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Swedish IndTech

A survey of the technology, the market, and Sweden's position within the supply industry for industrial digitalization.

The estimates for the Swedish-market presented in this report are derived from a project for which Mälardalen University contributed to the analysis. We would therefore like to give special thanks to Henrik Christensson, Björn Holmdahl and Henrik Halvarsson.

About PiiA

Process Industrial IT and Automation (PiiA) is a strategic innovation program that aims to guide the industrial sector into collaborations where new technologies can be tested and new ways of working developed. PiiA is also involved in the study of wider trends and the sharing of useful case studies from its own portfolio as well as lessons learned from other countries and initiatives.

About Automation Region

Automation Region is an independent centre of excellence for automation and digitalization that brings together companies, researchers, authorities and investors to make the Swedish industrial sector smarter.

About Blue Institute

Blue Institute is an independent research institute that helps individuals and organizations to understand and shape their future. We believe that learning and knowledge can be increased through dialogues in which participants are both anchored to their unique situations and open to benefit from other perspectives. We create environments where individuals can meet, lead processes, and undertake different types of analysis work, ultimately producing better decisions.

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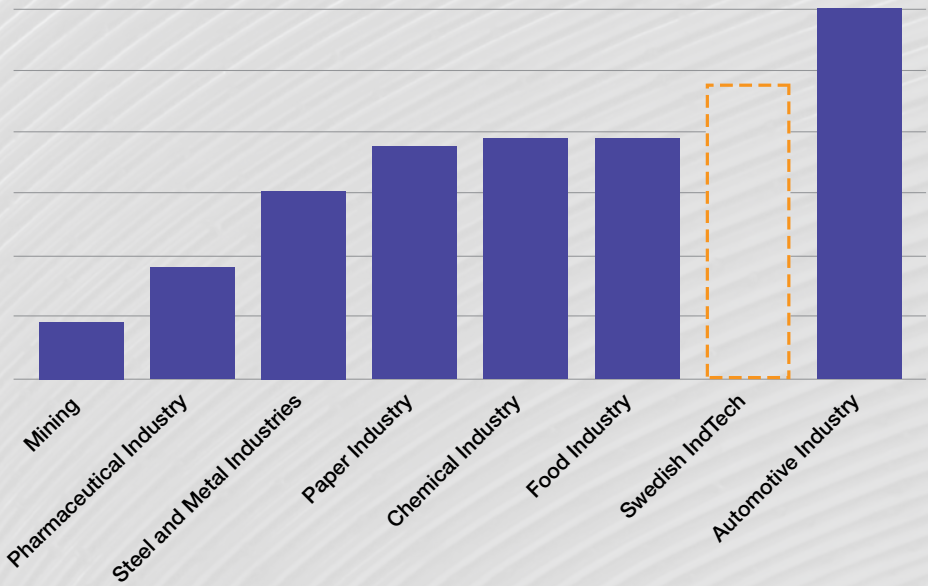


Swedish technology companies' estimated turnover of industrial digitalization technology compared with that of large traditional industries.

Foreword

Sweden’s export of technology is an ongoing and resounding success, within which IndTech is a quiet achiever. We want to change that.

The export of industrial technology is a cornerstone of Sweden's economy with a century-long history. With the industrial sector now undergoing digitalization, its traditions are evolving and a new market system is emerging. Hundreds of small and medium-sized technology companies are now rubbing shoulders with leading suppliers such as ABB (industry and power technology), Ericsson (5G /IoT) and SAAB (security).

Sweden’s industrial digitalization sector has a turnover of SEK 105 billion. If we expand its definition to take in the increasingly digital content produced by machine suppliers such as Alfa Laval, Atlas Copco, Epiroc, Volvo CE, Sandvik and TetraPak as well as the work of consulting services, the figure is much higher at SEK 238 billion. To put it another way, the Swedish IndTech industry is comparable with traditional core industries, although in many cases it is experiencing greater growth and profitability.

IndTech can be characterized as innovation-driven structural transformation occurring hand in hand with increasing demand. Dynamic market conditions facilitating growth are providing opportunities, and Sweden's open-trade economy coupled with our world-class industrial sector means that we have a distinct advantage on the IndTech market. The country’s vibrant start-up movement is meeting a need for the increased use of AI and internet tools and promises both renewal and future growth. By collaborating to develop the sector, Sweden's primary industries are also gaining a decisive advantage and putting themselves ahead of the curve, while technology suppliers are producing products for a world market with an estimated value of SEK 3.5 trillion. In other words, Swedish IndTech has great potential to be a win-win proposition.

The purpose of this survey of the Swedish and global IndTech industry is to provide clarity around the sector while increasing its visibility. Sweden’s export of technology is an ongoing and resounding success, within which IndTech is a quiet achiever. And it’s time that people knew about it!

Västerås, April 2021

Catarina Berglund
Automation Region

Benjamin Ståhl
Blue Institute

Peter Wallin
PiiA

Introduction

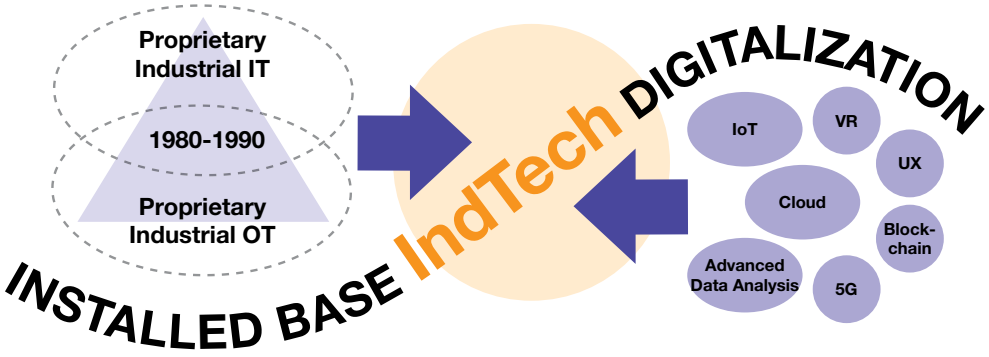


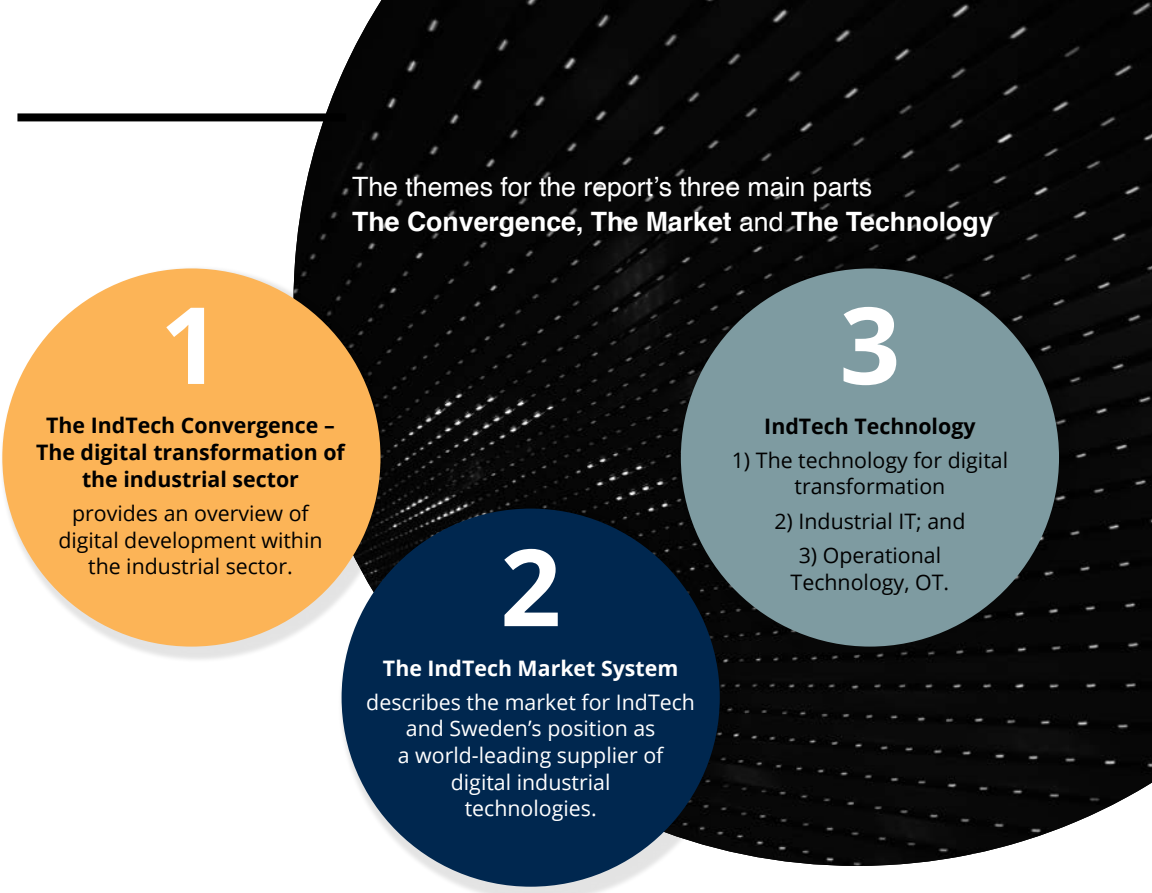
Figure 1: IndTech is a convergence between 1980s-1990s technology in the form of the industrial sector's installed base and modern digitalization including clouds, IoT, and AI.

The industrial sector is in transition. Powerful forces are coming together and creating a new industrial paradigm within which sustainable energy systems and industrial processes that reuse and develop new materials and production methods are fundamental driving forces. Digitalization is making it possible to develop new production technologies and is changing the way people and organizations collaborate, develop, and do business. All this is changing business models and our underlying financial system.

This report focuses on the digital changes now affecting how industrial companies develop, produce, reach the market and manage assets. We call this approach 'IndTech', and it is based on the understanding that IT and production systems are digitally merging. This development suits Sweden very well, given that it is a world-leading industrial nation with an extremely solid foundation on which to build. What's more, digital efficiency is a prerequisite for continued growth and prosperity for our society.

The starting point from which the industrial sector is digitalizing is an installed base of 1990s technology. This applies to both automation and industrial IT, where the value of the installations around the world is estimated to be SEK 50 trillion. (Blue Institute and PiiA, AI & Digital Platforms, 2019). Within the industrial sector, the service life of technological tools is often determined by the availability of servicing and spare parts or the need for major rebuilds. Unlike consumer industries, industrial technology is not replaced when "a new model is launched"; stable production is key. In practice, this means that existing structures tend to have long lifespans, gradually needing to be supplemented over time with open digital solutions and standards.

A scenario is emerging within which things such as cloud services, IoT/IIoT and advanced data analysis are becoming important tools for combining existing equipment with modern digitalization. These platforms are crucial for the future and the manufacturing industry needs to have good



strategies in place to allow for such investments.

Suppliers, technologies, organizations and cultures from a wide variety of areas are all coming together in the open market in a new dynamic that is also reshaping the marketplaces for IT, automation, telecommunications and digital technology.

The themes for this report's three main parts are The Convergence, The Market and The Technology. **The first part**, *IndTech Convergence - The digital transformation of the industrial sector* provides an overview of the digital development of the industrial sector. **The second part,** *IndTech Market System,* describes the market for IndTech and Sweden's position as a leading global supplier of digital industrial technology. **The third part,** *IndTech Technology*, provides an overview of three key technology areas, namely:

1) The technology of digital transformation;
2) Industrial IT; and
3) Operational Technology (OT)

You can find additional information to deepen your knowledge of the different parts in appendices 1 and 2.

The comprehensive market analysis within this report is unique, even within the international arena. This has required us to construct a new framework for references and data sources that, in some cases, have proved to be contradictory, with different definitions encountered for the very same concept. Taking stock of all the suppliers of technology in the world and their output has created uncertainties. We have tried to address these by cross-referencing additional sources in the same area and then trying to assess suitability and create average values. That said, market analyses are not an exact science. However, we believe we have achieved our goal of providing an overview defining the boundaries of what IndTech is – and what it is not.

Definitions and limitations

1 The market analysis in the study is, generally speaking, limited to catalogued IndTech products which are based on hardware or system software, or combinations thereof.

