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Artificial Intelligence in Japan (R&D, Market and Industry Analysis)

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1 Executive Summary

Artificial intelligence (AI) was one of the strongest fields of development in 2015 and this trend will likely continue in 2016. AI is a technology that utilises machine intelligence and human-thinking ability to process various data to make predictions, recommendations and decisions.

Artificial intelligence technology is a convergence of various technologies, algorithms and approaches. In 2016 and beyond, AI is expected to bring about a major shift in the perception of this technology that will become more accepted by people.

Like any disruptive technology, however, AI carries some risk and presents policy challenges along several dimensions including jobs, safety and regulatory questions.

On the software side, there will be more sophisticated AI-based platforms in the future and there is a trend towards platforms becoming open-sourced. Utilisation of deep learning will require large investments in computing power that many companies cannot afford. Therefore, open platforms are expected to impact the market positively. For high tech corporations such as Google, Facebook and IBM, this is a way to promote their brands.

The trend towards multi-party collaborations will increase as there are limits to what individual companies can research and utilise AI on their own.

The Japanese government is betting on AI as the key to rewrite Japan blueprint for the future. Prime Minister Abe has called for greater use of AI and robotics including IoT as part of the government's economic growth strategy, urging businesses to invest more into researching new technologies.

So far, many Japanese companies have been relatively slow in taking advantage of opportunities that AI presents.

Some Japanese companies have sought outside partners to further their ambitions, for instance SoftBank and Toyota. Toyota is stepping up its efforts to tap AI technology, and in January 2016 established a R&D unit in Silicon Valley [1]. The firm has realised that it has to work faster and harder to stay competitive.

Japanese companies are looking to acquire start-ups in the U.S. but they do not always know what they want to do with the start-up technology.

Japan has a weak branding strategy compared with rivals such as IBM which has promoted its AI-based *Watson* platform for a variety of services.

For a long time, Japanese companies have developed their technology in-house to protect their intellectual property. But the age of *jimae-shugi* (in-house supply of its technology) is gradually coming to an end as a single technology can no longer cover everything [2]. Today when AI will become a mainstream enterprise element, Japanese companies have to become more open-minded. AI should not be seen as a minor enabler of efficiency but should be integrated into the corporate strategy.

Advances in AI are bringing about challenges for the Japanese society. Nomura Research Institute, for instance, in a recent report predicts that nearly half of all jobs in Japan could be performed by AI-enabled robots by 2035 [3].

Japan's AI market is estimated to grow from JPY 3.7 trillion in 2015 to JPY 87 trillion by 2030. In 2015, AI solutions for the wholesale and retail sectors were valued at JPY 1.45 trillion or about 39 percent of the total market value, comprising the largest AI sub-segment.

By 2030, the transport sector (driverless taxis and trucks) is expected to grow to JPY 30.48 trillion. Including driverless cars (manufacturing sector), together these two sectors will have a market value of JPY 42.65 trillion or 49 percent of the total forecasted market value.

Business opportunities for European companies include *AI technologies* and *AI solutions*.

The utilisation of deep learning in AI has not reached mainstream in Japan. Therefore, this sub-segment will offer potential for European companies as AI and robotics are prioritised in the government's growth strategy.

The automobile industry in Japan will need deep-learning solutions to develop driverless cars. This constitutes another potential area for European companies that are able to offer attractive solutions for self-driving cars. A recent trend is that automakers like Toyota and Honda are lacking specialised personnel to develop the necessary technology for driverless cars. This further stresses the chances for Europe in this field.

Apart from the AI and robotics sector as well as automated driving technology, the study has identified application areas such as solutions related to marketing, information services and security that could offer additional opportunities for European companies.

In marketing, AI-applied solutions provided by Japanese companies are related to data analysis, automated marketing and image recognition. These areas as well as other areas where European have capabilities could constitute additional business opportunities

Before considering entering the Japanese market, it is important to study the Japanese market in detail and be prepared to offer an extensive after-sales service system as Japanese customers are very demanding. Equally important is to have the full understanding of top management in Europe as relationships in Japan are long-term.

Choosing the right mode for market entry is a crucial issue as well as adapting products and solutions to the needs of the Japanese market.

2 Scope of the Report

This report is the result of extensive secondary research into the current status of artificial intelligence in Japan. It presents an industry overview and provides insights into the market trends, market size, market drivers and challenges that affect the growth of the market. Information on key players and the market size as well as new product developments including R&D activities will also be covered.

Secondary sources referred to for this study include magazines, journals, company financials, press releases, databases, annual reports, company websites as well as government sources.

2.1 Definition of Artificial Intelligence

The term artificial intelligence is difficult to define and has been debated for many years. In this report, artificial intelligence refers to the development of computer software capable of performing tasks that normally require human intelligence (mimic human behaviour).

The AI technology can be divided into four broad categories: Machine learning (ML), natural language processing (NLP), image processing, and speech processing. In recent years, deep learning (DL) has gained worldwide attention and is a subfield within machine learning.

2.2 List of Abbreviations

AI	Artificial intelligence
AIRC	Artificial Intelligence Research Center
AIST	National Institute of Advanced Industrial Science and Technology
DL	Deep Learning
FY	Fiscal year (from April to March the following year)
ICT	Ministry of Internal Affairs and Communications
JV	Joint Venture
METI	Ministry of Economy, Trade and Industry
MEXT	Ministry of Education, Culture, Sports, Science and Technology
ML	Machine Learning
NLP	Natural Language Processing
RIKEN	*Ri*kagaku *Ken*kyujo (Institute of Physical and Chemical Research)

3 Global Overview

This section provides some brief information on the global artificial intelligence market.

In 2014, the overall global investments in AI were more than USD 1.9 billion, an increase by more than 50 percent over 2013. In 2015, the investments are estimated to be roughly USD 2.7 billion or 5 percent of total VC investments that totalled USD 55 billion in 2015 [4].

AI-driven technologies are predicted to be the next disruption to the enterprise software. Currently, the penetration of AI has hit almost every industry sector.

Artificial intelligence is one of the current buzzwords. Originally, the term was coined by John McCarthy in 1956.

There have been several "boom-gloom" cycles since the 1950s when the first boom occurred. The second boom followed in the 1980s. The current third AI boom started early in the 2010s when U.S. companies such as Google and Facebook established AI research laboratories. Advances in the development of deep learning technologies have reignited broad interest in AI research.

A different paradigm has emerged. Instead of trying to program computers to act intelligently, AI today is able to analyse large amounts of data with powerful computers and sophisticated algorithms, and to some extent learn patterns by themselves.

AI is not new but the underlying technologies have reached an inflection point. The disruptive power of AI is forcing hardware manufacturers such as automobile manufacturers to follow the direction of AI companies as the software is going to play a major role in the future.

