HOW TO MEASURE INDUSTRY 4.0 READINESS OF CITIES

G. Nick, F. Pongrácz
Doctoral School of Regional Economics and Business Administration Széchenyi István University - Győr, Hungary
ferenc.pongracz@hu.ibm.com

Abstract: *Industry 4.0 programs and other initiatives like the industrial internet are changing the way the industry works today. Cities with existing significant industrial capacities or the ones who want to attract such investments need to prepare for the changing needs of the industry. We expect the the trends of automation and efficiency improvement to continue. The production section of the value chain is becoming more and more competitive and therefore less profitable relative to Research and Development or Product design. We also expect product quality and meeting personal customer needs to become key differentiators in the new area of personalized mass production. Nowadays innovation is happening in ecosystems. We are proposing a measurement system called Smart Collaboration Index to assess innovation capabilities of cities in the new area.*

Keywords: INDUSTRY 4.0, INNOVATION, COMPETITVENESS, SMART COLLABORATION INDEX, HUNGARY

Introduction

Industry 4.0 related initiatives in Hungary

Following the international trends on May 6 2016 a National Industry 4.0 Technolgy Platform was established in Hungary with representatives of the following areas:

- Academy
- Government
- Production companies
- Small and Medium businesses
- IT companies
- Professional organisations

The Hungarian Ministery of National Economy has published a strategy document about the directions of innovative development of the industrial sector of the country called Iriny Plan named after Janos Irinyi a Hungarian chemist and inventor of the noiseless and non-explosive match. The program provides an analysis of the Industry 4.0 initiatives of a list of European countries including Germany, Austria, Romania, Slovakia and others.

There are multiple indicators suggest that there is a need for the shift of paradigm. Hungary among other neighboring countries has been successful in job reation with foreign direct investment especially in production industries.

According to the annually published IBM Global Location Trends report [Spee, 2016] Hungary was among top 20 countries in the world in terms of jobs created by foreign direct investments and among top 5 in terms of jobs creatred by foreign direct investment per million inhabitants.

When we talk about industry 4.0 readiness however according to a study published by Roland Berger the analysis shows that while Hungary is among the most indistrialised countries in Europe in terms of manufacturing output versus GDP while based on indicators like production process sophistication, degree of automation, workforce readiness and innovation intensity the country is below the Eurepean average [Roland Berger, 2014].

Roland Berger Industry 4.0 Readines index uses the following sets of indicators when creates country rankings

1. Industrial excellence:
    a. production process sophistication
    b. degree of automation
    c. workforce readiness
    d. innovation intensity
2. Value network:
    e. high value added
    f. industry openness
    g. innovation network
    h. internet sophistication

An another importand aspect of the equation that industial production capacities are not spread evenly from geographic point of view but centralized in production hubs. On of this production hubs is the city of Győr in North-West Hungary where Audi has a major production plant that itself employs 12 000 people [Coface, 2016]. This means high employment level and good tax revenues for the city, but on the other side also means high dependency.

Need for proper measurement and collaboration tools

Cities that are highly dependent on the success of production industries are advised to proactively analyse if the local environment is competitive in the current times of exreem fast technology developments and shift of paradigm caused by the growing impact the Industry 4.0 vision has on business decisions made by the key industrial players.

Cities need to apply proper measurement frameworks to assess the readiness for upcoming changes and they also need platforms and modern ITC solutions to facilitate the collaboration of the local business ecosystem of small and medium business in order to adopt to the growing expectations set by the key players of the gobal industrial production value chain.

