

# The Tracking of Industrial and Digital Revolutions and the Importance of Human Capital Development

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## Abstract

*The following paper highlights new approaches of comprehending the core aspect of human capital development within the ongoing process of new technological development era. The literature review dwells with headlining key aspects in relation to education and production, aspects that influence the ongoing development, as well as highlighting the importance of solid binding links which causes multiple issues along with its rewards. One of the prominent concern that highlights unusual issues, as well as unique rewards, represents the development and assimilation process of digitalization. In this regard, new atypical and unique jobs that appear within society, offers new possibilities together with new obstacles which need to be solved differently.*

**Key words:** industrial revolution, digitalization, human capital development, path-dependence, future developments

**J.E.L. classification:** E24, J24, O14

## 1. Introduction

To outline the contemporary trend of digitalization, briefly highlighting the outline and trace of technological development in respect to industrial revolution, represents the framework of understanding why the changes would exist in the first place. The second approach encompasses the reshaped core perception of production (productive and non-productive sectors) within each phase of the industrial revolution. When it comes to the redefining the meanings of production, mostly it also depends on what sectors the units of production are analyzed. Hence, productive sectors, and non-productive sectors (also known as service sectors), have theoretically different methods of measuring, especially when it comes to income or expenses. For instance, in the productive sector, where the measure could be made on the number of produced vehicles, the sales of the cars could represent the units of efficiency and production, hence the economic growth. However, when it comes to the non-productive sectors, such as teaching or educating, domain of military or security (cybersecurity as well), the measures are mainly different, due to the fact that the expenses and the results are different in this case. Moreover, pointing out which are the significant units of measure represented mostly by the income implemented for each sector by the state. The third part highlights the relevance of culture in relation with the ongoing technological development. Until now, most of the units of measures were either products, or needed services. However, there is an unclear situation in regard to the importance of cultural aspects, which are analyzed together with productive and non-productive sectors. This situation needs to be considered due to the fact that efficiency could affect ethical aspects. Meaning which are the limits which an enterprise could increase efficiency, without putting in danger ethical aspects, or there also could be intrinsic aspects (beliefs, or desires) which could be changed in order to increase efficiency.

## 2. Theoretical background. The industrial revolutions and the perspectives of logistical and ethical barriers

A suitable illustration of the four industrial revolutions was highlighted by author Prisecaru (2016) presented within authors Min Xu et al. article (2018), detailing briefly (within Table 1) the period together with the transition period, the main energy input source thrusts, followed by the output torque of technical achievements, the output of main developed industries, as well as the means of transportation of that peculiar era.

Interestingly enough, simply by analyzing the table, we witness aspects which need to be considered. For instance, the first outstanding aspect represents a rather decrease trend of the time period between the period and transitional period of each era. As we observe in table 1, the period between each industrial revolution becomes relatively faster and shorter compared to the former period. This aspect could be also influenced by other indicators which develops other means and opportunities in terms of development. As example in this regard, by also analyzing the main source of their energy resource, as authors Min Xu et al. (2018:90), point out:

*“The first industrial revolution [...] The steam engine allowed the transition from farming and feudal society to the new manufacturing process. [...] The second industrial revolution began in 1900 with the invention of the internal combustion engine. This led to an era of rapid industrialization using oil and electricity to power mass production. The third industrial revolution [...] was characterized with the implementation of electronics and information technology to automate production. [...] The fourth industrial revolution now involves computer generated product design and three-dimensional (3D) printing [...]. (Prisecaru, 57-62)”*

Each industrial revolution encompasses peculiar and distinct sources of developments, starting with the type of resources which were used before. As first example, as author Prisecaru (2018) highlighted, in the first industrial revolution coal represented the main source input to develop steam as primal source output of energy. Besides the aspect that the obvious transition from feudal society towards a new method of industrial manufacturing process, the rather curious aspect represents the logistics methods which were used in that period, rather than the processing and end-product period. For instance, that era’s capacity of gathering the main source input of energy represented one of the most significant as well as the first step of coordinating a new internal mechanisms of a given enterprise.

