The Tech-Based Economic Development and the Future of Jobs

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Abstract: *Public awareness regarding high-tech importance in improving economic growth is becoming more and more crucial in analysing an evolving labour market with greater impact on the future global economy. High-tech sectors have been essential for achieving the sustainable development of both advanced and emerging economies, hence our paper has as main objective to study the most significant trends in tech-based development emphasizing the role of technological adjustment in promoting the major changes in the future of jobs. Taking into account the spillover effects of high technologies for boosting economic growth, our research aims to provide a comparative analysis regarding the leading countries in the field. The present paper takes into consideration selected relevant technology indicators and World Development Indicators in order to evaluate the countries' potential regarding their high-tech advancement and adaptation of the labour market to the market requirements. Using a quantitative analysis and a qualitative approach (based on the most relevant theories in the literature such as the "triple helix" model for tech-based development), the present paper shows that a cutting-edge technology also requires new skill sets for working in certain circumstances.*

Keywords*: high-tech, technology index, future of jobs, research and development, "triple helix" model*

1. Introduction: the relationship between tech-based development and the future of jobs

The high-tech sector is related to those industries that use the scientific knowledge in the production of goods and services. Certain authors (Hill et al., 2014) point out that high-tech industries are commonly considered those industries in which the scientific knowledge used is rapidly advancing and so are the attributes of the products and services resulting from its application. The most often used example of high-tech industry is the computer industry. Among the most important high-tech industries in terms of their contribution to national GDP/are: telecommunication (where new technologies based on the Internet and wireless connection have proliferated, consumer electronics with the digital technology underlying products from high-definition DVD players to videogame terminals and digital camera, pharmaceuticals, where new technologies are based on cell biology and genomics, aerospace with the combination of new composite materials and more efficient jet engines).

While high-tech product types are continuously evolving, there are some shared features identified by the most important researches in the field (See Table 1).

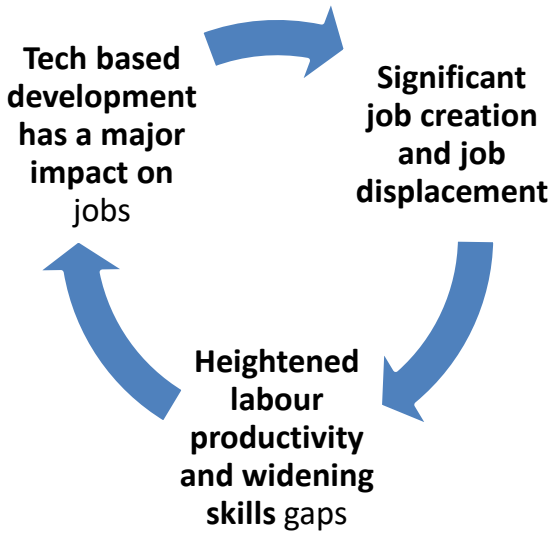
Table 1: Specific features of high-tech products

High –tech products features	Author, Year								
	Goldman, 1982	Riggs, 1983	Shanklin, Ryans, 1984	Von Hippel, 1986	McIntyre, Grunenwart, Rosenau and Vernor, 1988	Nystrom, 1990	Allen 1992	Hecker, 1999	Sahadev, Jayachandran, 2004
Short-product life circle[1]	x	x	x		x	x	x	x	x
Closely related to technological development		x	x				x	x	x
Symbiotic with science		x	x				x	x	
Connected with existing technological infrastructure				x	x				
Difficult to explain functioning criteria				x					

Source: Authors' representation based on the studied literature.

Taking into consideration the main drivers of tech-based development, our research highlights the role of technological adjustment for promoting the major changes in the future of jobs. In our opinion, the relationship between tech-based development and the future of jobs is shaped by the creative destruction concept (See Figure 1).

