Sustainable Development in Accordance With the Concept of Industry 4.0 on the Example of the Furniture Industry

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Abstract. Sustainable development, as an integral part of building an economically rational market, is a challenge which is faced by many branches of the economy. The paper is an attempt to assess the opportunities provided by Industry 4.0 in the process of sustainable development of the furniture industry in Poland, making use of the experiences resulting from the participation of the Author in the project co-funded by the Erasmus+ Program of the European Union "Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry - MSIE4.0".

1 Introduction

Global economic development brought about that the industry should respond relatively quickly to the market requirements while complying with high quality standards. Economic criteria clearly depict the pattern which technology, employees and resources ought to adjust to. Production processes adapted to the dynamics of changes imposed by the economic leader (regardless of who they are) should be possibly the most innovative and automated. The human being, wishing to be a part of this process of changes must "be a lifelong learner" simultaneously having an interdisciplinary experience". The environment ought to "produce" infinite amounts of resources and help (taking into account, e.g. clean air) the human existence. The idea of sustainable development allows for maintaining a relative balance between the listed criteria.

The economy and more specifically its development largely depends on production capacities. The processes of automation and digitization lead to the transformation of the currently existing factories into the so called Smart Factories, which allow for creating intelligent value chains. The industry operating in this way is described with the term of "Industry 4.0", which refers to "the fourth industrial revolution" taking place at the moment. The revolution is the reference to the previous stages in the socio-economic development of humankind which may include [1]: *revolution 1.0:* mechanization of production using water and steam driven machines; *revolution 2.0:* mass production based on the division of labor and electrification of machinery and equipment; *revolution 3.0:* use of electronics and information technology to automate production.

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The origin of the term "Industry 4.0" comes from the government of the Federal Republic of Germany when in 2011 it was used by the initiative group "Industrie 4.0" (representatives of the world of business, politics and science) who identified the name with the concept of increasing the competitiveness of the German economy. Meanwhile, the government, while providing the support, acknowledged that the name of "Industry 4.0" would be an integral part of the program of the development of the country. The key objective of the program is leadership in the field of innovative technologies on a global scale [2].

The essence of "Industry 4.0" is brought to creating intelligent value chains, based on sociotechnical systems which are dynamic, self-organizing and optimizing, perceived as smart factories [3]. They are created by spontaneously emerging virtual networks: Internet of Services [4], Internet of Things [5], cloud computing [6], which include both employees, machinery and equipment: augmented reality [7], artificial intelligence [8] Human Machine Interface [9], and supporting IT systems: robotics [10], intelligent production [11], digital transformation [12], cyber-physical systems [13]. These value chains are to a certain extent a dynamic network which is centered around a unified object of cooperation. The network is subjected to constant reconfiguration, which depends on the current objectives and conditions, ensuring high flexibility and production efficiency.[1] The solutions changing the modern industry into the one operating in accordance with "Industry 4.0" make the Internet a driving force in the organization of operational work [14].

2 Sustainable development

In accordance with the Polish Environmental Protection Act, sustainable development is understood as "[…] socio-economic development in which there takes place the process of integrating political, economic and social activities maintaining the natural balance and durability of basic natural processes in order to guarantee the possibility of satisfying basic needs of individual communities or citizens of both modern generation and future ones [15]." The definition of sustainable development is associated with the UN since the report of this organization recorded it for the first time in 1987 in Our Common Future as a result of the work of the World Commission on Environment and Development [16]. Satisfying the needs of each of the key factors of sustainable development, being in the mutual correlation, is a very difficult process. "The fourth industrial revolution", being an integral part of economic development and processes taking place in a globalized world, is also a challenge in the field of its significance in balancing the needs of all participants of economic processes. From the point of view of the organization, it is very important to maintain a balance between innovation which is the measure of the efficiency of the organization and practices of sustainable development which is aimed at achieving efficiency in the field of sustainable development due to a gradual improvement in its individual processes. [17]

