Ádám Török*

Science or *competitiveness?* *Science* and *competitiveness!*

Acceptance speech at the Hungarian Academy of Sciences

In economic political debates, it has been endeavoured increasingly frequently in Hungary since 2002 to reassess the economic role of each sector. Attempts to relieve the state budget affect a broadening range of public services, and standpoints more on the radical side doubt justification for state financing even in case of previously consensual public services. Reassessment of the state's functions and duties is particularly observable in sectors where the link between financing and output is indirect, or where the social benefit of output is only partially or not at all measurable in pecuniary terms. It is a natural aspiration not to provide more abundant funding to the welfare state than what is affordable and matches the development level of the respective economy. However, sectors that do not just "swallow" money without any short-term or long-term social benefits, but provide services that are necessary for the future development of the economy cannot be considered to be a part of the welfare system. This includes education, healthcare and, most particularly, an indistinct area that is sometimes referred to as science, or as research and development (R&D), or, at other times, as the national system of innovation (NIS).

The abovementioned debates over economic policy have not spared this area, either. Various surveys have been produced of the Hungarian R&D sector or the national system of innovation since the early 90s[1]. Most of these clearly revealed that only a small portion of the amounts provided to Hungarian research and development institutions was returned in the form of innovative products and services that proved competitive on the market. The facts revealed by the researchers could justly be interpreted to say that Hungarian R&D is pursued detached from the economy, mostly defying the needs of the economy, and it only follows its own goals interpreted in the narrow sense (scientific excellence, academic progress, international success in applications for funds). If one attempts to evaluate the functioning and performance of the Hungarian R&D sector from the aspect of competitiveness, the conclusions can be expressed in two distinct statements, as follows:

❶ The Hungarian R&D sector alone is not sufficiently competitive.

❷ The Hungarian R&D sector does not sufficiently contribute to increasing the competitiveness of the economy.

* The author wishes to thank *Gyöngyi Csuka, Zsuzsa Deli-Gray* and *Kitti Schwartz* for their help and advice, and takes full responsibility for any errors and inaccuracies.

The present study will assess these latter two theses, which were also voiced frequently in the Hungarian government communication between 2004 and 2007, and an attempt will be made to interpret them more in-depth. We are interested in the bilateral relationship between competitiveness and R&D, a mutual link between an important measurement of economic performance and probably the most important field in creating knowledge, so far only partially explored in the literature.

ABOUT VARIOUS INTERPRETATIONS OF COMPETITIVENESS

Competitiveness has become a catchword in modern economics, and besides, it has also gained ground as a political talking point. With economic science split into two major branches, theoretical and applied economics, as opposed to business/management studies, now full-fledged disciplines, competitiveness research has been assigned to the latter area. It mostly entails corporate competitiveness research, while the analysis of the competitiveness of national economies has ended up in a kind of no-man's-land between theoretical (macroeconomic) and business/management research. A typical standpoint, although far from exclusive in the field of economics, is represented by *Paul Krugman* (Krugman, 1994; Krugman – Obstfeld, 2003), who definitely rejects any interpretation of the notion of competitiveness at the macro level.[2]

Krugman's sharp counter-opinion is partly rooted in his observation that economic relations among countries rely on cooperation at least as much as on competition, but he also points out that the operation of multinational companies widens the gap between measuring corporate performance and that of the national economy. This objection is valid in itself, but it ignores the fact that measuring trade benefits is traditionally applied to business premises and not to companies (since *Smith, Ricardo, Mill* and the Heckscher–Ohlin-theory), and this approach is also adopted by international trade statistics.

