Antonín Klas

ROLE OF DOMESTIC TECHNOLOGICAL DEVELOPMENT IN INNOVATIONS

Abstract: *The aim of this article is to analyze the development of innovation activities and research as the factors of knowledge-based economy in the Slovak Republic (SR). The phenomena of technological progress are examined on data on exports in the EU countries and in the SR according to technological demands, the structure of innovating enterprises share by technological level, mutual dependence between innovations (measured by number of EPO patents) and economic performance (measured by means of GDP/capita). In this connection, also the contributions of total factor productivity (TFP), capital, labour force, foreign direct investment (FDI) and GERD on the GDP growth rate are analyzed. The author identifies also the basic deficiencies in research and innovations in Slovakia together with a proposal on how to overcome them.*

Keywords: *innovations, technological progress, economic performance, foreign direct investments, R&D expenditures.*

JEL: 0 30, 0 31, 0 32

Introduction

The aim of this article is to point out on the example of the Slovak economy the problem, why the post-socialist countries compete by cheap labour force, and little by a more expensive qualified workforce, though the educational level of the population as well as the technological level of production is rising. Equally the share of innovative enterprises and the share of scientific and engineering staff in the overall number of workforce are ascending. In our article we will try to analyse the reasons, why the qualified workforce is not adequately used for the needs of innovation development and what conditions are to be created in order to overcome this situation and to support development towards the knowledge-based economy.

Present Situation

Slovakia similarly like other post-socialist countries uses mainly the low-priced workforce to remain competitive, although the numbers of university and secondary

school graduates are growing rapidly. Within the period from 2000 till 2008 the number of university graduates increased 2.7-times and that of secondary schools with *maturita* (secondary school-leaving examination) 1.5-times. But the real wage of a secondary educated grew faster (1.4-times) than the real wage of a university educated worker (1.3-times; SO SR, 2009). This fact indicates that highly-skilled workers contribute less to the benefit of economic growth and the knowledge-economy development.

Slovakia like other post-socialist countries constantly increases technological level of its production. This is obvious from the comparison of the impact of technological progress on the export structure development in the EU countries and in Slovakia. Since 1997 until 2004 exports in high-tech branches in Slovakia grew by 2.1 percentage points (p. p.), in medium high-tech branches by 10.4 p. p., in medium low-tech branches it declined by 7.5 p. p., and in low-tech branches it declined by 5.1 p. p. This tendency can also be seen in imports. The structure of technological level of production is clearly approaching the structure of EU 15 countries (Table 1).

Table 1

Export structure by countries and technology demanding in % [1]

Country	Year	Technological level				
		High	Medium high	Medium low	Low	Total
EU 15[2] Exports in total	2003	21.9	41.7	15.8	20.5	100
	1994	16.3	40.7	17.3	25.5	100
Difference p. p.		**5.6**	**1**	**-1.5**	**-4.9**	
SLOVAKIA Exports in total	2004	7.6	46.3	27.8	18.2	100
	1997	5.5	35.9	35.3	23.3	100
Difference p. p.		**2.1**	**10.4**	**-7.5**	**-5**	

Source: [1] STAN OECD, 2007, [2] OECD, 2005a, pp. 207 and 208. Own calculations.

Similarly as in the EU-15 also in Slovakia, the higher technological level is reflected in the structure of innovative enterprises (Tab. 2). In the EU-15 the share of innovative enterprises within the high-tech production is by 25 p. p. (69 – 44) higher, than the share of innovative enterprises in low-tech level. A similar difference, though to a lesser extent, is seen also in Slovakia (19.7 p. p.= 43.7 % – 24 %).

Table 2

Shares of innovative enterprises in %

Country	Technological level of production			
	High	Medium high	Medium low	Low
EU 15	**69**	**65.0**	**49.0**	**44.0**
Denmark	88	86.0	60.5	64.5
Netherland	74	75.0	60.0	43.0
Ireland	88	85.3	70.7	65.5
Finland	51	46.0	37.5	28.5
Sweden	75	64.0	49.0	46.7
Slovakia [x]	**43,7**	**34.9**	**25.1**	**24.0**

[x] in 2006; **Source:** Eurostat, 2002, SO SR, 2008, p. 20.