The implications of the ICT revolution

ICT revolution

Information and Communications Technology is not just one of the fast growing industries or disciplines but plays key role in the fundamental changes we are experiencing in the global economy and as a result in Urban spatial structures as well. ICT is in a uniqe position first because of the exponential technological developmnet of the performance of the basic electronic components often reffered as the Moore's Law and secondly because ITC technologies are the key drivers of the revolutionary development of all domains from Medicine throuth Energy Disttribution to the Automotive Industry. Experts predict that this exponential developmet will continue at least in the next 10-15 years. Probably the most well known description of the intensifying changes caused by the distruptive ITC based innovation is the Wall Street Journal article by Marc Andreessen published in 2011: Why Software Is Eating the World. In his visionary article Andreessen predicted that „more and more major businesses and industries are being run on software and delivered as online services—from movies to agriculture to national defense. Many of the winners are Silicon Valley-style entrepreneurial technology companies that are invading and overturning established industry structures. Over the next 10 years, I expect many more industries to be disrupted by software,

with new world-beating Silicon Valley companies doing the disruption in more cases than not." Five years later it is enough to have a look on the changes on the list of the top 10 global companies by market value to appreciate Software has been really eating the World.

The emerging technology companies are representing a new management philosophy that is focusing on disruptive innovation versus the traditional corporate thinking built around the principles of efficiency and strong marketing. The Global Startup Ecosystem Ranking report published by Compass.co summarises the reasons for the declining performance of the traditional corporations and the success of the inoovation based startups. According to the authors in the US „Since 1965, labor productivity has more than doubled. During the same time period, companies experienced a 75% decline in Return on Assets (ROA) and a decline of almost 80% in the length of time an S&P 500 company could expect to remain on that list."

Reasons for the declining company performance:

- Greater competition due to economic liberalisation and globalisation
- Information transparency. Customers are empovered and well informed due to the extensive usage of the internet including social media chanels
- Declining consumptions due to the emergence of sharing economy

Reasons for the success of the innovation based startups:

- Startups can now be built for thousands, rather than millions of dollars. The cost of product development has fallen by a factor of 10 over the past decade.
- A higher resolution venture finance industry. Instead of small number of big bets tipical investment are generally in the $10,000 to $500,000 range, which means they can make a whole lot of small bets and give birth to a larger number of startups.
- Entrepreneurship developing its own management science based on the Lean Startup philosophy
- Speed of consumer adoption of new technology

Industry 4.0

The 2011 Hannover Expo opened a new era for the German Industry due to the public debut of the science project called Industry 4.0. According to the concept the smart factories of the future will produce smart products for the global market. Deeper horizontal and vertical integration is expected from every member of the value chain while the collaboration will move to a service based model. Physical and virtual worlds are converging and the product itself becomes intelligent and it will control the production. Personalized, custom made products are going to be produced using advanced mass production technologies.

In recent decades, manufacturing and producing systems were gradually supplemented by information technology support instruments, for controlling more and more complex technologies, multisite production and supporting logistic processes has become a more and more complex task. The more and more pronounced and unavoidable role of IT at companies changed living and working conditions the importance of which is unquestionable.

Miniaturization and the development of communications technologies enables the amalgamation of physical and virtual worlds and a new, so-called CPS – Cyber-Physical System is created in which traditional regionalist definition of space requires a new approach.

Industrial production becomes integrate able to an intelligent environment called 'smart factory' in specialized literature.

Based on this technological evolution has Germany announced the vision of future Industrie 4.0 with the core element of integrating CPS into the production and logistics systems, and the introduction of a network of instruments and services into production processes, influencing value creation, business models, organizational structures, decision and communication mechanisms, creating thereby a shift of paradigm that may be deservedly called the fourth industrial revolution.

The new smart factories are still operating in geographical environment and the performance of these production units is linked to the circumstances offered by the society and the city/region they belong to. Importance of the collaboration between the Industry, the Universities and Local Governments is increasing as human factors are becoming essential in the innovation driven global competition (Tripple Helix, Quadruple Helix, 4th and 5th Rothwell Generations).

Innovation does matter

Designed by Apple in California. Assembled in China. Printed on the back of iPhone a product that has been making legendary profit. Over the past decades, number of studies are published analyzing the phenomena that profitability in production value chain is increasingly shifting towards research, development and innovation versus production and delivery of services.

Stan Shih, Acer's founder introduced the concept called Smiling curve around 1992. In a graph where the vertical axis represents value-added and the horizontal axis the sequential steps in the production value chain, from research and development through manufacturing to marketing activity the resulting curve appears like a smile. This is an easy to remember visualization of the observation, that the beginning and end of the value chain brings considerably higher added value than in the middle of it.

