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Industry 4.0: How to assess the readiness of firms

Judit NAGY

Corvinus University of Budapest
judit.nagy@uni-corvinus.hu

Industry 4.0 is a buzzword nowadays. The expression was first used in German High Tech Strategy 2020, and refers to the possibilities of digitalization, robotization, automation and network operation. Computers, robots and internet were available in previous decades, too, but even cheaper prices of these, and the penetration of tools that can be connected into the network as well as the volume of data generated by them, now opens up a new era. The competition among firms depends even more on their capability of collecting, structuring analysing data and making the right decisions based on it.

In this paper, I collect the typical technologies and tools that are associated with the fourth industrial revolution. I also review what steps companies should make to move towards adapting these Industry 4.0 technologies, in order to be able to exploit the advantages of digitalization.

The Industry 4.0 technologies are spreading. There are industries in which this spread is quicker (automotive, electronic) while slower in others (FMCG), however, development cannot be evaded. I will introduce several models that can help defining the Industry 4.0 development level of different firms. The models help evaluating – among others – the companies' digital IQ, the technological preparedness, the data analytics skill as well as how these are applied within the company or even involving suppliers and customers. That can help companies to evaluate their own situation as well as to see the steps ahead.

The last part of the study is based on interviews with Hungary-based manufacturing companies, which already have some experience on Industry 4.0 and I test the introduced classifications on them.

Introduction

In economics history three industrial revolutions have occurred in the past centuries. All of the revolutions were triggered by the increasing customer needs that could not be satisfied at the actual level of technology – either

in volume or in quality -, and has resulted in the fast development of transportation and communication.

The *first* industrial revolution has started with the appearance of steam engines and the mechanization of textile industry at the end of the 18th century. Thanks to the development, steam revolutionized the rail transportation and postal services became faster, not to mention the increasing production capacities of various industries (Allen, 2011).

The *second* industrial revolution was initiated by electricity and internal combustion engine and this is also the era when mass production technologies appeared. We can date this to the end of 19th and beginning of 20th centuries. This way firms became able to produce even larger volumes to satisfy standardized (mass) needs, the communication became even faster by the spread of telephone networks, as well as transportation became easier thanks to the popular, relatively cheap, consequently spreading motor cars (Mokyr, 1998).

In the middle of 20th century computers have appeared which led us to the *third* industrial revolution. In the next 30-50 years computers conquered the industry as well as everyday lives (Greenwood, 1997). Just like in other industrial revolutions, when computers and parts started to become cheaper they were applied in increasing number of machines, tool, and products. The network of computers and communication by them (Internet) has been started to be used in the 90s by the public, while military and several connected industries have used it for decades. The communication has been revolutionized again, and by this it became available for firms to control subsidiaries located at geographically far distances. This has led us to even greater production volumes – thanks to the use of computers in production: automation and robotization – as well as to cheap production processes in low-wages countries, and also - the explosive growth of global transportation.

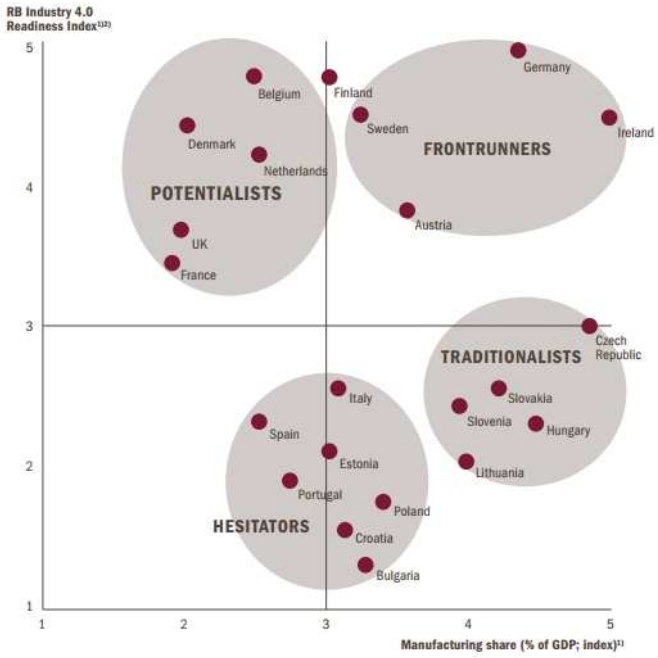
Nowadays we experience the *fourth* industrial revolution. The computers are available in every processes in companies, in every household, in everybody's pockets in form of smartphones. This makes possible to step even one stage higher, to exploit the advantages of the widespread network of tools, machines and products that can communicate with each other (Kocsi & Oláh, 2017). The data generated in these networks can be used many ways to improve customer satisfaction and production efficiency. Companies are still working on finding out how to use and exploit the possibilities, and it is very interesting to watch this process and study their behaviour. The aim of this paper is to report about how researchers measure the development stages of companies in this 4th industrial revolution and what their motivation is to develop.

