SZÉCHENYI EGYETEM
UNIVERSITY OF GYŐR
REGIONÁLIS- ÉS GAZDASÁGTUDOMÁNYI DOKTORI ISKOLA

Head: Prof. Dr. Tamás Dusek, Professor

Krisztina Julianna Tanács

Chartered economist

The link between Industry 4.0 and regional innovation - Hungarian, Slovak and Serbian experiences

Draft thesis

Thesis supervisors: Dr. habil. Ilona Papp Associate Professor

Dr habil. Zsolt Roland Szabó Associate Professor

Győr, March 2023

Content

1. Rationale for the choice of the topic, aim of the thesis

Exploring the links between Industry 4.0 and regional innovation is a highly topical but under-researched subject.

My work aims to focus on the role of regionality in the process of digital transformation.

The world as we know it is being radically transformed thanks to the leaps and bounds of technological change in recent decades. Technological and IT developments are generating major changes in economic and social terms. Within the broad topic of the social impact of digitalisation, I sought to answer the question whether there is a link between the innovative character of regions and the digital (Industry 4.0) development of companies, and if so, what exactly is the link.

The real challenge of the coming years will be to adapt to the changing conditions brought about by technological innovations, to absorb and apply new knowledge. According to Mihály Csótó (2018, 37), the striking feature of today's information society is the incredible speed of development of technical tools, "the increase in the

number, diversity and complexity of technologies in the human environment, and their change and continuous transformation". As a consequence, technology is determinant of the functioning of the individual and society.

Individuals, for-profit and non-profit organisations, educational institutions, countries need to recognise that the world is evolving at an accelerated pace and that technology can provide the leverage to stay in the loop. Technological progress can be defined as a significant factor in economic life and social transformation. As József Imre (2000) points out, the acquisition of a competitive advantage is nowadays not determined by geographical location, the possession of rich natural resources and raw materials, but by "skills, technical/technological excellence, the capacity to innovate, information, cooperation and ambitious enterprises", which has made "technology an active factor in shaping social and economic policy".

There is a strong back-and-forth link between technological progress and a well-functioning market

economy. Continuous technological progress is leading to revolutionary changes that are significantly transforming productive units, homes, cities and the entire infrastructure.

2. Structure of the essay

In the theoretical part of the thesis, I will introduce the factors of digital development, from the industrial revolutions to Industry 4.0, the digital transformation.

I have dedicated a separate chapter to research and development and innovation, including a definition of the concepts and their impact on the economy. I have systematised the types, models and generations of innovation.

I then moved on to regional innovation, with the European Innovation Scoreboard and the Regional Innovation Scoreboard providing a map illustrating the level of innovation in each country and region.

I then looked at the trends and directions of urban development and the evolution of urban and rural populations.

After presenting the literature review and the theoretical background, I defined the hypotheses.

The quantitative research is based on a questionnaire survey, I have described the questions and the sample.

The results of the study are presented in a summary of the findings.

After evaluating the hypotheses, I identified a possible way forward.

3. Research questions, hypotheses

Based on the theoretical models, I based the research on six hypotheses.

H1. Digitally more advanced companies are located in more innovative regions.

H2.The digitalisation of production and manufacturing is more significant in less developed regions, while the digitalisation of sales is more significant in more developed regions.

H3. For more innovative companies, marketing innovation is significant.

H4. Where digitisation of production is strong, there is less emphasis on digital skills and training of workers.

H5. Companies that are strategically committed to digitalisation will have a more digitally literate workforce and a higher priority for spending on research and development.

H6. Firms with a high level of digitalisation of marketing are committed to continuous training of employees and consequently have a high number of scientific publications and patent applications.

4. Research methodology

After reviewing the literature, the questionnaire sample was analysed.

In the course of the research I examined data from Hungarian, Serbian and Slovakian enterprises in the context of Industry 4.0 and regional innovation. I operationalised the hypotheses formulated earlier. Some of the hypotheses were tested by means of a questionnaire, while others were tested through the indicators of the Regional Innovation Index.

The questionnaire survey was conducted in 2019, with a face-to-face interview to complete the questionnaire, which consisted of 5 main parts and 26 groups of questions.

