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Overview of industry 4.0 tools for cost-benefit analysis

Abstract

The Fourth Industrial Revolution, which was formulated by the German Government in 2012, designated the high digitalization of production processes as the industrial innovation strategy for the next decades. However, in the fifth year following the announcement of this digital revolution, there have been few signs of this in the Hungarian economy, which is closely connected to the German economy. One of the reasons for this is that industrial actors are unaware of the benefits of digitalization and do not have any information on what kind of charges are incurred during these projects. This issue is covered in this article. Different tools of Industry 4.0 are discussed from the point of view of the concrete benefits that a production company can gain from them and the costs incurred from them.

Keywords: Industry 4.0, Fourth Industrial Revolution, tools of Industry 4.0, cost-benefit analysis

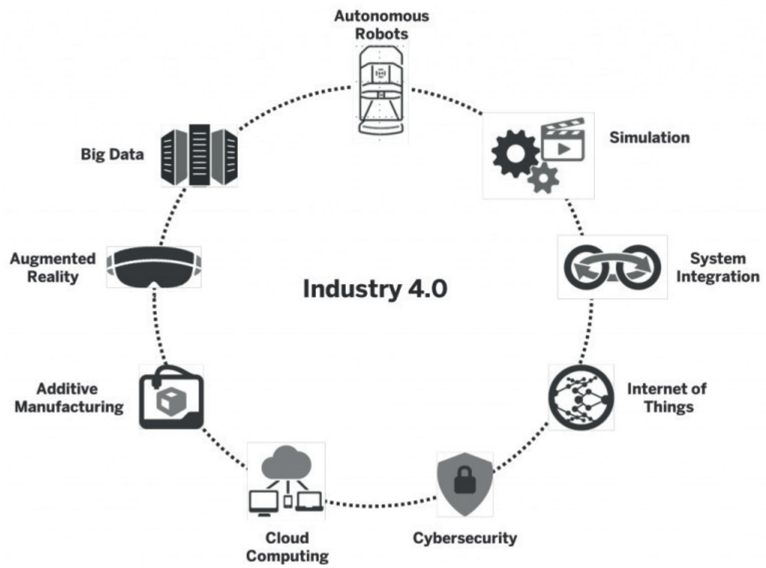
INTRODUCTION

The demographic, economic and technological changes in the world and in Europe have led the German industrial actors to announce a new industrial revolution in the 2010s (Kagermann, 2015). This revolution was named Industry 4.0, which became the European Union's major industry and production innovation strategy (International Electrotechnical Commission, 2015). As a member of the European Union and as a significant partner of the German economy, the Hungarian economy's main innovation direction will be Industry 4.0 and intensive digitalisation.

The general goal of the Fourth Industrial Revolution is to increase productivity and efficiency (Thames–Schaefer, 2016). There are six basic principles related to Industry 4.0 (Hermann et al., 2015; Kagermann, 2015): collaboration between the physical and virtual world, real-time operational capacity, virtualization of manufacturing processes, decentralization of the management system, service orientation, and high modularity.

There have been nine technologies related to these guidelines (Figure 1). These technologies include the Internet of Things, Simulation, Big Data Analysis, Cloud Computing, System Integration, Augmented Reality, Cooperative Robots, Additive Manufacturing, and Cyber Security.

Figure 1 Technologies of the Fourth Industrial Revolution



Source: Design for Industry 4.0, The University of British Columbia

Industry 4.0 innovation investments are far more than standard technological developments. The Fourth Industrial Revolution has an impact on the entire production process, with its tools the actual model of the value chain and the structure of the information network are changed, but the exact consequences are still relatively unclear. More and more publications are emerging about the practical implementation of these technologies, but there is very little information regarding their costs. It is particularly important to know the cost of these implementation projects not only because of the return on investment, but also from the point of view of what changes can be expected in the value chain.

In this article, the focus is on the issue of what are the benefits of the various technologies of Industry 4.0 for a company and what costs are incurred during their application. This article is not designed to produce a concrete, comprehensive impact study but rather to pay attention to the cost aspects for a company decision maker when using the various technologies. In the following chapters, the benefits, and the expected costs are discussed, then a specific cost accounting example is mentioned for each technology.