2 An IndTech product is defined by its ability to collect data and/or algorithmize, calculate and/or use the results to influence, monitor, or optimize processes that contribute to industrial value adding.

3 Most standard products require customization via equipment installations and software development, and these processes can range from the simple to the very complex. Later on in the life cycle of equipment, the need for service and maintenance arises. All this represents a great value proposition for systems and machine suppliers, consultants and service companies. Services and custom systems belong to the IndTech area when viewed as part of the overall market, but there are significant demarcation problems and challenges around drawing comparisons domestically and internationally. Therefore, with the exception of point 5 we do not include these areas in this study.

4 This analysis, in line with our definitions, looks at suppliers across the world, while providing a separate account of the overall global market share held by Swedish companies. It also takes in the growing number of standard software as cloud services. For clarity, all market data is consolidated into the IT and OT sections. These, in turn, consist of a total of 15 subordinate branches of technology, which are reported separately for in-depth studies in appendices 1 and 2

5 As an exception to the above limitations, the analysis in Part 2 is supplemented by estimates of the digital system technology component of Swedish machinery and service exports. This is to give an overall picture of the Swedish IndTech industry, albeit one with a higher degree of uncertainty.

Examples of sources for our global market analysis:
Allied Market Research, Credit Suisse, Fortune Business Insights, Frost and Sullivan, Gartner, Global Industry Analysts, Grand View Research, Industry Arc, Interact Analysis, International Federation of Robotics, IoT Analytics, Market Data Forecast, Market Watch, Markets & Markets, Master Fox Consulting, McKinsey, Mordor Intelligence, Oliver Wyman, Research and Markets, Statista, Swira, Transparency Market Research, UpKeep

Part 1. The convergence

The digital transformation of the industrial sector.

IndTech involves technologies from different fields and time periods coming together and changing operating conditions for the industrial sector, enabled by digital transformation. The word digitalization usually refers to combinations of mobility, clouds, platforms, social interaction, the Internet of Things, AI and large amounts of data.

IndTech - The basics

IndTech is a three-way convergence between the operational production technology (OT) used by the industrial sector, the industrial IT segment, and (new) digital development. Both industrial OT and IT have their roots in early computerization in the 1970s and both areas are now being influenced by digital technologies, such as cloud services, IoTs and advanced data analysis. More efficient vertical information exchange between the OT and IT levels of the industrial sector has the potential to unlock value through better integration. Increased data exchange in value chains, meanwhile, is increasing efficiency between companies and the entire industrial system. Additionally, the amount of data involved is creating opportunities for new business models and organizational forms. Such change is usually collectively referred to as the Fourth Industrial Revolution (Industry 4.0) or the digital transformation of industry.

> IndTech involves technologies from different fields and time periods coming together and changing operating conditions for the industrial sector, enabled by digital transformation.

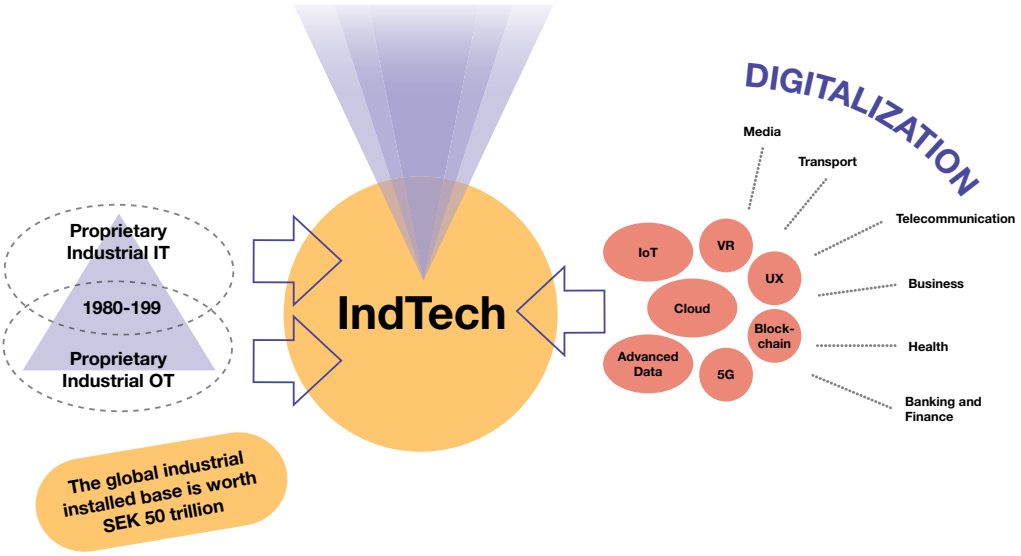


Figure 2: The IndTech Model: Traditional automation and IT, often proprietary with roots in the 1980s and 90s, meets new digital technologies that provide development opportunities within a world market worth over USD 400 billion. Digital solutions often have completely different origins to industrial ones; media, trade, and banking/finance were in the earlier wave of digital transition.

The ideas behind IndTech took shape as early as the beginning of the 2010s. This is when Blue Institute (and later the strategic innovation program PiiA) began to combine practical innovation development within the field with systematic feedback of knowledge-building in the industrial sector. By autumn 2018, the subject had crystallised enough for us to publish the *Swedish IndTech 2018* report.

When it comes to real, practical use in the industrial sector, IndTech differs from digitalization models that have a complete reinvention of the sector as their starting point. In the western world, greenfield-type projects are rare, whereas brownfield projects are far more common. For proponents of reinvention, the large installed base of older but well-functioning technology is seen to be limiting the pace of digitalization. But this installed base of IT and computerized automation technology can also be seen as an expression of the accumulated knowledge behind Sweden's industrial successes. In most respects, Sweden's current export successes are based on production methods that are highly computerized and data-driven, and which, when properly utilized, can effectively blaze a trail for digital change.

IndTech also sets itself apart by specifically addressing the market system behind the technology, as this is crucial for development. The companies and institutions that develop and manufacture IndTech technology operate in a world market worth over USD 400 billion. It's a market which is also growing significantly faster than the industrial sector average and it's one in which Sweden has an unusually strong position. We also count a strong academic element as an important part of the market system, with basic and applied research a basic requirement for suppliers aiming to develop competitive products.

So, IndTech effectively involves technology from different fields and time periods coming together and changing operating conditions for the industrial sector through the enablement of *digital transformation*. The word *digitalization* usually refers to combinations of mobility, clouds, platforms, social interaction, the Internet of Things, AI, and large amounts of data. *Industrial IT* encompasses a market for product development support, resource management, production, business and administration of maintenance, and fixed assets, which has been growing since the 1970s. Meanwhile, operational technology (OT) whose roots also lie in the in the 1970s with microcomputers, takes in installations on factory floors with control systems, sensors, actuators, drive and electrical systems, instrumentation, and robots.

The reasons for the convergence of the three fields are strong. System integration, advanced analysis, and increased automation can provide efficiency improvements worth billions of crowns every year (PiiA and Blue Institute, AI & Digital Platforms, 2019). At the same time, the digital solutions driving change have mostly been developed outside the industrial sector. Sectors such as media, trade, and finance have been at the forefront of digitalization and IndTech, creating challenges for adopting it in completely different sectors. Nevertheless, it is the *opportunities* created by these circumstances that will accelerate innovation systems and technical standardization, transforming the industrial sector worldwide.

DX is the current abbreviation for digital transformation used by both suppliers and other organizations. "DX is the integration of digital technology into all areas of a business, fundamentally changing how you operate and deliver value to customers. It's also a cultural change that requires organizations to continually challenge the status quo,experiment, and get comfortable with failure. "

CIO-Wiki

In a simple sense, the three fields featured in Figure 3 can be described as verticals that cross existing IT and OT domains, enabling old and new to be gradually integrated and fulfilling the prerequisites for digital transformation. ***These verticals are collectively called digital transformation technology, or DX technology***

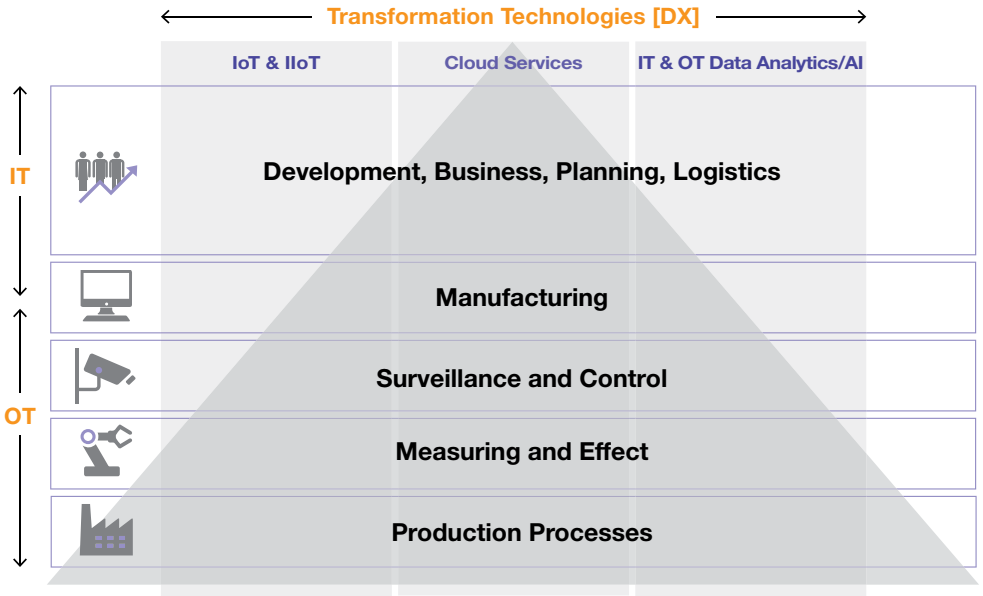


Figure 3: A diagram of the automation pyramid featuring the areas covered in this report. Development can be summarized as integration in vertical and horizontal directions. The illustration shows the three verticals of integration technology forming a digital platform capable of combining old and new builds, allowing for step-by-step modernization and digital-transformation consolidations. In short, DX.

> That such hierarchies need to be dissolved to make way for more flexible arrangements has long been discussed...

Time to tear down the pyramids

IT and automation within the industrial sector are often described using hierarchical information models. The so-called 'automation pyramid' model is described and supported by the ISA-95 standard. Within the model, IT for business support ranks above OT, which is closely connected to production.

That such hierarchies need to be dissolved to make way for more flexible arrangements has long been discussed, and radical proposals abound. However, the industrial sector's large installed base of older but well-functioning technologies means that gradual change is on the whole more likely than sudden sweeping changes. In the short term, the focus is therefore on eliminating information silos through practical integration between computers, organizations and companies. In the long run, interoperability with complete interchangeability of information based on accepted industry standards can be foreseen.

Digitally integrated production and business concepts along with organizational models present the industrial sector with an opportunity to address challenges around increasing resource scarcity, climate and environmental threats. Other technological shifts throughout history have demonstrated the importance of being prepared, with an ability to convert and adapt being rewarded with competitive advantages. The goal in the current situation is to unite existing IT/OT structures within concepts that provide the opportunity to:

1) have digital capacity cost-effectively delivered as, for example, cloud services; and
2) use IoT for data collection and as a future application platform; and
3) apply advanced data analysis techniques, including AI, for automation, optimization, and creating collaboration strategies between humans and machines.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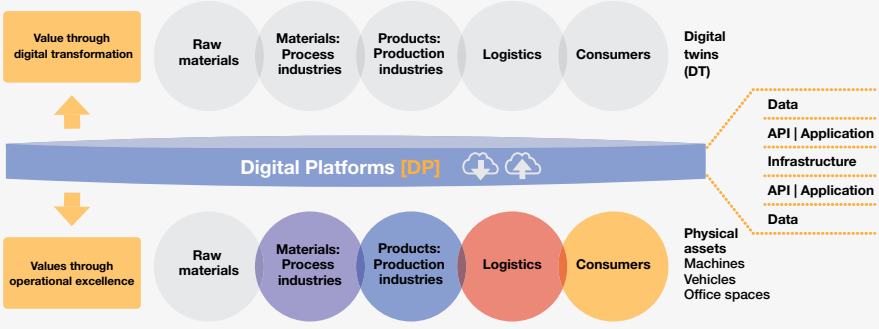
ONLINE
ONLINE
ONLINE


Value through digital transformation
Raw materials
Materials: Process industries
Products: Production industries
Logistics
Consumers
Digital twins (DT)
Data
API | Application
Infrastructure
API | Application
Data
Digital Platforms [DP]
Values through operational excellence
Raw materials
Materials: Process industries
Products: Production industries
Logistics
Consumers
Physical assets
Machines
Vehicles
Office spaces

Digital transformation

The industrial sector's value chains are built around adding value to materials and these need physical maintenance in order to last over time. Seen from a *digital* perspective, it is *data flows* through these value systems, over time and through space, that add new value. One way of defining *digitalization* is actually the free, value-creating flow of information and data. Since computerization started in the 1970s, this has provided the basis for everyday functional support for operations, business, and maintenance. What is now changing is the importance of data for organizational and relationship models based on networks and metaphors from the natural ecosystems. Products are being digitalised, while new business models are being supplemented with value-creating data-delivery services. The connections between production and product data are increasing as requirements for product variants and customer adaptation increases. This also applies to raw materials and base materials where supplied production data describing properties can increase the value added further down the chain, and vice versa.