The first part asked about the main characteristics of the company, the second part asked about the respondent, and the third, larger section was designed to explore the company's characteristics related to Industry 4.0, drivers and barriers.

The fourth session included questions on the level of digital maturity, and the fifth session included questions on the National Technology Platform for Industry 4.0.

Several tests were carried out using SPSS:

Descriptive statistical analysis,

KMO and Bartlett test

Definition of a book point

Principal component analysis

Pearson correlation

Analysis of variance (ANOVA)

5. Evaluation of the hypotheses

The hypotheses were confirmed by the test results.

H1. In the countries surveyed, the most digitally advanced companies are located in the most innovative regions.

The test results give a clear picture of where the more innovative businesses are located in the more digitally advanced areas. More advanced firms are also attracting stakeholders, inspiring competitors, supporting vocational training in nearby schools, university courses and departments. At the same time, companies are more willing to locate their development departments in a more developed region, because of the availability of infrastructure, highly qualified staff, business partners, subcontractors or prime contractors. It is a self-exciting spiral. If a company wants to maintain its position in such a market, it cannot afford to be left behind. It must constantly invest in training its people, in R&D investment

Validated by

H2.The digitisation of production and manufacturing is more significant in less developed regions, while the digitisation of sales is more significant in more developed regions.

The ANOVA test and Scheffe test results helped to test the hypothesis. For production, if production lines and processes are automated, it is not necessary for workers to

have the highest digital skills. For production units, it is more important to have an adequate workforce for operations. Also, wage levels in smaller municipalities are lower than in capital cities, for example.

The most suitable locations for production are areas away from populated areas, suburbs of cities, villages, small towns. However, sales, marketing, data processing, analysis and development all require high skills, and well-qualified workers are attracted to the more developed cities and the capital. In the production group, significant results were obtained comparing firms operating in cities with firms operating in the capital.

Production and manufacturing are less typically located in the capital cities, and are more likely to take place in industrial parks, suburban areas and smaller settlements. It is important for the efficiency of production to automate processes as much as possible.

Typically, manufacturing plants in cities are installing and operating smart factories and sub-units, and supporting production with implementation systems for efficiency and digital transformation. Since manufacturing units are

typically located in cities rather than in metropolitan areas, the use of digital technologies and automated manufacturing is also relevant for firms located in cities. As more and more automation is incorporated in the manufacturing process, there is less need for digital training of manufacturing staff. Manufacturing data is collected digitally, but is processed and evaluated in development centres.

The results of the study suggest that the strategic engagement dimension of digital development is significant for companies operating in the capital city. These firms are more likely to adopt digital solutions in their operations, to have integrated digitalisation into their strategy, and therefore to plan for digital development over the long term, and therefore to have a planned future development direction and mission and vision. Of course, management commitment, support and engagement for change is essential for this.

Firms in the capital are more likely than those in rural areas to provide appropriate digital training for their employees, with more lifelong learning. This may be

explained by the fact that manufacturing and production are generally not located in the capital cities, but in rural settlements and industrial parks, and that digital training is less relevant in manufacturing-related jobs (production line workers) than, for example, in the research and development department of a company.

Joint work with universities and research centres is also more common in metropolitan enterprises, both because of their physical proximity and the nature of the work. In the case of several larger firms, there is also a geographical separation between the development and production sites of the firms. Labour with the skills needed for development is more likely to be available in the capital cities than in smaller municipalities.

The use of digital technologies in research and development activities is more common in firms in the capital than in rural enterprises. Finally, the use of digital solutions in customer relations is also more common in metropolitan firms than in those operating in small villages.

Validated by

H3. For more innovative companies, marketing innovation is significant.

In the marketing group, the digital transformation of firms in the capital is significant compared to both cities and smaller municipalities.

Typically, market data is collected and analysed, reports, statements and management reports are produced in larger, metropolitan centres, analytical and research departments using digital applications. The digitalisation of sales, web shops, online advertising, marketing activities and digital payment systems are more relevant for companies in the capital. Also for companies in the capital, the use of digital technologies in services is more typical, making processes and systems simpler and easier to manage. It is also part of marketing to make the company attractive to prospective employees. It is well known that there is competition in the labour market for employees with the right skills and who are open to learning more. In addition, digitalisation can also be used in recruitment and selection, for example in job advertising, reception of applications, screening,

notification, online interviewing, which is more common in metropolitan companies than in rural ones.