The cyber security aspect is a “concomitant” of other technologies due to increased digitization. Companies should pay careful attention to the design and configuration of intellectual property associated with manufacturing (Sadeghi et al., 2015). In addition, a highly important aspect of a production organization is the high availability of IT systems. Various hardware and software companies take special care to ensure that their products are equipped with security and authentication features (Dahad, 2018), but each Industry 4.0 technology needs to keep an eye on security considerations (Ashibani–Mahmoud, 2017). These are in many cases approaching system design factors in which it is difficult access their costs, and we do not specifically mention them in each technology.

We must also mention the necessity of the network connection. One of the root causes of the Fourth Industrial Revolution is the high-speed, relatively low-cost network systems. They are highly scalable, with low response time, wireless and high-speed connections. The speed and availability of the network at an industrial level can greatly influence the benefits of each technology ("Internet of Things," 2016). With regards to the details of the technologies we did not count separately the network capacity and its hidden cost.

In the cost side analysis, the sustainability aspect must be mentioned as well. More and more companies aim to reduce the environmental burden. Certain technological solutions may be conducive to the company's performance and profitability but cause excessive environmental pollution (such spares made from 3D printing) in the entire manufacturing process. We do not specifically mention this in the analysis, but sustainability issues can be important strategic considerations in the long run.

Due to the author's deeper knowledge in the Hungarian industrial environment and the publication is primarily intended for Hungarian industrialists, in the cost calculation examples the costs are also shown in HUF.[1] The cost of the energy was based on the corporate price valid from 1 January 2017 in Hungary ("Current prices - Business - E.ON," 2018). The average Hungarian wages were considered in the calculation of the labour costs ("Salaries in Information Technology field," 2018).

1. INTERNET OF THINGS, SIMULATION AND INTEGRATION

1.1. BENEFITS

Using the Internet of Things technology, various physical quantities of the manufacturing processes are measured with smart tools and, if necessary, modifications can be made in the system with these tools. In practice, this is accomplished by placing smart, uniquely identifiable sensors and executors in certain places in the production environment. With the continuous operation of the sensors a constant and accurate digital image of the production processes is calculated.

[1] We calculated 320 HUF=1 EUR, 275 HUF = 1 USD and 1.13 USD = 1 EUR for the exchange rate.

Data from devices can be integrated into a common system so that we can get a true picture of the performance of the production equipment or manufacturing processes. Using this data, it is easy to find out what are the failures and the bottlenecks in the manufacturing process and how to use the available resources more efficiently. The technology makes it possible that the production process is customized for the product and the environment, and it is constantly looking for optimal settings. Consequently, their application can increase the company's manufacturing efficiency.

Another advantage is that intelligent sensors can be used to create a digital twin pair of manufacturing equipment. The further life span of these devices can be simulated (Jia et al., 2015). This eliminates and prevents certain machine malfunctions. In addition, a greater automation level can be achieved with the Internet of Things, which also increases the average production performance.

In connection with the Internet of Things, we need to mention another segment of Industry 4.0, that is system integration. Benefits of the Internet of Things cannot really be exploited until the company is not connected to a common IT system (Bischoff et al., 2015). In regards to the Fourth Industrial Revolution, there are three types of system integration (Figure 2). One such technique is vertical integration, which is understood to mean an IT link between a company's departments (VDI/VDE-GMA and Zentralverband Elektrotechnik- und Elektronikindustrie e.V., 2015). Another technique is product life cycle integration. From this aspect the whole life of one product is followed from its initial raw material state all the way to scrap (Stock–Seliger, 2016). A further technique is horizontal integration, which is the knowledge, information and resource sharing of the different actors in the supply chain (VDI/VDE-GMA and Zentralverband Elektrotechnik- und Elektronikindustrie e.V., 2015).