The technological level is also accompanied by an increased share of educated workforce in manufacturing branches (Tab. 3). In 2004 in high-tech branches the share of university educated employees was two times higher than in low-tech branches (6.9 % against 3.4 %). In the EU 15 countries it was 1.9-times higher (22.2 % against 11.7 %).

The technological level also imposes requirements on the quality of employees in the field of science and technology. This is reflected in the of share of scientific and engineering staff (S&E) in total number of human resources in science and technology (HRST, Tab. 4).

Table 3

Educational level structure of workforce by technological level of manufacturing branches over the years 1998 - 2004 in % in minor developed countries[x] and in Slovakia

Technological level	Educational level						Total
	University		Secondary		Elementary		
	EU	SR	EU	SR	EU	SR	
Low	11.7	3.4	50.0	87.6	38.3	9.1	100
Medium	17.4	7.2	52.8	85.1	29.8	7.7	100
High	22.2	6.9	54.5	87.3	23.3	5.8	100

[x] AT, BE, DK, FI, NL, SE; **Source:** WIIW Research Reports 356, August 2009, pp.16 and 17; own calculations.

Table 4

Total number of human resources in science and technology (HRST) in thousand and the share of scientific and engineering employees (S&E) in % by technological level

Country	High-tech		Medium high-tech		Medium low-tech and Low-tech	
	HRST	S&E in %	HRST	S&E in %	HRST	S&E in %
EU 15	946	28.4	3458	24.1	3822	9.5
SK	9	22.3	28	16.6	59	4.3

Source: Eurostat (2006), own calculations.

While on the high-tech level the share of S&E staff amounted to 22.3 %, on the medium low-tech and in the low-tech levels it was 4.3 %. In the EU 15 countries it was 28.4 % and 9.5 %.

In spite of this development, which largely copies the development in the EU- 15, Slovakia still competes mainly with its low-priced workforce. Though the number of skilled workforce in Slovakia is growing, foreign investors as the main importers of modern technology do not use it as a source of innovations, because they develop innovations in their home countries. The more expensive creative Slovak workforce remains thus unexploited. Due to this, there arises a question concerning the reason of this situation.

National Research as the Key Factor of Home Technological Development

One of the main reasons can be seen in the economic development based on excessive share of imported technology and only little on domestic development of technology. Out of the total R&D expenditures on technological development in Slovakia as much as 89 % falls upon import of technology, while on home-based research it is only 7 %[1]. In the EU countries this proportion makes 36 % to 21 % (Eurostat databases, 2008). Though the imports of foreign technology contributed significantly to technological restructuring in the Slovak economy, the need to make use of home research base was decreasing. Data in Table 5 clearly indicate on the one hand how Slovakia´s lagging in technology was overcome by the imported technology; on the other hand, how the sources for home research and development were decreasing. Till 2003 the contribution of technological progress measured by the total factor of productivity (TFP) was represented in negative figures. Due to the impact of growing share of foreign direct investments in GDP, the technological lagging was continuously decreasing, and in 2007 the contribution of technological progress reached practically the same positive value as the contribution of physical capital (4.56 against 4.73). On the other hand, the R&D expenditures since 1996 till 2007 dropped from 0.91 % to 0.46 % GDP. It was the business sector that was most severely affected. Since 1997 till 2007 the number of R&D employees decreased in this sector from 7,408 to 2,699 (FTE), (SO SR, 2010 and 2001). Many company research institutes, which survived, changed their orientation to activities with a rapid commercial effect (metrology, engineering activities, etc.) and to a great extent, they lost the status of a research organisation.