Figure 4: Industrial digitalization as seen from a systems perspective, with a bottom layer of physical assets for which efficiency is achieved via automation and optimization. Digital twins (top) will eventually reflect complete real-world value chains and thus approach the vision of achieving self-organization. The real value chain, like the digital twin, depends on the data-bearing platform in the middle of the illustration.

> The links between production and product data increase in importance as the requirements for product variants and customer adaptation increase.

Data already plays a crucial role driving industrial efficiency, but the bar can be raised further still through the use of more data, better organisation, and new methods. Given sufficient data and computing power, dynamic models of operations, machines, and products can be created. Real-time models located on digital platforms are also called Digital twins (DTs) and can be used to develop services and business models. Digital twins are already important instruments for planning, design and collaboration.

Digital platforms, as shown in the middle of Figure 4, are infrastructural functions needed to collect, store, refine, and distribute data. In practice, 'one' digital platform usually consists of complexes of platforms adapted for different tasks and provided by different companies and organizations.

In summary, *data* is the key word for digitalization. Platforms ensure that information is collected, calculated, modelled, and used for business support and automation. Model-based digital twins can predict what will happen, and in this way provide a basis for new forms of business and business development. When all this happens at the same time, with organizations and business models adapted to the new conditions, what we call *'digital transformation'* of the industry takes place.

How far have we come?

The industrial sector has come a long way in terms of digitalization and is, for the most past, in its second phase. The third phase involves very rapid development and major impacts on the sector from digital transformation.

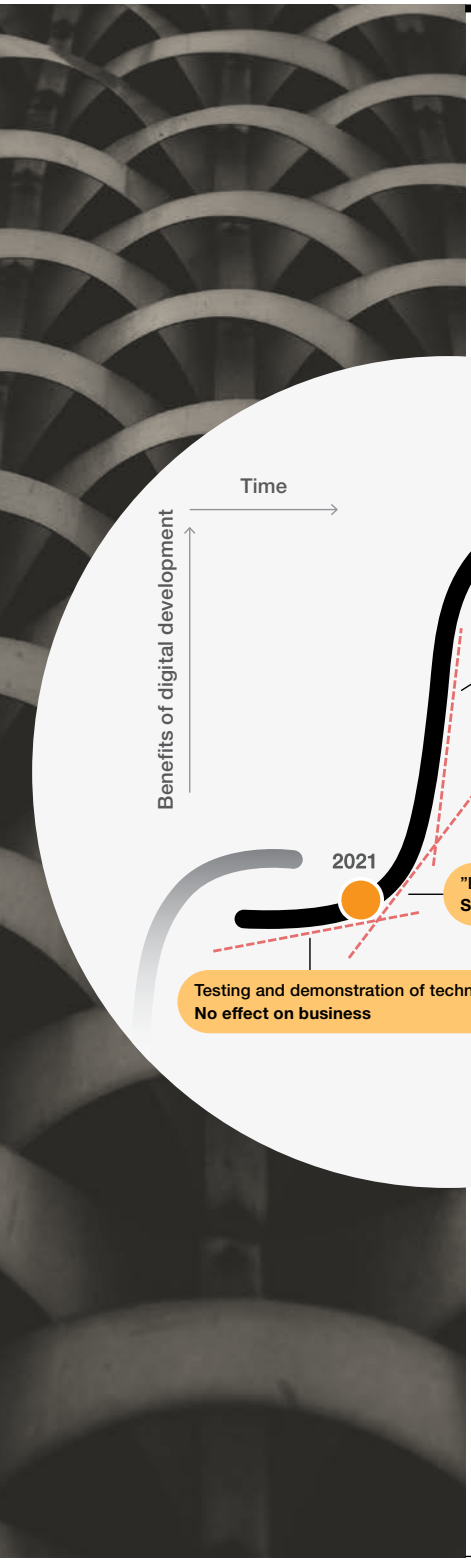


Figure 5: The S-curve depicts the digital development of the industrial sector. This is divided into three phases, starting with testing and demonstration, followed by companies striving to find business models. The third phase involves very rapid development and major impacts on the sector from digital transformation.

The S-curve is a model used to illustrate how new innovations create markets. In our case, we use it to describe the cumulative development of the digitalization of the industrial sector in three phases. In the first phase, the sector leaves an earlier paradigm shown in the figure by the end of the preceding S-curve and the beginning of a new one. The first phase begins with testing and demonstration of digital technology and new systems. In 2021, digitalization of the industrial sector has in general terms reached the second phase within which the sector begins looking for ways of applying new technological possibilities. We call that phase ‘in search of best practice’.

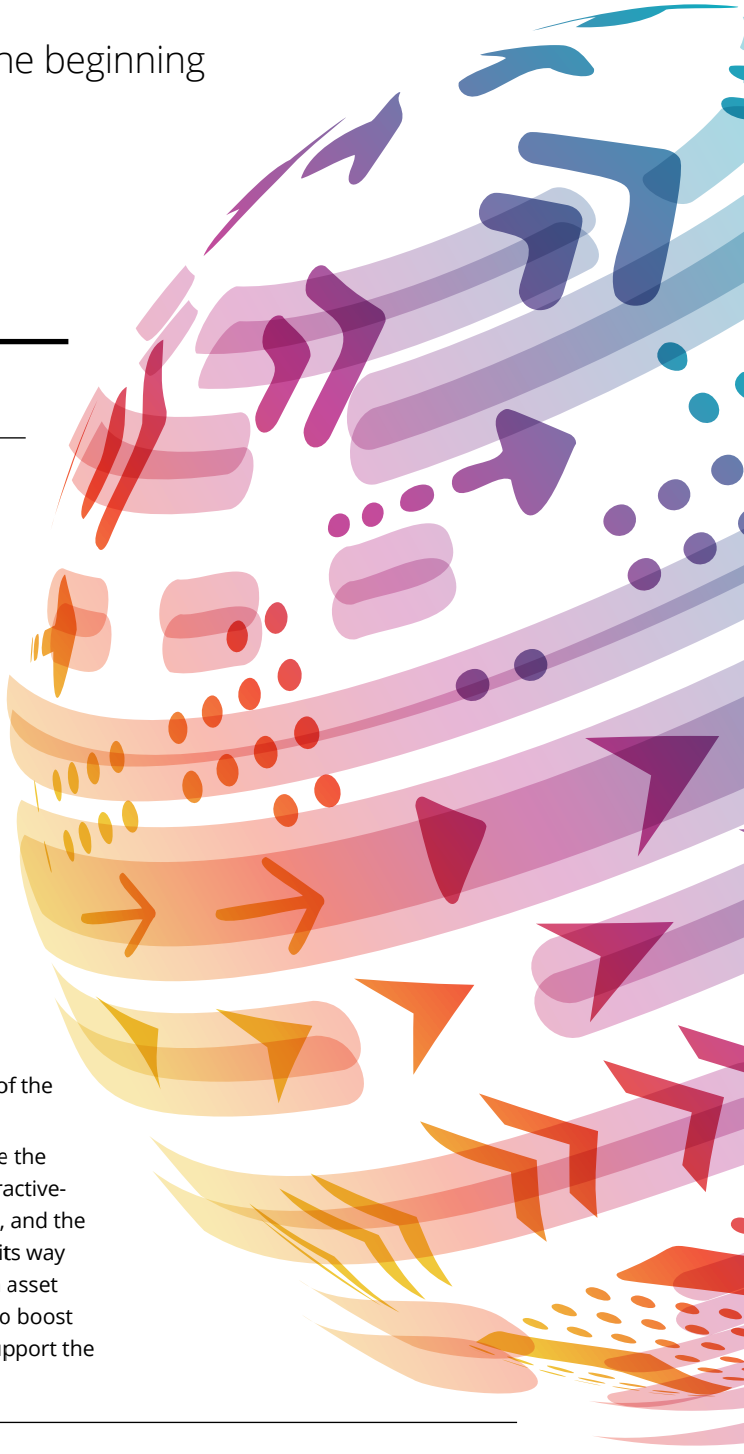
Up until now, this new, digital value-adding has not delivered any major financial returns; that will come in the third phase. In the steep part of the curve, development is rapid and affects both organizations, processes and relationships. This leads us to new ways of producing and doing business, with major business impacts due to digital transformation.

Part 2. The market

and how it is changing

Global prosperity is continuing to grow, presenting the industrial sector with resource and sustainability challenges. This requires the development of processes for raw materials, material production and production/assembly.

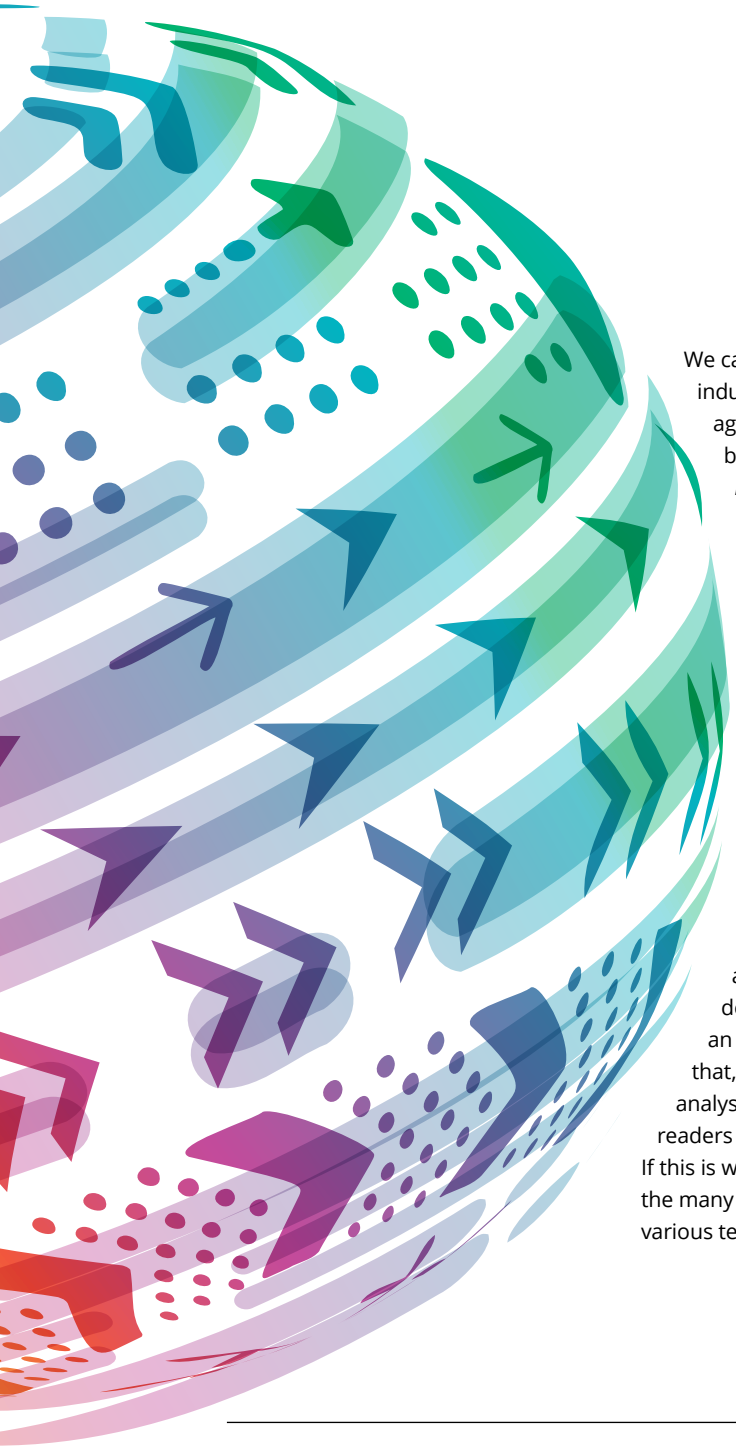
"... we are still only at the beginning of development.