Figure 1: Drivers of transformation regarding the future of jobs



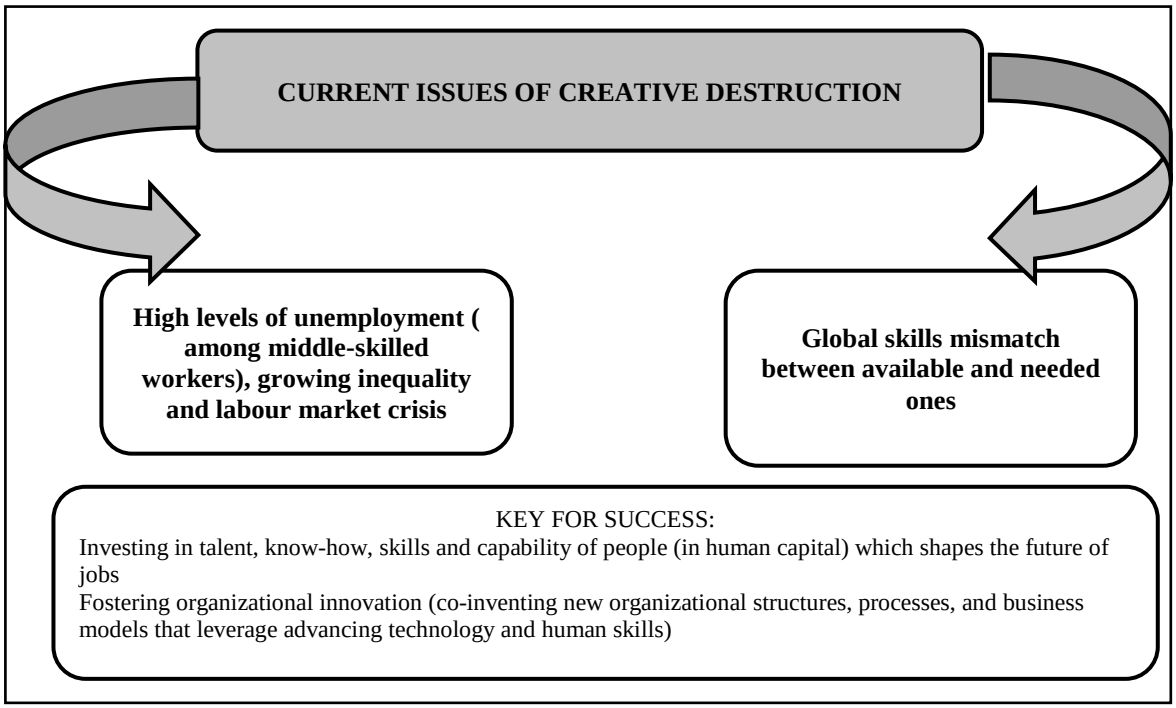
Source: Authors' representation based on studied literature.

Job displacement is related to the fact that human high skills are more valuable than ever, but other have become worthless while in many industries and countries, the most in-demand occupations or specialties did not exist 10 years ago, and the pace of change is set to accelerate. In this process of creative destruction

[1] As Goldman (1992) points out that many high-technology products are characterized by a "short" product life cycle (PLC) - a short life on the market, a steep decline stage and the lack of a maturity stage.

there are two major issues: the high levels of unemployment of middle-skilled workers and the mismatches between available and needed skills (See Figure 2).

Figure 2: Current issues of creative destruction



Source: Authors' representation based on studied literature.

2. The triple helix model in tech based development

As some analyses (Dumitrescu, Poladian, Drăgoi, 2015) have pointed out, , investing in cutting-edge technologies is essential for the success of tech-based growth, since in the ICT era such technologies are diffused and automatically absorbed in the economic development. Taking this into account, we consider the degree of policy framework openness is of high relevance in order to leverage overall technology-based growth and the transformation of their economy (See Figure 3). In our opinion, in the quest to promote a "great transformation" of sectors and of the economy, both industrial advance and research and policies progress must promote technological learning and competence building as main engines for tech-based development. In practice this goal requires incentives and instruments pertaining to both policies mentioned (industrial and R&D) to approach technological development from different perspectives.