Figure 2 Horizontal and vertical integration of the Internet of Things

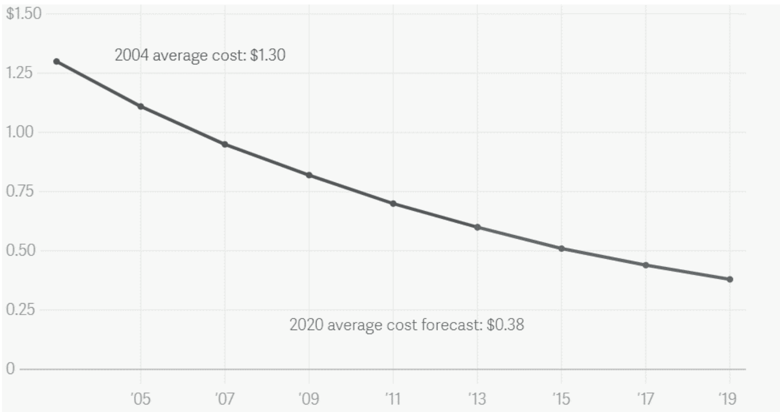
Source: Gehrke et al., 2015

1.2. COSTS

The most important costs of the Internet of Things are the specific hardware, software deployment and employee wages.

The most basic costs of hardware deployment are the various smart sensors and executors (Mital et al., 2018). Their price depends significantly on the type and conditions of the usage of the technology. The trends show that with the spread of technology the price of these devices has generally declined sharply in recent years, and this process will be typical in the near future (Figure 3) ("The average cost of IoT sensors is falling," 2016).

Figure 3 The average cost of IoT sensors over the last decade



Source: The average cost of IoT sensors is falling, 2016

Additional hardware costs are part of signal processing systems, and are also dependent on their complexity (from a few hundred to thousands of dollars ("IoT Gateways," 2018)). In addition, a mass storage is needed that is capable of storing data from the sensors and the controlling logics. An IT cloud is becoming more and more commonly used as the storage system for this. The benefits and costs of the cloud computing are explained in detail in part 3. Generally, the prices of these hardware solutions are showing a decreasing trend lately.

On the software side it is necessary to have a well-designed system that stores the signals in a proper structure in the databases. In addition, an application that evaluates and displays stored data to users is essential. Of course experts with relevant experience are needed to build and operate these systems.

System integration must be considered, so it is necessary that the entire company and other companies in the supply chain are included in a common information system. The cost of this consists of diverse hidden costs beyond the hardware and software costs (such as network expansion and security costs).

This high level of integration leads to a new level of standardization and information sharing between companies.

1.3. EXAMPLE

The costs of the Industrial Internet of Things can be very varied depending on the portion and the depth of the production is plant to implement. To illustrate the costs we will consider a small project related to the Internet of Things as an example (Parra et al., 2018).

This example shows a pilot project in the area of agriculture. Smart wireless sensors (WSNs) monitor the water quality and fish behaviour in aquaculture tanks during the feeding process. The monitored parameters are the water temperature, conductivity, turbidity, the presence of an oil layer over the water, the illumination of the tank state, the presence of the worker and the fish's behaviour. The data management application must be prepared by a skilled expert. In contrast to the project we must count the salary of the programmer too.

These devices could send the monitored data to an IT cloud. The specific costs of the cloud are discussed in the next section. The system stores the data for a longer term and it can retrieve measurement results for several months. Of course, the analogy of this project can be applied to a manufacturing environment with similar hardware and software solutions.

Sensors (temperature, conductivity, etc.) costs: 47.44 EUR = 54 USD (15 490 HUF)

Node costs: 40.22 EUR = 45.5 USD (13 000 HUF)

The software deployment requires approximately 80 hours programming time: 1000 USD (285 000 HUF)

Cost of Internet of Things pilot project: 1099.5 USD (313 500 HUF)

2. BIG DATA ANALYSIS

2.1. BENEFITS

With Big Data Analysis in the case of manufacturing firms right conclusions are expected to be drawn from such data which significantly exceeds human and standard processing capabilities. In addition, the data is very large, varied and it must be quickly processed (Hilbert, 2016).

The Big Data Analysis can save a lot of time, since fast and reliable data can be obtained from the economic operators. In this way, current and future market trends can be determined, which can be a competitive advantage to your competitors (Chen et al., 2014).