IndTech in Sweden and the World

A key part of what IndTech delivers is insights into the system behind the supply of digital industrial technology. This might be described as the innovation system that allows for collaboration between the market (the industrial sector and industrial suppliers), knowledge accumulation from academia/institutes, and supportive public initiatives. In this context, knowledge of the market is a basic prerequisite for developing priorities that will facilitate sustainable industrial growth. To date, the global innovation system has invested around SEK 1.5 trillion (Blue Institute and PiiA, AI and Digital Platforms, 2019) per year in digital technologies for use by the industrial sector, but we are still at the beginning of the development.

In Sweden, we need to continue to make the right policy decisions to develop the attractiveness of the segment, the supply of skills, and the rules of play. Yet, *Swedish IndTech* is on its way to becoming a recognised brand and an asset worth managing well. It has the power to boost business start-ups nationwide and to support the export of advanced technologies.



We can do this by providing the Swedish industrial sector with insights that encourage investment, and by investing in building knowledge within the field. *Mälardalen University's* AI-oriented postgraduate education stream, *IndTech Research Academy*, is a leader in this respect. The capital market needs to better understand the sector and its development potential so that it can allocate more resources. Suppliers, meanwhile, can also make better decisions if they have a higher level of knowledge of the market in which they are involved.

In this part of the report, our aim is to share market analyses and provide an overview of IndTech's characteristics, size, and dynamics, while proposing a definition framework. Our goal is to develop a knowledge base that provides an overview and structure. Having said that, our primary purpose is not conducting analyses or creating market data to help readers make individual business decisions. If this is what you are seeking, we refer you to the many detailed market studies that exist for various technology areas and geographies.

Swedish IndTech SEK 238 billion

While undertaking the basic data collection for this analysis, we have, for practical reasons and to facilitate international comparability, limited the study to standard products. By this we mean *catalogued IndTech products and services*. Estimates produced in collaboration with Mälardalen University in 2019 put the turnover of Swedish supplier companies at SEK 105 billion, spread across the product areas found in Figure 6.

When compared with corresponding previous measurements made by PiiA, Automation Region and Mälardalen University in 2012 and 2015, that figure suggests that the value of the IndTech market has increased respectively by SEK 52 billion and SEK 33 billion. This equates to an average annual growth of approximately 8 percent.

Beyond these supplier companies, Sweden is responsible for a significant portion of the export industry that supplies machines with increasingly advanced IndTech content. We also have a prominent ICT and industrial consulting sector. We have estimated these shares at approximately SEK 108 billion (system solutions) and approximately SEK 25 billion (consulting services). This means that *Swedish IndTech* in total is worth SEK 238 billion and that the sector compares well with other Swedish sectors involved with raw materials, the process industry, and many of the larger segments in the manufacturing sector.

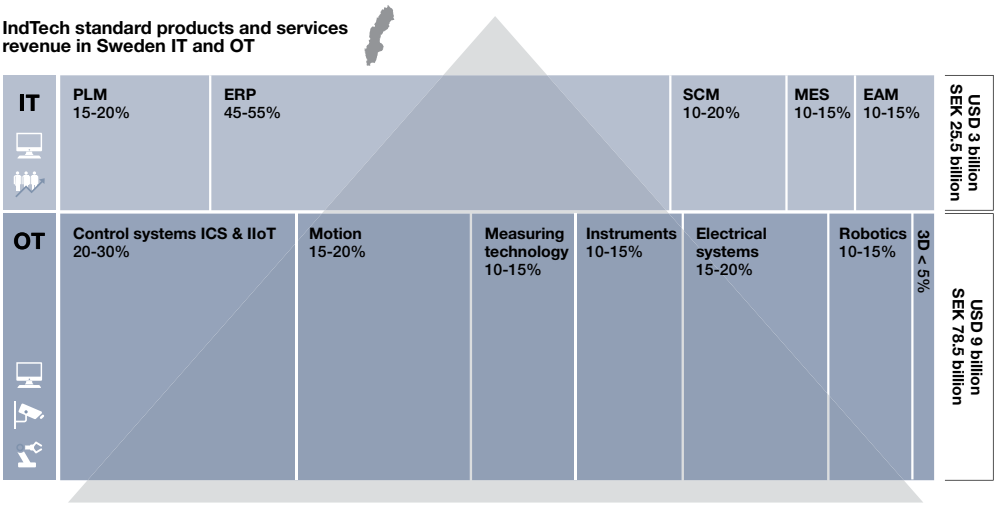


Figure 6: Turnover of Swedish companies for standard products with shares in the IT and OT areas. Explanations: PLM Product Lifecycle Management, ERP Enterprise Resource Planning, SCM Supply Chain Management, MES Manufacturing Execution Systems, EAM Enterprise Asset Management.

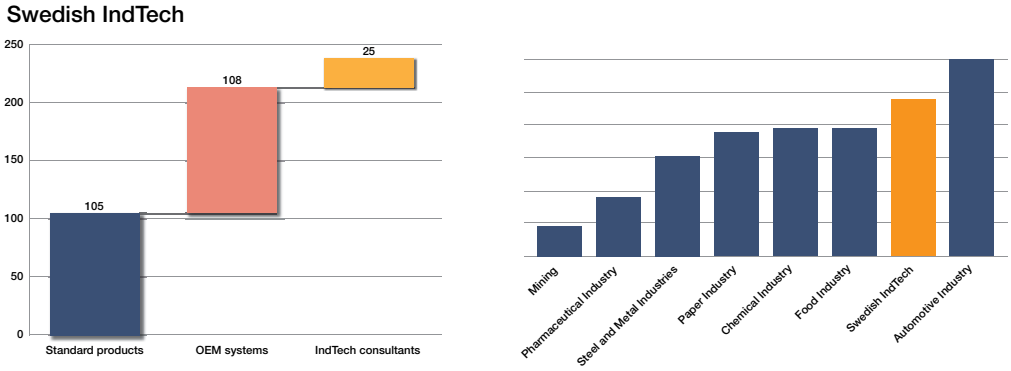
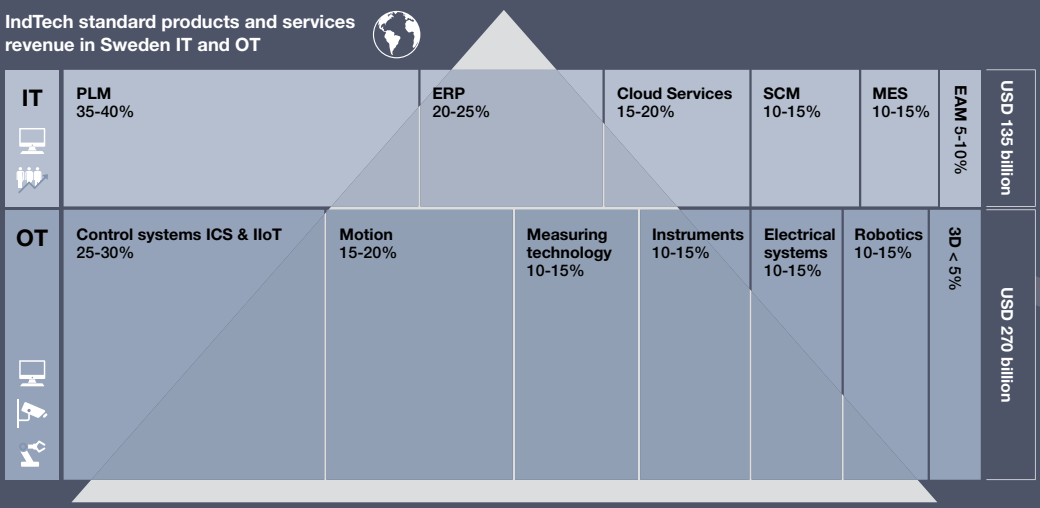


Figure 7: The complete Swedish IndTech industry consists of three parts: standard products; digital content from Swedish machine and system suppliers (OEMs); and IT and technology consultants.



World market worth SEK 3.5 trillion

In our analysis, we estimate that the world market for IndTech defined as '*standard products*' is approximately USD 405 billion (2020), with a growth rate of 6-7 percent. Industrial IT's share is USD 135 billion, with the remaining USD 270 billion accounted for by technology for factory floors, OT.

According to Figures 6 and 7 above, the Swedish suppliers' share (of standard products) is estimated to be approximately SEK 105 billion (USD 12 billion). This corresponds to a global market share for standard products of 3 percent, outperforming the relative size of our economy in the world by six to seven times. Or, put another way, Sweden has a global market share for IndTech that you would expect from economies such as France, the United Kingdom or Germany.

The global IndTech sector is characterized by innovation-driven structural changes combined with underlying demand from the industry remaining strong. The initial effects of Covid-19 were greater than the financial crisis, however the overall impact on the industrial sector has been lower thanks in part to due to political measures aimed at containing the crisis and, above all, rapid industrial adaptation. On the other hand, the pandemic is reinforcing structural trends such

Figure 8: IndTech global turnover for standard products, with shares in the areas of IT- and OT. Explanations: PLM Product Lifecycle Management, ERP Enterprise Resource Planning, SCM Supply Chain Management, MES Manufacturing Execution Systems, EAM Enterprise Asset Management.

> Sweden has a global market share for IndTech that you would expect from economies such as France, the United Kingdom or Germany.

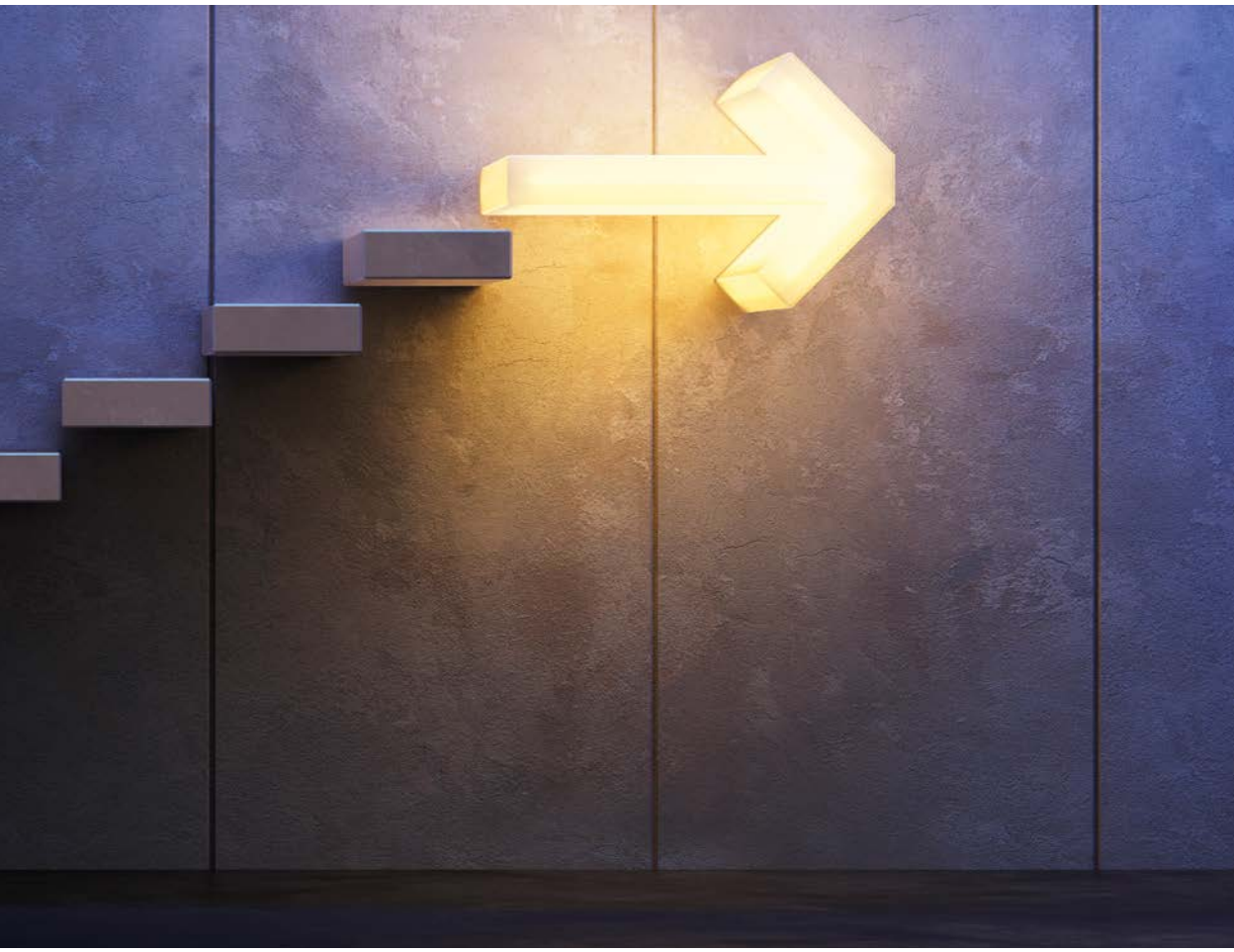
as e-commerce, sustainability, globalization and geopolitical fragmentation. These are areas that potentially require more digitalization.