For example, while the industrial development strategies set overall economic targets, the research and development policies could provide the institutional infrastructure for learning, as well as individual targets and supportive incentives to firms. In order to create an effective "triple helix" model for tech-based development, it is necessary first to ensure human capital and material resources as well as the availability of cooperation between the institutions along with the circulation of ideas and innovations. Etzkowitz (2008) refers to these as human, material and organizational factors. Among human capital factors he indicates the need for a critical mass of scientists and engineers linked through social networks, research groups and a pool of scientists and engineers interested in setting up their own firms. In his view, the essential material resources are the capital from private or government sources that could provide inexpensive and appropriate space for new innovative start-ups.

To maximize the likelihood of successfully implementing a strategy for knowledge-based economic developments and at the same time high technologies, organisational factors are needed. According to Etzkowitz (2008) such factors are:

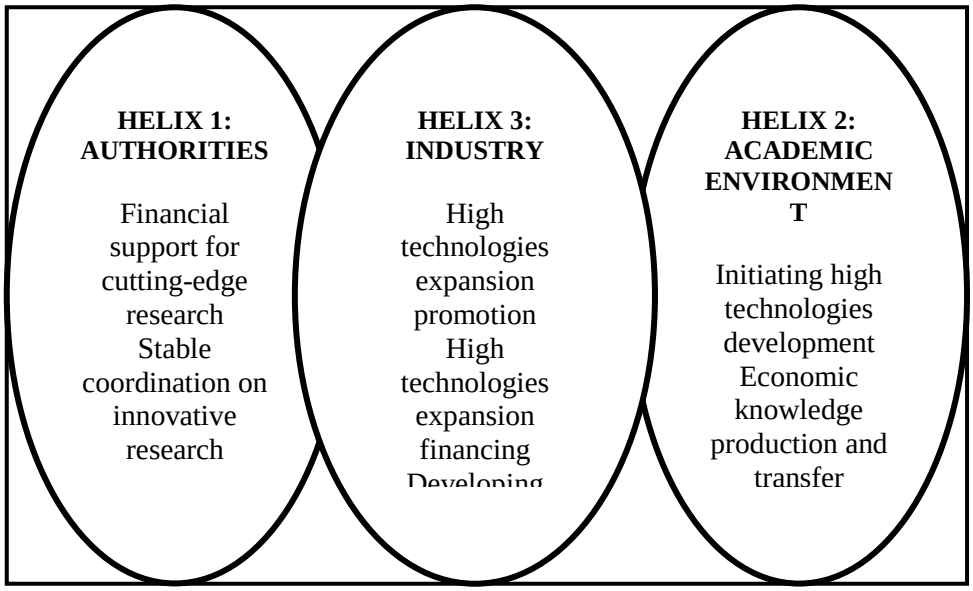
- opportunities for scientists and engineers to learn business skills or gain access to persons with these skills;

- university policies designed to encourage faculty members and students to interact with industry; applied research institutes, centres, and incubator facilities to assist firms with development problems and to provide mediating linkages between academic scientists, engineers and industry.

Konde (2004) highlights that in the less technologically developed countries the "triple helix" formation is weak since each element of such a development model is working within an isolated environment. Therefore, the main aspects of the "triple helix" model are represented by internal communication and knowledge exchange within each element as well as by communication and knowledge exchange among all elements. The sharing of information and knowledge is feasible if it is exchanged intensively within the "triple helix". Thus, Dzisag and Etzkowitz (2008) are pointing out that the circulation of ideas and innovations are key criteria for the functioning of the "triple helix" model. It should be noted that based on the "triple helix" theory (Etzkowitz et al., 2008), parties participating in the knowledge creation process are taking over the roles of other participants which conditions dynamic interaction, interweaves interests and opinions. Academic systems are undergoing changes in order to channel their work towards commercial needs. However, for to the "triple helix" to function, the cooperation between industry and universities represents a critical problem. For truly stimulating tech-based development the interests of the industry must be integrated into the planning and organization of scientific research at universities.

