Business Innovation Observatory

Big Data

Artificial Intelligence

Case study 9

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1. Executive summary

Artificial intelligence (AI) concerns the study and development of intelligent machines and software. The associated ICT research is highly technical and specialised, and its focal problems include the development of software that can reason, gather knowledge, plan intelligently, learn, communicate, perceive and manipulate objects. AI also allows users of big data to automate and enhance complex descriptive and predictive analytical tasks that, when performed by humans, would be extremely labour intensive and time consuming. Thus, unleashing AI on big data can have a significant impact on the role data plays in deciding how we work, how we travel and how we conduct business.

Private companies as well as public bodies seek to enhance their competitive advantage by better understanding ever-growing amounts of data. AI offers the technology and methodology to do so, which is why the market for AI-based tools and applications is growing rapidly. Estimations value the 2013 AI market at €700 million, and expect it to grow exponentially over the coming years, exceeding €27 billion by 2015.

Thus, the uptake of this trend can benefit European companies as well as the EU-economy and labour market, as the development and management of AI requires highly skilled workers in a variety of disciplines. More specifically, AI will lead to an increase in demand for skilled labour, particularly for computer scientists and mathematicians. Furthermore, as AI developers aim to have software function in the same way as the human brain, knowledge on how the brain works will likely become more important and will spur research in the area.

It is promising to see European technology companies developing AI applications that are in global demand, opening up sales and support offices in Silicon Valley as well as the BRIC countries. Further to the increased demand for skilled labour, Europe will also be positively affected in the following ways:

- Increased business activity and business revenue, resulting in the subsequent spill-over effects and tax revenue;

- The internationalisation of European firms, increasing opportunities for foreign direct investments; and

- Inspirational examples of successful firms, spurring entrepreneurship.

The development of AI for big data in Europe has a number of drivers and faces several obstacles. These drivers and obstacles impact both technology companies developing solutions and companies looking to implement AI. Drivers include a highly educated workforce, scalability of developed solutions and public support programmes fostering innovation. Obstacles include the difficulty of attracting funds both for company set up and early financier divestment, high administrative burdens for small companies and unfavourable tax environments.

The innovative solutions of companies interviewed for this case study testify to the added value of applying artificial intelligence, which typically leads to increased revenue, cost reductions, improvements in customer satisfaction, and productivity increases. Conversely, client uptake of artificial intelligence is hampered by a number of issues and problems, which include the long investment horizon of some artificial intelligence innovations, limited understanding of the potential of data generated by their own organisation and hesitation towards potentially disruptive technologies.

Concerning the promotion of artificial intelligence companies, there has been a lack of support offered by governments in Europe. Policy gaps are noted in funding support, tax systems, immigration policy, employment regulation, university-industry interaction, mentorships and international patents. Thus, European governments can address these policy gaps by improving access to funding, reforming tax systems to promote innovation, public procurement of innovation, reforming immigration policy, fostering administrative simplification, reforming employment regulation, encouraging university-industry interaction, encouraging mentorships and re-visiting international patent rights.

2. Big data: Artificial Intelligence

Big data describes the stunningly increasing growth, availability and utilization of information in today's world. The continuously increasing volume of structured and unstructured information, the variety of it, and the speed with which it is generated, through social media, sensor data as well as transaction data, poses today's leaders and specialists with both increased opportunities and devilish challenges. With big data benefitting from increased storage capabilities, thinking moves away from what records to keep to ponder the question of how to make sense of these large volumes of data.

About 90% of all data in the world has been generated in the last two years, coming in from traditional databases, text documents, email, meter-collected data, video, audio, stock ticker data and financial transactions. It is estimated that of all this data, only 20 percent is numeric, leaving 80% of non-numeric data. The sources and channels through which this data manifests is manifold. To access this data, to determine its relevance and to figure out ways to turn it to their advantage, businesses have turned to a subdivision of computer science that since its conception has spoken to the imagination: artificial intelligence.

Artificial intelligence (AI, sometimes also referred to as 'machine learning') aims to study and develop intelligent machines and software. The associated ICT research is highly technical and specialized, and its focal problems include the development of software that can reason, gather knowledge, plan intelligently, learn, communicate, perceive, and manipulate objects. A distinction is made between 'strong AI' (intelligent software that matches or supersedes human intelligence) and 'applied AI' (also called 'narrow AI' or 'weak AI').

Artificial intelligence is used in a variety of ways and can be found across a large number of sectors, from assembly line robots to advanced toys, and from speech recognition systems to medical research. Its most common application is to find patterns in data, which is why it is commonly applied in online search engines and recommendation sites.

Artificial intelligence would allow users of big data to **automate and enhance complex descriptive and predictive analytical tasks** that would be extremely labour intensive and time consuming if performed by humans. The scale on which big data operates can exceed ordinary understanding. A popular example is offered by Google's search term correlation of a handful of search terms and the flue, which is claimed to be the result of testing 450 million mathematical models. Another is that of Google Translate, which, when determining if the English word "light" should be translated to French as "lumière"

(referring to brightness) or "léger" (referring to weight), is said to incorporate billions of pages of translations into its judgment. These huge amounts of computations on such vast amounts of data would make it impossible for any human to uncover or emulate the precise reasoning behind the choices the software makes.

However, counter to how artificial intelligence can be portrayed in popular culture, it cannot yet make decisions for its user. AI can only help users in making their decisions, and as such can provide valuable methodologies with which to engage big data challenges:

- **Particle Swarm Optimisation (PSO)** is a computational method used in data mining to efficiently harvest useful information from big data, by iteratively improving candidate solutions to optimize a given problem. These candidate solutions (dubbed particles) can be moved around a search spaces through simple mathematical formulae. These particles follow flocking rules to form swarms, moving the swarm towards solutions, eventually allowing a particle to find a position that exceeds minimal requirements given to a solution.