Compared to the nineties, nowadays the smile is becoming wider and increasingly half-sided. It is becoming wider, because on one hand technological developments, and more and more sophisticated management methods are resulting higher cost efficiency and on the other hand potential locations of production plants are in furious competition for investments. Meanwhile, due to the opportunities created by cloud computing and digitalization long list of software-based innovators are transforming whole industries including Automotve.

The smile is becoming half-sided because in the area of social media the traditional marketing tools are proven to be less effective. Consumers are way more informed that they used to be ten or even five years ago, do not accept marketing messages without criticism and rather value design and experienced product/service quality.

The new buzzword is Mass Customization where in production companies are combining low unit costs of mass production processes with the flexibility of individual customization. This client centric approach is focusing on the customer needs: we are not looking for customers for a product, but we are looking for a solution to solve a customer problem in a way that exceeds expectations. This is a creative process, that requires teamwork and specific skills.

Discussion: Examples for current measurements

There are multiple indexes, reports and rankings created and published that are measuring the competitiveness of a specific geographic unit from different angles.

Diamond model

One of the most popular analysis frameworks for global competitiveness is Michael Poerter's Diamond Model . Porter identifies four factors with high impact of national and regional competitiveness. These are:

- Factor conditions that can be found in a given territory and and strengthening competitiveness like skilled workforce or linguistic abilities
- Demand conditions: competitive large home market can create competitive advantage
- Related and supporting industries
- Firm Strategy, Structure and Rivalry

Porter has originally developed his diamond model to analyze National competitiveness but he has been applying it to regional competitiveness as well. Globalization in fact resulted an increased importance of regional competitiveness relative to the national level.

Authors argue, that success in global competition is depending on local factors. Traditional factors of production are available for almost all economic players: mobile factors can be transported with insignificant limitations and production/service centers can be placed to the locations of immobile factors. Even technologies and generic business knowledge can be accessed almost anywhere at any time on the globe. While the production/service provider and support units of the global corporations has been spread over the Globe, core innovation capabilities are usually placed in few central regions in few leading countries. This highly competitive regions are often referred as Global Regions. Global regions like Silicon Valley in the US are taking leading role in determining global competitiveness versus Corporations.

Word Bank Doing Business Index

The Doing Business index is focusing in the environment Small and Mediun Size Entrprises are operating in. According to the 2014 report. The data collected are relating to the largest business city of each economy and covering 10 areas:

- starting a business
- dealing with construction permits
- getting electricity
- registering property
- getting credit
- protecting investors
- paying taxes
- trading across borders
- enforcing contracts
- resolving insolvency

World Economic Forum Global Competitiveness Index

World Economic Forum Global Competitiveness Index assesses the competitiveness landscape of 140 economies, and its aim is to identify and measure the drivers of their productivity and prosperity. The index groups its indicators into 12 categories the so called pillars. These are:

- Institutions
- Infrastructure
- Macroeconomic environment
- Health and primary education
- Higher Education and training
- Goods market efficiency
- Labor market efficiency
- Financial market development
- Technological readiness
- Market size
- Business sophistication
- Innovation

The Global Startup Ecosystem Ranking

The Global Startup Ecosystem Ranking report ranks the top global 20 startup ecosystems based on indicators, that are grouped into 5 categories:

- Performance
- Funding
- Talent
- Market Reach
- Startup Experience.

European Digital City Index

The aim of the European Digital City Index is to describe how well different cities across Europe support digital entrepreneurs. The the index groups its indicators into the following categories:

- Access to capital
- Business Environment
- Digital infrastructure
- Skills
- Entrepreneurial Culture
- Knowledge Spillovers
- Lifestyle
- Market
- Mentoring and Managerial Assistance
- Non-Digital infrastructure

Startup Ranking

Startup ranking is measuring the internet and social influence of the registered startups and offers a by country view. It is listed here because this approach is different to the methods many other index uses.