The economic situation of each country is generated by the emphasis on continuous economic growth, which is very often associated with an increasingly high consumption of already limited natural resources. This is related to the lack of synthesis between the exhaustibility and renewability of raw materials, which recently has been the source of many environmental and social problems. Sustainable development, as an idea practiced for many years, encounters numerous economic, political and cultural barriers, which i.e. lead to crossing the limits of tolerance of the nature. [18] The industry depending on renewable natural resources is the furniture production. In accordance with the report by PDF (Polish Development Fund), the furniture industry (taking into account manufacturing industries), in terms of net export value, occupies the second position and at the same time constitutes a significant part of the Polish economy. In 2016, exports of goods in the CN 94 group (the

descriptive version of the Combined Nomenclature 2016 - Chapter 94: furniture; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings; lamps and lighting fittings, not elsewhere specified or included; illuminated advertising, illuminated signs and the like; prefabricated buildings) exceeded PLN 48 billion. The share of sales of this industry (according to PKD – Polish Classification of Activities 2007, Chapter 31) in GDP for furniture producers (over 49 employees) remains at the level of about 2% and more than 130 thousand people are employed in this industry. [19]

2.1 The industry - automation

The development of the furniture industry brought about that it began to face some constraints resulting at least from the globalization of distribution or problems with human capital resources. Striving for production automation and robotics will allow for gaining a competitive advantage using economies of scale. This is associated with an increase in investments in the use of the latest generation solutions in the field of the automated interoperational transport; additionally, the implementation of the methodology of the operation of Lean principles (e.g. Lean Production), the use of autonomous and collaborative robots as well as or above all the use of all available IT resources in the correlation of subsequent stages of production. [19]
"Industry 4.0", in its concept, includes the areas closely related to IT. Its main elements include: *1. Industrial Internet of Things – IIoT*, originating from Internet of Things – IoT: formulated by Kevin Ashton in 1999. It consists in the use of data transmission via the Internet network using the radio identification of RFID to manage the value chain [20]. *2. Smart Factory*: constitutes the key characteristic of Industrie 4.0. It is assumed that factories are managed comprehensively thus being less susceptible to disturbances. In this way, they are able to produce more efficiently and humans, machinery and resources communicate with each other following the principles of social network [21]. *3. Cyber-Physical Systems (CPS):* consists in combining the computational layer and physical processes, where the system of the review of the manufacturing process functions in the feedback loop. Physical processes are identified as the data source used for calculating the control signal of the selected executive objects [22].

2.2 The society - education

Rapid economic growth, among others in Poland, brought about an increase in the need for employees. Increased production caused by a high share of sales in GDP, also in the furniture industry, brought about the same effect. The statistics by Central Statistical Office show that, in Poland, in 2017 there were registered 1081746 unemployed people with the following educational background: higher education - 149491; post-secondary, upper secondary vocational education - 234599; general secondary education - 117266; vocational education - 281679; lower secondary education and below - 298711. The number of the unemployed steadily indicates a downward trend. [23] In turn, the analysis of the higher education market conducted by Wiśniewska-Sałek or Ulewicz [26], indicated that the number of engineering graduates, which are of particular significance in industrial sectors, varied [24]. The detailed listing is presented in Figure 1. A drop in the interest in engineering studies in the context of other types of studies showed the smallest declines and in the academic year of 14/15-13/14 – even large increases. Obviously, the situation of a declining population among young people is the interpretation of such a downturn. Managerial skills, which freely allow for keeping up intellectually with communication technologies, may also become significant. Such people, while excluding practical

knowledge, have the ability to use "computer technologies" at the same time constituting the so called senior manager [25].