3.1 Global Market Size

There are many estimates concerning the size of the artificial intelligence market. According to Bank of America Merrill Lynch, the global AI solutions market will grow to USD 70 billion by 2020 from USD 8.2 billion in 2013 [5].

The global AI market is expected to increasingly be impacted by growing government funding and strong technological base.

The U.S. dominates the global AI market through its leadership in machine learning. The machine learning technology is the base for artificial intelligence and is used across all major application areas. In 2015, machine learning was the largest segment of AI.

Other major markets are Japan, Europe and China. Recently, China presented a three-year program for artificial intelligence growth. The aim is to create a market worth more than 100 billion yuan (USD 15.2 billion) by 2018, when the country shall be in line with global AI technology and AI industries [6].

The integration of AI in many application sectors such as retail, finance and healthcare, just to mention a few areas, is expected to strongly push the growth of the market in the years ahead, including Japan.

Deep learning, which attempts to replicate the workings of the layers of neurons in the human brain, is a breakthrough in the 50-year history of AI. Tractica, a U.S. market-research firm, forecasts that annual software for enterprise applications of deep learning will reach USD 11.1 billion in 2024, up from USD 202 million in 2015 [7].

Market estimates for some AI sub-segments are presented below.

According to Frost & Sullivan, healthcare AI revenues are estimated to reach USD 6.66 billion in 2021, up from USD 633.8 million in 2014 [8].

Strategy Analytics, a U.S. research and consulting firm, forecasts that autonomous driver-assisted systems will grow from 5 billion Euro in 2012 to 16 billion Euro by 2019 [9].

Concerning natural language processing (NLP), ReportsnReports estimates that the global NLP market will grow from USD 3.8 billion in 2013 to USD 9.9 billion in 2018 [10].

One characteristic of AI technologies and related applications is that systems tend to be highly customized for each environment and process.

3.2 Global Market Trends, Drivers and Challenges

Trends:

Growing availability to low-cost quality AI technologies will likely see many new start-ups entering the AI field.

To stay competitive and be a step ahead of competitors, companies will continue to search for experienced talent. And universities will adjust their AI curriculums to help produce that talent.

The trend that many tech companies are investing in open-source AI platforms will continue and contribute to the growth of the market.

The capability to utilise more data will enable companies to achieve higher efficiencies in their value chains.

There is a need for international standards. Japan proposed setting up a set of basic rules for developing AI at the G-7 tech meeting in Japan in April 2016. One proposed rule would be to make AI networks controllable by human beings [11].

Drivers:

Increasing overall global investment in AI is pushing the global AI market. Google and Facebook, for instance, have been busy shopping for AI ventures in the past years.

The development of more powerful and affordable cloud computing infrastructures is having a strong impact on the growth potential of AI. Major reasons for recent advances in AI are the availability of large amounts of data online with which to train systems.

Machine-learning technologies constitute a major driver of the market that has contributed to corporate productivity increases.

Other drivers are diversifying application areas of AI as well as increased level of customer satisfaction by users of AI products and solutions. In its report “Artificial Intelligence Market – Global Forecast to 2020”, MarketsandMarkets refers to machine learning technology that will allow financial analysts to draw conclusions for stock reactions in co-

ordination with market movement and that this will enhance customer satisfaction as the AI-based application will eliminate the need of scrolling through huge data to arrive at a conclusion [12].

Challenges:

The paradigm shift towards AI will bring about challenges across multiple sectors of the economy.

A study by Gartner, emphasises some negative aspects of artificial intelligence. The study reveals that millions of jobs will be replaced by AI-based technology systems [13].

Researchers at University of Oxford has published a study estimating that 47 percent of total U.S. employment is "at risk" due to the impact of AI advances [14].

Lack of trained and experienced staff will likely have a negative impact on the growth of the AI market. In the short term, the global "hiring war" for talent will continue.

Another challenge is the need to create relevant business models.

Over the past few years, there has been growing concern about the potential for AI. For instance, that AI could eventually pose a threat to humans. Elon Musk, CEO of Tesla Motors, is cautioning against giving AI complete autonomy that could threat the humanity [15].

Others emphasise that the exponential growth of AI one day would lead to a technological singularity, a point when machine intelligence will overpower human intelligence and lead humans into an unknown world of no return.

3.3 Global Players

There are about 900 companies working in the AI field, mainly in the U.S. and Western Europe.

Major corporations such as Google, IBM and Facebook have embraced AI to differentiate themselves from competitors. Other global players include Microsoft and Apple. IBM is introduced in section 9.2 that gives information about foreign player in the Japanese market.

Information on Japanese players is given in section 8.

Google

Google is an American multinational technology company specialising in Internet-related services and products. It was founded in 1998 and has 57,000 employees worldwide. The sales were USD 74.5 billion in 2015.

Recently, Google announced that it will move from a mobile first to an AI-world first [16]. In March 2016, Google's AlphaGo computer program defeated one of the world's top go players that draw worldwide attention.

In May 2016, Google and Fiat Chrysler Automobiles launched a joint project to develop experimental vehicles.

By 2020, Google is aiming to commercialise self-driving cars that utilise AI.

Facebook

Facebook is a social networking service launched in 2004 by Mark Zuckerberg and four of his Harvard College roommates. Facebook has more than 1.65 billion monthly active users as of March 31, 2016. The revenues were USD 17.2 billion in 2015 and the number of employees is 12,600.

Facebook is looking to simplify repeatable tasks for businesses with new APIs that enable AI to be built into *Messenger,* a mobile tool that allows users to instantly send chat messages. With more than 900 million people using this app at least once a month, it is one of the fastest growing products in the world.

Facebook has open-sourced its deep learning code to anybody who wants to use it. Facebook hopes that developers will speed up the AI behind its computing framework [17].

Microsoft

Microsoft is an American multinational technology company headquartered in Redmond, outside Seattle. The company develops, manufactures, licenses and sells computer software. Microsoft was founded by Bill Gates and Paul Allen in 1975. The sales in 2015 were USD 93.6 billion and it employs 118,000 people.

Microsoft *Azure* is an AI-based cloud computing platform that provides cloud services including those for analytics, storage and networking.

Microsoft is currently working on the *Bing Concierge Bot* that will be able to respond to users over platforms like Skype and Messenger. The bot runs errands on behalf of the user, by automatically completing tasks for the user.

In 2015, Microsoft added machine learning to its cloud software platform.

Apple

Apple is an American multinational technology company headquartered in Cupertino, California. The company designs, develops and sells consumer electronics, computer software and online services. The sales in 2015 were USD 233.7 billion and the number of employees is 115,000.

Recently (June 2016), Apple announced that it is opening up many applications to outside developers, including its messaging platform *iMessage* and virtual assistant *Siri*. This is a departure for Apple that in the past has kept these systems tightly controlled.