- **Agent-based computational economics** studies dynamic systems of interacting agents and can be used to simulate economic processes and even entire economies, through agent-based models. In these models, the interaction of agents is modelled according to rules that model behaviour and social interactions, which allows for behavioural forecasting as well as price movements. This methodology requires expert involvement in order for the rules and models to accurately reflect reality, which then could tap into big data to provide for dynamic, real time analysis and forecasting.

Unleashing artificial intelligence on big data in such a manner can have a significant impact on the role data plays in deciding how we work, how we travel and how we conduct business. More and more aspects of our lives can become predictable, from travel time to customer satisfaction to how long it will take an abled bodied worker to complete a given task.

Also, artificial intelligence could provide this type of information ahead of time, allowing for improved planning, scheduling, and decision making, providing users with critical information at the right time to make the best opportunities when they present themselves. Moreover, tying the use of artificial intelligence on big data to responsively designed user applications allows for improved user experience that benefits from receiving the required information based on interaction context, without swiping, pinching, scrolling or clicking.

3. The potential and relevance of artificial intelligence for big data

The big data market is in a nascent stage and is expected to develop as companies as well as public bodies seek to enhance their competitive advantage by better understanding the ever-growing amounts of data. Artificial intelligence offers the technology and methodology to do so, and the market for artificial intelligence-based tools and applications is growing rapidly. Uptake of this trend can benefit European companies as well as the EU-economy and labour market, as the development and management of artificial intelligence requires highly skilled workers in a multitude of fields.

3.1. Understanding the artificial intelligence market for big data

It is difficult to quantify the exact size of the market for artificial intelligence. Definitions of what should and should not be considered artificial intelligence vary, as well as the Euro-value estimations of current and future business. The Economist estimates the data management and analytics industry to be worth more than €56 billion and growing at almost 10% a year[1]. The application of big data analytic solutions has been estimated as having a €250 billion potential annual value to Europe's public sector administration[2]. However, it is hard to break down to what extend these analytics can be considered artificial intelligence. Mind Commerce values the 2013 artificial intelligence market at €700 million, to grow exponentially over the coming years[3], while Global Industry Analysts forecast the artificial intelligence market to exceed €27 billion by 2015 (Figure 1)[4].

### Figure 1: Estimated AI Market Value (in EUR million)
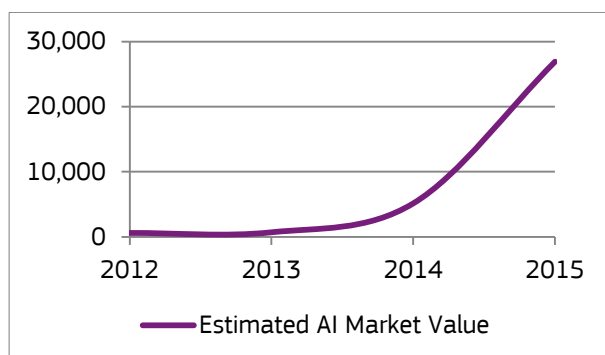
Source: MarketReportsOnline, 2013, Artificial Intelligence in Big Data, Commercial Apps, Mobility and Search Global Industries Analysis inc, 2009, Artificial Intelligence – A Global Strategic Business Report

Although widely considered very promising, the market for artificial intelligence is at an early stage. As an academic discipline, it is recovering from its second and longest academic winter since its conception half a century ago[56]. Those working on artificial intelligence notoriously disagree on what artificial intelligence is actually about[7]. However, the emergence of big data has initiated what resembles a renaissance for the idea that artificial intelligence might be of relevance beyond the academy.

Overall, the big data market consists of companies offering big data infrastructure, software solutions, or professional services. Although market data is limited, it is estimated that approximately €3.5 billion was generated in revenue in the big data market in 2011, in infrastructure, software and services[8]. The relative market shares of these segments are shown in Figure 2. Excluding hardware, the market for big data software and services can be estimated at €2.4 billion, yet it is hard to gauge the share of this revenue that can be considered artificial intelligence.

Figure 2: Segmentation of the big data market, 2011
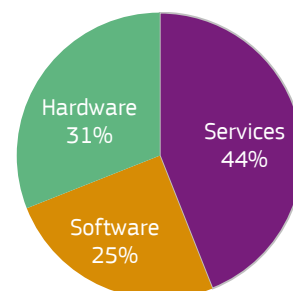
Source: Kelly, J. 2013. Big Data Market Size and Vendor Revenues. Wikibon Article

Artificial intelligence can find use in many different sectors, from advanced manufacturing to fundamental research in life sciences. In any industry that deals with large amounts of data, techniques and technologies based on artificial intelligence can be of value. Artificial intelligence solutions are by nature multidisciplinary, involving computer science, mathematics, statistics and philosophical thinking. Some of the applications of artificial intelligence have origins in academia, while others have been thought up by private companies or even individuals that managed to attract online business. The artificial intelligence market and the market for analytics and decision making software some-what overlap, as artificial intelligence technology can be the basis for software that supports, facilitates and improves analytics and decision making. However, artificial intelligence technology also has big data applications outside of analytics and decision making, e.g. improving and executing negotiations or mediating between conflicting parties.

The companies featured in this case study do not yet generate stellar revenues, yet they all have started out small and their number of staff has increased as their business grew. The development and application of artificial intelligence is done by highly skilled professionals, most of them university graduates in computer sciences or mathematics. To demonstrate the market in which they operate, and the impact these companies have on the regional economy and the society in which they are embedded, we will turn to the four companies we have spoken to (Table 1).