The Big Data concept can be adapted to the manufacturing environment as well. In that field the status of the manufacturing machines and processes can be used as input data. In this way a very reliable picture of production on the operating level can be calculated. The weaknesses of the system can be chosen, and the future failure of each item can be determined. Hence, the whole manufacturing process will be significantly more controlled.

2.2. COSTS

The application of Big Data Analysis requires large amounts of accurate and reliable data as input elements. If the object of the analysis is the production data, the easiest way for data acquisition is to use the Internet of Things. The cost of these data collection systems is detailed in the previous chapter. Other data sources may include information from the integrated processes of partner companies and data from the market.

The Big Data Analysis uses large volumes of data that cannot be handled using the standard data-processing systems. These data volumes can efficiently be stored and processed only with a distributed system, such as the Hadoop ("What is Hadoop?," 2018) file storage, MapReduce programming framework, and HiveQL programming. With these systems the operation of cheaper hardware can be linked to each other, and that can significantly reduce the cost of handling data even in petabyte sizes. The biggest advantage is that these are often open source systems, thus, the investment costs are mostly only hardware stocks and staff wages. Furthermore, they can run a processing process parallel to clusters, so even large data sets can be quickly processed. In addition, it is flexible and scalable, therefore, the system is appropriate in the case that there is a change in the company and there is an expansion of its tasks (ATKearney, 2013). For the design, preparation and use of this entire infrastructure a high-skilled workforce is required.

2.3. EXAMPLE

The main costs of a realised project of the Big Data Analysis in industry is presented below (Winter et al., 2013). The aim of the authors is to compare the traditional data storage technology from a cost side to the technology which supports the distributed processing of large datasets.

The authors list the following costs arising from the Hadoop Big Data technology:

- Cost of procurement and development of the system
- Cost of maintenance and support of the system
- Cost of storage and power consumption for storage computers

The study's conclusion based on American wages and a five-year cost horizon is the following:

Data set: 500 TB

System cost: 1.4 million USD

Administration: 0.8 million USD

Application development: 7.2 million USD
Full cost: 9.4 million USD

That is, a large-scale 500-terabyte of data for a 5-year-long Big Data Analysis requires 9.4 million USD. This means roughly 1 million HUF per terabyte per year. This is approximately one third of the traditional data storage method, according to the study.

3. CLOUD COMPUTING

3.1. BENEFITS

Using an IT cloud means that a company does not manage its data and services using its own dedicated hardware but it deposits the data on the devices of an external service provider. The operating details of the IT service are separated from the user, they are accessible on a network through the internet (Kim, 2009).

There are different types of IT clouds (Kim, 2009). They have in common that the user company does not need to incur hardware investments from the building of a local data centre, and so it is relieved of the overhead costs of these systems. On this basis, maintenance of the IT system in the whole company becomes simpler and the IT department can be reduced.

Clouds can be scaled in an extremely flexible way. You can easily add more computing and storage capacity, which, with a long-term or a temporary increase or decrease in the company's IT system, can lead to cost savings (Xu, 2012). The user company only has to pay the expense of its actual demand. For this reason IT cloud services are highly recommended for small and medium-sized companies as they can have a high-capacity IT system like large companies but they do not have to pay the one-off investment cost, rather only the fee of the data they use.

Members of the company can quickly and easily access the company's data and services wherever they are; a server computer and internet connection are the only requirements. It is the so-called 'cloud experience' when a user sees that they can 'connect to anybody, at anytime and anywhere', to this end a more efficient flow of corporate information can emerge.

3.2. COSTS

Companies often use IT clouds as outsourcing services. There are numerous cloud computing companies on the market that offer various customized services. The price of these services is primarily determined by the type of cloud service (software, platform or infrastructure service) you want to use. Another major factor influencing the price is the size of the used capacity (for example computing capacity or storage space).

In addition, other components also affect how much the service costs, for instance, the geographic location of the cloud, or the amount of time (full-time or partial) the company wants to use it. In the latter case, the company only pays on-demand. Other factors that influence the cost are the prospect of future capacity reductions or expansion and that of the relocation of the company ("Google Cloud Platform Pricing Calculator | Google Cloud Platform," 2018).