Siri will be coming to desktop computers and soon-to-be released desktop and mobile operating systems will be powered by artificial intelligence [18].

4 Japan AI Industry

The current and third AI boom started around 2012.

During the second AI boom in the 1980s, expert systems that emulate the decision ability of human beings were further developed. Such a system consists of a knowledge base and an inference engine (if-then rules: if A then B). It is a program that answers questions about a specific domain of knowledge using logical rules that are derived from the knowledge of experts.

In 1982, the Japanese Ministry of International Trade and Industry (MITI) invested USD 446 million for the fifth generation computer project to advance the field of AI including development of expert systems [19]. The objectives were to build machines that could translate languages, interpret pictures, and reason like human beings.

But the project failed to come up with a "killer" app and not much was ever commercialised. The project came to an end in 1992. Computational limitations and lack of supporting data were factors that can explain this failure.

4.1 Current Status

Many analysts have pointed out that the Japanese AI industry today is not very competitive on the global scale. For instance, when it comes to research papers on AI between 2008 and 2013, most of these come from Western countries and China. Only about 2 percent come from Japan [20].

Several headlines in recent articles have brought to the attention the current status of the Japanese AI industry. One headline example is "Japan must promote AI without restrictions". Other articles emphasise the need for an "AI revolution" as well as asking the question "Is revival possible with AI".

In contrast to this, Professor Yutaka Matsuo, University of Tokyo, claims that AI is one of the few limited areas that could offer business opportunities for Japan's industries [21]. But for the Japanese *monozukuri* (Japanese-style manufacturing processes) to get an upper hand over competition, Japanese companies have to embrace deep learning more intensively and not only focus on IoT.

The Japanese government has recently announced that it will set up an AI panel with the aim to design a road map for development and commercialisation of AI by the end of FY 2016 [22].

Several venture capital funds have recently been set up in Japan with focus on AI. Realtech Fund, targeting technology start-ups, is one example into which Japanese companies have invested money. This fund is one of the largest venture capital funds in Japan involving only private-sector companies. Investments are made in 10 fields including AI [23]. The plan is to invest in 40 technology start-ups by 2020.

According to Recof, a mergers and acquisitions consultancy, investments in domestic businesses by corporate venture funds increased by 430 percent in 2015 over 2014 [24].

During the last 10-20 years, Japan has lost its technology leadership to companies in the west, and largely because of software shortcomings. Japan is still at the forefront in hardware such as robots. But this stronghold is in danger of being lost, because software is increasingly critical to making those products work and to compete on the international market.

When it comes to deep learning, there is a clear difference between Japan and the U.S. In Silicon Valley, deep learning is mainly a way to make software better. Many Japanese companies, however, tend to look at deep learning differently, as a way to just improve the hardware.

4.2 Key Industry Drivers

In 2015, the government presented the Japan Revitalization Strategy. The new growth strategy is based on AI and robotics. For a long time, Japanese companies have been focusing on robot manufacturing itself (hardware) while overseas companies have focused more on the software side. Japanese manufacturers now need to implement a more customer-oriented perspective to develop robots that more match the users' needs. The aim of the government is to trigger a robotics revolution with AI-equipped robots that can communicate with each other.

In May 2016, a Cabinet Office Council on industrial competiveness announced that the introduction of self-driving cars, drones and technologically enhanced production management including smart factories is expected to raise Japan's productivity. The goal is to increase the GDP to JPY 600 trillion by 2020 from the level of about JPY 500 trillion [25] in 2015. A sub-goal is to create a JPY 30 trillion market for new emerging technologies.

A report by a separate council on regulatory reform is recommending 80 changes in fields such as medicine, employment and investment (May 2016).

AI and robotics will be a key to enhance the productivity of the service industries, for example, health care and long-term care services.

Another development that over time will cause the AI market to expand is the trend that Japanese corporations are setting up AI R&D bases in the U.S., for instance Toyota and Hitachi [26]. In addition to applications in self-driving cars, Toyota is planning to use AI to improve people's lives (via robots). By being exposed to new ways to incorporate AI into products and platforms, the domestic AI market will likely be positively impacted as a result of this.

R&D centers at public Japanese research institutes such as AIST and RIKEN have also been established and this is expected to speed up new technological advancements within the AI field. These R&D centers are presented in section 7.2.

The shrinking population will start taking a toll on the labour market as the population continues to grey. Statistics show that people aged 65 and older accounted for 26 percent of the population in 2015. Japan plans to make up for the shortfall in the working population with wide use of AI-powered robots [27].

4.3 Current Trends

Artificial intelligence has started to gain attention in Japan beyond research institutes and corporations already active in this field. Media coverage is expanding with frequent articles appearing in economic newspapers such as Nikkei Shimbun. Special editions of economic journals are also contributing to make AI more known among people in Japan.

Small and mid-sized companies have also established AI research labs in recent years such as Recruit Holdings (2015) and Dwango (2014).

Honda recently announced (June 2016) that it will establish a R&D base in Tokyo specialising in artificial intelligence. The firm will consolidate most of its AI-related R&D activities in Japan into this base called Honda R&D Innovation Lab Tokyo [28].

Other corporations are expected to follow this trend to set up own AI R&D bases.

The merger of AI applications and consumer products are expected to increase in the future. For instance, in May 2016, Sharp launched an AI robot and smartphone in a single package. This product, named *RoBoHoN* incorporates AI and IoT technology [29].

In June 2015, Japan launched the *Industrial Value Chain Initiative* with 30 companies to develop communications for linking factories and facilities [30]. The power of connecting networks is expected to get more attention in Japan and will also serve as a way to cope with similar developments in Europe, in particular in Germany that in 2013 introduced *"Industry 4.0"* to promote the digitization of manufacturing.

AI is also changing the way business is done. In 2015, a Japanese venture capital firm became the first company in history to nominate an AI board member for its ability to predict market trends faster than humans [31].

4.4 Challenges

Apart from growth drivers, the Japanese AI market is also characterised with major challenges.

Nomura Research Institute has tried to quantify the potential impact of artificial intelligence on the job market and has indicated that there is a possibility that about half of Japan's labour force may be replaced with robots or artificial intelligence within the next 10-20 years. In particular, the impact on jobs in the service sector will be strong.

It will be important to orient the AI boom in the right direction to achieve the full value of the possibilities of AI. In this respect, it will be important to closely monitor the development overseas.

There are many considerations in privacy, security, regulations and law to be taken into account when integrating AI technology into private-sector activities.

The need to develop new business models to cope with the new realities of emerging AI technologies is also an important issue.

4.5 Insufficient Regulatory Framework

Current regulatory frameworks were not designed with AI in mind. This is valid not only for Japan but also for other AI markets.