Table 1: Company case studies

Company	Location	Business innovation	Success signals
Path Intelligence	UK	Footpath technology, mapping 3D visitor journeys to generate data-driven insights into visitor and customer behaviour	Entered multiple foreign markets, Winner of several technology awards.
QlikView	Sweden	Business discovery platform, allowing for associative data exploration	VC funded, entered numerous foreign markets, winners of several awards including the Network Products Guide's 2013 Hot Companies and Best Products Award,
Expertmaker	Sweden	Making online interactions with e-commerce customers more intelligent and more precise	In use in major implementations in various industries and in various parts of the world
CogniCor	Spain	Complaint resolution and negotiation technology	2012 Most innovative European Startup Award Winner, selected for the Microsoft pre-incubation programme

The innovations developed and commercialised by these companies can be applied to a wide range of industries (Table 2), which include the retail, transport, health care, telecom, and e-commerce sectors. These companies are highly internationalised, sometimes with physical presence in several countries. They have been able to grow and expand abroad, as their solutions can be scaled with relative ease. However, the nature of their applications as well as the tailoring than can be required has leaded them to be physically located near some of their clients just the same.

The companies studied in this report show that it is not uncommon for AI technology companies to start off in close proximity to a university and several other technology companies. After a while, when the company starts to grow and sales pick up, these companies open up sales and support offices near their client base. In some cases, this means establishing a physical presence on the other side of the world.

Table 2: Examples of the various sectors for artificial intelligence on big data

Company	Sector of Big Data Market	Client Sector
Path Intelligence	Software / Services	Retail, transport, human logistics, entertainment venues
QlikView	Software / SAS / Services	Large variety of sectors, including automotive, health care, education, and banking
Expertmaker	Software / SAS	E-commerce
CogniCor	Software / SAS	Telecom

This was the case for Expertmaker, a company that decided to keep its technology centre in Sweden whilst opening up a sales and support office in San Francisco to be in close proximity of their clients in Silicon Valley. In a similar fashion, QlikView, also from Sweden, has opened up sales and support offices in nearly every country they sell to. Both companies realised that their technology, although software base and therefore scalable with relative ease, requires specific tailoring and customisation for each customer as well as extensive introduction as to how best unlock the benefits of their artificial intelligence-based products.

3.2. The benefits of artificial intelligence

Artificial intelligence can provide unexpected business intelligence for organisations, enhance knowledge on their customers and improve customer interaction with the company, and in some case even replace entire departments as intelligent, learning machines perform tasks until now strictly reserved for humans. Not surprisingly, demand for solutions made possible by artificial intelligence is increasing in the private sector as well as in the public sector.

The innovative solutions addressed in this report engage a variety of demands and market gaps for applications driven by artificial intelligence in different sectors. Path Intelligence analyses and predicts human behaviour to allow for better spatial planning. Cogni-Cor uses adaptive learning to have computers negotiate with humans to mediate and resolve

Business intelligence is an umbrella term that includes the applications, infrastructure and tools, and best practices that enable access to and analysis of information to improve and optimize decisions and performance.[ix]

complaints. QlikView's associative experience provides answers as fast as users can think up questions, while Expertmaker offers the customers of e-commerce companies an interaction experience that is similar to asking questions to a flesh-and-blood sales person helping to find gift ideas.

Mapping 3D visitor journeys to generate data-driven insights into visitor and customer behaviour - Path Intelligence has developed Footpath technology, which combines data from multiple sources to analyse and predict consumer behaviour. Tapping into spatial data from mobile phones and purchasing data from points of sale, and combining this with other data sources, Footpath looks for meaningful patterns to predict consumer behaviour. This can be used to reposition goods on shop floors to increase sales or to relocate stores within malls to increase traffic, but also to change the layout of train stations and stadiums to improve human logistics by allowing for shorter transfer routes and better access to emergency exits.

Innovative solution – Path Intelligence provides Footpath Technology, which consists of discreet monitoring units able to read the anonymous signals that all mobile phones send. Using this data, Footpath maps geographic movements from location to location and the data collected is fed back to their data centres. Their sophisticated analysis on aggregated data allows for patterns and trends to emerge.

"Where do your visitors go when they leave your anchor locations? To other stores? Or straight to the exit? The paths people take and the places they visit reveal if visitors are comparing prices to find the best offer". – Path Intelligence

Those patterns and trends are of interest in business planning, allowing for a greater understanding of the spatial relationship between people, events and locations.

The intelligence offered by Footpath can benefit anyone in charge of an area that at times contains crowds of people. Managers of football stadiums or railway stations can replace the rational choice models often used for behavioural predictions, with Footpath analysis that tracks and analyses movements in real time. Store owners and managers of shopping centres can benefit from accurate and up to date analysis of the correlation between customer routing and customer spending.

Path Intelligence is a British technology company that was founded in 2004 and is headquartered in Portsmouth near London, UK, and has offices in London, New York and San Francisco (USA).

Delivering associative business intelligence that empowers business users by driving innovative decision-making - QlikView works the way the mind works. QlikView is a leading business discovery platform that enables users to explore big data and uncover insights that enable them to solve business problems in new ways. With QlikView, users can interact with data associatively, which allows them to gain unexpected business insights and make discoveries like with no other platform on the market.

Large organisations can have a tendency to hoard large amounts of data without understanding why they would need specific data, or how they could use it to their advantage. Regular database analytics can help these organisations retrieve specific data and analyse it along predetermined paths. This can leave interesting opportunities for data analysis untouched. QlikView aims to help users get more out of big data.

Innovative solution – QlikView's associative experience provides answers as fast as users can think up questions. It lets users interact with data without limitations to generate insight in completely new ways. QlikView accesses, analyses and captures data from mobile devices as well as databases, relevant data from multiple sources. QlikView explores associations in the data to enable real-time social decision making within the organisation, interacting with dynamic apps and dashboards.

"We sell the highest level of convenience when it comes to business intelligence. What is really important is that we help clients move from being happily unaware to being happily aware" – QlikTech

More than 28,000 organizations in more than 100 countries around the world depend on QlikView to help them drive smarter, faster decisions every day. QlikView is said to change their business by providing them with a business discovery platform that is easy to use and at the same time incredibly powerful. QlikView users report a 34% employee productivity increase, a 23% cash flow increase, a 16% revenue increase, a 20% decrease in operating cost, and a 186% return on investment.