With global prosperity continuing to grow, the industrial sector is facing resource and sustainability challenges that will require the development of processes for managing raw materials, material production, and production/assembly. For circular business models to replace linear models, traceability across processes is required, and this can only be achieved through extensive development of digital technologies. Furthermore, the pandemic has highlighted the differences between outsourcing, offshoring and the self-sufficient control of materials and semi-finished products. We can expect the value systems involved here to be at least partially rebuilt.

Such measures require investments in IT and create a need for production that is both local and highly automated. This rapid technological development is also self-reinforcing. It is part of a global process of upscaling made possible by the exponential development of capacity which in turn delivers increasing value for the same money. In other words, IndTech will be easier to profit from.

Unsurprisingly, China is among the most important geographic markets for IndTech. While the pace of overall investment here has slowed, the automation market is expected to be an exception. The option of using cheap labour has long since passed as wages and the middle class grow.

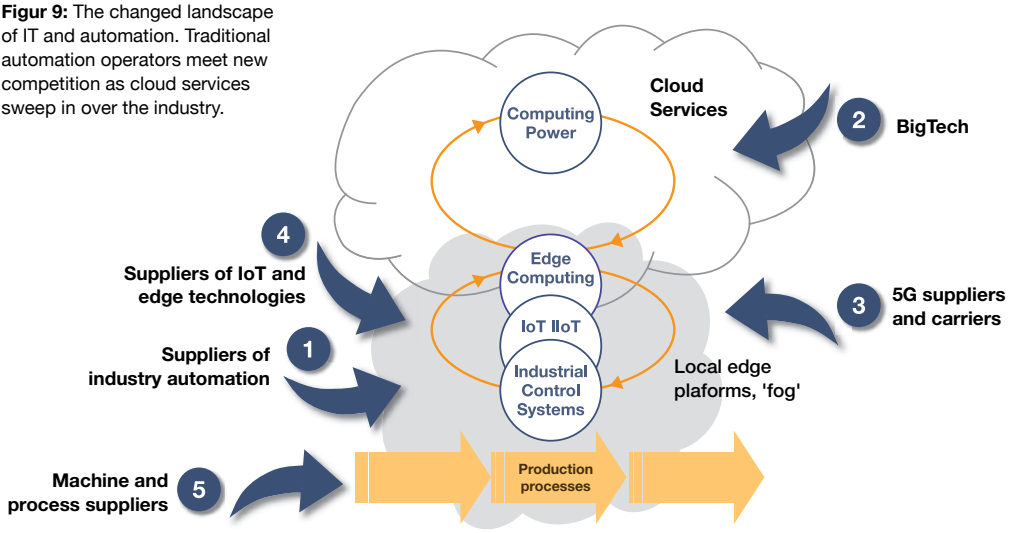
At the same time, the level of automation in Chinese industries remains relatively low when compared to other industrialized countries. Growth of between 15 and 40 percent per year cannot be discounted. The automotive industry's demand for discrete automation along with the chemical industry's investments in process automation will be driving factors. Corresponding patterns are expected to recur as more developing countries follow suit. This includes India and markets in Southeast Asia. At the same time, the industrial sector in the west stands on the verge of a complete digital transformation that will require substantial investment over the next 10 years.



> At the same time, the industrial sector in the west stands on the verge of a complete digital transformation that will require substantial investment over the next 10 years.

Overall, the analysis suggests that we are seeing continued strong demand for IndTech. And as the market is basically well-consolidated with a diversified customer base and established market channels in which price discipline can be considered high, conditions are in place for the segment to maintain good earnings. But farsighted strategies are required. Margins among OT suppliers are estimated to be 3 to 4 percent higher than the industrial average. At the same time, the automation sector is heterogeneous and profitability between different product segments can vary greatly. For suppliers of industrial IT, the overall picture is similar, however earning capacity is somewhat higher.

Figur 9: The changed landscape of IT and automation. Traditional automation operators meet new competition as cloud services sweep in over the industry.



Development of the supplier industry

With continued expectations of high demand and a global growth rate of seven percent, the market outlook for IndTech suppliers is good. The application of IoT, cloud services, and data analysis increases the breadth of the offering. At the same time, different technological environments are coming closer together. Discreet and continuous automation technology continues to be integrated, as does the entire IT and OT area, while the exchange of information between companies is increasing within value chains. These are examples of innovation-driven changes that are creating industrial demand and at the same time changing the conditions for suppliers. The boundaries between IT, automation, and digitalization are shifting or fading away and the marketplace is changing character as BigTech, ICT companies and OEMs all take on new roles.

An important motivation for this study was to contribute to the knowledge of market system so that the *Swedish IndTech* sector can take a share of and a strong position in the changing market. The state of the market, with its powerful dynamics and strong underlying demand, is producing opportunities. That the market logic is changing is especially clear to suppliers of industrial automation systems (1 in Figure 9) who are leaving behind a closed world with proprietary rules of engagement in favour of open standards and also new competitors.

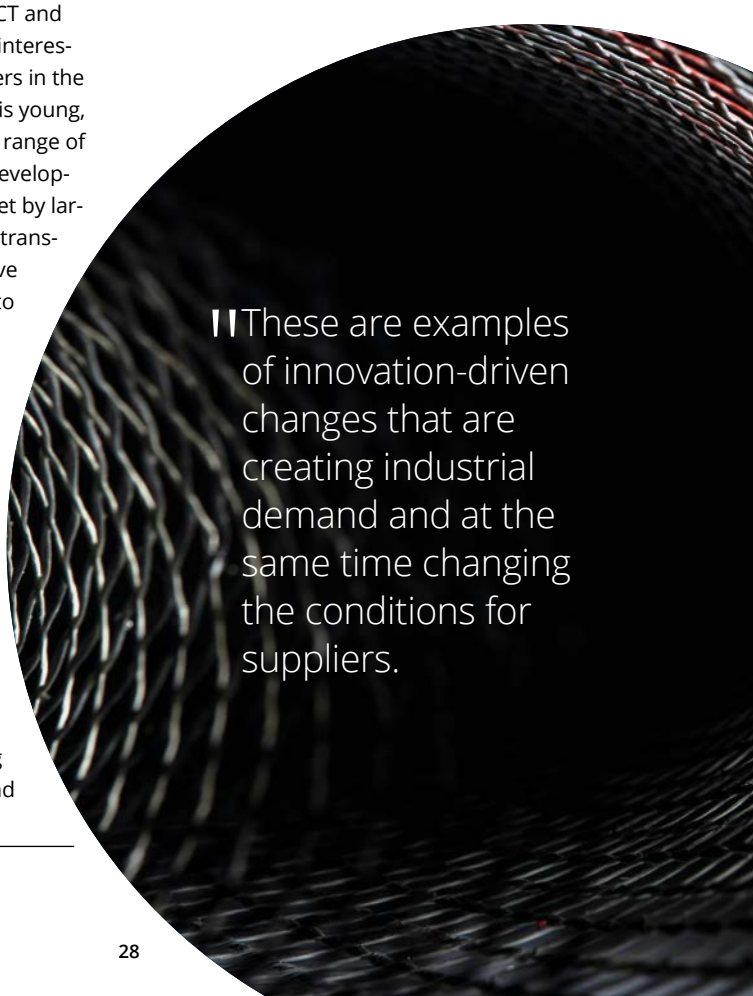
We can now see how providers of cloud and platform services (2 in the figure), so-called Hyperscalers, create alliances as the market channels for different industry verticals. One such channel involves the suppliers of industrial control systems. However, the market oligopoly for cloud services in effect means that BigTech sets the rules of the game. Automation companies, therefore, need to reduce dependency and create room to manoeuvre. They can do this by refining the value of the cloud in a way that creates clear customer values, is difficult to copy, and is based on the automation industry's domain knowledge and relationships.

This, in turn, is producing offerings that have a greater content of industrial IT and advanced data analysis – a development that can be accelerated through acquisition strategies and alliances. Siemens has had a long period of systematic acquisitions in the PLM area. Another example is the merger between Schneider and the English software company AVEVA. In part, this involves production-oriented IIoT platforms such as Siemens MindSphere and the GE-developed Predix. A probable result of this development is consolidation, providing space for three or four broad industrial platforms and about 25 industry-specific ones. According to consulting firm Oliver Wyman, there are currently 150 initiatives.

At the same time, 5G providers (3) are seeing opportunities within IoT. Operators will be able to increase revenues by as much as 34 percent if the industrial sector increases its use of wireless communication, according to Ericsson. This also involves easily accessible technology. ICT and IoT companies are already developing interesting technological solutions for end users in the industrial sector. IoT as an industry (4) is young, fast-growing, broad, and covers a wide range of sectors beyond the industrial sector. Development costs and production can be offset by large volumes, and many sectors such as transport, infrastructure, and healthcare have quality requirements that correspond to those of the industrial sector. Technology and applications for IoT platforms represent a great opportunity for Swedish IndTech companies. At the same time this dynamic is leading to proprietary automation technology meeting competition from new quarters, lowering the prices of parts of the automation range.

Cloud platforms and IoT are also providing machine suppliers (5) with new tools for meeting their automation and analysis needs, and this category of companies is also changing with digitalization. Machine builders and the automation industry are competing, in part, for the connected optimization and maintenance of customer facilities, with strategies that also include access to valuable data from industry manufacturing. Such data can be used to create new products and services.

In summary, a new dynamic is emerging for suppliers to the sector, which is based on platforms and within which the ability to offer real customer value will be crucial. In order to avoid being marginalized by this new dynamic, the automation sector must develop the advantages it currently holds through domain, process knowledge, and customer relationships. Suppliers who succeed stand to gain a highly developed role within the industrial sector as 'vertical' knowledge providers of efficiency and quality values. While others will be able to develop cost-effective products based on open standards by affirming the economies of scale that IoT development entails.



> "These are examples of innovation-driven changes that are creating industrial demand and at the same time changing the conditions for suppliers.

Part 3. The technology

changing the industrial sector

The technology for digital transformation, Industrial IT and Operational Technology, OT.

Technology for digital transformation, DX

The automation pyramid, featuring the fields of IT and OT, was the starting point for the model that PiiA and Blue Institute established to describe the technological structures at play during digital change. The digital transformation platform can be illustrated as a matrix with three verticals covering: IT and OT; cloud services in the centre; and (I)IoT and data analysis. The concept can also be described in other ways, but as a rule, cloud services, IoT, and data analysis are all involved in cases where the term DX is used to explain digital transformation. Traditional IT and OT fields are moving away from proprietary standards towards open ones. However, the demarcation between IT, OT and DX is that the latter has sprung from open standards, with the internet as the common denominator. It also means that the connections between IoT, cloud services, and modern analytics tools are strong, featuring well-functioning integration as a starting point.