3.3. EXAMPLE

To calculate the cost of the IT cloud, the author uses the Career Portal on Rightscale Cloud Computing Solutions and then compared the prices to those of the best-known service providers (Google, IBM, Amazon and Microsoft) ("RightScale Cloud Management," 2018). The author checked offers for standard, high-memory and high-capacity processors.

The fees of these service providers widely vary (Table 1). With high-capacity processor, high memory and local SSD storage, Microsoft Azure is the most affordable with its 683 USD (188 000 HUF) annual price.

Table 1 Fees of IT Cloud Services

VM Type US Linux	AWS 1Y RI Annual	Google 1Y CUD Annual	Azure 1Y RI Annual	IBM Monthly + 30% off Annual
Standard 2 vCPU w Local SSD	$867	$884	$508	$764
Standard 2 vCPU no Local disk	$622	$524	$508	$624
Highmen 2 vCPU w Local SSD	$946	$1,013	$683	$998
Highmen 2 vCPU no Local SSD	$850	$653	$683	$998
Highcpu 2 vCPU w Local SSD	$666	$751	$543	$418
Highcpu 2 vCPU no Local SSD	$543	$391	$543	$418

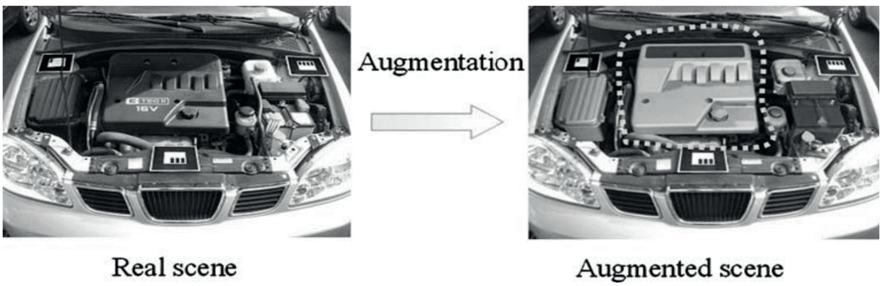
Source: "RightScale Cloud Management," 2018

4. AUGMENTED REALITY

4.1. BENEFITS

Augmented Reality can display a variety of predefined virtual models in the real environment at specific locations (Figure 4) (Lima et al., 2017). Its technology can be excellently used for various educational activities, as it helps the spatial thinking. Di Serio et al. (Di Serio et al., 2013) have shown that it has a positive impact on learning motivation. For this reason, this technology can make it easier and faster to learn the practical part of some types of educational activities, since it associates extra information with the real environment. The user can examine certain models and objects in all directions, just as they would a normal three-dimensional object. This extra information is mostly explanations (e.g., identifying raw materials) or some instructions (e.g., an assembly step).

Figure 4 Application of Augmented Reality



Source: Lee–Rhee, 2008

With the use of Augmented Reality, maintenance tasks, like tasks for repair and inspection, can also be carried out ("Augmented Reality applications accelerate motor-vehicle repairs and support technical trainings," 2018). These can be realised in the same way as installation operations. The system points to the object in which the repair is to be carried out or that needs to be checked. Thus, even a less-qualified worker can fulfil tasks that require deep system- and device-knowledge.

Further use of the system is in the prototype production. In construction or design engineering it can be very helpful to see the model in the environment and surroundings before it is actually built.

4.2. COSTS

To use Augmented Reality a mobile platform (tablet, smartphone) or a headset display (e.g., Microsoft HoloLens ("Microsoft HoloLens," 2018) is needed. The headset devices, due to their high price and low reliability, are not so widespread yet in the industrial environment. Meanwhile, high-speed tablets are affordable even for relatively small companies.

The library packages for augmented reality applications are open-source, or they are relatively low in price (e.g., $ 99 / month ("Vuforia Augmented Reality SDK," 2018)) that a medium-sized company can easily afford them. These library packages can be implemented at a relatively low-price ("Products - Unity," 2018) that allows for a development environment that can produce one's own software. The programming environment and the library packages require high-level of competence and experience.