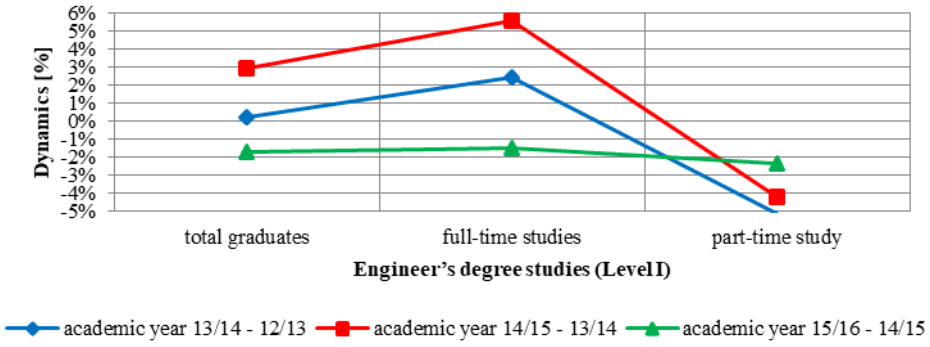

Fig. 1. The dynamics of changes in the number of graduates in the Poland from the academic year of 2012/2013 to 2015/2016.

Social Product Development (SPD) is one of the elements of "Industry 4.0" from the social point of view. This idea has no unambiguous definition. It is identified with the involvement of the team (which includes the qualified group of people from the inside or/and the outside of the company) in the development of the product using: technologies, social tools and media. Users have impact on the product life cycle (subsequent stages of design), due to which a new product, introduced into the market, has a shorter time of development and is burdened with lower investments. [22] From the point of view of the furniture industry, the fact that, with such a large share of this industry in the national economy, only 3 universities provide education in the field of tree farming and 4 universities – in the field of forestry, seems to be disturbing.

2.3 The environment - natural resources (wood)

The wood industry, as relating to the renewable natural raw material, is one of the key and most difficult to implement parts of sustainable development. The situation depends on the time which is needed by forest stands to "recover" its resources and its general usability in purifying the air and, on the other, the rapid development of the industry indicates an increased demand for this raw material. According to the statistical data published by Central Statistical Office, the area of forest land in Poland in recent 6 years (2010-2016) increased on average by 0.19% with an increase of 0.2% in woodiness, at the same time occupying less than 30% of the area of the country. In accordance with the Regulation by the Minister of Environment, the minimum felling age for individual species ranges from 30 years, e.g. for poplar and up to 120 years for oak and ash, it is connected with the problem of sustainability. On the basis of the data by Central Statistical Office, it can be observed that in years 2010-2016 the dynamics of changes (chain index) of restoration and a forestation in Poland was the following: 8.7%; 2.1%; -3.8%; 2.2%; 3.4%; -1.0%. At the same time, in the research period, there was received the following dynamics of changeability of the acquired large timber: 3.90%; 0.29%; 2.34%; 5,21%; 1.77%; 2.09% due to which there was acquired 33568291 m^3 of wood in 2010 and as much as 39129329m^3 in 2016. The restoration of forest land may take place naturally or artificially. With a significant increase in the acquisition of large timber in 2016 compared to 2015 there was artificially restored only 1.4% more of forest land with no natural restoration (-13.4%). The assumptions of "Industry 4.0" do not directly translate into the environment but indirectly, through more efficient use of raw materials for production, it is possible to

reduce production waste or utilizing a more appropriate technology use it more significantly.

3 Conclusions

Industry 4.0 very clearly and legibly outlines the bridge between the economy and social expectations. On the one hand, it creates the grounds for the development of technological innovation but, on the other, shows how important the human being is in this whole process. On the one hand, it fosters economic development and, on the other, satisfies staff shortages with automation. On the one hand, it streamlines and optimizes production time and, on the other, allows the transfer of dangerous and burdensome tasks from the human being to the machinery. It allows for using the mental potential of the human being instead of crushing it. All these activities bring about that there may occur the co-integration correlation between sustainable development and "the fourth industrial revolution". An example of the implementation of the assumptions of "Industry 4.0" in accordance with the social dimension of sustainable development is the project MSIE4.0. Project assumes an increase in opportunities and capacity of universities in Thailand (based on the experience of European countries, including Polish) to provide a high-quality syllabus – based on competencies for Masters courses in the field of industrial engineering, which supports sustainable smart industry (Industry 4.0) and is compliant with European Qualifications Framework.