The main aspect which need to be considered in this situation, represents mainly the needed resources to maintain the industrial revolution, the important logistics that fuel in the end the maintenance of the industrial revolution, for what rewards were those acts done for, and finally, which were the main expenses invested in order to achieve not only the first steps of industrial revolutions, but the followings as well. This being mentioned, the second industrial revolution, developed from coal as main input resource source towards oil and electricity. Interestingly enough, the development towards internal combustion engine, which consequently developed new products (cars, for instance), and concomitantly new perspectives in terms of internal mechanisms, besides the shortening of logistics and time as well. For instance, in order to progress towards new means of development, it also represents a new method of efficiency. Hence, considering that the main source of energy remained coal for each industrial revolution, would this have been accepted in the future? Probably not, due to the increase protection of nature, for example, but this aspect we will detail it later on. Nevertheless, extracting other sources of energy, also means that there could have been significant changes in the strategies of logistics, which were changed in order to achieve faster developments in other domains.

As consequence, if electricity was not achieved with the help of oil extraction and oil refining, then the next industrial revolution would not be reached, respectively new means of production and further efficiency would not have been reached. The third industrial revolution developed efficiency, and logistics even further, eliminating mainly the majority of the search of coal and oil resources (theoretically), and started pursuing other sources of energy, such as natural gas (an alternative form of energy from oil and coal), and even more efficiently the development of nuclear energy. The third industrial revolution also brings significant products necessary for the next industrial revolution, such as the appearance of computers, robots, planes, more efficient cars, and so on. However, the interesting aspect start mainly between the third and fourth industrial

revolution, because the main source of energy input starts to be limited by other ethical barriers, which are mainly two important aspects: (1) the protection of workers, and (2) the protection of environment. Both of mentioned spheres deal with the reaction of society itself. In the first case, the protection of workers with social protection policies, develops an interesting restriction.

Enterprises are theoretically limited to develop if they do not respect some ethical or other similar types of barriers (such as the destruction of nature for the development of the industry), or if they do not offer significantly better protection for workers in terms of instruments, suitable equipment's, etc., but also adequate income in order to perform, for instance if the income is not high enough, then individuals will not be interested to work that specific job, yet on the other side, if the income is too high, then it is possible that the end-product is not profitable enough, meaning that there is no more interest in developing that sector anymore. Finally, there is the fourth industrial revolution, which searches even further alternative methods of energy input resources, such as green energy, consequently developing even further products and other aspects which constructs our society in our days. Nevertheless, even though there are mainly new searches for alternative energy resources, this will not necessarily mean that there will also be at the same efficiency level, because of to the ethical and practical limitations of those resources. For instance, a comparison between nuclear energy and green energies, on one hand the nuclear energy offers significantly higher energy output than the wind power energy, or solar panel energy. Hence, even thou nuclear plants are mainly dangerous for the environment and the society (Chernobyl case), the energy output is relatively higher than the green energy outputs. For instance, even if the solar panel generate significant higher energy generation, storing that energy in batteries represents a challenge (besides the energy consumption during night), or in the case of wind power energy, when there is a possibility that there will be a lack of winds.

Conclusively, the protection of nature represents one of the highest priority in order to maintain our current society, however, on the other side, if there is not enough energy to generate, then there is the possibility that the next industrial revolution to not occur, due to the lack of energy. However, this does not mean the fact that there is a decrease in terms of development, on the contrary, it means that due to societal constrains, the internal mechanisms of development changed from "hard and solid products" (trains, cars, computers, robots, etc.) towards "complex and digital products" (internet, genetic engineering, software's, digital platforms, higher performance electric cars, significant efficient planes, ultra-fast trains, decrease in size among electric circuits). This new approach in respect to development, also need another suitable approach of human capital development, which will be detailed further in the next part.