At the G-7 tech meeting in Japan in April this year, Japan proposed establishing a number of basic rules on R&D of AI. The wish of the government is to develop international rules that AI developers will have to comply with.

At other occasions, the Japanese government has emphasised that legislative changes are necessary in Japan to address technological advances in artificial intelligence. Today, AI-related algorithms have become quite sophisticated, capable of self-learning, and are largely different from "classical" algorithms of the first and second AI boom.

What has been discussed so far is related to Japan's copyright law. This law covers only works that have been produced in a creative way and, therefore, do not apply to works produced via AI [32].

In contrast to Japan, current legislation in the U.K. has amply leeway to address ownership of AI-made works.

Japan also has to address the imminent arrival of driverless cars. Relevant road transport laws and regulations have to be revised including accident liability issues (who to blame when AI systems go wrong).

The Legal Society of Robotics stresses the importance to regulate the use of smart robots [33].

The development of comprehensive safety standards including safety certification processes is equally important.

AI applications may infringe on current personal data regulations that have to be addressed as well.

5 Domestic AI Market

Artificial intelligence is increasingly entering a commercialisation phase in Japan.

5.1 Market Potential

According to the Japanese government, AI technologies are expected to generate an economic return of about JPY 121 trillion by 2045 [34].

According to a study by Ernst & Young Institute, a Japanese think tank, the size of the AI market is estimated to grow from approximately JPY 3.7 trillion in 2015 to JPY 23 trillion in 2020, a six-fold increase [35]. And by 2030, the market size will reach about JPY 87 trillion.

The breakdown by industrial sectors is shown in table 1 below. The transport sector including driverless taxis and trucks will show the largest increase over the forecast period and is estimated to reach JPY 30.5 trillion by 2030.

The manufacturing sector that includes self-driving automobiles is predicted to grow to approximately JPY 12.2 trillion by 2030.

Table 1: breakdown of Japan's AI market by sector (2015 – 2030)

Unit: billion yen

Type of sector	2015	2020	2030
Agriculture, forestry & fishery	2.8	31.6	384.2
Manufacturing	112.9	2,965.8	12,175.2
Construction	79.1	1,215.7	5,922.9
Electricity, gas & communications	30.0	521.7	1,881.0
Information services	182.5	824.5	2,373.1
Wholesale & retail	1,453.7	4,684.4	15,173.3
Financial & insurance	596.4	2,261.1	4,731.8
Real estate	4.9	242.6	485.3
Transport	0.1	4,607.5	30,489.7
Distribution	46.5	144.3	503.5
Technical services	9.0	244.0	614.9
Advertising	633.1	1,930.5	3,604.7
Entertainment	226.0	599.0	1,510.4
Education	203.0	503.9	928.5
Medical care and welfare	34.3	576.1	2,182.1
Living-related services	130.8	1,711.1	4,001.5
Total	**3,745.0**	**23,063.8**	**86,962.0**

Source: Ernst & Young Institute

The study gives examples of major AI-related factors that will impact the market: improved cost efficiency, further development of a driverless society and wide use within the manufacturing industry.

5.2 Customers

Organisations in many sectors of the economy are already using AI technologies/solutions in diverse business functions.

In *banking* speech recognition technology is used to automate customer service telephone interactions. Mizuho Bank has started to use a combination of IBM's *Watson* AI platform and Softbank's *Pepper* humanoid robot to provide customer support [36].

The Mitsubishi UFJ Financial Group has begun a service utilising IBM's *Watson*. Customers can contact the bank using the *Line* online chat app.

The *public sector* has adopted AI technologies for a variety of purposes. West Japan Railway, for instance, is using AI to detect signs of intoxication in passengers at train stations [37].

In *media* & *advertising* a number of companies are utilising data analytics technology to automatically draft articles such as corporate earnings summaries.

CyberAgent, a Tokyo-based leader in AI-empowered Internet ad business, supports advertising and promotion activities to clients in Japan.

Several *Technology companies* use AI technologies to enhance products or create new product categories.

In the *recruitment* sector, companies use people analytics to help clients find the best candidate for a position. One example is Forum Engineering, a large Tokyo-based temp agency for engineers [38].

Additional business sectors using AI solutions are the *automobile industry*, *retail, healthcare* and *manufacturing.*

Major corporations like Fujitsu are getting more open to show their latest AI research. This is necessary to get potential clients to understand what it is all about. The firm is consulting with clients early on to apply their AI technologies to businesses.

6 AI Applications

This section looks at the market landscape surrounding the AI industry in Japan. Examples of some of the applications are briefly described in the section that deals with the competitive landscape (section 8).

Potential benefits of AI technologies include *faster decisions*, *better outcomes* (for example, medical diagnosis), *higher efficiency* (better use of skilled people, facilitating complex decision making) and *lower costs* (automated call centers).

6.1 Application Areas

Artificial intelligence is being used across various applications, and the number of specific business applications is continuously increasing.

- *Business decision making* (inferring likely consequences of given situations)
- *Business process improvement* (logistics optimisation, workplace automation)
- *Predictive analysis and forecast.* Japan Weather Association has partnered with retailers and food producers to develop a new AI-based system for predicting food demand. This association estimates that over 30 percent of industries are subject to weather-related risks. An AI system would be able to reduce some of Japan's food waste problem [39].
  Nomura Securities has recently introduced a new AI-based stock trading system for institutional investors. The system makes assessments utilising vast amounts of price and trading data, and predicts how share prices will be trending [40].
- *Fraud detection* (detecting irregular patterns)
- *Transport* (driverless cars, driverless tractors). Kubota is developing an AI-based autonomous tractor for use in rice paddies that could raise the productivity when the farmers are greying [41].
- *Medicine* (ability to analyse massive amounts of genomic data for better diagnosis, platforms for scanning medical literature and facilitating care management recommendations)
- *Control systems* (elevator management optimisation through interpreting, predicting and monitoring)
- *Advertising.* Scigineer, an Internet advertising service provider, has developed an AI-based recommendation engine, *Deqwas*, that precisely match the interests of each recipient [42].

7 R&D

In recent years, R&D related to AI is picking up momentum in Japan.

AI teaching programs at universities are being created. At University of Tokyo, for instance, Professor Yutaka Matsuo has received extensive support from companies.

7.1 Research at Universities

Some examples of research at universities are listed below.

University of Tokyo. Professor Yutaka Matsuo is conducting research in artificial intelligence to realise breakthroughs in deep learning.

The Institute of Medical Science, University of Tokyo, under the guidance of Professor Satoru Miyano, is conducting a study to find optimum cancer drug combinations for each patient. IBM's AI-based Watson cognitive computer system is used [43].

At *Keio University*, a group led by Professor Tadahiro Kuroda has been able to develop an AI that can detect lung cancer in urine with about 90 percent accuracy [44].