Development stages in theory

Consultant companies tried to capture the development stages on macro and micro level, too. Roland Berger classified the different countries while Geissbauer et al. (PriceWaterhouseCoopers, PwC) assessed companies along their Industry 4.0 preparedness.

Roland Berger (2014) developed a rather macro level Industry 4.0 readiness index which includes how sophisticated the production processes are in a nation's industry, what is the degree of automation, how innovative the workforce is and what is their attitude towards innovation. They also considered the value added, openness, innovation network and internet sophistication while calculating the index. The results were depicted in a chart where the vertical axis represented the extent of the index, while the horizontal axis represented the share of manufacturing (%) form GDP. This way Roland Berger classified the European countries into four clusters (Figure 1) (Berger, 2014).

Figure 1. Country classification along I4.0 readiness



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(Source: Berger, 2014:16)

Frontrunners are countries that are traditionally known of their large share of manufacturing in GDP as well as of highly innovative and responsive corporate behaviour. We find the leading Industry 4.0 firms in these countries which dictate technology and show the path to others.

In *Potentialist* countries manufacturing has been regressed in the past decades, however the corporations have innovative attitude and they have to find the way to exploit it.

In the group of *Traditionalist*, we can find mostly Eastern European countries, in which manufacturing has a reasonable share from GDP, but the technology, the production methods are not very developed, and also,

these countries are not known of their innovativeness and readiness to change.

The *Hesitators* have decisions to make. They have to develop both the role of manufacturing as well as the technology and attitude towards digitalization. Some of them suffer from financial problems that makes development uneasy. On micro level Geissbauer et al. (2016) differentiated four development stages for firms from digitalization aspect.

The firms that are *Digital novices* have only isolated digital solutions and applications. They have different online and offline sales strategies and offers, they still focus on products rather than customers. Their vertical and horizontal value chain is partly supported by ad-hoc digital solutions, and the company still works along functional silos. Data collection and analysis contains many manual processes consequently is not extensive enough. The IT architecture is fragmented and mostly used to support in-house processes (Geissbauer et al., 2016).

Those companies who lay a little more emphasis on digitalization can reach the level of *Horizontal integrator*. This case, the functions and processes along the internal value chain are more or less integrated (I changed the original name of this category because Geissbauer et al. called this vertical integration, however, it only concerns the intra-firm processes). The company has a digital product and service portfolio, and online and offline sales channels are also integrated. Thanks to the internal integration, data and information can flow easily, processes can be carried out cross-functionally, however external integration with partners is not present yet. Data analysis is supported by central business intelligence system and information is used in decision support systems. The IT architecture is homogenous within the firm.

Vertical integrators extend their digitalization activities on/with their partners, primarily along the value chain. The partners can offer integrated customer solutions collaborating over company boundaries. Individual customer needs can be satisfied, and all value chain members are integrated with interfaces. Processes and data flow also across company boundaries in order to fulfil customer needs and optimize processes. A central business intelligence system collects all relevant internal and external data, supports decision making and makes some kind of predictive analysis. IT system is common with partners. The culture of data sharing and common customer satisfaction and processes is present.

Digital champions are the firms that master all the methods mentioned previously. They develop new, digitalized business models, innovative products and services. They work on this together with not only the value chain partners but more firms and institutions (e.g. research institutions) that can help them achieve high level of success. They apply Customer Journey Management and complex CRM techniques. Digital champions are fully digitalized and integrated with their partners. They formulate a digital eco-system, where everyone can focus on their core competency and rely on the others. They can access every relevant real-time operations information. The collaboration is a key value driver (Geissbauer et al., 2016).

As we can see, criteria for each level are getting even complex and only the very best companies – or supply chains – can be classified as digital champion. In my research I could not find any digital champion examples in Hungary. There are many companies in our country where Industry 3.0 technologies would still make a huge development, and digitalization is very far ahead. However, it is interesting to see how firms are trying to develop and what path they choose.

In the following chapter I analyse how the four interviewed companies affect Hungary's position on Roland Berger's chart, and I also classify them along PwC's categorization.

