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What benefits do initiatives such as Industry 4.0 offer for production locations in high-wage countries?

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Abstract

According to claims made by the proponents of initiatives such as Industry 4.0, information technologies will in the future play a substantially more significant role in production processes both for the service sector and for the production of physical goods than they do today. This paper starts by discussing the origins, essence and expectations of initiatives such as Industry 4.0. It then proceeds to outline concepts and examples around such initiatives. Finally, it offers a realistic view of the likely future effects. The paper has a special focus on examples in Switzerland.

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1. The origins, essence and expectations of initiatives such as Industry 4.0

The term *Industry 4.0* was coined by Acatech, the German Academy of Science and Engineering. They set up a working group in 2011 as part of the response to the American "cyber-physical systems" initiative, and their report was published in 2013 [1, 2]. It postulates a fourth industrial revolution, following on from the previous revolutions of mechanization, electrification, and computerization. As early as 2012, it was receiving widespread support from the German government and in scientific circles, reflecting the fact that it had become a concerted initiative [3]. Leadership in this area came from both the political and scientific arenas. Significant financial resources were (and continue to be) made available by the German federal government, by the German states, by the BMBF (Germany's Federal Ministry of Education and Research) and the DFG (German Research Foundation) to finance ongoing work by German research institutes and by industry. The initiative is also fully supported by employers' associations [4].

This digital revolution should replace many production technologies that have been used until now, and should do so in a disruptive manner, as happened within a very short time in the second half of the 1990s when digital photography came in. At the same time, individualization of products to customers' requirements will become more widespread, without significantly increasing costs. The aim is full digitization of production technology, resulting in a "smart factory": products and production systems will become (more) intelligent, which means more versatile, more efficient, more ergonomic, with better integration throughout the entire supply chain – right to the customer. And they will make decisions autonomously, as decentralized as possible. The claim that this initiative is a "revolution" is openly stated in advance, in contrast to the first, second and third industrial revolutions, which were only recognized as being revolutions after the event.

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The term CPS "cyber-physical systems" was first used in the USA between 2006 and 2009. It was initially an initiative sponsored by the National Science Foundation (NSF) [5, 6]. In a CPS, information technology devices which control physical objects (e.g. mechanical and electronic objects) work together over a communication network. Key building blocks for this sort of system include concepts like intelligent sensors, the Internet of Things, big data as well as technologies of additive manufacturing or medical engineering. In industry, the trend is increasingly towards a complete network that covers all of the relevant machines, both within a company and across companies, and regardless of the machine's manufacturer. The digital components should allow automated production to adapt increasingly quickly to changing requirements.

A prerequisite for CPS is a very high degree of standardization. In the USA, a first step in this direction was taken in 2014 when the *Industrial Internet Consortium* (IIC) was founded. Many large companies work together in this organization to draw up common standards, which facilitates interoperability between systems [7]. Since also Industry 4.0 cannot be implemented without these common standards, the "Plattform *Industrie 4.0*" initiative was set up in Germany [8].

In 2015, Japan responded by launching a largely industry-led initiative called IVI, "Industrial Value Chain Initiative" [9]. It was accepted that the way in which standardization occurs is the key for economic success. So one of the aims of the IVI is to create common standards for technologies that can connect factories, and to internationalize Japanese industrial standards.

In Switzerland, four industry associations responded by launching the "Industrie2025" initiative in 2015 [10]. It is closely modelled on Industry 4.0. The name underlines the long-term aspect of the transformation process, which is supposed to be a rather continuous process. Due to Switzerland's political system and regulatory policy, there is no government-supported program like Germany's Industrie 4.0. For many years, the CTI (Commission for Technology and Innovation) of the Federal Department of Economic Affairs, Education and Research has supported industry-led research projects with universities, universities of applied sciences and colleges. In such projects, the CTI finances the salaries and expenses of the academic personnel, while the companies have to cover their costs themselves. Between 2017 and 2020, the CTI is also supporting two National Thematic Networks in the CPS field: Additive Manufacturing – AM Network, and Swiss Alliance for Data-Intensive Services (data + services) [11].

To keep this article as concise as possible for readers with practical experience, we will not provide a full list of previously published literature here. [12] contains a larger selection of publications, with a focus on contributions from Germany.

2. Concepts and examples around Industry 4.0

Companies expect that, finally, the benefit of initiatives such as Industry 4.0 will be a contribution to the company's net profit. Drivers for this include new products that address customers' needs, and more effective and more efficient processes in R&D and production.

For many years now, and especially in high-wage countries, standardization and automation have been at the forefront of all industrial initiatives, since they are the two key components of industrialization. If an initiative is successful, it leads to an increase in effectiveness as well as efficiency. In this respect, initiatives in the classical industries sector, i.e. the production of physical goods, behave in the same way as initiatives in the service sector [13]. Digitization in the context of initiatives such as CPS, Industry 4.0, IVI or Industrie2025 often involves both sectors. The contribution in [14] contains a comprehensive discussion of CPS in manufacturing, but also looking into the service sector. The following examples from the various key building blocks discussed in Section 1 also often involve both sectors. Most of the examples in this and the following Section are taken from the Swiss industrial and services sectors. They broadly meet the aims of initiatives like Industry 4.0 discussed in Section 1, namely (1) individualization of products, (2) full digitization of production technology along the supply chain, and (3) autonomous decision making in decentralized product and production systems.

2.1. Smart Sensors

Apart from simply measuring things (as a conventional sensor would), a *Smart Sensor* can also process the measured data and make the results available in the required form. The (decentralized) "intelligence" is provided by a microprocessor. Here again, the driving force is the need for individualized production. Figure 1 shows some examples, including accelerometers, motion sensors and magnetic field sensors for functional movement therapy [15].

Fig. 1. An example of a smart sensor. Valedo sensor. (Source: Hocoma)

The use of sensor technology helps improve accuracy in the observation of the patients' movements. In a fully digitized way, the data collection results can be processed by the sensor, and converted to movement objectives that are tailored for the patient and which can be displayed on a mirror, for example.

2.2. Internet of Things (IOT) and Big Data

The *Internet of Things* is a network of material or non-material goods or objects ("things") that are connected to each other and that can exchange data. An integrated computer identifies each "Thing" and can communicate via the Internet infrastructure [16]. As a sensor, or with the help of a sensor, the "Thing" can capture useful data, which it can then autonomously and in a fully digitized way send on to other