it will not be a part of their revenue. Comparison of market shares between them might yield measurement errors.

14.3.4 Geographic Exposure

The estimates for geographic exposure are collected from Morgan Stanley report 2011. However, since the calculations will be made for the year 2013, estimates need to be updated. For Siasun only a Chinese version of annual report where available for 2013. In addition, it is not always the case that the companies provide estimates for geographic exposure strictly toward China. The calculations for Siasun are made presuming that geographic exposure is equal for 2013 as in 2011. For Siasun this is likely since they are small and the growth in revenue should come as a result of a growing Chinese market. Based on the statement it is more likely that the domestic exposure have increased rather than decreased for Siasun.

For ABB Group only an estimate for Asia as a whole where provided in the annual report 2013. This was estimated to 26 percentage. From Morgan Stanley report the geographic exposure are set to 20 % toward China. Since robotics are a small part of ABB Group we do not expect the geographic exposure to have increase significant because of robotics and as the estimate for the entire Asia is 26 %, this estimate are more likely overestimated than underestimated. Therefore, equal exposure are assumed.

In KUKA AG`s annual report from 2013 it says that China is now 20 % of their order backlog for 2014. Assuming that every countries pays roughly the same price for each unit this means that 20 % of their sales revenue comes from China. In Morgan Stanley report 2011, they have estimated an 11 % exposure toward China. As revenue includes new robotic sales and service on old one, one would expect the geographic exposure for revenue to be smaller for revenue than for order backlog so the estimate seems reliable. However, as KUKA have estimated that they have increased their revenue in China we use a 13 % estimate for 2013.

Yaskawa estimate are provided from their annual report 2013 (19%). From Morgan Stanley the estimate was 25 %, which means that it has dropped 6 % on 2 years assuming that the estimate are calculated using the same method. The estimate should be a good estimate since it is provided by Yaskawa annual report 2013.

Fanuc estimates are assumed the same as in Morgan Stanley because they only provided estimates for Asia as a whole minus Japan in their annual report 2013. Fanuc has decreased there net revenue from

2011 to 2013 and should experience a drop in exposure in China like Yaskawa have, rather than an increase. The estimate are overestimated rather than underestimated.

14.3.5 Estimated revenue from the Chinese market

The revenue are calculated using estimates for geographic exposure multiplied by estimated revenue from robotic and system. For ABB Group and Fanuc it is unclear whether geographic exposure concerns strictly robotic systems or the entire company (looks like it concerns robotics). If they concern the entire company, the calculation assumes that every product yields equal revenue in China. For ABB Group and Fanuc this is probably not the case as other products generates more revenue than robots and should to a bigger extent be presence in China. The estimates are uncertain and most likely overestimated. However, as it looks like they concern strictly robotics the estimates are treated as valid. KUKA AG only operates with robotic systems hence the estimate should be a good estimate. Yaskawa estimate are strictly robotic towards China and should be good estimates. Siasun is small and the geographic exposure estimate are high for China hence measurement errors will not make a big different.