Methodology

Once a company goes down the Industry 4.0 road it must invest in several tools, technical solutions and methodologies. Then, the level how company uses these and how it becomes master of them, reveals the differences between firms.

The qualitative research - that is the basis of this paper - was carried out during the summer of 2017. Four manufacturing firms were interviewed with the aim of getting insight into the attitude of companies to digitalization, if they started any development project, how developed they are and what motivates them to improve. All analysed companies are operating in Hungary, but their ownership structure varies. Details about the companies can be seen in Table 1.

Table 1. Information about the interviews carried out

Interviewed company	*Ownership structure of firm*	*Industry*	*Position of interviewee*	*Revenue/ # of workers (2016)*
V1	Hungarian private	electronics	CEO	4 M € 75 people
V2	American private	automotive	Lean & 6σ manager	176,5 M € 1500 people
V3	German private	automotive	operations manager	113 M € 900 people
V4	German private	automotive	team leader	1,65 B € 5300 people

(Nagy, 2017)

The interview method was semi-structured interview and each of them took approximately one hour long.

Experiences of the interviews

We can state, that every company admits the importance of Industry 4.0 and feels the wind of change in its industry. They are all in traditional industries – electronics and automotive – where the pressure for product and technological innovation is high.

Regarding the Roland Berger study, Industry 4.0 readiness of the interviewed firms are different. V1 is a real *Traditionalist*: it operates for a long time in Hungary (it was founded in the previous political-social era) and now operates as an electronic custom manufacturer for large electronic firms. It applies the technologies it is requested to. It feels the need for development but has either no funds for innovation or potential and human capital to do so. This company follows the method of applying the tested and well-tried technologies that mean low risk and are already relatively cheap (V1 interview, 2017).

V2, V3 and V4 are subsidiaries of international, sometimes large companies, which play leading role in innovation in their industries and rather can be regarded as *Frontrunners*. In case of V4, the company is very well known of its innovativeness and high-tech technologies, so this company feels that they have to play a key role in the fourth industrial revolution, ad headquarters supports the ideas of subsidiaries. The global company leads plenty of projects in many of its subsidiaries to experiment possible innovation both in products and technologies (V2, V3, V4 interviews, 2017).

V2 and V3 are subsidiaries of international companies that are operating in industries that are also highly affected by Industry 4.0. However, in these companies, it is not the parent company who motivates the subsidiaries to innovate. In these cases I met two exceptional leaders, who realized the importance of having a leading role in digitalization in their industries and started to improve the Hungarian sites, and nowadays both are pilot-factories within the global group, innovating and improving digital technologies which are tested and then exported into the other factories. This completely different attitude towards the necessity of innovation and risk causes that V2, V3 and V4 are really can be regarded as Frontrunners (V2, V3, V4 interviews, 2017).

The PwC categorization can also be employed for the four companies to see how developed they are in adapting Industry 4.0 technologies and methods.

The interviewed companies are still at the beginning phases of applying Industry 4.0. Those firms which belong to global groups have an advantage, they get inspiration, monetary fund and motivation from their parent company to innovate, or even operate in an environment where innovation is a must. In case of V4, the initiation came directly from headquarters to set up Industry 4.0 working groups and find out which innovative solutions how can be applied at the company. In case of V2 and V3 the agility of Hungarian leaders led to start Industry 4.0 working groups and pilot

projects. V1 company has an Industry 4.0 working group, too, and they are assessing the available technologies that is worth to be purchased.

The pilot projects are usually isolated, affect one or only a few parts of (mostly) manufacturing activities, and the extension to the internal value chain as well as the entire group is still slow. The first step that has already been taken by the firms is to install data generator devices (sensors, RFID, 3D scanner) to manufacturing equipments. This way monitoring and data collection about the entire manufacturing process is started and the companies can move on to the next difficult questions: data analysis and decision support. In this question V4 is the most advanced amongst the four interviewed companies. V2 and V3 make a lot of effort and develop to reach good data analysis softwares and techniques, while V4 masters it. For example V2 and V3 employ a lot of software engineers to develop their own analytical systems which can cooperate with the ERP system as well as has a user-friendly interface to operators and the management. This costs a lot for these firms. V4 has a Spanish subsidiary which produces ultra-sound sensors and 170 GB of data is generated by the production lines during one day which is analysed with methods used in web search engines (V4 Company News, 2016). This way the system is capable of discovering complex cause-effect situations and can provide reliable information.