In the market, serious efforts (Zappar, 2018) have been made to be able to use the technology of Augmented Reality without any deeper programming skills. In this way, the user can provide the relevant information on a graphical interface. However, in industrial environments, tasks with Augmented Reality can be extremely varied, so specialised situations in your own development environment is necessary. For this reason a professional who is responsible for preparing and maintaining the right applications is vital for the company.

4.3. EXAMPLE

To use Augmented Reality high-performance tablets, licenses for the programs, and the payroll of a professional programmer were calculated.

4 high performance tablet prices ("iPad Pro," 2018): 4 x 800 USD = 3,200 USD (880 000 HUF)

Price of a programming computer: 2,000 USD (550 000 HUF)

Programming environment license fee ("Products - Unity," 2018): 125 USD/month (32,500 HUF/month)

Programming license fee ("Vuforia Augmented Reality SDK," 2018): 99 USD/month = (26 000 HUF/month)

Full time programmer: gross 2,200 USD/month (600 000 HUF/month)

One-off expenses: 5,200 USD (1 430 000 HUF)

Cost per month: 2,424 USD (666 500 HUF)

5. COOPERATIVE ROBOTS

5.1. BENEFITS

Cooperative robots (cobots) can combine the flexibility of working with human beings and the robustness of robots. Unlike industrial robots, the cooperative robots do not perform a fully automated operation that is separated from human labour but become an integral part of human work (Figure 5). They can take on the repetitive, burdensome and dangerous part of work (Morioka–Sakakibara, 2010). In addition, they can also relieve the human workforce, which then can be transferred to a less automated field in the factory.

Figure 5 Production environment of industrial robots (left) and cobots (right)

Source: Kagermann et al., 2011

Being easily reprogrammed, cobots are extremely flexible. With them high-quality and high-performance can be achieved even in small quantities of manufacturing. Thus, economic production can be ensured almost independently of the number of units ("GyártásTrend - Szintet lépett az ipar 4.0," 2018).

5.2. COSTS

The price of a cobot is about 1.5 times of the industrial robot with similar parameters (Bélanger-Barrette, 2018). However, the comparison is not entirely appropriate, as it is possible to use a cobot for completely different tasks. For this reason there is a much cheaper version of the cobots, which can be used for simpler, lesser-duty jobs ("Low-cost cobot resurfaces after two years of development - Drives and Controls Magazine," 2018). An additional cost is the tooling of cobots, which is considerably cheaper compared to industrial robots. Furthermore, they can be added to the enterprise's IT system without any excessively high costs because manufacturers develop their tools in line with Industry 4.0's expectations, and falling within the Internet of Things.

To be able to use the device properly, it is necessary to program the cobot. According to the manufacturers and other different users, these robots are much easier to set up for the right task. After a short manual training with the help of a graphical user interface they can be reprogrammed without any deep specific knowledge or experience ("Robot or cobot," 2018; Conrad, 2017).

5.3. EXAMPLE

When calculating the full cost of the application of a cobot only the investment and operating costs of the equipment is taken account. Since it is easy to handle, it is not needed to employ a specific programmer for this task.

Cost of Cooperative Robot ("CobotsGuide," 2018) including tooling, transport and training: 70,000 USD (19 million HUF) (approximately).

The maintenance cost is 1,000 USD (275 000 HUF) per year.

Machine running costs, which operate throughout the year: 3,490 USD (960 000 HUF)

One-off expenses: 70,000 USD (19 000 000 HUF)

Annual cost: 4,490 USD (1 235 000 HUF)