A team from *Future University*, *Nagoya University* and the *Tokyo Institute of Technology*, under guidance of professor Hitoshi Matsubara (Future University) is engaged in research to make AI create a story plot and finally write an entire novel [45].

University of Tsukuba. Professor Masakazu Hirokawa at the AI laboratory is working on creating algorithms that can help robots learn. His ambition is to develop the software to enable a robot to adapt itself to each user.

7.2 Research at Public Research Institutes

Many research centers have recently been established at public research institutes.

Artificial Intelligence Research Center, AIRC. This center was established in May, 2015, at National Institute of Advanced Industrial Science and Technology (AIST) [46]. The aim of the research center is to develop AI technologies that will offer applications to self-driving cars, medical services and financial services including robotics. Junichi Tsujii is the director.

Ministry of Education, Culture, Sports, Science and Technology (MEXT) set up a strategic *Center for AI Development* at RIKEN (Institute of Physical and Chemical Research) in April 2016. The center will be related to RIKEN's AIP project (Advanced Integrated Intelligence Platform) and also cover big data and IoT [47]. In September 2016, the center will launch a research hub near Tokyo station.

The government plans to promote the development of AI technologies in cooperation with other entities. The public-private initiative will involve 20 companies and research institutes, and researchers will be able to gather at the hub near Tokyo Station.

Professor Masashi Sugiyama (41), University of Tokyo, will be the head of the center.

The aim is to develop practically applicable artificial intelligence for the medical and financial fields within 10 years. Collaborative research will be conducted in cooperation with national institutes under Ministry of Economy, Trade and Industry (METI) and Ministry of Internal Affairs and Communications (ICT).

National Institute of Informatics. Professor Noriko Arai is developing an AI system that she hopes can pass the entrance exam to the University of Tokyo [48].

7.3 Collaboration between Companies and Universities/Research Institutes

Some examples of collaborations between companies and universities/research institutes are listed below.

Hitachi in a joint project with researchers at *Tohoku University* has developed AI-based software capable of backing up its decisions with facts, background and context [49].

On June 1, 2016, *NEC* and *AIST* jointly established an AI lab. The aim of the three-year collaboration is to make up for AI's shortcomings. AI is not much helpful to uncover solutions to problems with only limited data, such as predicting rare events such as major disasters [50].

The researchers intend to use AIST's advanced simulation technology to generate data on different situations. They hope to develop AI that can use this additional data to find solutions out of reach so far.

Keio University and *Ubic Medical* are working on developing a device that enables real-time objective assessment of mental symptoms by quantifying facial expressions.

Video Website operator *Dwango* will work with partners including *University of Tokyo* to conduct research on AI capable of making autonomous decisions [51].

*CyberAgen*t, an online advertising agency, and *Meiji University* are developing an AI-based system to automatically generate ads.

7.4 Corporate Research

Hitachi is carrying out research to use AI to detect signs of diseases, including unknown warning signs. The firm has started a pilot program analysing about 150 pieces of medical data and believes that AI can play a major role in reducing medical costs [52].

Interprotein, a company strong in molecular designing technologies, and *A.I. Squared*, an artificial intelligence-based solution provider, are jointly conducting research on AI drug discovery [53].

8 Competitive Landscape: Japanese Players

The competitive landscape consists of large players, small to mid-sized companies and start-ups. Many companies are well-positioned to benefit from the AI boom.

8.1 NEC

NEC is a leader in the integration of IT and network technologies headquartered in Tokyo. NEC's electronic devices business includes semiconductors, displays and other electronic components. Consolidated sales in FY 2015 were JPY 2.8 trillion. The total number of employees is 99,000.

NEC has been active in AI research since the 1980s. The company will intensify R&D of artificial intelligence technology and the commercialisation of solutions, and is planning to increase staff working with AI to 1,000 by 2020.

NEC's solutions incorporating AI-related technologies are divided into 4 groups. Public safety solutions include urban surveillance systems and crowd behaviour analysis. Landslide prediction solution and plant failure sign detection system are examples of infrastructure/plant management solutions.

Human resource matching is a marketing solution and quality analysis is an example of solutions for improvement of operational efficiency.

8.2 Fujitsu

Fujitsu is a leading ICT company offering a full range of technology products, solutions and services. The total number of employees is 159,000. Fujitsu has been active in the AI field since the 1980s. The sales in FY 2015 were JPY 4.7 trillion.

Through the AI Application Consulting Department, Fujitsu is providing consulting services that utilise artificial intelligence. AI-specialist consultants work with clients proposing AI-enhanced solutions that will bring about business transformation and innovation.

Fujitsu has developed software that identifies the emotions on people’s faces.

8.3 Toshiba

Toshiba is a multinational conglomerate corporation headquartered in Tokyo. Its products include information technology and communications equipment, electronic components, power systems, consumer electronics and household appliances. The number of employees is 199,000. The sales in FY 2015 were JPY 6.6 trillion.

Toshiba has developed a new analytics system based on AI for use at its mainstay flash memory plant in Japan. AI is being used to monitor the semiconductor yield rate and will automatically classify defects and detect causes as well as analyse incident trends.

Toshiba has also developed a dialogue-based virtual assistant specialised for inheritance advice.

8.4 Hitachi

Hitachi is a multinational conglomerate company headquartered in Tokyo. Hitachi is a highly diversified company that operates eleven business segments including high functional materials & components, financial services, power systems, electronic systems & equipment, railway systems and construction machinery. It employs 336,000 people. Total consolidated sales were JPY 9.7 trillion in FY 2015.

Hitachi has developed an AI program that enables robots to deliver instructions to employees based on analyses of big data and working routines. A logistics work efficiency improvement rate of 8 percent has been achieved [54].

Its core machine-learning technology called "H" is designed to help clients boost their sales, cut costs and improve employee satisfaction. While earlier AI systems and software had to be customised for various uses, "H" can learn on its own to achieve different outcomes [55].

Recently, Hitachi teamed up with Kyoto University to research AI technologies. One theme will involve developing AI to ease traffic congestions, based on the mechanism by which fish cooperate to move in unison.

In FY 2016, Hitachi plans to triple development spending in areas such as AI, sensors and robotics.

Hitachi aims to add 100 new AI experts by March 2017 at its research center in California. This will bring the total number of the center's staff to about 200 including 100 researchers sent over from Japan.

8.5 Mitsubishi Electric

Mitsubishi Electric is a world leader in the manufacture of electrical and electronic equipment used in information processing and communications, consumer electronics, energy, transportation and building equipment. The total number of employees is 121,000. Total sales in FY 2015 were JPY 4 trillion.

The company has developed a "compact AI" technology that can work without the use of large servers. The compact AI is expected to be implemented in embedded systems applications in vehicles (autonomous driving systems) and robots starting from 2017 [56].