Since Industry 4.0 (pilot) projects are rather isolated within the Hungarian companies, the integration that firms pursue is horizontal integration. V2 and V3 are quite good at it, while V4 started to develop systems connected to its suppliers and customer. I have to note, that in case of V4 many suppliers and customers are other subsidiaries of the same group, consequently the risk taken by sharing data and close collaboration is a little bit lower.

The summary of the development stages of the four firms is shown in Figure 2. The white colour represents that in a given aspect the company is less developed, and as the colour gets darker the development stage increases (Nagy, 2017).

Figure 2. Development stages of firms in different aspects (white=no development at this area at all; black=highly developed area)

Aspect Com-pany	Digital business model	Digitalization of product-service protfolio	Horizontal and/or vertical integ-ration	Data analytics	Agility of IT infra-structure	Digital culture
V1						
V2						
V3						
V4						

Conclusions

In my paper I was dealing with how we can measure a firm's or a nation's Industry 4.0 readiness. I introduced two models, one from Roland Berger which evaluates nations along an Industry 4.0 readiness index - which was developed by the consultancy company – as well as along how important manufacturing is from the nation's GDP point of view.

The second model is composed by the PriceWaterhouseCoopers and analyses the Industry 4.0 development stage of a firm from many aspects and according to the result, classifies them into four groups.

In order to achieve a leading role in the competition, companies must adapt to Industry 4.0. In industries like electronics, automotive and other industrial manufacturing companies are highly affected by the pressure to innovate. Companies usually *start* the development with implementing small parts (RFID, sensors, etc.) in order to monitor their production processes (machines, products, people) and generate data (cyber-physical system-CPS, cyber-physical production system-CPPS). The *second* step is to build (or buy) a system which can analyse the data and can provide a user-friendly interface to share and show the result. This way, the data generated in the processes can be transformed into relevant information real-time and decisions can be made. As a company develops, even more processes are started to be monitored, even more data is collected and analysed, and decision making can be based entirely on real time operations information. Part of this step is to build connection between the CPS, the data analytics system and the ERP system to make information available for the entire company integrating the internal value chain (horizontal integration) (Rüßmann et al., 2015; Wang et al., 2016; Nagy, 2017)

The *third* step is the vertical integration, when data collection and information sharing is extended towards the (most important) suppliers and customers. This way even more operative as well as strategic decisions can be supported, planning and optimization can be a collaborative, boundary-spanning activity. The *fourth* step is formulating a complete digital ecosystem, where all the suppliers, customers, and other relevant partners are connected into the network, everybody can access the relevant real-time information which supports him/her in carrying out his/her task on the highest possible level. This is however a little bit utopian, and can be realized when business interests say so (Geissbauer et al., 2016; Wang et al., 2016; Nagy, 2017)

Roland Berger considers Hungary to a Traditionalist country, where manufacturing has a relatively large share from GDP, but Industry 4.0 readiness is not too high, because of the low value added manufacturing companies, the low level of innovativeness and the available funds for innovation. The Hungarian Government as well as EU are intended to support (fund) innovation and there are many programs for primarily Small and medium –size enterprises (SME) to apply for funds and buy/develop new technologies. A problem with this is that even my non-representative research refers to that the engines of technological development are not

the SMEs. They can rather adopt technologies and solutions which already have been developed and tested. The companies which have money, capability and opportunity to do this, are rather large, more frequently, international firms (Multi National Enterprise - MNE). State is better to find ways how SMEs can learn from MNEs, and a good initiative is the Sample factory project and the Night of Modern Factories, when these modern factories open up their gates and visitors can get a little insight into modern technologies.

In PwC classification, the companies which were interviewed are either Digital novice or Horizontal integrators. They already started to apply data gathering tools and methods and develop analytical system, but improvements are rather isolated and extend at last to internal value chain. Only the largest company started to develop vertical integration, but since suppliers and customers are also parts of the group, this is a special kind of vertical integration.

Interviews showed that ownership background of the firm is a very important factor in preparing the firm for Industry 4.0. The technological background, the group innovativeness and the imported improvements, the available money for developments are generally better in an international company. I also discovered an other factor, too, which is self-motivation. In two interviewed factories the personal attitude and motivation of the leader generated the need for innovation and both Hungarian subsidiaries play outstanding role in the group, developing new methods and technologies, trying them and in case of success, exporting them to other subsidiaries. The Hungarian-owned company follows a Follower strategy, does not take risk and cost of long time development, rather applies what already well-tried and works.

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