Validated by

H4. Where digitisation of production is strong, there is less emphasis on digital skills and training of workers. The results obtained in the second hypothesis support the idea that production units are strongly digitally developed, i.e. production machinery and equipment are automated. Their operation does not require expertise and, in most cases, can be carried out by skilled workers.

Validated by

H5. Companies that are strategically committed to digitalisation will have a more digitally literate workforce and a higher priority for spending on research and development. Strategic commitment is most correlated with lifelong learning, which may be explained by the fact that firms that are committed to digital transformation are constantly acquiring and expanding knowledge, since without renewing and improving the knowledge base, long-term development is inconceivable.

Management is committed to digital transformation and employees recognise the need for it.

There is a strong link with international patent registrations, which shows that the knowledge gained is put into practice by the company, by developing new products, services and processes and then protecting them in the international market.

There is also a strong stochastic relationship with academic joint publications and public-private sector joint publications. The results of scientific research in the companies involved are presented in international and national academic publications. A significant relationship is also found for the most cited publications, showing that the scientific results can be used by other researchers and professionals.

Both business and public R&D spending are strongly linked to strategic engagement. It is undeniable that continuous development and digital transformation require investment in research and development, which requires significant financial backing.

Validated by

H6. Firms with a high level of digitalisation of marketing are committed to continuous training of employees and consequently have a high number of scientific publications and patent applications.

The marketing component showed significance with several questions of the RII indicator. Lifelong learning, public and business R&D expenditure, joint public-private publications, international patent applications. Good professionals are also needed to sell and promote products and services. The high level of R&D expenditure suggests that innovative solutions are also being used in sales and advertising by the firms surveyed. The research and experience gained in marketing activities are shared in the form of scientific publications. There is a strong link with lifelong learning, i.e. these companies place a strong emphasis on the continuous training of their employees and the development of their knowledge.

Validated by

6. Future direction of research

My work can help companies that have recognised that digital transformation is the key to their survival, or companies that are currently looking for a new location.

The future direction of the research would be to replicate the studies in panels and extend them to other regions. Further replication of the data collection and comparison of the results could provide an interesting new basis for further research. Presumably, the level of digitalisation of firms has improved significantly since the 2019 survey, as the use of digital tools and the digital skills of employees increased dramatically during the pandemic. It would also be worth revisiting whether the impact of firm localisation has changed as digitalisation has increased.

In addition, it may also be interesting to examine how the more advanced regions in terms of digital transformation differ by type of settlement.

7. Bibliography

Mihály Csótó (2018). In Nemeslaki András ed.. Nemeslaki, Dialog Campus Kiadó, Budapest 37-56.

József Imre (2000) *Science, technology, competitiveness. Science, technology, innovation, science and technology. Science, Technology, Science*, Technology, Science, Technology, Science. http://anyagokvilaga.hu/tartalom/2000/apr/aktualis/imre_jozsef.htm Retrieved 15.05.2019.

8. Publications of the author

The Role of Innovation in Formation of the Future Economy (2017) In: János Tibor Karlovitz Educational Theory and Theory of Education ME/BTK/Tanárképző Intézet (ed.) Essays in Economics and Business Studies Komárno: International Research Institute, pp 37-40 (2017)

A milestone in innovation: the application of key enabling technologies (2017) In: Adrienn Reisinger Petra Kecskés SZE/Regional School of Economics and Business (ed.) "Youth - Visions of the Future" : electronic version of the Kautz Gyula Memorial Conference 15 June 2016

Conference location, time: 2016.06.15. - 2016.06.15.

Győr: Széchenyi István University, Paper 22 (2017)

Comparing regions of the European Union according to their innovation performance (2018) In: Karlovitz J T (ed.)

Selected Papers from Responsibility

Conference location, time:: Budapest, Hungary 2017.12.03. - 2017.12.04.

Komárno: International Research Institute, pp 83-93 (2017)

Robot technology in the future economy (2018) In: Adrienn Reisinger, Éva Happ, Zsuzsanna Ivancsóné Horváth, László Buics (eds.)