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References

1. J. Bendkowski, Zeszyty Naukowe Politechniki Śląskiej, **112** (2017)
2. H. Kagermann, W. Lukas, W. Wahlster, VDI nachrichten, **13** (2011)
3. P.N. Koustoumpardis, J.S. Fourkiotis, N.A. Aspragathos, International Journal of ClothingScience and Technology, **19**, 2 (2007)
4. J. Cardoso, K. Voigt, M. Winkler, ICEIS 2008, LNBIP, **19** (2009)
5. T. Qu, S.P. Lei, Z.Z. Wang, D.X. Nie, X. Chen, G.Q. Huang, Int. J. Adv. Manuf. Technol., **84**, 1-4 (2015)
6. F. Scavo, B. Newton, M. Longwell, Computer Economics Report, **34**, 8 (2012)
7. V. Paelke, IEEE Emerging Technology and Factory Automation (ETFA), (2014)
8. S.P.L. Kumar, Engineering Applications of Artificial Intelligence, **65** (2017)
9. D. Gorecky, M. Schmitt, M. Loskyll, IEEE International Conference on Industrial Informatics (INDIN), (2014)
10. B. Kehoe, S. Patil, P. Abbeel, K. Goldberg K, IEEE Transactions on Automation Science and Engineering, **12**, 2 (2015)

11. R.Y. Zhong, X. Xu, E. Klotz, S.T. Newman S.T, Engineering, **3**, 5 (2017)
12. A. Ustundag, E. Cevikcan, *Industry 4.0: Managing The Digital Transformation* (Springer, Berlin, 2017)
13. N. Jazdi, IEEE Conference on Automation, Quality and Testing, Robotics (AQTR), (2014)
14. W. Torbacki, data odczytu 27.04.2018: http://www.ptzp.org.pl/files/konferencje/kzz/artyk_pdf_2018/T2/2018_t2_716.pdf
15. Prawo ochrony środowiska z dnia 27 kwietnia 2001 r., art.3, pkt.50.
16. A. Pawłowski, Środkowo-Pomorskie Towarzystwo Naukowe Ochrony Środowiska, **11** (2009)
17. F. Susanto, W. Arafah, Z. Husin, Polish Journal of Management Studies, **16,** 2 (2017)
18. A. Pabian, Zeszyty Naukowe Politechniki Częstochowskiej Zarządzanie, **28**, 1 (2017)
19. Polskie Meble. Raport specjalny. Inwestycje dla Polski, Data odczytu 27.04.2018: https://www.paih.gov.pl/files/?id_plik=30887
20. K. Ashton, Data odczytu 29.04.2018: http://www.rfidjournal.com/articles/view?4986
21. H. Kagermann, W. Wahlster, J. Helbig J., Data odczytu 27.04.2018 : http://www.acatech.de/fileadmin/user_upload/Baumstruktur_nach_Website/Acatech/root/de/Material_fuer_Sonderseiten/Industrie_4.0/Final_report__Industrie_4.0_accessible.pdf
22. P. Wittbrodt, I. Łapuńka, Data odczytu 29.04.2018: http://www.ptzp.org.pl/files/konferencje/kzz/artyk_pdf_2017/T2/t2_793.pdf
23. Bank Danych Lokalnych: https://bdl.stat.gov.pl/BDL/start
24. A. Wiśniewska-Sałek, Knowledge For Market Use 2017: People In Economics – Decisions, Behavior And Normative Models. International Scientific Conference Proceedings, Pavla Slavíčková (Ed.), Palacký University, Olomouc (2017)
25. L. Kiełtyka, Przegląd Organizacji, **8** (2016)
26. R. Ulewicz, Polish Journal of Management Studies, **8** (2013)