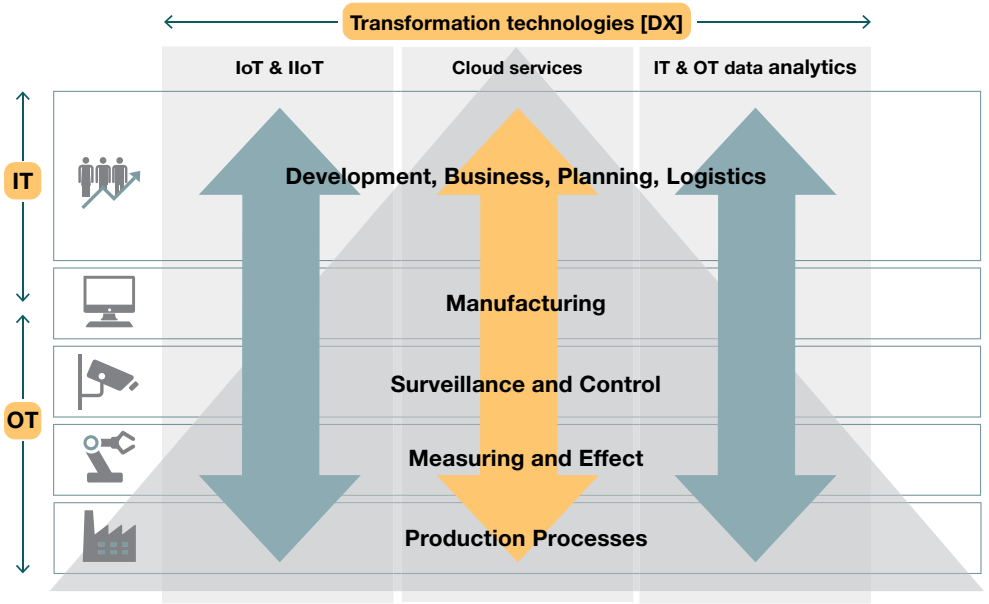
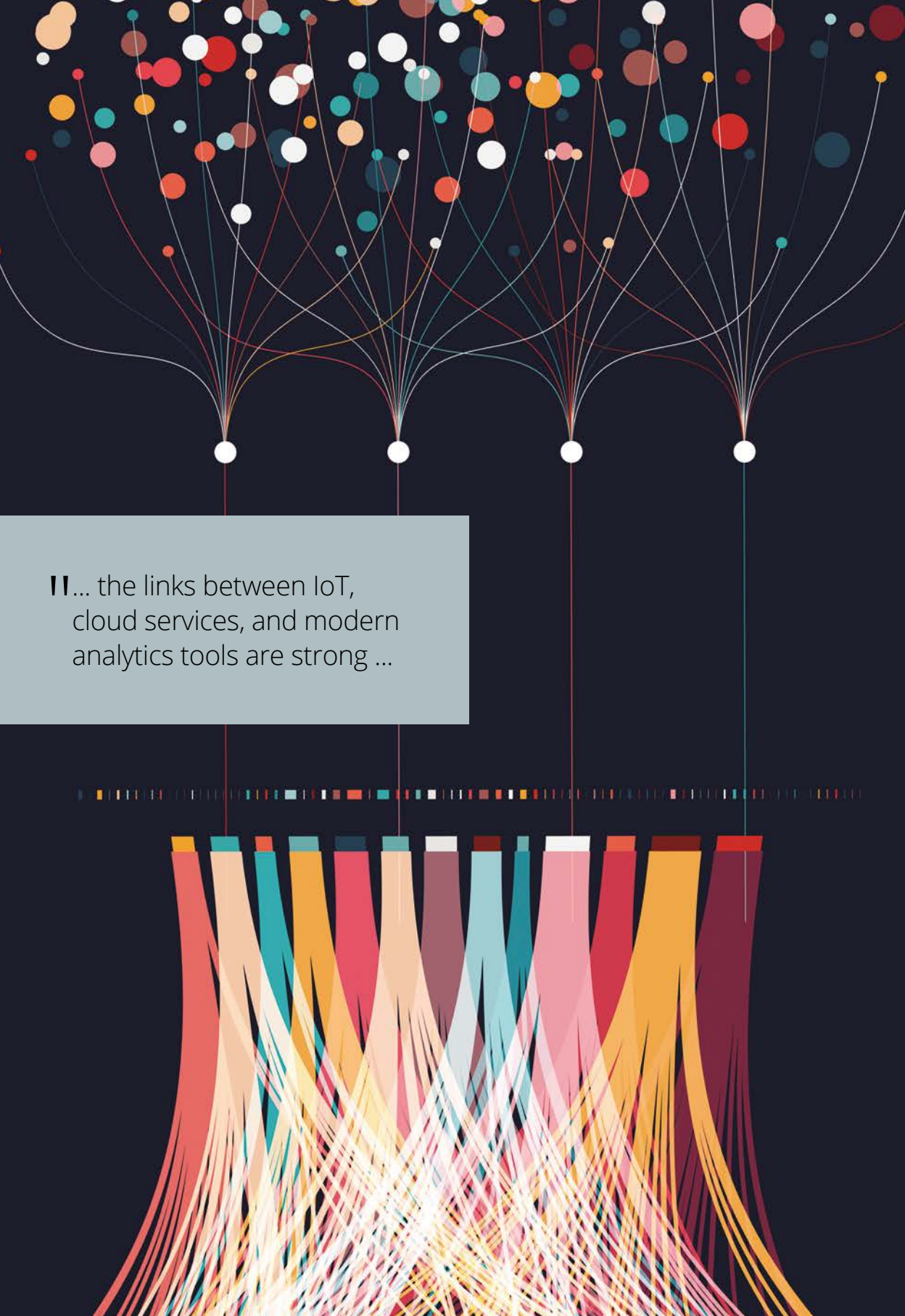


Figure 10: The technology structure consists of the two traditional fields, Industrial IT and Operational Technology, OT. The illustration shows the three verticals of integration technology form an intermediate digital platform (Transformation Technology DX) that is capable of combining old and new architectures and facilitating step-by-step modernization and consolidation



> ... the links between IoT, cloud services, and modern analytics tools are strong ...

CLOUD SERVICES

As a distribution technology for computer power, cloud technology is one of the most important innovations of our time, comparable to the importance of mass production to industrialization.

Estimates from IDC suggest that 60 percent of all IT operations currently take place outside the walls of companies. This is predicted to increase to 80 percent by 2025, according to Gartner. At the same time, the number of suppliers per company will increase. This development is due to efficiency gains, flexibility, and simplicity. It only takes 15 minutes and a credit card to create a complete development environment. Scaling up to 1,000 servers is just as achievable. The cloud makes failures less costly and success cheaper. This is a basic driving force for a market that, according to Gartner, is approaching USD 260 billion as intense consolidation occurs among major suppliers.

An accepted definition of cloud computing comes from the US National Institute of Standards and Technology (NIST). The institute describes it as *a model that provides easy access to a combination of configurable computer resources (networks, servers, storage, software, and services) for both buyers and suppliers*. In addition, there are a number of prerequisites for an offering to be perceived as a cloud service:

> It only takes 15 minutes and a credit card to create a complete development environment.

Basically, cloud computing can be described as a stack of services within which the core layers are:

- **SaaS applications (Software as a Service)** developed for end users and usually delivered via the web. SaaS is a fast-growing market within which the service is delivered from one to many, with APIs that integrate the applications.
- **PaaS (Platform as a Service)** – a set of tools and services for coding and distributing software. Service concepts are refined together in concert with development. For example, aPaaS (application Platform as a Service) exists to specify application development within areas such as IoT or data analysis. Microsoft, Salesforce, IBM, SAP, and Google are battling it out for leading market position.

There are established collaborations around OT within the automation industry. ABB is working with Microsoft on its *ABB Ability* concept, and Siemens is working with IBM and SAP on its *MindSphere*.

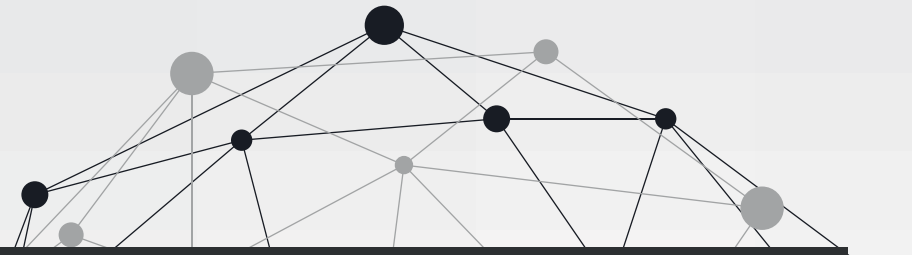
Self-service on request:
the possibility for an end user to register for instant access to the service.

A wide access network:
to access the service via standard platforms such as PC, laptop, mobile, etc.

Resource sharing:
across multiple customers

Dynamics and elasticity:
the capacity must be scalable to cope with demand peaks and troughs.

Measurable service:
the use is measured, delivered, and invoiced as a service.



• IaaS (Infrastructure as a Service)
is the hardware and software that drives servers, storage, networks, and operating systems. The business model is based upon making it easier and cheaper to buy a service rather than investing in the systems and expertise needed to create it. Amazon had an early association with IaaS and has grown to become the world's largest cloud provider, followed by Microsoft.

Other technologies that are currently trending are:

• Hybrid clouds
These are combinations of private clouds (with their own data centres) and public clouds provided by companies such as Amazon and Microsoft. Hybrid clouds make it possible to segment information according to security classification and they provide good control over the operating environment. Data can be moved between the private cloud and the public to optimize security and costs. Business-critical information can, for example, be handled in the private sector, while the company's website is placed in the public cloud to cope with traffic peaks.

• Edge
is a technology which complements cloud technology, and is implemented in association with things like IoT to addresses weaknesses with the centralized cloud structure. By moving the computing capacity closer to "things" and users, requirements for response times, bandwidth, integrity and autonomy can be met.

Many forecasts predict that the trend for centralization has already been broken and we will see a sharp relocation of processing power. Traditional automation technology has always met the formal requirements for distributed computer technology for the reasons above, but is now being adapted to Edge /IoT and new standards.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THE INDUSTRIAL SECTOR'S INTERNET OF THINGS - IIOT

If the cloud and platforms constitute the infrastructure for digital transformation, then IIoT technology can be used to achieve local efficiency improvements in situations where data needs to be cost-effectively collected and delivered.

> "IIoT is an industry-leading edge technology that uses the cloud and the internet.

There is also potential for IIoT around interoperability, where previously separated functions can be enabled to interact in systems of systems, and hidden values can be extracted from what is called industrial dark data. It has been estimated that only one percent of the data collected in processing plants is used for purposes other than simple alarm- and event reporting. The information contained in dark data may be combined with technology to achieve process optimization and better maintenance.

Development of IIoT involves an extension of both IoT and traditional control system technology, with two overlapping origin concepts at the bottom. These are the German initiative Industrie 4.0 and the American Industrial Internet, originally established by General Electric. IIoT is an industry-leading edge technology that uses the cloud and the internet. A central part of the concept is the idea of the cyber-physical system (CPS), which in real time integrates real-world dynamics with models, data processing and analysis.

The architectures involved are still strongly associated with the layers of the automation pyramid. The difference between today's established system models and the goal of IIoT is interoperability. With the help of new standardized network protocols that can handle time sensitivity together with protocols such as OPC-UA and built-in network intelligence, secure communication from the factory floor via edge computers to the cloud is made possible. An additional benefit is flexible, so-called 'global' accessibility to optional data.