Founded in 1993, QlikTech originated in Sweden (Stockholm) and today serves more than 28,000 customers in 100 countries.

Making the internet more intelligent - Expertmaker, a Swedish company that has branched out to Silicon Valley, adds artificial intelligence to their client's applications. Depending on the business of the client, Expertmaker can crunch big data to uncover data associations practically undetectable by humans, or collect and analyse user

information in real time to make user interaction more intelligent and precise, improving user experience.

Expertmaker operates based on a vision to make the internet better. In close cooperation with academia and individual developers, Expertmaker organises 'hackathons', intense software development sessions that can last several days consecutively, to share ideas to further develop what they foresee will become an enabling technology.

Innovative solution – Expertmaker's goal is to make the internet more intelligent by making it easy for companies to add artificial intelligence to their services and apps. Expertmaker's AI server is a cloud-based high-speed computational AI server for running their artificial intelligence solutions. It offers very fast performance for live operations with its distributed architecture and parallel computation hardware.

"We believe that by using this type of technology you can have higher cross-sales. It's going to be more targeted to your needs. Interactions are going to be more precise. We can give this 20% bump in accuracy, which makes all the difference in determining winners in e-commerce."
– Expertmaker

Most clients of Expertmaker are e-commerce companies, companies that sell products and services online. E-commerce is a highly competitive sector, and Expertmaker helps their clients in e-commerce to make their online interactions with their customers more intelligent and more precise. In this way, Expertmaker helps e-commerce companies increase their sales. By guiding customers better though their online content, and presenting them with more suitable offers and suggestions, the clients of Expertmaker can offer their customers an interaction experience that is similar to asking questions to a flesh-and-blood sales person helping to find gift ideas.

Founded in Sweden in 2006, Expertmaker specialises in tailor made artificial intelligence big data analysis platforms.

Enabling smarter agreements in mediation and complaint resolution – CogniCor has developed technology that can help people reach an agreement. Their basic assumption is that negotiating to reach an agreement is a second nature to humans, and is part of our daily activities. Artificial intelligence can be set up to streamline a negotiation process, eliminating redundancies, decreasing time spent waiting, and improving the negotiating experience for all parties involved.

The foundations for CogniCor's technology were laid out in the dissertation of its founder and current CEO. Merging the outcomes of her PhD research with a theoretical research project into mediation technology for the Catalonian government, CogniCor's founder uncovered a way for artificial intelligence to deal with complaints that in most organisations are dealt with by customer service representatives in call centres – at great expense.

Innovative solution – CogniCor offers an automated complaint resolution service. Based on adaptive learning and rich business intelligence extraction, their artificial intelligence-based technology minimises the need for human intervention in resolving complaints, and analyses the root cause of complaints to help prevent future complaints from arising. Also, their negotiation technology can negotiate and settle claims for organisations dealing with individual consumers.

"If you want to rent a house, in most parts of the world you would go online, contact the renting agency, make an appointment and negotiate a price. That's a 10% overhead, this human mediation. Technological support could reduce this overhead. Same for complaint processes, which often relate to refunds of limited value. This was the inspiration to start CogniCor."
– Cognicor

Clients of CogniCor can have their customers file complaints, and negotiate settlements with an artificial intelligence developed by CogniCor that is capable of learning, negotiating and mediating. This reduces the need for call centres that can be a drag on company profits. Also, it reduces time customers spend waiting in frustration, improving customer experience in an attempt to turn a complainer into a loyal fan of the organisation.

The cost of call centre operations are estimated at approximately €40 per complaint handled, excluding the costs of refunds and settlements. Applications driven by the technology of CogniCor can be of great value to organisations that currently sport large call centres to deal with customer complaints and requests, such as telecom providers and utilities. CogniCor estimates to achieve cost reductions of up to 70% on operations, and up to 50% on value of refunds.

CogniCor is a Spanish AI company founded in Barcelona in 2011 as a spinoff of the Artificial Intelligence Research Institute of the Spanish National Research Council.

3.3. The client perspective

These four companies have managed to bring artificial intelligence to a wide variety of sectors that all have a similar demand for technology that helps to better understand and facilitate customers and employees. Path Intelligence analyses and predicts human behaviour to allow for better spatial planning. CogniCor uses adaptive learning to have computers negotiate with humans in order to

mediate and resolve complaints. QlikView's associative experience provides answers as fast as users can think up questions, while Expertmaker offers the customers of e-commerce companies an interaction experience that is similar to asking questions to a flesh-and-blood sales person helping to find gift ideas.

The drivers for client uptake

From these cases, it appears organisations exploit the potential of artificial intelligence either to anticipate on decisions made by people outside of their organisation, or to facilitate decision making by people within their organisations:

- **Anticipating decisions** – Artificial intelligence that anticipates human decisions is based on the premise that decision making can be inferred by analysing patterns in outcome data. By analysing large volumes of data on human behaviour, patterns can be inferred that inform software systems on factors that influence human decision making, allowing these systems to predict behaviour. Based on these predictions, software systems can generate suggestions on how to influence human behaviour, or even interact with humans with a specific outcome in mind. In example, Expertmaker's multi-AI technology has been implemented by the developers of the RedLaser mobile app to create a mobile shopping companion that offers recommendations based on advanced analytics of store deals data and user behaviour, allowing users to research, shop and buy right on their smartphone. The app has been downloaded more than 26 million times.

- **Facilitating decisions** – Artificial intelligence that facilitates decision making is founded on the idea that by understanding the associative reasoning of the human mind, software can predict the information needs of a user and provide relevant data and intelligence even before a user has realised this information would come in useful. This type of technology is more than a time saver, as it would allow for unexpected data associations that can trigger new thinking, which for companies working with QlikView has led to a 23% cash flow increase, a 16% revenue increase, a 20% decrease in operating cost, and a 186% return on investment.