"Sport - Economy - Tourism": electronic version of the Kautz Gyula Kautz Memorial Conference, 8 June 2017

Conference date and place: Győr, Hungary 2017.06.08.

Győr: Széchenyi István University, pp 1-12 (2018)

The role of knowledge and technology in Hungary's economic development (2018) In: Svéhlik Csaba (Svéhlik Csaba Marketing) (ed.)

Challenges in business in the 21st century : Best of KHEOPS V. (2006-2018)

Budapest, Vienna: Kheops Automotive Research Institute, pp 347-355 (2018) (KHEOPS Scientific Conference)

The impact of technological changes brought by Industry 4.0 with special regard to autonomous vehicles (2018) In:Gábor Keresztes (Gábor Keresztes Gazdálkodás- és szervezéstudományok) (ed.) Tavaszi Szél 2018 Konferencia = Spring Wind 2018.

Conference location, time: 2018.05.04. - 2018.05.06.

Budapest: National Association of Doctoral Students (DOSZ), pp 422-433 (2018)

Innovation and the presence of key enabling technologies in Hungarian enterprises (2018) In: Enikő Korcsmáros (Enikő Korcsmáros, Economics) (ed.)

Book of papers of the X. International Scientific Conference of the János Selye University 2018 = Zborník X. medzinárodnej vedeckej konferencie Univerzity J. Selyeho - 2018

Conference location and time: Komárno, Slovakia 2018.09.11. - 2018.09.12.

Komárno: Selye János University, pp 305-316 (2018)

Economic and social impacts of autonomous vehicles (2019) In: Adrienn Reisinger, Petra Kecskés, László Buics, Judit Berkes, Bernadett Balassa (eds.)

"Cultural economy". Electronic version of the Kautz Gyula Memorial Conference

Conference location and time: 2018.06.05. - 2018.06.05. (Széchenyi István University)

Győr: Széchenyi István University, pp 1-10 (2019)

Industry 4.0 - the road to a digital future - Exploring Industry 4.0 readiness in global and European contexts (2019) SPACE-Economy-HUMAN (2064-1176): 7 1 pp 175-190 (2019)

The impact of the penetration of autonomous vehicles on economy and society (2019) ACTA PERIODICA (EDUTUS) (2063-501X): 17 pp 96-117 (2019)

9. Author's conference presentations

Milestone in innovation: deploying key enabling technologies (2017)

"Youth - Visions of the Future" : Kautz Gyula Memorial Conference 15 June 2016.

Conference location and time: 15.06.2016 - 15.06.2016 (Széchenyi István University)

The Role of Innovation in Formation of the Future Economy (2017) 4th IRI Economics Conference International Research Institute Komarno, Slovakia

Conference location and date: Bratislava, Slovakia, 19-20 January 2017.

Robot technology in the economy of the future (2018) "Sport - Economy - Tourism": the Kautz Gyula Memorial Conference 2017, 8 June.

Conference location and time: 2017.06.08.(Széchenyi István University)

Comparing regions of the European Union according to their innovation performance (2017)

Conference location, time:: Budapest, Hungary 2017.12.03. - 2017.12.04.

The impact of technological changes brought by Industry 4.0 with special focus on autonomous vehicles (2018) Spring Wind 2018 Conference-Spring Wind 2018:

Conference location and time: 2018.05.04. - 2018.05.06. (Széchenyi István University)

The economic and social impact of autonomous vehicles (2018) "Cultural economy". Kautz Gyula Memorial Conference

Conference location and time: 2018.06.05. - 2018.06.05. (Széchenyi István University)

Innovation and the presence of key enabling technologies in Hungarian enterprises (2018) Xth International Scientific Conference of Selye János University 2018 -Zborník X. medzinárodnej vedeckej konferencie Univerzity J. Selyeho - 2018

Conference location and time: Komárno, Slovakia 2018.09.11. - 2018.09.12.

Komárno: Selye János University

The economic and social implications of the rise of autonomous vehicles (2019) Smart Transport Conference organised by the National Association of Doctoral Students, Department of Engineering Sciences

Conference location, time: 2019.March 08.

The role of knowledge and technology in Hungary's economic development (2018) XIII Kheops International Scientific Conference Kheops Automotive Research **Institute**

Conference date and place: Mór 2018. 11.14.