Table 5

Development of GDP growth rate, TFP, capital, workforce, share of R&D expenditure and FDI stock on GDP in the Slovak Republic in %, over 1996 - 2007

Year	GDP accrual (A+K +L)	Contribution of factors to GDP growth			FDI share in GDP	R&D expenditures on GDP
		TFP[2] (A)	Capital (K)	Workforce[1] (L)		
1996	6.94	–7.68	12.83	1.79	9.57	0.91
1997	4.38	–6.54	11.35	–0.43	9.75	1.08
1998	4.39	–5.49	10.05	–0.17	13.02	0.78
1999	0.03	–5.05	6.57	–1.49	15.48	0.66

[1] 3 % to external research and 1 % to other external knowledge.

2000	1.36	–2.94	5.01	–0.71	23.21	0.65
2001	3.40	–3.02	5.92	0.50	26.45	0.63
2002	4.75	–0.38	5.06	0.07	34.78	0.57
2003	4.73	–0.30	4.19	0.85	44.20	0.57
2004	5.16	0.96	4.07	0.13	49.77	0.51
2005	6.55	0.94	4.59	1.02	49.88	0.51
2006	8.50	1.96	4.74	1.80	68.40	0.49
2007	10.42	4.56	4.73	1.13	54.10	0.46

[1] Weighted growth rates by Eurostat methodology, *adjusted-wage share*, weight for capital calculated till one.

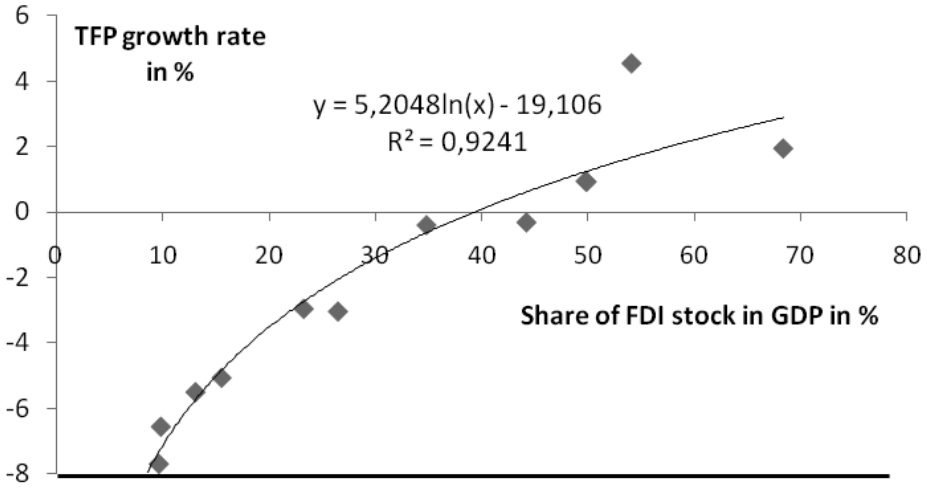
[2] $g(TFP) = g(HDP) - (1-\alpha)\ .\ g(K) - \alpha\ .\ g(L)$, while g(.) indicates growth rate of the respective quantity.

Source: ŠO SR (2009a); EC (2008); UNCTAD (2009); own calculations.

Though the dependence of TFP on FDI is high ($R^2 = 0{,}924$), the decreasing growth of TFP clearly indicates that the imported technology alone does not suffice for a sustainable technological progress (see: Graph 1).

Graph 1

Relation between the TFP growth rate in % and the FDI stock share in % of GDP in the Slovak Republic over 1996 through 2007