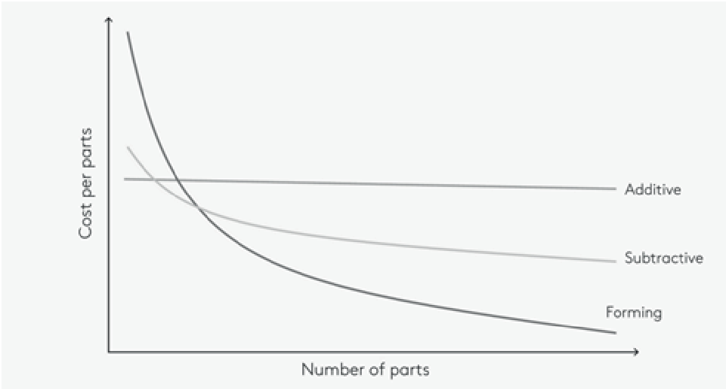
6. ADDITIVE MANUFACTURING

6.1. BENEFITS

Additive manufacturing is a relatively new production method. Unlike traditional methods of subtractive manufacturing, which remove materials in order to make the finished product, additive production equipment produces the finished product from a powdered raw material by adding it layer to layer until the product is totally finished ("3D Printing vs CNC Machining," 2018).

With additive manufacturing technologies the specific production cost of a product does not depend on the number of pieces, in contrast CNC machining and shaping processes the cost decreases in line with the increase of the pieces (Figure 6) ("Innovation in Creation," 2016). Thus, additive manufacturing technologies are primarily cost-effective for prototypes or for a smaller quantity of items. In accordance with Industry 4.0 standards 3D printers can economically produce completely unique products. The principal reason is that there is no product-specific tooling used in this technology. Furthermore, it is easier to achieve JIT (just-in-time), always on-demand production, and there is no large inventory.

Figure 6 Comparison of various manufacturing methods' costs over number of parts

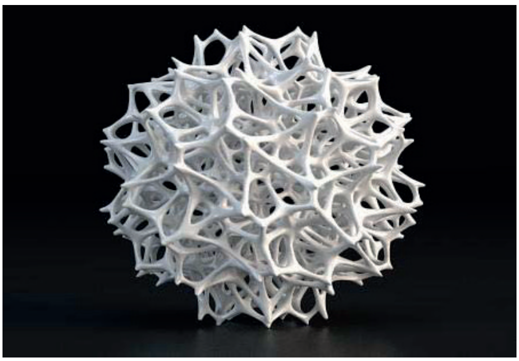


Source: "Innovation in Creation," 2016

Compared to traditional production time, additive production time is relatively high. However, on the other hand, it is needed to take into account that with additive technologies all components can be produced 'under one roof' (Thomas–Gilbert, 2014). Therefore, there may be fewer actors in the supply chain, which reduces the vulnerability of the manufacturing process. Hence, transport costs and time, i.e., total lead-time and the total cost of the series can be reduced.

Furthermore, with 3D printers it is possible to economically produce complicated-shaped geometric models and assemblies that conventional production cannot handle (Figure 7).

Figure 7 Complicated-shaped part produced by a 3D printer



Source: Benaroya et al., 2013

In addition, 3D printing may open a new chapter of support and supply with regards to products because in the future users could exchange their product or print a new one in their home. Thus, transport and storage costs of the manufacturing companies could cease.

6.2. COSTS

The primary costs related to additive technology are the following: the costs of the machine and that of the raw material, overheads and programming fees.

The price of a 3D printer with additive technology is very variable, for industrial use it can cost from $2000 to $750,000, depending on the specifications, similar to a traditional CNC machine ("3D Printer Price - Stratasys 3D Printers," 2012) ("The Best Industrial 3D Printers," 2018). The manufacturers nearly always annex the software for the 3D printer. Nevertheless, experts are predicting a steady decline in the price of printers due to the widespread use of this technology ("Innovation in Creation," 2016).

The cost of the raw materials used for this technology, however, significantly differ from the ones in traditional methods. They are approximately ten times more expensive than those used for traditional production technologies (Atzeni–Salmi, 2012). For this reason, several methods have taken on priority status in 3D printing that can reduce the amount of raw material, such as the proportional reduction of the model size [56] or the substitution of the solid shapes to net (Kroll–Buchris, 2018).

An additional cost is the overhead costs of the equipment. The final energy consumption of the equipment using additive technology per finished product depends greatly on the compactness of the volume of the finished product. At low compactness / cavity ratio, it is the additive technology that has high rates, and in contrast it is the conventional CNC production which consumes less energy per product (Morrow et al., 2007). The production time of 3D printers is relatively high compared to other technologies; it may take up to several hours to produce a simple model.