Mitsubishi Electric will put elements of AI to work in driver-assisted systems in 2017. The systems will monitor the driver's face and heartbeat, as well as steering wheel movements in order to warn of sleepiness with the aim to prevent car accidents.

The company has also developed an AI-based system that optimises elevator management.

Mitsubishi Electric emphasises that AI is merely a way to add value to devices functioning as a "key supporting player".

8.6 Sharp

Sharp is a multinational company that designs and manufactures electronic products. Since 2016, Sharp is an integral part of Taiwan-based Foxconn Group. Sharp employs more than 50,000 employees worldwide. Consolidated sales in 2014 were JPY 2.9 trillion.

Sharp has recently launched a walking, talking robot smartphone (*RoBoHoN*) utilising AI.

Source: Sharp homepage

8.7 Sony

Sony is a multinational conglomerate corporation headquartered in Tokyo. Its diversified business includes consumer products and electronics, gaming, entertainment, and financial services. Consolidated sales in FY 2015 were JPY 8.1 trillion and it employs 131, 700.

Sony recently (May 2016) announced a tie-up with U.S. Cogitai, a start-up specialised in AI. The partnership will work on technology by which a camera can suggest new options of photo-shooting after learning the user's preferences (photo-taking patterns) [57].

Sony is currently shifting its focus from "mere survival" to innovation. Once deep in the red, its bottom line is now back in the black.

In April 2016, Sony established a new department devoted to mid- and long-term business development. It will focus on AI and robotics and one aim is to develop AI platforms that can function as a cutting-edge foundation for its products and services.

8.8 NTT Group

The Nippon Telegraph and Telephone Corporation, commonly known as NTT, is a Japanese telecommunications company headquartered in Tokyo. The NTT Group consists of five main group companies: NTT East, NTT West, NTT Communications, NTT DoCoMo and NTT Data. The group employs more than 240,000 people.

NTT subsidiary companies work on AI products and services by utilising the research results available from NTT Research.

In October 2015, NTT Data established the AI Solutions Promotion Office. With its information application knowhow platform, NTT Data will support front and middle office assistants in communications with consumers and the public sector.

NTT Communications uses an AI algorithm to protect more than 4,000 corporate customers from cyberattacks.

8.9 SoftBank

SoftBank Group is a multinational telecommunications corporation with operations in broadband, Internet and technology services. The sales in FY 2015 were JPY 8.7 trillion. SoftBank employs 69,000.

SoftBank and Boston-based Cybereason have formed a joint venture (April 2016) in Japan to provide a cyber-security platform that utilises AI.

SoftBank has entered an alliance with IBM to introduce IBM's AI Watson system in Japan. The two organizations are targeting Japan's education, banking, healthcare, insurance and retail industries to provide clients with more relevant information on products and services, and to improve overall decision making by analysing diverse, high volume data streams.

SoftBank has entered a partnership with AKA LLC, a key innovator in AI social robot innovation, in order to facilitate the development of AKA's *Musio*, the world's first artificially intelligent robot friend [58]. A picture of Musio is presented below.

Source: Homepage of AKA LCC

In July 2016, SoftBank announced a research collaboration with Honda with the aim to give cars the ability to read the moods and learn the preferences of drivers, not only by using cameras and sensors but also by conversing with them.

8.10 Toyota

Toyota is an automotive manufacturer headquartered in Toyota located east of Nagoya. Toyota is the world's first automobile manufacturer to produce more than 10 million vehicles per year. The number of employees is 338,000 and the consolidated sales in FY 2015 were JPY 27.2 trillion.

In 2015, Toyota has announced that the firm will spend USD 1 billion over the next 5 years in a joint AI research project with Preferred Networks related to technology to connect vehicles.

In order to stay competitive and tap artificial technology, Toyota established a research unit in the beginning of 2016 in the U.S. Toyota's ambition is to be at the forefront of autopilot technology, given that the future is driverless cars.

In August 2016, it was announced that Toyota will join a public-private initiative to develop a core AI technology for applications in fields such as manufacturing and infrastructure management. Toyota and NEC will work with RIKEN to develop systems that can detect signs of impending production machinery failures utilising sensor data.

Toyota, Panasonic and other companies recently contributed about JPY 900 million to Tokyo University to endow positions in artificial intelligence.

8.11 Fanuc

Fanuc is a Japanese multinational corporation and one of the world's leading manufacturers of robotics and factory automation. The company had its beginnings as part of Fujitsu developing early numerical control systems. The sales in FY 2015 were USD 6.1 billion. Fanuc has 5,300 employees worldwide.

Fanuc is working with Preferred Networks, a leading Japanese provider of artificial intelligence solutions, to develop the FIELD system platform that connects robots, devices and sensors to optimise manufacturing production through analytics.

8.12 Preferred Networks

Preferred Networks was founded in March, 2014, as a spinoff from Preferred Infrastructure, specialised in artificial intelligence, particularly in deep learning. The firm is headquartered in Tokyo and employs 30 persons.

Preferred Networks has teamed up with Fanuc, one of the largest makers of industrial robots in the world, which has invested JPY 700 million in the company to develop smarter robots.

Preferred Networks has also teamed up with Toyota (self-driving cars), Panasonic (research on automotive and audio visual products) and Cisco Systems.

In October 2015, the firm launched an operation system for deep learning technology called *chainer* that helps engineers write AI-enabled programs.

In July 2016, Preferred Networks established a company, *PFDeNA*, to develop AI technology together with smartphone game provider DeNA that is known for its partnership with Nintendo. In the future, Nintendo's smartphone games might be powered by AI technology.

8.13 Ubic

Ubic, headquartered in Tokyo, was founded in 2003 as a provider of international litigation services. Sales in FY 2015 were JPY 10.6 billion.

Recently, Ubic has obtained patent in Japan for semantic analysis technology using its proprietary AI engine, *KIBIT*, that is covering three fields: digital marketing, healthcare and business intelligence. In the U.S., the patent authorities have declared that Ubic's analysis technology meets the requirements for patentability.

Ubic has developed a small robot called *KIBIRO*. Equipped with the AI engine *KIBIT*, the robot can recommend new books based on what people have read in the past and other preferences.

Ubic Medical, a wholly-owned subsidiary founded in April 2015, has developed an AI-based system to mitigate patients' risks of falling. And it also has a system to detect mental disorders [59].

8.14 Canon

Canon is a multinational corporation headquartered in Tokyo. The firm manufactures imaging and optical products including cameras, camcorders, computer printers and medical equipment. The consolidated sales in FY 2015 were JPY 3.8 trillion. The number of employees is 192,000.

Canon is planning to completely automate domestic manufacturing of digital cameras by 2018 by using AI robots. This will serve as a new paradigm for domestic factories that are facing the problems of a shrinking labour pool and rising personnel costs [60].