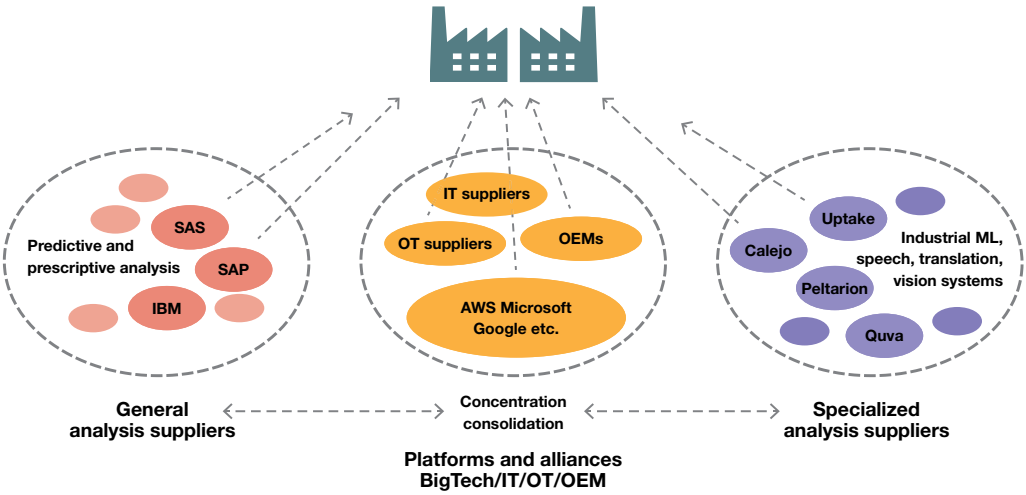
5G technology is often interconnected with IIoT and its robustness and response times along with the general benefits provided by wireless connections mean that application development is fast. In practice, 2, 3, and 4G are already used. 5G together with Wi-Fi, Zigbee, Bluetooth, LoRa WAN, and NFC are all technologies that will be frequently used in the future. An advantage of 5G is the opportunity it presents the industrial sector to build its own networks covering, for example, an entire industrial estate.

In this market analysis, we classify IIoT under industrial control systems, which is logical as IIoT as a concept is largely based on the further development of DCS, SCADA, and PLC technology. But open standards and lower entry thresholds mean that established automation suppliers are being joined by new players. This is leading to new market dynamics and accentuating ongoing structural change in the industry.

ADVANCED DATA ANALYSIS

Industrial data analysis is a broad – and in many respects established – area of application. The area is currently being changed by different variants of machine learning technology.

Figure 11: Within the market structure, industrial platform alliances and centre formations are flanked by two groups with more independent initiatives. The trend is for continued concentration as BigTech companies as well as IT and OT suppliers seek differentiation.



In summary, we note that the cloud, (I)IoT and data analysis form an effective triad for digital transformation. Computer power is obtained cost-effectively through the cloud, (I)IoT connects people, data sources, and control machines, data analysis is capped with value-creating algorithms. All three areas are characterized by lightning-fast technological advances and almost unlimited resources, more than the traditional IT and OT areas combined. This paves the way for an interesting development in the next few years.

The range of available AI technologies is growing at record speed, with interest in other, just as effective, statistical methods increasing as a result. Infrastructures, tools, algorithms, data, and ready-made models are offered as standard products by all platform providers. The automation industry is building machine learning capacity into control, monitoring, and measurement systems, and telecommunications providers are offering smart cloud-integrated edge technology.

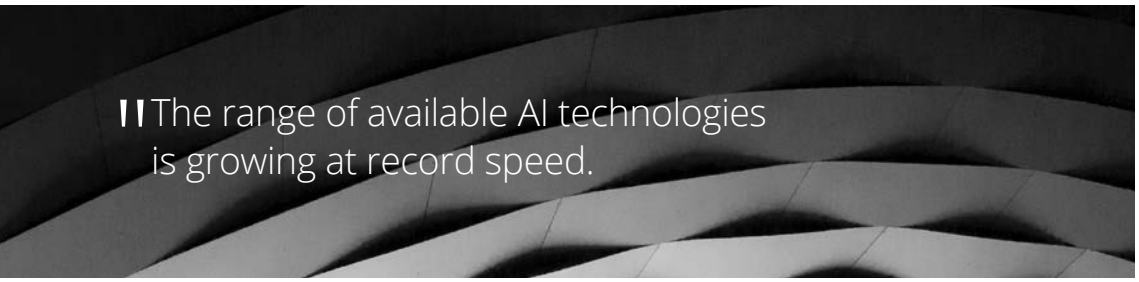
In parallel, application-specialized AI suppliers are growing and all market studies are now showing increased growth. According to estimates from analysis company Markets & Markets, the market for machine learning, language management, and vision systems will grow from approximately USD 22 billion in 2018 to just over 190 billion in 2025. This represents a growth rate of 40 percent annually, and AI development in the IT consulting industry is considered to be one of the most important technological breakthroughs ever.

But it is the big tech companies that are driving the development. The platform companies Apple, Alphabet, Microsoft, Facebook, Amazon and IBM together have a value of over USD 4 trillion and account for 55 percent of the value of the Nasdaq 100 index. These companies are also behind the western world's commercialization of AI with long-term strategies, very large R&D programs, and aggressive acquisitions. Further concentration of resources, expertise, and access to data is expected as part of the 'war of the platforms' for market domination, where the leading contenders are Microsoft, Amazon Web Services, and IBM.

In this new market landscape, market dominance of platform companies is always in the background. Generic cloud products reach end users directly or through specialized domain providers. In the industrial sector, it is the automation, process, and machine suppliers that are adding industry-specific values. The function of the automation providers is, therefore, as targeted market channels which increase the value of the mass production of computer power and machine learning.

Seen as a market structure, platform alliances and centre formations are flanked by two other markets. One consists of companies that sell predictive analytics and build individual platforms. According to a qualitative evaluation by the analysis company Forrester, this segment is led by SAS, IBM, and SAP followed by a long list of smaller players.

The second flank consists of specialized companies that deliver systems for speech, language, vision, and generally applicable machine learning platforms for, among other things, the industrial sector. Here, too, the list of small and medium-sized players is long in a still immature and development-intense sector under strong consolidation.



> In the manufacturing industry, design complexity is growing with more customer customization.

Industrial IT systems

Software solutions, in general, and data analysis algorithms, in particular, are playing an increasingly important role in the industrial sector. IT suppliers are being challenged by advanced product requirements where the integration of development, production, and market functions in complex supply chains has been a strong driving force over the past 15 years.

Digitalization involving clouds, mobility, analysis, and social media is now creating conditions for the next wave of application development within which the Internet of Things, AI, and collaborative technology will all be important parts in the sector's ongoing development. For the purpose of this report, we consider the following program families as branches of the industrial IT area.

- Product Lifecycle Management (PLM)
- Enterprise Resource Planning (ERP) including Customer Relationship Management (CRM)
- Supply Chain Management (SCM)
- Enterprise Asset Management (EAM)
- Manufacturing Execution Systems (MES)
- Cloud Services (mainly IaaS and PaaS, while applications are included in other IT and OT products)

Customer value is a significant driving force in the field. Within the manufacturing sector, design complexity is growing in line with increased customization for customers. An increased number of variants requires advanced logistics in the value chains and new production methods. For one BMW premium vehicle, for example, the number of options was 33 times larger in 2015 than in 2008, and development has done anything but slow down. In the process industry, as well, demands for flexibility are increasing as the number of product variants increases to satisfy the manufacturing sector's need for precision and quality.

As a consequence, IT software is generally experiencing higher market growth than hardware for the OT area. In a recent analysis from Credit Suisse (Credit Suisse, Industry Software Deep-Dive), software was estimated to be increasing at double the rate of the rest of the IndTech market. In addition, profit levels are higher, as is the valuation of companies. For suppliers, complete solutions and aftermarket offerings with stable revenues are interesting strategies. High costs for both development and sales are offset by the minimal material costs and applications with high IP value that are difficult to copy. The risk of being imitated is lower, and since the industrial sector's choice of software providers is long-term, price competition is decreased.

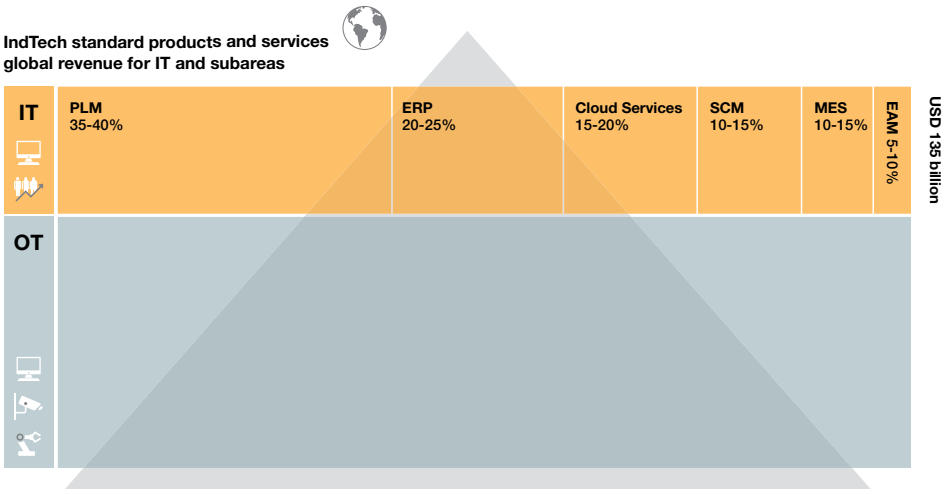


Figure 12: The IT area's share of IndTech corresponds to USD 135 billion and consists of six subdivisions: PLM, ERP, cloud services, SCM, MES, and EAM (where the respective share of the market is stated as a percentage).

The market for industrial IT as defined above was estimated at just over USD 130 billion in 2020. For several areas, the growth rate is higher than that for operational technology. The MES field, which integrates production with administrative processes, is growing by 15 percent per year. System support for fixed assets and maintenance (EAM) and optimization of supply chains (SCM) is also growing by more than 10 percent. Most significantly, cloud services for platforms and infrastructure (PaaS and IaaS) are increasing by approximately 20 percent. The two major areas of ERP and Supply Chain Management (SCM) are increasing at a slower pace. One explanation is that west's industrial sector has been investing in this type of system for several decades. Growth comes from new markets and the upgrading of existing installed bases.

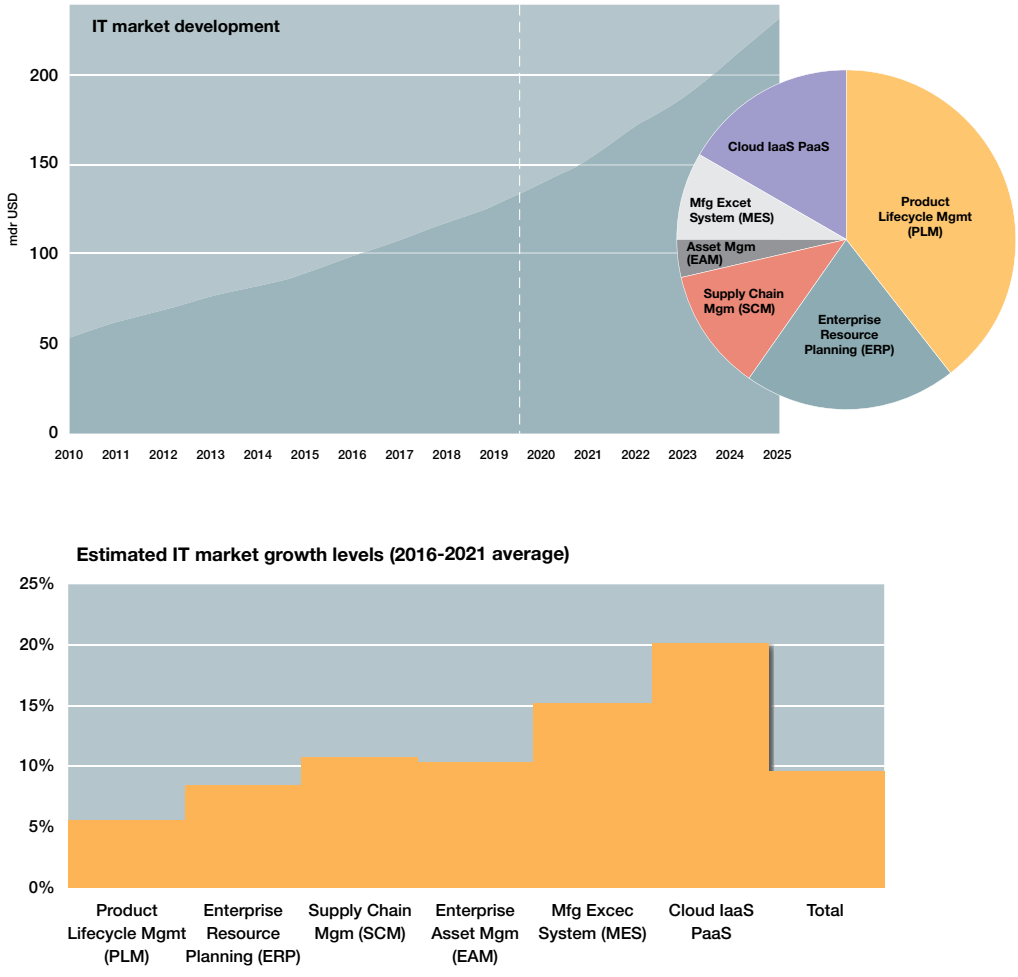


Figure 13: Industrial IT market shares and indicated growth levels and market development.