Therefore, scientists should consider the impact of their developed scientific products on the industry as well as scientists working in industry businesses should be able to access the newest information regarding evolutionary science advancements. The evolutionary path that the "triple helix" model takes in axes acting interchanging on the circumstances, time and opportunities, creates a dynamic environment of acting parties, whose acting must be concerted in order to reach a common goal. This requires the creation of a knowledge-based organizational model which would aim at integrating each party interested in the whole system.

Figure 3: The triple helix model for tech-based development



Source: Authors' representation based on the studied literature

2.1. The countries potential in terms of their high-tech advancement and the adaptation of thelabour market to the future of jobs

In order to evaluate the national potential in terms to high-tech advancement and the adaptation of the labour market to the changing requirements we have selected (based on a series of indicators – global technology index, capacity for innovation, global innovation index, R&D expenditures and high-technology exports) relevant advanced and emerging economies: Japan, the US, the Russian Federation, China, South Korea, the Czech Republic, Hungary, Poland and Romania.

In the current global environment the selected countries have achieved different performances regarding tech-based development (See Table 2).

Table 2: Indicators for tech-based development

Country	Global Technology index (MPI)						Global Competitiveness Index (WEF)				Global Innovation Index (WIPO)	
	Technology index		I. R&D investment		II. Patents per capita		Innovation environment		Capacity for innovation			
	2011 (out of 75)	2015 (out of 139)	2011	2015	2011	2015	2011 (out of 142)	2015 (out of 140)	2011 (out of 142)	2015 (out of 140)	2012 (out of 142)	2015 (out of 140)
South Korea	8	**1**	7	3	-	1	14	19	20	24	18	11
Japan	2	**2**	4	5	2	2	4	5	1	14	22	16
US	3	**4**	6	8	1	5	5	4	7	2	5	4
China	30	**14**	26	17	-	11	29	31	23	49	35	25
Russian Federation	21	**22**	22	29	36	18	71	68	38	84	62	43
Czech Republic	25	**29**	21	21	26	43	33	35	25	26	28	27
Hungary	33	**34**	32	27	24	47	34	51	41	131	31	33
Poland	37	**46**	45	34	44	40	58	64	49	72	49	39
Romania	49	**65**	50	48	52	49	95	75	78	63	48	48

Source: Authors' representation based on Martin Prosperity Institute (MPI), World Economic Forum (WEF) and World Intellectual Property Organization (WIPO) data.

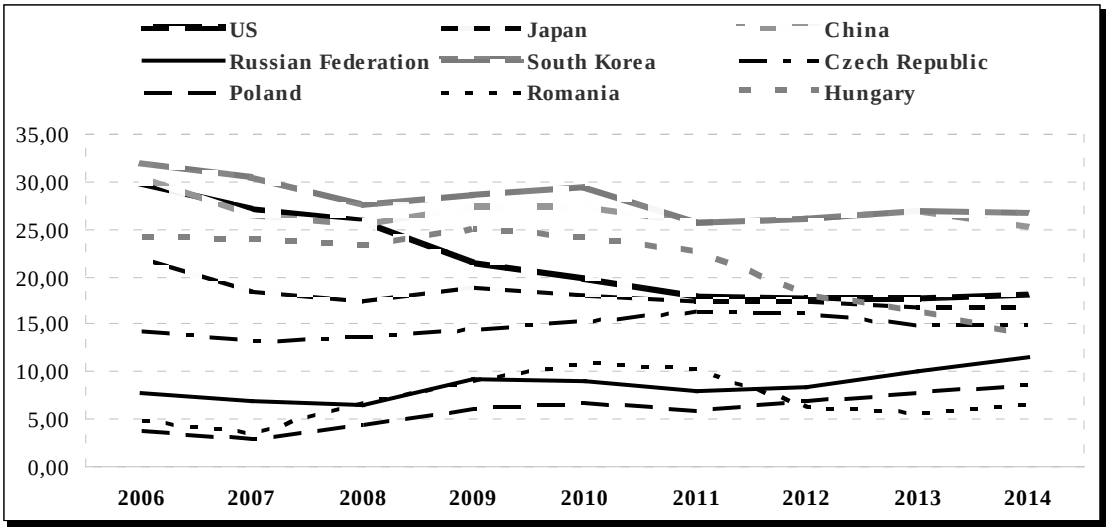
As we can see from Table 2, even if South Korea and Japan don't have the advantage of a large market size as in the US and China, these countries have performed very well in the field of high-tech development being rated the first and the second in Global Technology Index in 2015. The overall highly innovative environment in Japan has also been favoured, according to World Economic Forum (2015), by very sophisticated businesses and unique products and production processes, high-quality research institutions and company spending on R&D, coupled with an excellent availability of scientists and engineers.