9 Foreign Players in the Japanese Market

9.1 Zen Robotics

Zen Robotics is a Finish company and a leading supplier of an AI-based robotic waste separation technology headquartered in Helsinki.

In Japan, Zen Robotics has entered into a distribution deal with Sun Earth, a leading domestic technology supplier to the Japanese waste management industry [61].

9.2 IBM

IBM is an American multinational technology and consulting corporation headquartered in New York. The consolidated sales in 2015 were USD 81.7 billion and it employs 377,000 people worldwide.

IBM's supercomputer platform *Watson* is an AI-enabled technology platform that uses natural language and machine learning to detect patterns from large amounts of unstructured data.

IBM's *Watson* is being utilised in Local Motors electric self-driving minibus that can be built by 3-D printer as an on-demand transportation solution. Recently (June 2016), this minibus was presented in Maryland in the U.S [62].

In 2015, IBM formed an alliance with SoftBank to introduce IBM *Watson* to the Japanese market. In February 2016, a Japanese language capability version was released. The goal of the collaboration is to launch new applications in Japan powered by the *Watson* platform.

In August 2016, as a possible first in Japan, it was reported that doctors have used *Watson Healthcare Platform* to diagnose a rare type of leukaemia. The platform was able to carry out the diagnosis in 10 minutes, while it would have taken about 2 weeks for doctors to arrive at the same conclusion. This was possible because the platform was able to analyse data from millions of research papers through a cloud-based AI-powered computer system.

9.3 YouAppi

YouAppi is an Israeli pioneer in AI-based data-driven mobile customer acquisition, combining the power of machine learning with proprietary predictive algorithms.

In Japan, the firm is working with Bandai Namco. Its *OneRun Platform*, a marketing tool, is being used by customers in many countries [63].

10 SWOT Analysis

A SWOT analysis of Japan's artificial intelligence industry is presented below.

Strengths:

- Japan has a large pool of AI researchers to draw on from the 5th generation computer systems project in the 1980s
- Supportive governmental policies have created a base for further development of the industry
- AI R&D bases established overseas will contribute to widening the base of AI in Japan and increase potential application areas

Weaknesses:

- Slow implementation of innovations and delay in translating AI advances into business opportunities
- Moderate sales targets for some corporations. At Fujitsu, for instance, the target is just JPY 50 billion by FY 2018.
- Japan lags behind the U.S. and China in terms of the number of AI-related patent application filings
- Japan's AI industry currently not very competitive on the global scale
- Few Japanese companies are aggressive in terms of initiatives related to AI
- Investments in AI smaller than the ones being made by tech companies in the U.S.

Opportunities:

- AI applied to robotics could be a big chance to revive Japan's industrial "glamour of the old days"
- AI will help the industry move up the value chain

Threats:

- Japan's AI industry is slow in introducing open-source AI platforms that has become mainstream for large tech companies in the U.S.

Comments:

It is apparent that the Japanese AI industry is starting from a lower level compared to the U.S. Professor Yutaka Matsuya, University of Tokyo, however, claims that Japan now is well positioned to capitalise on the current AI trends.

To become a strong global player, Japan has to acquire a mind-set that spans borders and cultures as many Japanese companies are still imbued in the success during the third industrial revolution.

11 Associations, Organisations and Forums Related to AI

The Japanese Society for Artificial Intelligence (JSAI). The Japanese Society for Artificial Intelligence (JSAI) was established in 1986 and currently has about 3,200 members. The purpose of the society is to contribute to social innovation in Japan with research and development of artificial intelligence. JSAI organises annual conferences, joint workshops and international symposiums as well seminars on different AI fields [64].

Recently, JSAI has presented a draft ethics guideline for AI researchers, which touches on how research in the AI field should be carried out.

Whole Brain Architecture Initiative (WBAI). Whole Brain Architecture Initiative (WBAI) was established as an NPO in 2015 to support the development of AGI (artificial general intelligence) through open R&D communities. The WBA approach is to learn from the architecture of the entire brain with the aim to make artificial general intelligence (AGI) to surpass the human brain capability around the year 2030. WBAI is working to foster human resources for artificial intelligence, as well as develop base software technologies with high public value. Hiroshi Yamakawa, director of Dwango AI Laboratory, is the chairman [65].

The Japan Robot Association (JARA). In 1972, the Japan Industrial Association was formed. The current name, Japan Robot Association (JARA), was adopted in 1994. The Association aims to further the development of the robot manufacturing industry by encouraging research and development on robots and associated system products and promoting the use of robot technology. The number of regular members is 32 with 110 corporate supporting members. Recently, AI technology is being integrated into robotics drawing wide attention among member companies [66].

Legal Society of Robotics. Thirty members who are legal scholars, robotics engineers and bureaucrats are working to establish a Legal Society of Robotics. The group is led by Ryota Akasaka, a researcher at Keio University. The forthcoming society will promote discussion among law scholars, robot developers and representatives from various fields to agree on the roles and responsibilities of robots in society.

12 Trade Fairs

IEA/AIE (Industrial and Engineering Applications of Artificial Intelligence and Expert Systems) 2016 is an International Conference on Industrial, Engineering & Other Applications of Applied Intelligent Systems that will be held in Morioka, August 2-4 [67].

CONTENT TOKYO/AI World 2016. CONTENT TOKYO is a group of 6 exhibitions, specialising in the areas of entertainment content creation, distribution, licensing, technology, service and marketing. This event will take place between June 29 and July 1 in Tokyo. At a special exhibition area, AI World will present cutting-edge AI technologies related to content production, data analysis and data prediction [68].

Japan Robot Week 2016 will take place in Tokyo between October 19 and 21. This exhibition is especially focusing on service robots and related technologies/components [69].

ROBOTEX 2017: Robot Development & Application Expo. ROBOTEX 2017 will take place between April 18 and 20. The expo will cover industrial/service robots and development technology including IT and AI [70].

13 Challenges and Opportunities for European Companies

13.1 Key Success Factors

What does it take to succeed as a European company in Japan? The most important success factors for market entry to Japan are:

- *Build long-term relationships*. There is no easy and quick way to succeed in Japan. It takes long time to get a firm foothold in Japan and it is equally important to have the full understanding of the top management (company-wide commitment).
- *Research the Japanese market intensively beforehand.* There are significant differences between doing business in Japan and in Europe. For instance, Japan presents challenges uniquely distinct from many other markets and before taking the final decision it is necessary to have a good understanding of the business environment.
- *Attention to detail and follow-through are critical*. In no other country are the requirements for customer support and service more demanding than in Japan. Serving the customer is a vital part of the Japanese business culture. Quick responsiveness to customer demands is important.
- *Adapt products to Japanese market needs*. The concept of localisation or fitting in with the local market is an aspect that always has to be taken into consideration. Usually, it is not enough with a standardised approach when trying to enter the Japanese marketplace
- *Choose the right mode for market entry.* Entry mode often depends on a number of factors and it is necessary to be very selective in the process to get access to the right distribution channels.