A rather large number of clients can testify to the added value of applying artificial intelligence to a company in this manner. Adding to their competitive advantage, as a result of implementing this type of technology organisations have reported increased revenue, cost reductions, improvements in customer satisfaction, and productivity increases.

- **Increased revenue** – As web shops manage to guide their visitors more accurately through their offerings and provide suggestions that better suit their visitors'

preferences, they are able to make more sales and increase their revenue. Also, organisations that alter the layout of their physical locations based on behavioural predictions can increase their sales by better routing customers through their stores.

When a leading clothing retailer considered renting more space at one of two prospect locations, Footpath technology was implemented to demonstrate how dependent that brand's success was on the presence of key brands around them. By generating this insight and identifying appropriate new store opportunities based on our data, Footpath technology helped both retailer and shopping centre to open several successful new stores. In another example, a company approached the management of a shopping centre to demand a significant rent rebate and lower monthly rental costs, as they perceived a reduction in store traffic. Footpath technology was deployed to demonstrate that traffic to the two adjacent shops had actually improved on the previous year. Sales data also showed higher average spends. These results allowed the management of the shopping centre to sit down with the struggling tenant to discuss how they could help improve sales rather than lowering rental costs.

- **Cost reductions** – Organisations that improve the efficiency of their operations thanks to enhanced business intelligence, or even replace entire departments by AI-based software, can dramatically reduce costs, which is an immediate benefit to their bottom line. This is the case for CogniCor's conflict resolution technology, which is adopted by Telefonica Movistar, one Europe's largest telecom companies, and which enhances its complaint resolution activities achieving cost reductions of up to 70% on operations, and up to 50% on value of refunds.

- **Customer satisfaction** – Faster response and throughput times, fewer redundancies, more accurate information and a more tailored approach can greatly enhance a consumers experience when interacting with an organisation and can generate preferential results for both parties. The subsequent improvement in customer satisfaction can benefit organisations by more returning customers, increased follow-up sales, and positive mouth-to-mouth by transforming a frustrated complainer into a loyal fan. This development is actively being chased by the CogniCor team working at Telefonica Movistar to enhance its complaint resolution activities to achieve increased customer satisfaction.

- **Increased productivity** – Business solutions that employ artificial intelligence are able to reach better decisions in less time, and can increase the level of proactivity throughout an organisation. Also, information repositories that are able to learn from user interactions and improve their understanding of associations between information can facilitate users faster and

more accurately, and even offer unexpected yet useful suggestions on data associations. Accordingly, companies working with QlikView report a 34% employee productivity increase.

Artificial intelligence can be applied in nearly all sectors. It is a horizontal, non-sector-specific trend. Applications developed in one sector often also have significant potential in other sectors. CogniCor's complaint resolution technology is developed with the telecom sector in mind, but could just as well be of benefit for utility companies and airlines. Path Intelligence's Footpath technology was developed for shopping centres, and can be of great value to managers of railway stations and large stadiums. According to QlikTech the business discovery platform QlikView is suitable for all sectors that deal with big data, from banks to pharmaceutical companies.

A system like this is like bio-science computers or evolution computation in that it finds relationships that are not detectable by humans or can be retrieved through statistics. This has been used for predictive medicine and to run clinical trials, but we are also working with Ebay and Vodaphone. – Expertmaker

Nearly 25% of respondents in a survey by the Economist Intelligence Unit indicate they are still learning to manage their data, and that for the most part their data remains untapped[x]. As competitive pressures mount and successful examples of business strategies that incorporate artificial intelligence are spread through-out different industries, demand for artificial intelligence is expected to increase dramatically.

Artificial intelligence involves highly skilled specialists. An increase in demand for artificial intelligence will lead to an increase in demand for skilled labour, particularly for computer scientists and mathematicians. Yet as AI developers aim to have software function in the same way as the human brain, knowledge on how the brain works will become more in demand as well, spurring research in that area.

Artificial intelligence is expected to prove an important economic driver through the impact it has the organisations it is applied to. One of our interviewees went as far as to call it the next enabling technology. From the perspective of European competitiveness, it is promising to see European technology companies developing artificial intelligence applications that are in worldwide demand, opening up sales and support offices in Silicon Valley as well as the BRIC countries. These developments positively affect Europe:

- More demand for high skilled labour, in most companies even with a bias for young technology talent;

- Increased business activity and business revenue and the subsequent spill-over effects and tax revenue;

- Internationalisation of European firms, increasing opportunities for foreign direct investments;

- Inspirational examples of successful firms, spurring entrepreneurship.

The barriers for client uptake

Uptake of artificial intelligence in organisations can be hampered by a number of issues and problems. Examples of these challenges include the long investment horizon of some artificial intelligence innovations, limited under-standing of the potential of the data generated by their organisation, and hesitation towards potentially disruptive technology.

The long investment horizon refers to significant upfront expenditures to which not all returns will be short term. Also, as this technology is cutting-edge, proof-of-concepts and cost-benefit analyses are not easily construed. As a result, companies interested in applying artificial intelligence may postpone or reconsider making any deep investments, especially in the current economic climate. The concept through which Expertmaker looks to diversify itself from competitors by implementing artificial intelligence within their clients' IT environment through a systemic methodology. Although this can deliver far greater value compared the implementation of individual applications or add-ons based on artificial intelligence technology, this also requires a substantial upfront investment that is greater compared to individual apps and add-ons, and the increased value takes longer to materialise. Consequently, Expertmaker has not yet made a profit from its endeavours.