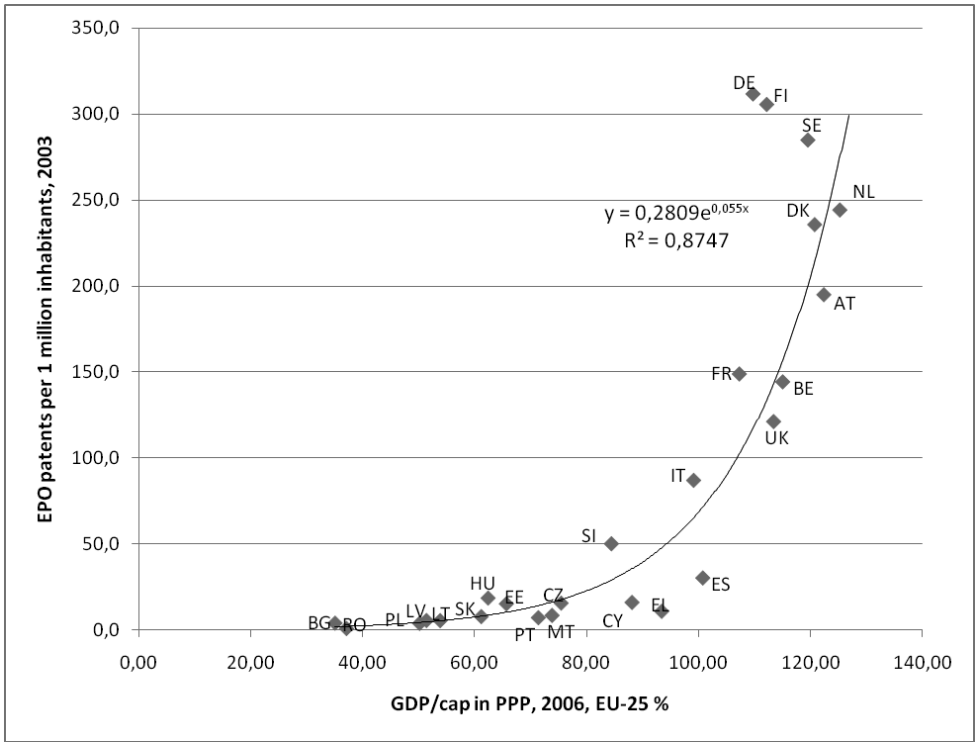
Source: SO SR (2009a); EC (2008); UNCTAD (2009); own calculations.

Without a strong impulse of innovation activities based on domestic research it is impossible to achieve a sustainable technological progress. Inadequately low investments into domestic R&D exert negative influence on the economic development, since they decrease the effective use of imported technology in domestic conditions as well as the chances of its further improvement needed for maintaining competitiveness. However, there exists a serious problem of how to increase the interest of enterprises to finance innovations based on domestic creative potential.

Innovations cannot be attributed only to the knowledge economy. They accompany development of all production systems. As a factor of knowledge economy they appear after reaching a certain degree of economic performance, i. e. after a full utilisation of the chances of production factors in a traditional industrial economy. This can be seen on dependence between the innovation growth measured by number of patents and growth of economic performance (Graph 2).

Graph 2

Number of EPO patents per million inhabitants to relative GDP/cap. in EU 27[1]



[1] GDP/cap. to average GDP/cap. EU 27 in %. EU 27 countries except Luxembourg and Ireland.

Source: (EC, 2008), (EUROSTAT, 2008); own calculations

As can be seen on the growth of patent number of patents, roughly after achieving the mean EU economic performance (=100), the growth of patents increases rapidly. Since 1985 the growth has an exponential character. As long as the economic performance is low, enterprises are short of financial means for realizing their competitiveness by means of innovations based on domestic technological development. They acquire their competitiveness mainly by utilising low-priced workforce, which also attracts foreign investors looking for production capacities for innovations developed by more expensive workforce in their home countries.

After achieving roughly average economic performance of the EU countries, the situation changes. The low-priced workforce which increases its price along with the growing economic performance loses its competitiveness and is being pushed out by more competitive innovations. Further growth cannot be achieved without an increased innovation activity. Innovative products with higher selling prices are also capable to cover higher wage expenditures for the skilled workforce. Since Slovakia is below the critical point of economic performance, there is no willingness on the part of enterprises to pass from the use of cheap workforce towards more expensive production factors requiring higher investments into own innovation development. Therefore, as long as the enterprise sources for financing own innovation development are insufficient, a support from public sources is an inevitable condition for innovation development based on domestic R&D. At the same time, it is required to support the growth of economic performance, either by increasing foreign direct investments or domestic investments, which increases the standard of living and consequently the price of labour. Under these conditions the enterprises are forced to change their competitiveness based on cheap workforce to a more effective competitiveness based on the innovations can utilise a more expensive highly qualified workforce.