Table 1. Main characteristics of industrial revolutions

Period	Transition Period	Energy Resource	Main Technical Achievement	Main Developed Industries	Transport Means
I: 1760-1900	1860-1900	Coal	Steam Engine	Textile, Steel	Train
II: 1900-1960	1940-1960	Oil Electricity	Internal Combustion Engine	Metallurgy, Auto, Machine Building	Train, Car
III: 1960-2000	1980-2000	Nuclear Energy Natural Gas	Computers, Robots	Auto, Chemistry	Car, Plane
IV: 2000-	2000-2010	Green Energies	Internet, 3D Printer, Genetic Engineering	High Tech Industries	Electric Car, Ultra-Fast Train

Source: Prisecanu, P. (2016). "Challenges of the Fourth Industrial Revolution." *Knowledge Horizons. Economics*, 8(1), 57-62. <https://search-proquest-com.ezproxy.libraries.udmercy.edu:2443/docview/1793552558?accountid=28018>.

### 3. Findings. The prioritization of production and the importance of human capital development

When it comes to comprehending and measuring units of production, or simply the definition of production in general, firstly it depends on what type of production is envisioned, followed by the level of expenses on those specific spheres. Thus, the peculiar difference between productive-, and

non-productive sectors lies among their forms of products, and calculated (theoretically) with the level of investments, or governmental expenses, for those sectors. For instance, considering the article from authors Tuan T. Chu et al. (2018), they mention that:

*“Researchers have differentiated between productive and non-productive government expenditure and have shown how a country can increase its economic growth by changing the mix between these alternative forms of expenditure (Tuan T. Chu et al. 2018)”*

Moreover, as author Tuan T. Chu highlights, other academicians such as Kneller (et al. 1999), who also considers that:

*“[...] productive government spending influences private sector productivity and hence has a direct impact on growth, while non-productive expenditure, which normally has an effect on citizens’ welfare, is likely to have a zero or negative growth impact.”*

There are many aspects to develop when it comes to expenses in general, because as I mentioned previously, there are production units which are significantly easy to measure within the production sector (such as the number of produced cars, followed by the profit after the industry sells the cars), compared to the non-productive sector (services in general, such as teaching, or in general theoretical services) which as author Kneller (1999) mentioned “is likely to have a zero or negative growth impact”.

However, author Kneller mentioned mainly the fact that the ‘growth impact’ within non-productive sector (or service sector) are theoretically unattractive and unprofitable when it comes to invest as private entity, but most needed among citizens, compared to the production sector. This situation, nevertheless, is partially true, due to the fact that the service sector in general is difficult to be measured. In addition, there is also the aspect of necessity and efficiency, thus the production sector cannot maintain or perform without the non-production sector. Employees in order to be suitable within an industry, it needs firstly the basic preparedness of skills and knowledge in order to be a top performance employee. In addition, and considering author’s Prisecaru (2016) table, there is also an indication of an increased need of highly educated employees in order to perform in the new industrial era (such as, IT employees, digital engineers, robotic engineers, etc.).

Moreover, the base necessity of human capital development lies together with the industrial revolution, when it comes to development in terms of increasing productivity within new spheres, and not automatically within the production sectors. Undoubtedly, the production sector remains one of the main source of progress and development, however without the development of service sector, especially in regard to human capital development, the production sector cannot develop at its peak performance. However, considering authors Tuan T. Chun (2018) results, even if the education of citizens in general in respect to the new trends of industrial developments, the governments in general prefer to expend towards mainly the productive sector and ignoring, if not reducing, expenses within the non-productive sectors. Tuan T. Chun (2018) highlights that:

*“[...] the findings show that a shift in government expenditure towards productive government expenditure and away from non-productive expenditure has a positive relationship with economic growth. In relation to low- to middle-income countries, we find a similar relationship, [...]. However, by shifting from non-productive to productive forms of public spending, countries can move closer to a more optimum growth level. These results support our conclusion that our low- to middle-income countries sample has followed the fiscal policy approach of high-income countries, in allocating government expenditure in favour of productive government spending at the expense of non-productive expenditure to enhance economic growth.”*