Although it can be quite clear what the benefits are of artificial intelligence technology for big data, not all organisations interested in applying artificial intelligence technology have the full under-standing of how much data they actually generate and collect, and what can be the business intelligence potential of having new and advanced insights from this data. In this sense, the market is not always ready to take up this tech-nology. In the experience of QlikTech, many potential clients

"Most companies have little clue on data potential for their own business. The crux is to keep explaining the benefits of QlikView. We had a customer that decided for us because QlikView would make him more environmentally friendly through what I expect would be an interesting indirect effect, and an odd one." – QlikTech

have limited understanding of the role and possibilities of data for their business, requiring a lot of explanation in order to understand the benefits QlikView technology can bring. In one case, a customer decided to implement QlikView technology on the expectation it would enable his company to operate more environmentally friendly – an effect yet to be observed by the people of QlikTech.

Also, companies looking to benefit from artificial intelligence can prove hesitant towards introducing potentially disruptive technology into their work processes and IT operations, as this might entail new thinking that requires redesign of processes and structures on a fundamental level. Also, from a risk perspective organisations may decide to maintain their current systems to run in parallel, to serve as contingency systems in case new technology will malfunction. With of CogniCor's technology able to replace entire call centre

departments, such considerations come to the forefront of organisations that depend on good customer service. CogniCor experienced that although the potential for positive impact generated by its negotiation technology was significant, potential customers proved hesitant to introduce this technology into their company, as it could pose a technology risk and would require significant organisational change as well.

4. Drivers and obstacles

The development of artificial intelligence for big data in Europe has specific drivers and faces several obstacles. These drivers and obstacles impact both technology companies developing solutions and companies looking to implement artificial intelligence.

Drivers include a highly educated workforce, scalability of developed solutions and public support programmes fostering innovation. Obstacles include the difficulty of attracting funds both when setting up a technology company and when early financiers look to divest, high administrative burdens for small companies, and unfavourable taxation.

4.1. The importance of access to finance

Without exception, the CEOs we interviewed mentioned their company struggled for funds at the time their company was developing its artificial intelligence technology. For most, business angels and venture capitalists offered indispensable lifelines. In general, these are the two most common types of investors in information technology start-ups, and it is not at all easy to convince them of the potential of an innovation.

Although vital to most start-ups, over time these financiers will look to divest as the company develops, eager to pursue

"At the outset it was tough to get funding, with on-going debates around valuations.When you need money, nobody will lend it to you. Now there's 200 million in the bank, everybody wants in." – QlikTech

new investment opportunities. Young companies with plans to expand suddenly find themselves faced with a funding gap often referred to as the 'valley of death', describing a situation wherein a technology company is no longer interesting for angle investors and venture capitalists, and not yet

interesting for long-term investors that have a lower appetite for risk.

In some cases, governments can step in to address this funding gap, often by reducing the funding needs through co-financing mechanisms and by offering guarantees to private financiers (often banks). Path Intelligence and

Expertmaker both enjoyed government-backed bank loans that covered part of their funding needs. However, the CEO of Path Intelligence think banks in the UK are entirely ignorant on technology start-ups and require education, especially since successful IPOs do not occur frequently enough in Europe.

Another way in which these companies address their quest for cash is by offering industrial partners (often potential clients) a stake in their company. Industrial partners tend to better understand the potential of artificial technology than most investors. Viewing this as an opportunity to fund the development of an interesting product without financing the entire development, these larger organisations acquire a minority stake in the technology company, providing a much-welcomes capital injection. Expertmaker and CogniCor both entered into this type of collaboration with industrial partners. Table 3 provides an overview of the source of funding for the companies reviewed for this case report.

"We've had more success with industrial investors that understand this technology from their own business. When they have a strategic roadmap that includes this technology, we can be successful with them. Much more than with financially oriented investors." – Expertmaker

Table 3: Source of funding for company cases

Company	Source of funding
Path Intelligence	Angle investors to fund the prototype, followed by a government-backed bank loan and a venture capital injection
QlikTech	A relatively small amount of European venture capital at first, and larger amounts of American venture capital to expand the company
Expertmaker	Angle investors, investments from industrial partners, government-backed soft bank loans
CogniCor	Government funding through the Youth Entrepreneurial Programme, funding from the Wayra incubator network, angle investments, investments from industrial partners acquiring a stake in the company

4.2. Artificial intelligence, a knowledge-intensive industry

Artificial intelligence technology companies often are founded in areas close to a university and in proximity to other technology companies (Table 4). CogniCor is based in Barcelona, the location of the organisation it was spun-out from. QlikTech and Expertmaker both are located near Lund, a technology region that is home to the Lund Institute of Technology as well as companies such as Ericsson and Sony. Path Intelligence is established in Portsmouth, close to the University of Portsmouth (previously known as Portsmouth Polytechnic) and home to the headquarters of both IBM Europe and the bulk of the British defence industry.

Both QlikTech and Expertmaker have chosen to open up sales and support offices near their clients. For Expertmaker, this meant opening up an office in San Francisco, close to their client base in Silicon Valley. QlikTech has opened up offices in every country its clients are located. However, both companies have chosen to keep their R&D activities in Sweden, near Lund, stating that on-going cooperation with the university is of key interest to them. Companies developing artificial intelligence value the importance of proximity to both a technical university and other technology companies.

"We're located in an area with a good and growing technology scene. Good interaction with the university has been key. We've established an open door policy both ways, exchanging experiences. We've been very keen on working with universities, running seminars, wanting to listen in."
– Expertmaker

Table 4: Regional industrial factors for company cases

Company	Industrial framework conditions
Path Intelligence	Set up in Portsmouth, sourcing the necessary talent from the University of Portsmouth (previously known as Portsmouth Polytechnic), London and abroad. The bulk of the British defence industry is located in the area, as well as IBM. Now also has offices in London, New York and San Francisco.
QlikTech	Started out on a science park in Lund (Sweden) near the Lund Institute of Technology as well as other technology companies including Sony and Ericsson, where they benefited from an educated workforce and the presence of a vibrant engineering community. When penetrating markets abroad, QlikTech establishes a physical sales and support presence locally.
Expertmaker	Founded in a technology-rich area near Lund and Malmö in Sweden and still performs its development activities there, drawing talent from local universities. Their sales and support office is located in San Francisco, home to their client base.