As for the selected emerging economies, the Russian Federation has been rated higher than the Czech Republic and Hungary in the Technology Index, in part due to the enhancement of the overall innovative environment since 2011. However, its Capacity for Innovation has slid down the rankings since 2011 - 46 places to 84th in 2015. The highest capability for conducting own research and pioneering new products among the selected emerging economies was that of companies from the Czech Republic (the 26th in the Capacity for Innovation), due to the strength of large spending on R&D.

Even if the ranking in the Global Innovation Index differs from the previous two, it reveal the same innovation leaders: the U.S., South Korea and Japan. China joins the top 25 (the 25th), being followed by the Czech Republic (the 29th), Hungary (the 34th) and The Russian Federation (the 43rd).

The technological performance of a country could be assessed taking into consideration the country's export structure, particularly the part of high-tech products exported by it. Thus, one relevant measure that we use for this purpose is *high-technology exports* (% of manufactured exports in USD billion) which is a World Bank indicator.

Graph 1: High-tech exports as % of manufactured exports (2006-2014)



Source: Authors based on World Bank data

South Korea has taken first place among selected countries in 2014, outrunning China, the US and Japan in relation to this indicator. However, China has clear progresses on high-tech exports, which have increased 35 times since 1996 and have risen almost twofold since 2009. According to the Asian Development Bank, China has brought to an end Japan's dominance of Asia's high-technology exports in 2014 (Bloomberg, 2015), recording double-digit growth in its patent filings in 2014 (WIPO, 2015). Notwithstanding these progresses the leaders in breakthrough innovation are still a small group of countries, Japan, the U.S. and the South Korea belonging to this group.

3. Drivers of high tech performances

The recent global financial and economic crisis has prompted both developed and emerging economies to rethink their growth model, generating strategies based on new technology[2]. Each country has its own set of elements used to foster and accelerate technology-based growth.

There is wide consensus that the main assets or so-called "drivers"of tech-based economic development are:

- The intellectual infrastructure,
- The spillovers of knowledge (from universities, informal networks), physical infrastructure, technically skilled workforce, capital, quality of life, entrepreneurial culture (Berglund, 2011) etc.