In this regard, it is debatable if the necessity of expending further within productive sectors diminishes the economic pressure from the non-productive sectors. Furthermore, the necessity of maintaining the private sector as a type of vanguard of economic and industrial development represents one of the significant factors in terms of developing new methods of efficiency. Moreover, regardless of expenses within researching industrial development, but also researching a more efficient method in educating and discovering new trends of human capital development also represents a significant priority, which needs to be supported economically. In this respect, the decision-making actors within governments, also represents one key aspect of understanding the maintenance, or the change factors, hence:

*“[...] our findings have implications for governments in deciding how to allocate their expenditures. For high-income countries, allocating more expenditure to education, housing and general public services will enhance economic growth. Meanwhile spending more on health and economic affairs bring the same result for low- to middle-income countries. However, expenditure on social protection has a negative impact on economic growth for both sets of countries (Tuan T. Chu 2018).”*

Within this quote, there are three aspects which need to be highlighted, thus: (1) the implication of the governments, (2) expenses in regard to health and economic affairs, and (3) expenses in respect to social protection. Starting with the first aspect, the implication of the governments represents one of the most important actors in terms of changing the prioritization of internal mechanisms with policies, or legislative means. In this regard, the concept of path-dependence (Colin and Farrell 2004) becomes further significant when it comes to changes, or transitions, at a high magnitude level. Comparing high-level income countries, with low-, middle-income countries, also points out the fact that, theoretically, high-level income countries rejoice the implementation and development of latest developments in terms of industrial and human capital developments. Meaning that countries with low-, middle-income did not increase the allocation for “*more expenditure to education, housing and general public services*” (which will enhance economic growth) due to the lack of economic sustainability from the production sector, compared to high-income countries. This aspect also proves the importance of the necessity of transitioning from one industrial revolution, towards the next one, due to the fact that, there could be latter countries which if not stagnating, could decrease in terms on economic growth, especially when it comes to worldwide economic competition and technological developments. The second aspect, encompasses the fact that health and economic affairs, could mean that the ongoing internal mechanisms are already performing. For instance, the existing expenses within the healthcare system depends mainly on the existing ‘routine’ within that society, with the condition that there will not be any kind of a health crisis, which will put eventually pressure on public expenses. The economic affairs, on the other hand, creates or maintains economic relation betwixt states.

However, economic affairs have also a significant role when it comes to international Trade Agreements. These agreements, theoretically could increase even further economic growth among the states. The third aspect regarding the social protection expenses, generally is rather a non-profitable domain, but necessary to the welfare state, respectively to the citizens. This sector represents mainly a vanguard toward multiple situation which the state needs to use the finances in order to offer possibilities for the citizens to either be protected economically (unemployment expenses, accident expenses, peculiar expenses in respect to pension, and so on), and regardless on the income of each state, it needs to be funded and further adequately prepared for current status-quo needs of internal mechanisms of the given state.

#### **4. Conclusions**

Due to new approaches and new technological discoveries which aid towards a significantly improved way of increasing production, along with preparing, and educating employees to handle new methods and habits in order to perform correspondingly with advanced knowledge. This paper concludes that there is not necessarily the need of finding new products, as well as new methods of comprehending the new industrial revolution, but rather understanding firstly the status-quo of already existing peculiar logistical methods of energy inputs, followed by significant and efficient methods of transportation, but rather focusing even further with developing human capital in order to perform with a high degree of complexity when it comes of digital technicalities. Meaning that the industrial revolution could actually develop not within the existing world, but rather within the digital world. However, the virtual reality could not be maintained if there is no economic sustainability, as well as the insurance of a solid social protection system, in order to maintain both existing as well as digital reality. Moreover, even if there is a peculiar trend of investing further in the production sector, investing within the non-production sector could mean further digital developments, as well as further industrial developments. This could also be considered as the beginning, if not already existing new industrial revolution, hence shifting towards the digital revolution within the industrial development.

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