In the additive manufacturing technology, the programmer's labour also needs to be taken into account. In a manufacturer environment, CAD models of the products are usually already available but they must be reconstructed for the additive manufacturing technology and technological settings must be also carried out. For these tasks, -high-qualified, well-experienced technicians are required. It is difficult to estimate the time and cost of this operation, it depends on the complexity of the product, the user's experience of this technology, and that of the specific manufacturing machine.

6.3. EXAMPLE

To illustrate the cost of additive production, the expenditure side of the preparation of an average product is shown. These expenditures are the followings: the cost of the manufacturing machine and that of the raw material, the overheads and the programming fees.

A manufacturing company's medium-sized, reliable 3D printer with high quality and speed data for industrial use with approximately 20 percent tooling, transportation and training costs:

- plastic (FDM technology, ABS material): 42,000 USD ("Dimension 1200 Reviews & Ratings," 2018) (11 500 000 HUF)
- metal (SLS technology, complete set): 144,000 USD (Metal, 2018) (40 000 000 Ft)

An additional 1,000 USD (275 000 HUF) is required annually for the maintenance.

Approximate preparation cost for a general model of 60x60x60 millimetres:

- ABS: 6.8 USD (1 850 HUF)
- Metal: 373 USD (102 500 HUF)

Production cost (ABS printing)

One-off expenses: 41,800 USD (11 500 000 HUF)
Annual cost: 1,000 USD (275 000 HUF)
Cost per piece: 6.8 USD (1 850 HUF)

Preparation cost (Metal printing)

One-off expenses: 144,000 USD (40 000 000 HUF)
Annual cost: 1,000 USD (275 000 HUF)
Cost per piece: 373 USD (102 500 HUF)

7. CONCLUSION

Economic actors believe that the Fourth Industrial Revolution shows the path of development in the near future. The new industrial revolution has an impact on all manufacturing processes and in the value chain there is a need for new types of networking and information sharing. New technologies are also introduced into the production environment in connection with the revolution. These technologies include the Internet of Things, Simulation, Big Data Analysis, Cloud Computing, System Integration, Augmented Reality, Cooperative Robots, Additive Manufacturing, and Cyber Security. The success of the dissemination of these technologies in a country can be mostly defined by the joint innovation activity of government, universities and the industry.

As the objective of the study, considering the Hungarian situation, was for the government to assess the importance of the fourth industrial revolution and its potential impact on the state economy, this occurred right on time. In 2016 it adopted the direction of industrial development with the Irinyi Plan in which industrial digitalization plays a major role. The so-called Irinyi II Venture Capital

Fund was published in 2017, which supports the local small and medium sized companies to improve the efficiency and digitization efforts related to Industry 4.0. In addition, it also finances more information hubs (for example the National Technology Platform). The major universities function as knowledge centres and they opened more information centres like the Industry 4.0 Technology Center at the Budapest University of Technology and Economics. They provide support to industrial companies in common projects.

Corporate engagement is still missing; since the announcement of the Fourth Industrial Revolution more years have passed and there is little practical implementation in domestic industrial companies. The explanation for this is relatively complex. One reason might be the lack of skilled workers in the sector, the other is the fear of cyber attacks but perhaps the main reason is that its exact consequences for the companies' budget and the whole economy at the moment are uncertain.

The decision makers at a company need to be aware of the applicability of these various technologies of the Fourth Industrial Revolution before starting their investment. In this article these technologies have been demonstrated, the expected benefits of each technology have been detailed, and it has been shown how cost-effective they are. With regards to technologies it can be generally stated that the prevalent trend is that their prices are constantly decreasing, their performance and reliability are rising, and they are increasingly accessible to a wider range of users.

These technologies can be useful on their own but it would be worth considering how these technologies would be used jointly by a manufacturing company or the entire national economy, if horizontal and vertical integration would be achieved in the entire value chain of a product. This requires further research and deeper analysis.

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