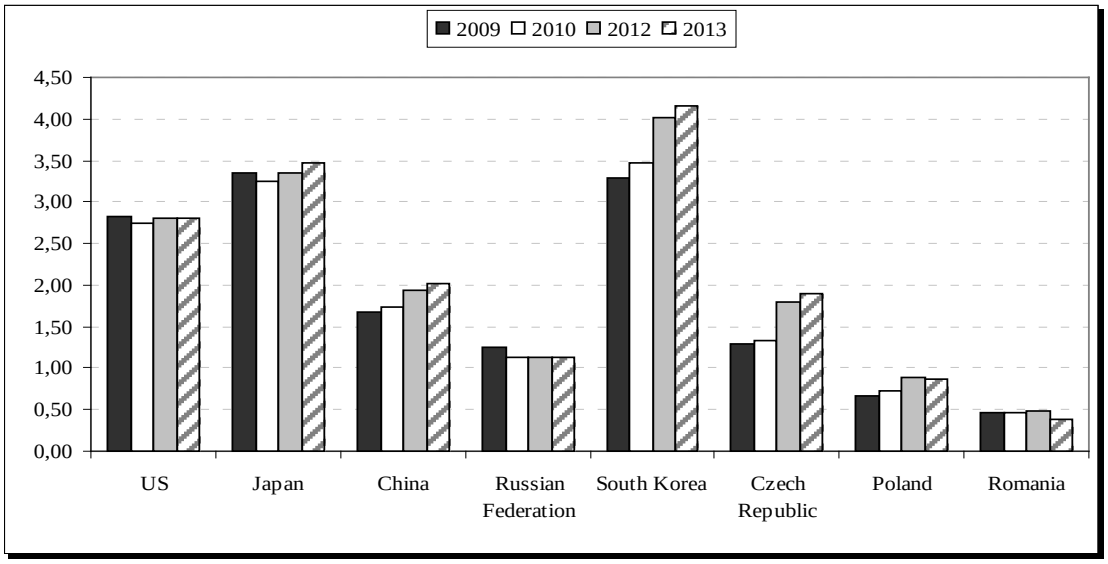
Both authorities and firms might play a major role in boosting high-tech development thorough investing in R&D. The main task for authorities in high technologies development is to encourage their expansion on the basis of the "triple helix" model. Etzkowitz (2008) concludes that this encouragement could be channelled through the following actions: the establishment of a legitimate authority in order to reduce uncertainty in interaction (e.g. government guarantees are given to private capital so that with such insurance it may take greater risks in investing in new ventures); using the tax system in a targeted fashion to provide special incentives and benefits for R&D expenditures; using the legal system to establish special rights such as patents or temporary monopolies to promote innovation; provision of a special research funding to establish a linear model of innovation (e.g. provision of public venture capital to create an assisted linear model of innovation).

A firm can enhance its absorptive capacity of new technologies by training its personnel, by carrying out R&D, and by using advanced manufacturing equipment (Schiller, Diez, 2007).

Our research has found that there is a direct link between R&D expenses and country's ranking in tech-based development global hierarchy (See Table 2 and Graph 2).

[2] i.e. Industry 4.0 in Germany, Re-industrialization in the US, Transition to an innovative socially-oriented type of development in the Russian Federation, Innovation-Driven Development in China etc.

Graph 2: R&D gross domestic expenditure (% of GDP)



Source: Author's synthesis based on World Bank data.

As shown in Graph 2, most countries have continuously invested in R&D and not even the crisis has endangered this trend. Investing in human capital and education is an essential condition of success. In order to achieve high-tech development and matching to labour market future challenges, the future of jobs is indisputably linked to investing in education. Such investment is the key for boosting knowledge based economy. While general education varies widely both across and within countries, it should be noted that countries should find a way to stimulate tech-based growth by investing in education in order to spur economic development in an inclusive manner.

4. Conclusion

The recent global financial and economic crisis has prompted developed and emerging economies to rethink their model of growth. Countries have their own set of elements used to foster and accelerate tech-based development. All these elements should be consolidated in a new model of growth (the triple helix model) based on several pillars: ensuring good quality education, enhancing organizational innovation and increasing state role in elaborating high-tech strategies and national education plans. Tech-based growth also needs the enforcement of national strategies for deepening exchanges of knowledge and experience among countries on training and skills development policies and systems. Our research has found that there is a *common pattern* of longstanding champions countries in the field of tech-based development: while innovation has remained a essential priority, supported by a steady flow of *R&D spending*, it is equally important to bear in mind that education and skills hold the key for achieving performances in the future of jobs, tackling unemployment, promoting competitiveness, and nurturing more inclusive and cohesive societies.

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