The above general success factors should always be taken into account when considering a Japan market entry. Other important factors are:

- *Offer a product that stands out and is unique compared to domestic versions, and of high quality.*

13.2 Challenges for European Companies

Some of the success factors presented in section 13.1 above could constitute challenges for European companies when entering the Japanese market.

- *How to approach the Japanese market*. Establishing a subsidiary, sell through a local distributor or a joint venture with a Japanese company are the main alternatives to consider. Long term the best strategy for entering the market may be a direct presence through a subsidiary. There is a need to analyse the advantages and disadvantages of each option.
- *Well-established system for after-sales service including follow-up and troubleshooting.* Japanese companies and customers are very demanding when it comes to the after-sales service. This can be a challenge for European SMEs as the after-sales service in Japan tends to be costlier than in Europe.
- *Lack of local experienced talent well-versed in AI technologies and its applications*. Japan has just started the race to catch up with the US and Europe. According to Nikkei Shimbun, there is a global lack of tens of thousands knowledgeable persons in the AI industry. This also holds for Japan and may negatively impact European SMEs planning to enter the AI segment in Japan.

- *Weak brand to offer*. Many small European start-ups in the AI field are not yet well known with "weak" brands that may prolong the process to get into the Japanese market.
- *Insufficient AI regulatory framework in Japan.* The AI industry is just about to take off and the regulatory framework is not on par with the current development stage of artificial intelligence in Japan. For European companies this may pose a challenge as it may be difficult to know the direction of forthcoming regulations as well as governmental policy preferences.
- *Cultural differences.* Japan's business culture is quite different compared to Europe and it may take some time to get a satisfactory understanding of important differences.

13.3 Potential Business Opportunities for European Companies

In Japan, artificial intelligence has entered a stage with growing public awareness and gradual uptake by enterprises. In comparison to the U.S. market, the number of products and solutions are still limited.

One can expect domestic companies working in the AI field to be more open to listen to what European/foreign companies have to offer, compared to traditional and mature business sectors that are competing upfront with overseas competitors.

The process to get in contact with potential Japanese companies may therefore be shortened.

Then, what can European companies offer? Potential opportunities are listed below divided into AI technologies and AI solutions.

AI technology:

- *Deep learning.*
  Deep learning has so far not been extensively utilised by Japanese firms developing AI technologies. This could, therefore, open up opportunities for European companies with capabilities in this field.
  Potential entry modes would be Joint Venture (JV)/collaboration or licensing.

Recent articles in Japanese newspapers (June 2016) indicate that automakers such as Toyota and Honda are "desperately" seeking personnel specialised in self-driving technology [71]. So far, Japanese automakers have mainly developed technologies to support drivers. But now they have to develop new technologies that can offer opportunities to European companies with capabilities related to automated driving technology.

- *Other AI technologies*
  In contrast to deep learning, domestic firms have a longer track record when it comes to other AI-related technologies such as machine learning.
  For this reason, the business opportunity in this sub-segment may be smaller.
  Potential entry modes could be JV/collaboration or licensing.

In case of AI technologies, other opportunities for European companies could be collaboration/joint development of new, wider AI frameworks with Japanese universities.

AI solutions:

This is an AI segment that is expanding in Japan. The approach, however, would be different from the AI technology segment.
The main entry modes would be JV/collaboration with domestic companies or own subsidiary.

- *JV/collaboration*
  Work together with a Japanese firm to develop joint AI solutions (platforms) that would offer access to existing distribution channels.
  One example would be to try to introduce solutions to unsolved/poorly served high-value problems facing businesses.

- *Start own subsidiary*
  Considering the current status of the Japanese AI industry that lacks experienced talent, this option may be limited to products/solutions that do not have to be extensively localised.

The current status of Japan's automobile industry can create business opportunities for European companies that can offer AI-based solutions applicable to self-driving technologies.

Among 35 listed Japanese companies that are considered strong in artificial intelligence, 8 companies are offering AI solutions related to marketing [72]. Some of the application areas offered is data analysis, automated marketing, image recognition and analysis of iPhone users' behaviors. This could open up possibilities for European companies with attractive solutions in these segments.

Other areas that could be interesting are information services and the security service segment.

Licensing could be one alternative but would limit revenues compared to other entry strategies.

14 Summary & Recommendations

Currently, the third AI boom is picking up momentum globally, including Japan although from a lower level.

Japan is trying to catch up with overseas markets, in particular the U.S. market, helped by governmental initiatives with a strong growth strategy focus on artificial intelligence and robotics. Connectivity between robots is the new direction in which the development is heading.

Japan's AI market is predicted to grow from JPY 3.7 trillion in 2015 to JPY 87 trillion by 2030. The transport sector that includes driverless taxis and trucks will grow from JPY 100 million in 2015 and is expected to reach JPY 30.5 trillion by 2030. The share of the market value of the transport sector to the total market value will increase from 0.003 percent in 2015 to 35.1 percent in 2030, witnessing a strong impact on the future AI market.

To get access to new technological advances in AI, several Japanese companies have set up R&D bases in the U.S. One example is Toyota.

It will be important to direct the development of the domestic AI industry to actual issues and develop products and solutions that meet actual needs of end-users.

Some of the challenges the AI industry in Japan is facing are the lack of experienced talent within the AI field and the development of safety standards. A regulatory framework commensurate with the current development level of AI has to be established.

Business opportunities in Japan for European AI-related companies include *AI technologies* and *AI solutions*.

The study has found that deep learning is not as utilised in Japan as in many overseas markets including Europe. This will offer opportunities for European companies with extensive experience and capabilities in this sub-segment of AI technologies. As the Japanese government has prioritised use of AI and robotics, the need for deep learning-driven solutions will increase in the years to come.

Additionally, the automobile industry that so far mainly has been working on technologies to support drivers including machine control systems will increasingly need deep learning-driven solutions to further the development of driverless vehicles. This will offer business opportunities for Europeans firms with capabilities and attractive solutions related to automated driving technology.

In the AI solutions segment, where Japanese companies, in particular start-ups, are trying to find niches, teaming up with European firms offering platforms with unique AI solutions could be one attractive way to address local needs, and this would also help European AI technology into the Japanese market.

The findings of the study showed application areas with many new entrants of Japanese AI companies. Marketing is a segment with many offered solutions including image recognition, data analytics and automated marketing. Offering of attractive marketing-based solutions including information services and security solutions could be potential additional areas for European companies.

To find out more about the current status of the Japanese market for AI solutions including AI technology, visiting trade fairs is one way to meet with Japanese companies to discuss business opportunities including partnering.

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