CogniCor	As CogniCor is spun-out of the Artificial Intelligence Research Institute of the Spanish National Research Council and has ties to the Autonomous University of Barcelona, CogniCor is located in Barcelona, Spain. It has recently opened up an office in India to benefit from IT talent there.

4.3. Scalability and applicability to different markets

A start up in any industry will benefit from the local presence of a critical mass of consumers, an easy exchange of goods and services, opportunities for collaboration as well as competition, and a regulatory environment that makes running a business not overly complicated. Although initially benefitting from the local presence of other technology companies, artificial intelligence companies are quick to introduce their products abroad (Table 5).

Table 5: Market distributions for company cases

Company	Target markets
Path Intelligence	Started out at a local shopping centre and now operates in 12 countries.
QlikTech	Started selling to a handful of interested technology companies in the Lund area, and now sells to 28.000 customers in 100 countries.
Expertmaker	Has moved their sales and support office to San Francisco to be in close proximity to their e-commerce clients. Expertmaker technology can be made applicable to a wide range of sectors, including life science research.
CogniCor	Currently used in the telecom industry, CogniCor's technology can be of value for any client facing organisation, and expansion is foreseen to the utilities sector and within e-commerce.

All four reviewed companies adopted an international focus early on. Path Intelligence started out at a local shopping centre and now operates in shopping centres, railway stations and stadiums in 12 countries. Expertmaker moved their sales office to San Francisco to be near the e-commerce companies in Silicon Valley, looking to broaden their scope to companies in pharmaceutical and life science research. QlikTech sells to customers in 100 countries and aims to have a sales office in each one. CogniCor is in an early stage, but already foresees expansion to other sectors on an international level.

4.4. Entrepreneurial culture and a skilled labour force

The cultural dimension of a region's business environment refers to the set of shared attitudes, values, goals and practices in the region, an entrepreneurial culture or even a strong regional labour force with qualified workers for a range of skills. The CEOs in this case all professed to benefit from the highly skilled university graduates delivered in their area, which is of vital importance for artificial intelligence companies.

In Barcelona however, no start-up culture existed, to the lament of CogniCor's CEO, with limited opportunities for networking, sharing of ideas or meeting potential investors. Consequently the vast majority of start-ups fail to come to fruition. Organisations such as Microsoft and Wayra have stepped in to offer some relief, but are selective in what start-ups to support. On the other hand, the quality of researchers and engineers in Barcelona is considered quite high and rather cost-effective, partly due to the natural draw that Barcelona has on young and ambitious people, which for CogniCor was an important factor to stay in Barcelona.

"I felt kind of all alone. There was no support in terms of business development. I was a researcher and new to the business world. I lacked a good network of start-ups and felt clueless, with no advisors. I made a lot of mistakes and wasted a lot of time."
– CogniCor

The two Swedish companies, Expertmaker and QlikTech, value the technology scene in their area and have regularly recruited from local academia. They herald the dynamic entrepreneurial culture that has emerged from Lund to Copenhagen (DK) in the past 15 years, with successful technology companies making headlines and venture capitalists generating a good return on investments.

4.5. Public support that helps drive the trend

Governments can support the development and success of European artificial intelligence companies, through measures that improve a young company's access to finance, to trainings, to business or legal advice, as well as through measures that boost knowledge transfer and internationalisation. The companies interviewed benefited from support measures such as soft loans and small research grants, yet clearly point to areas of improvement.

In Spain, the Catalonian government provides the youth entrepreneurial programme Barcelona Activa, which can sustain start-ups in their first year. Also, a co-financing mechanism can help young companies obtain private funds.

The Swedish government has established a revolving fund that provides mezzanine funding and equity investment to promising innovative companies, which has helped QlikTech. Expertmaker has benefited from the bank loans guaranteed by the Swedish government, which allowed them to borrow from banks that normally would consider them unfit for the bank's risk profile.

In the UK, Path Intelligence received a grant to cooperate with University of Portsmouth. However, this grant did not offer room for the flexibility required by Path Intelligence to develop their technology. Moreover, it appears to be hard for start-ups in the UK to benefit from government support schemes. There is very limited support for the development of prototypes, and existing grants are easier to access by large companies than by small ones, due to minimum requirements for revenue and headcount, as well as administrative requirements that pose a burden for small companies.

One of our earliest investors was a mezzanine financing and equity investor funded by the government. They had no intention of getting the money back, investing in incubators and re-investing any profits. The story with us was that they lent us 2 million euro. When time came to repay the loan, there was no money. We suggested to convert the loan into equity in conjunction with a funding round among Swedish investors and they agreed. They exited 125 million euro, which is their biggest success so far."
– QlikTech

Tax systems appear to be an obstacle for artificial intelligence companies. Start-ups can put any funds they manage to acquire to good use for the development of their technology, and could benefit from a tax holiday in their first few years. Also, start-ups would like to be able to design incentive schemes for their personnel, rewarding them with options or a direct stake in the company, yet national tax systems in Europe are set up in a way that makes this not at all worthwhile.

If you work in Sweden it is hard to have incentive packages that make any sense. You can't work American style where you give options etcetera, you'll get hammered by the tax authorities. I'd love to say: you're not making top dollar here, but if we're successful every body will be happy financially, but the tax system is not geared to this."
– Expertmaker

Another obstacle is posed by employment regulations and immigration policy. Hiring talent is difficult due to stringent labour regulations. Hiring talent from outside of Europe is even more cumbersome and often expensive. According to the CEOs, an ecosystem that fosters innovation should be open to highly talented workers. The support measures that the interviewed companies benefited from are listed in (Table 6).