Operational technology OT

Operational technology is a concept coined by Gartner in a 2006 study and the term is now generally accepted as the name for technology that measures and influences production in factories and similar facilities. OT in this report covers the following technical areas:

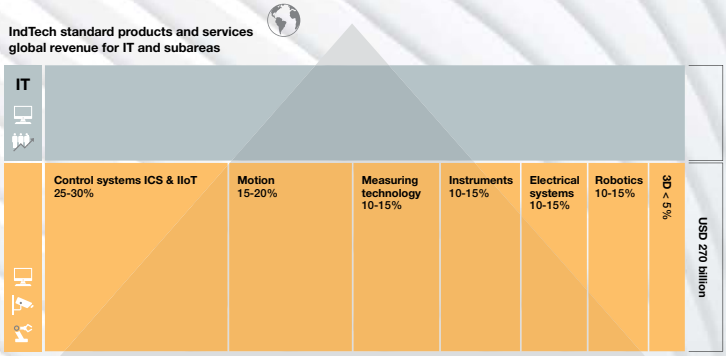
- Control system (ICS) including IIoT
- Robotics
- 3D printers
- Motion/Power systems
- Industrial electrical systems
- Process instrumentation
- Measurement technology: Sensors, Metrology, IIoT
- Cloud services
  (not described separately here, but can be included in the categories above and in IT)
- Advanced data analysis
  (not described separately here, but can be included in the categories above and in IT)

The global market for operational industrial technology was estimated to be some USD 230 billion per year in 2020. The growth rate is particularly high for new technology areas. 3D printers have experienced market growth of over 20 percent per year, but the market for industrial robots is also growing by about 10 percent, despite the fact that the average price of industrial robots is clearly decreasing. The largest market area is the control systems (ICS) followed by motion/power systems, measurement technology, and process instrumentation.

The market for OT is growing as the global industrial sector grows and the degree of automation increases in large countries such as China and India. At the same time, as the western world is undergoing a digital reset. This innovation-driven renewal is addressing interoperability and integration between functional levels in the industrial sector. The exchange of large amounts of data is a prerequisite for increasing efficiency.

Structured data is also the basis for advanced data analysis, which in turn is a prerequisite for raising automation and process optimization to higher levels.

We are now seeing development in which suppliers are swapping proprietary concepts for open standards. The industrial sector's IoT along with cloud-based infrastructures and platforms function as bridging environments between already installed and new technologies. But this is not without its problems from a security perspective. Not too long ago, OT installations were completely isolated environments. The fact that they are now being opened up to both intranets, the internet, commercial operating systems, and cloud services creates the potential for breaches of data protection. OT suppliers are therefore making great efforts to close possible security holes.



Figur 14: The market for operational technology (OT) in the industrial sector. With a monitoring/controlling environment through industrial control systems (ICS) and various user interfaces, motion that includes different types of power technology, measurement technology, instrumentation, electrical systems, robotics, and additive manufacturing with 3D printers.

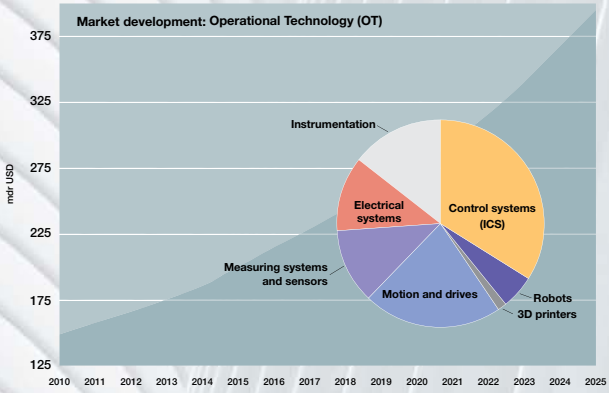
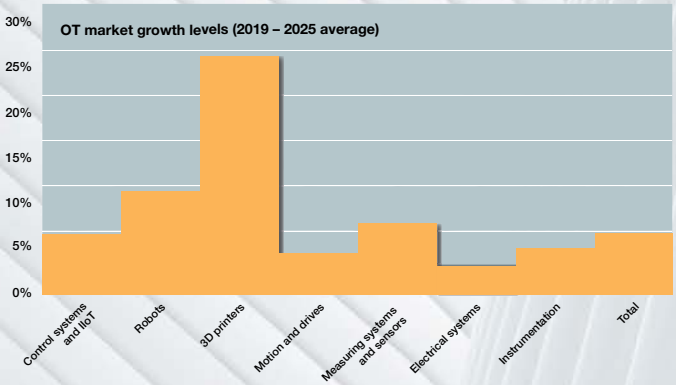


Figure 15: The world market for operational technology (OT) with aggregate volume increases, distribution across technology areas and growth rates.



Conclusion

Demand for increased sustainability in energy and production systems is the primary driving force for the transformation of the industrial sector – a transformation so extensive that it is being called an industrial revolution. Digitalization is playing both a generic and enabling role in the change, similar to that of mechanical technology in the first, and electrical engineering in the second industrial revolution. The industrial system is deeply connected to both digital technology and with the rest of society. One definition of the concept of digitalization is the free flow of information that allows for the creation of value.

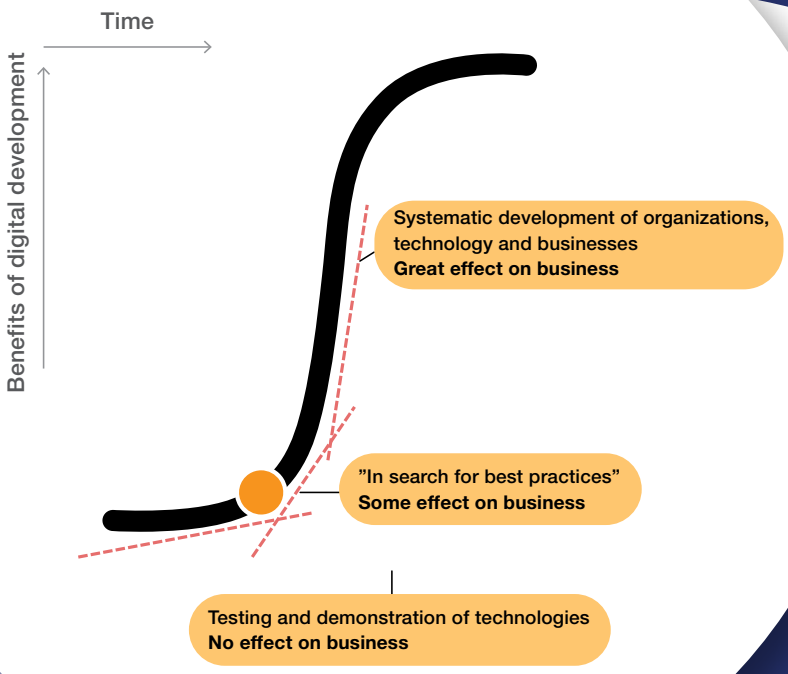
Development of the Swedish industrial sector has taken us to a point where our highly specialized and knowledge-driven sector is computerized and, as such, already driven by data. Valuable industrial knowledge has been built into computers and algorithms, it controls advanced production and it is difficult to plagiarize. This is the core of Sweden's industrial miracle. But there is still enormous potential for further development thanks to the benefits that our solid foundation provides for growing our competitiveness.

We also have strong opportunities to develop Swedish capabilities within industrial IT and automation technology to achieve success on the world market. Having *Swedish IndTec*h as a brand for both the manufacturing industry and a high-tech export business creates the means to increase Sweden's attractiveness to business start-ups and for technology export.

In this report, we have examined Swedish IndTech from three different perspectives: **the convergence, the market,** and **the technology.** These are meetings that are challenged by different cultures and market norms, but where the demands of the industrial sector require that different generations of technology and standards coexist. Over time, a new market system is developing as buyers' preferences change and the supplier industry is restructured. The result will be technology and applications that radically change the industry.

The S-curve is a model for describing the industrial sector's transition. In recent years, the innovation system has devoted itself to developing digital concepts and adapting them to the sector. The test and demonstration phase is now entering a period characterized by searching for best practice. In a few years, this period will turn into the broad industrial uptake of new digital technologies and a change that will affect most dimensions of the industrial system.

With the industrial sector adapting to digital requirements and technology suppliers in IT, OT, and digital technology creating a new market arena, advantages and opportunities are arising for a prominent industrial nation like Sweden. The purpose of this study was to provide decision-makers in various parts of the Swedish economy with knowledge in the hope that it will open their eyes to the opportunities.


Time
Benefits of digital development
Systematic development of organizations, technology and businesses
Great effect on business
”In search for best practices”
Some effect on business
Testing and demonstration of technologies
No effect on business

Appendix

If you would like to know more about any field, download and read more at www.swedishindtech.se

PLM

Product Lifecycle Management (PLM) involves the management of products across their life cycle, from conception and development to use and, finally, return or scrapping.

Sub sectors within Industrial IT

ERP

Enterprise resource planning (ERP) systems handle the flow of information within the boundaries of an organisation and also manage communication between customers and suppliers.

SCM

Supply chain management (SCM) focuses on the flow of money, goods and data from manufacturers to customers through value-added steps.

EAM

Enterprise Asset Management (EAM) involves the management of an organization's fixed assets.

MES

Manufacturing Execution Systems (MES) are software products that supervise production processes in factories.

Cloud Services

The cloud sector is typically divided into three sub sectors: public clouds where the model is to offer services via the internet; private clouds designed for internal use by particular organisations; and hybrid clouds that are a mix of public and private services.

ICS and IIoT

Industrial Control Systems (ICS) is the collective name for products that can monitor, control, and optimize production processes.

Robotics

Industrial robots is the largest and most established segment in an increasingly broad market for robots in general.

Sub sectors within OT

3D Printers

The world market for 3D printers has been estimated at about USD 15 billion, including additional services for industrial applications.

Motion

The motion field is the second largest market segment within operational technology and accounts for over 20 percent or USD 55 billion (2019).

Industrial Electrical Systems

Equipment for distributing and directing electric power to industrial equipment, such as industrial substations.

Process instrumentation

Instrumentation is defined as the knowledge of measuring and controlling process variables in industrial production.

Measurement technology: sensors, metrology, vision systems, and IIoT

Measurement technology is a central area that makes smart industrial production possible.

This report is about IndTech

IndTech is an area of digital development with the potential to help unlock the benefits of the fourth industrial revolution and a smart industrial sector. IndTech comes about when industrial IT and automation with their roots in the 1980s meet digitalization. It is an area with future growth potential in which Swedish suppliers are well placed to make a difference. Turnover for the world IndTech market is USD 405 billion – and that figure is growing rapidly. In Sweden, the sector goes largely unrecognised and yet is already worth SEK 100 billion. Conditions are in place for continued international growth.

PiiA

PiiA – Process Industry IT and Automation is a strategic innovation program with the task of driving digitalization within the Swedish process industry.

Supported by: VINNOVA Sveriges innovationsmyndighet, Energimyndigheten, FORMAS, STRATEGISKA INNOVATIONS-PROGRAM

Automation Region

Automation Region is an independent centre for excellence in automation and digitalization that brings together companies, researchers, authorities and investors to make Swedish industry smarter.

Supported by: VINNOVA Sveriges innovationsmyndighet, VÄSTERÅS STAD, Region Västmanland

blue institute

Blue Institute promotes research and knowledge development in marketing, entrepreneurship and organization.