Smart city and sustainability indexes

Numerous organizations and research groups published smart city and sustainable development indexes that are following similar logic and often overlapping sets of indicators. A list of some of this rankings:

- TU Wien European Smart Cities Ranking
- Smart City Index by Boyd Cohen
- IBM Smarter City Assesment
- Smart City Index Italy by Between
- Sustaina 100 by Sustaina
- Sustainable Development Goals by United Nations

Conclusion: Smart Collaboration Index

As we saw there is a long list of city rankings and measurement indexes exist, however we believe that there is a need for a special purpose index that focuses on the readiness of cities of the coming changes due to the forth industrial revolution. We propose such an index especially for cities with dominant automotive industry presence.

Our model called Smart Collaboration Index not only measures the current performance and the potential of the individual players of the ecosystem but also they collaboration capability and potential.

We are introducing a measurement structure with indicators grouped according to the following three dimensions:

1. Performance indicators versus enablement indicators
2. Indicators by players and they collaboration (quadruple helix model)
    a. Automotive Industry
    b. People
    c. Regulatory and Economic Environment (Government)
    d. Academy
    e. Collaboration of the above four
3. In each above group of categories we propose the following subcategories (based on IBM Smarter City assessment model):
    i. Prerequisites
    j. Management
    k. Smarter systems
    l. Outcomes

table 1

Structure of the indicatios of the Smart Collaboration Index

SYSTEM	PREREQUISITES	MANAGEMENT	SMARTER SYSTEMS	OUTCOMES
CURRENT AUTOMOTIVE PERFORMANCE				
RELEVANT INDUSTRY 4.0 INVESTMENTS				
PEOPLE PERFORMANCE				
PEOPLE INVESTMENT AND POTENTIAL				
REGULATORY AND ECONOMIC ENVIRONMENT FOR AUTOMOTIVE				
REGULATOR AND ECONOMIC ENVIRONMENT PROGRAMS AND POTENTIAL				
AUTOMOTIVE RELEVANT ACADEMIC PERFORMANCE				
AUTOMOTIVE RELATED ACADEMIC POTNTIAL				
COLLABOTRATION PERFORMANCE				
COLLABORATION POTENTIAL				

Performance indicators versus enablement indicators

We believe that it is important to measure both the current performance of the analysed cities as well as they potential for future growt or improvement due to the so called enablement factors. We also believe that the two types of indicators need to be clearly separated so that these topics can be analysed independently as well.

Performance indicators are factualy describing the current status of the analysed subsistem and they help to identify the relative position of the city compared to its peers.

Enablement indicators are related to the potential performance of the given subsystem. The relavant industry 4.0 investments for instance are enablement indicators that potentially could contribute to the future success on the local industrial players. In case there are no investments in this field we can not expect any success from them hoewer in case they are there the outcome is still uncertain up to a level. Multi player Industry 4.0 pilot programs are for instance enablers.

Indicators by players and they collaboration

According to M. Curley "Government, Academia, Industry and Citizens are collaborating together to drive structural changes far beyond the scope of any one organization could achieve on it's own" [Curley, 2014]

This quadruple helix model assumes that all the four players are working toward the same objectives utilizing they own skills and resources and collaboration of the player's ads an extra dimesion to the innovation process. Therefore, in the smart collaboration index we assess the performace and enablement indicators of the Industry, Academia, Citisens and the Government individually and we also assess the collaboration capability of the whole system. We are assuming that ecoystem based open collaboration model creates the best environment for industry 4.0 enablement.

Prerequisites, Management, Smarter systems, Outcomes

The third dimension of the index is measured using the following groups of indicators: Prerequisites, Management, Smarter systems, Outcomes

In the area of current automotive performance for instance prerequisite performance indicator is the currently available maximum production capacity of a major OEM manufacturing plant or the maximum production capacity of the Tier 2 suppliers in the city while an outcome performance indicator is the number of passenger cars or number of engines actually produced in the city that in most of the cases will not reach the maximum capacity.

Prerequisite for instance the existence and the number of such programs, a management indicarior is whether a formal management or evaluation system exists in relation to these programs, a smarter system indicatior is wheather an online collaboration tool is used by the whole involved ecosystem or whether big data analytics is applied during the progem and finally an outcome indicator is the commercial introduction of the technology that is piloted or the financial benefit resulted by the program

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