Table 6: Support Measures for Company Cases

Company	Region	Regional Support Measures Enjoyed
Path Intelligence	UK	Small research grant to work with universities. Government-backed bank loan. Some advice from the UK Trade & Investment government agency.
QlikTech	Sweden	Mezzanine financing and equity investment by the Industry Fund, a revolving fund set up by the Swedish government
Expertmaker	Sweden	Government-backed bank loans. Non-financial support from Invest Sweden, a government agency promoting business and investment opportunities in Sweden to foreign investors, which introduced Expertmaker in Silicon Valley
CogniCor	Spain	Youth entrepreneurial programme Barcelona Activa

5. Policy recommendations

Uptake of artificial intelligence can benefit European companies as well as the EU economy and labour market, as the development and management of artificial intelligence requires highly skilled workers in a multitude of fields. However, CEOs of technology companies have named several obstacles that could be addressed by government policy.

5.1. Policy gap analysis

Concerning the development of artificial intelligence companies, there is a lot of encouragement yet to be offered by governments in Europe. Gaps in policy are noted in funding support, tax systems, immigration policy, employment regulation, university-industry interaction, mentorships, and international patents.

- **Access to funding** – Artificial intelligence technology companies face difficulties finding early stage funds for researching their technology and developing prototypes, and suffer the 'valley of death' when early investors opt to divest while long-term investors remain disinclined to take on the risk.

- **Tax system that promotes innovation** – Early-stage start-ups find the tax burden heavy, and could benefit from tax holidays to focus their scarce funds on technological development. Similarly, they would like to have more possibilities to reward their staff with equity without negative fiscal consequences.

- **Public procurement of innovation** – As artificial intelligence technology is cutting-edge, proof-of-concepts and cost-benefit analyses are not easily construed, which can lead to interested companies to postpone or reconsider making any deep investments, especially in the current economic climate. Public procurement of innovation could provide for proof-of-concepts and show good practices to incorporate in cost-benefit analyses.

- **Immigration policy** – As these technology companies require highly skilled talent, they would benefit from an immigration policy that is more welcoming to non-European talent and less cumbersome for entrepreneurs looking to hire them.

- **Employment regulation** – It can be rather cumbersome to hire staff, especially for small start-up companies that have little experience in hiring processes and even less time to work out the administrative minutiae.

- **University-industry interaction** – European academics don not always understand industry. Technology start-ups at times find them isolated in academia, unconcerned with industrial exposure. A good amount of interesting research findings and technological development is believed to not make it out of universities.

- **Mentorships** – Guidance and advice from experienced entrepreneurs is in invaluable for technology start-ups that often do not think big enough or have not defined precisely enough why they run a business. Experienced entrepreneurs are thought to be able to have a big inspirational role for those that start small technology companies.

- **International patents** – Artificial intelligence technology companies find themselves involved in international patent environments that feature actors that use patent law to obtain technological information and engage in legal battles.

European governments can have a positive impact on the promotion of artificial intelligence as a European technology trend.

5.2. Promoting the uptake of the trend across the EU

European governments can address these policy gaps by improving access to funding, reforming tax systems to promote innovation, reforming immigration policy, fostering administrative simplification, reforming employment regulation, encouraging university-industry interaction, encouraging mentorships, and discussing international patents.

- **Improving access to funding** – European governments can improve the access to funding of young technology organisations by making it less difficult to obtain funds for early-stage technological development through seed funds and R&D grants; addressing the 'valley of death' through soft-loan guarantees, risk-sharing facilities, co-financing mechanisms, revolving innovation funds, intermediary bodies promoting private lending, and direct financing of debt or equity.

- **Reforming tax systems to promote innovation** – Tax reform to promote innovation can be targeted to improve liquidity of technology start-ups by offering them a tax holiday or the possibility of deferred taxation. Also, reform could be targeted to facilitate risk sharing between entrepreneurs and their staff.

- **Public procurement of innovation** – Public procurement of innovation could provide for proof-of-concepts and show good practices to incorporate in cost-benefit analyses, allowing private companies to make better-informed investment decisions when gauging the potential of applying artificial intelligence technology to their organisation.

- **Reforming immigration policy –** Immigration policy reform can make it less cumbersome for entrepreneurs to attract talent from outside of the EU. Currently,

entrepreneurs face a heavy administrative burden when hiring non-EU talent, and non-EU talent can face uncertainty concerning their legal status.

- **Fostering administrative simplification** – A "tell us once" principle that enables companies to submit information to a single public administration, tasked to then pass on this information to other administrative bodies. In addition, finding ways to reduce the administrative burden should be considered, as start-ups with their small number of employees can rarely dedicate the necessary amounts of time required to fulfil their administrative obligations for public support. Rules seem written for large companies, and are tough for small companies.

- **Reforming employment regulation** –Employment regulation reform can be targeted at reducing the administrative burden for entrepreneurs and small business start-ups, encouraging administrative simplification and removing redundant and conflicting regulations. If entrepreneurs could hire people from around the world without keeping track of the many different social security systems, it would simplify things tremendously.

- **Encouraging university-industry interaction** – University-industry interaction can be encouraged by reforming the job of university professors to include working with industry and start-ups, encouraging them to acquire shares and serve as board members of young technology companies.

- **Encouraging mentorships** – Mentorships could be encouraged by having existing intermediary bodies deploy mentorship programmes and matchmaking activities, making sure to attract experienced mentors from business that can serve as inspiring advisors to budding entrepreneurs.

- **Discussing international patents** – European governments can re-engage in international discussions on international patents to improve the protection of innovations.

6. Appendix

6.1. Interviews

Company	Name	Designation
Path Intelligence	Sharon Biggar	CEO
QlikTech	Lars Björk	CEO
Expertmaker	Gustaf Sahlman	CEO
CogniCor	Sindhu Joseph	CEO

6.2. Websites

Path Intelligence	http://www.pathintelligence.com/
QlikTech	http://www.qlikview.com
Expertmaker	http://www.expertmaker.com
CogniCor	http://www.cognicor.com/

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