The above mentioned relations are illustrated by Graph 3. Until the economic performance of the country reaches the average value of EU countries, the public R&D expenditures are higher than the company R&D expenditures. After reaching this point, the situation changes radically. The company R&D expenditures become the main source of innovation activities and start to grow after this point very fast[2] exceeding considerably the public R&D expenditures. Therefore, before reaching this point the public support to the growth of economic performance is a pre-requisite for transition from the industrial economy factors to the knowledge economy factors. Reaching the mentioned critical point is also an important condition for accomplishing the strategic goal of the Lisbon strategy, i. e. that two thirds of total R&D expenditure are covered by private sector.

However, supporting the innovation and technological development cannot be reduced only to financial sources. A significant role is played also by the concentration of innovators, either within the firm itself or within its locality. Contrary to the

[2] This is confirmed also by the high statistical dependance between the company R&D expenditures in % of GDP (P) and the share of EPO patents on 10 000 inhabitants (EPO) and public R&D expenditures in % of GDP (V):

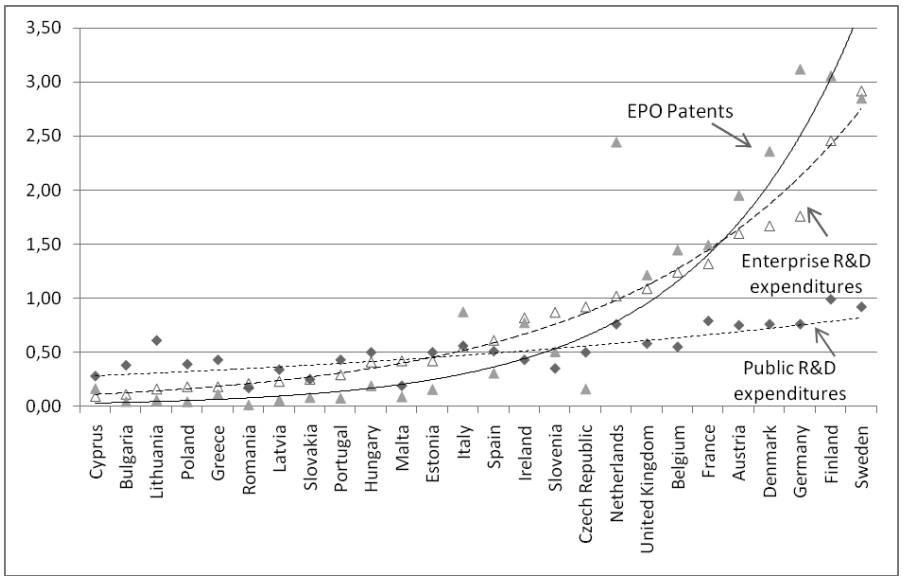
$$P = 0{,}514 * \text{EPO} + 0{,}708 * V \quad (R^2 = 0{,}84).$$

information dissemination which does not require personal contacts, the tacit knowledge embodied in the qualified staff is being transferred on the basis of personal contacts. Local concentration of innovators represents usually important centres of innovation development. They enable to use highly skilled specialized workforce, as well as tied up professions, financial, consulting and advisory institutions, sophisticated clients and also the existence of local academic research base. Local advantages of such a concentration of knowledge display a lower mobility and are therefore a sustainable source of comparative advantages.

The impact of local concentration can be illustrated by data on software patents. In regions with high concentration of innovators (Silicon Valley, Austin, Seattle and the like) the number of patents is high as well. Lower concentration of innovators decreases number of patents. Out of the 26 observed regions the first six ones with a high concentration of innovators recorded 67 % of total number of patents, while the remaining 20 regions recorded only 33 %. Similar tendencies can be seen even in big firms with higher innovators' concentration (IBM, Microsoft, Hewlett Packard, Sun Microsystems, Apple Computer, Compaq Computer etc.). Out of 18 observed companies the first six of them produced 85.8 % of total patents number and the remaining 12 companies produced only 14.2 % (Edward Elgar Publishing Ltd., 2006, p.122 and 123).

Graph 3

Patent activities and R&D expenditures by countries



New EPO patents per 10,000 inhabitants; enterprise R&D expenditures (% GDP); public R&D expenditures (% GDP);

Source: EC (2008): European Innovation Scoreboard 2007, Comparative Analysis of Innovation Performance. February 2008, Annex A. Luxembourg: European Commission 2008; Eurostat: European Structural Indicators, 4. 6. 2009, own calculations.

Many of the Slovak entrepreneurs do not realize the role of innovations for raising competitiveness, significance of which is growing namely during the period of crisis and will be even higher after the crisis is overcome. There is also missing a motivation to bear the risks connected with innovation activities. As long as Slovakia relied only on the technological import from abroad, there will be no sufficient push and pull to use the home creative and qualified workforce, as the main source of innovations and higher competitiveness.

Slovakia is also lacking an adequate strong technology-oriented segment of SMEs, as a base of innovation dynamics based on domestic sources. The share of innovative SMEs in Slovakia is lower than the half of the share in the EU-15 countries. With respect to the low fixed capital, the SMEs in comparison with big firms are more flexible in reaction to the market demands. They are capable to implement faster the development results into production process. They usually work also in segments which are unattractive for big firms. However, deficiency of their own sources does not relate only to their own research activities, but also to the use of results achieved by home research institutes.

The research support coming from public funds should not be limited only to SMEs; it should be provided also to big firms with a substantial larger innovation potential (see: Table 8).

Table 8

Share of innovative enterprises in total number of enterprises in % by size

Countries	Size of enterprise			
	Small	Medium	Big	Total
EU-15	39	60	77	44
SR	15	24	47	19

Source: Statistics in Focus 12/24 Eurostat.

It is also desirable to stimulate the multinational companies to shift their research capacities from their home countries to Slovakia, and also to more exploit the Slovak research capacities. The future innovation policy in Slovakia has to lay a higher emphasis on an adequate business environment, supporting an interactive learning process and innovation culture. This necessitates creating a higher relation of culture characterized by mutual confidence and correctness (social capital). Such a complex conception of innovation process including all the national sources in a national innovation system should create the main contents of an effective innovation policy.[3]

[3] "Innovation policy is considered as horizontal, and should be integrated into a whole range of vertical fields of policy. Conservatism of national governments follows mainly from the departmental isolation, which needs to be overcome." (EC, 2002).

Conclusion

The share of educated workforce in Slovakia is growing, but is constantly competing mainly with low-priced workforce. The transfer of new knowledge and technologies emerging from the universities and academic research into practice is insufficient. The society and economy do not fully utilise and appreciate them. This is also caused by the low economic performance, which enables the Slovak economy to compete mainly with its cheap workforce. The high share of imported technology and transfer of foreign R&D results decreased demands on the home research and reduced the R&D expenditures, the number of research employees and technical infrastructure of research.

As follows from the above analysis it is also the economic performance growth that is a crucial condition of innovation development. This growth is secured either by means of foreign direct investments or domestic investments, capable to produce appropriate sources for R&D financing. After achieving roughly the average level of economic performance of the EU-27 countries, further growth in competitiveness cannot be attained without an increased innovation activity. The enterprises are then forced to increase their R&D expenditures as a basic source of innovation and technological development. Innovative products with higher selling prices are at the same time capable to cover higher wage expenditures and to use in greater extent highly qualified workforce. Without achieving sufficient economic performance it is impossible to increase the share of innovation and technological development based on domestic R&D, nor to attain a sustainable economic growth and increased use of highly qualified workforce.

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