The notional and theoretical basics of competitiveness analyses are still unclear from many aspects. At first sight, "coping with competition" could be a spoken language synonym to the notion of competitiveness, but – surprisingly to certain economists – there is no generally accepted definition of competition as the basic category of market economy. This is meaningfully pointed out by *Robert Bork* in his fundamental work on the theory of competitive policy, who lists no fewer than five diverse interpretations of competition (Bork, 1993)[3]. On interpreting competition or, for that matter, competitiveness, it does make a difference which understanding is used as the starting point, but, unfortunately, no general agreement has been reached on this issue within the trade. This results in the fact that competitive analyses – particularly at the macro and sectoral levels – are actually produced without a solid theoretical foundation for the time being.[4]

In the absence of a theoretical background to the notion of competitiveness, a (lesser formalised) methodological framework to analysing competitiveness has evolved, which is considered for the majority of macroeconomic or sectoral investigations.[5] The first key issue here is the *measure* i.e. whether the competitiveness of market actors is measured against their own abilities or the competitors' performance. It is possible for a competitor to highly outperform their own abilities, and still be a laggard in the international field. The literature abounds in competitiveness measurements built on international comparison, but we will see that in certain cases – particularly for approaches concerning the supply side – market actors' own abilities are also considered.

■ In terms of methodology, competitiveness analyses at the macroeconomic or sectoral level (especially international analyses) can be classified in three groups (Török, 2006a). The point of approaches concerning the *supply side* is that countries in a more favourable supply position (for example, producing at lower wages or other cost advantages) are considered more competitive, because on a *ceteris paribus* basis we believe that cost advantages lay the ground for better market performance. These approaches are in line with practical experience mostly on price-sensitive markets, but where differentiated products attempt to acquire customers not only through prices but also through various special parameters and services, they are less applicable to actual market competition. This approach is represented when an explanation is sought for the good performance of "low wage countries" (or a less clear correspondence with "newly industrialized countries" (NIC) – "tigers"] in terms of foreign direct investment or commodity exports).

- The *demand side* approach is just the opposite of the previous one. It is not the cost factors of foreign economy that count, but performance itself, which can be measured through export growth or market share. Improved competitiveness on the demand side, however, can be apparent or temporary, if, for instance, market share only grew as a result of a competitor's elimination, or if temporary exchange rate changes are underlying a rise in the market share. In practice, it is not at all certain that the dynamics of competitiveness on the demand and supply sides are closely connected for a market actor, and this is why sole application of either of these approaches must be considered as one-sided, and, in specific cases, causing distortion.

- The third approach is *comprehensive in nature,* and does not directly represent a measure of coping with international competition. Competitiveness here is regarded as a general indicator of the economy's state, assuming that an economy that can be described by better indicators is more competitive. More developed, faster growing economies that create more jobs and have better balance indicators probably have better abilities to exploit their resources efficiently. This is the approach adopted for international country lists of competitiveness, such as the rankings regularly published on an annual basis by World Economic Forum or IMD.

The three approaches presented may equally be used on examining the competitiveness of science, R&D and innovation, as well as their impacts on competitiveness. Before that, it is worth clarifying the notions here.

SCIENCE, R&D AND INNOVATION

Creating, organising and using knowledge for economic purposes (more accurately: adapting for use for economic purposes) are three fields that can easily get mixed up. The boundaries are fuzzy because a senior research fellow at a research institution or an associate professor (similarly to their associates in other ranks) may perform scientific, R&D and innovative activities simultaneously, even literally at the same moment. Scientific results in general – unless they are a result of divine intuition, which has been diminishing since the early 20th century – can be achieved through R&D activities, and certain scientific or R&D achievements may be developed into an innovation subsequently. However, not all innovations have underlying scientific work or R&D, as linking existing pieces of industrial knowledge in a new way may also result in successful innovation. What is more – as shown by *Schumpeter* (1980, 1912) as early as at the beginning of the 20th century – new production processes, organisational solutions or sales techniques may also be regarded as innovation[6]. The notions of science, R&D and innovation are closely interrelated, but are not interchangeable.

Recorded and organised knowledge accepted by the relevant trade community and also appraised against its own *(not economic or political)* criteria may be considered as science. The emphasis here is on maintaining and further developing existing knowledge in line with an independent and full-fledged set of values which, at least in theory, the evaluation of performance should not be influenced by any kind of contact with politics or the economy.

In a certain sense, R&D is to *dynamise science.* This is because R&D is a purposeful and regular activity aimed at creating new knowledge, though it is not the only way to do so. An important constituent in creating knowledge is education; however, in that field – to borrow an analogy of the European Union's development – the emphasis is more on widening than on deepening, i.e. enhancing individuals' personal knowledge instead of acquiring new knowledge for the whole community.

Innovation is creation of knowledge, partly but not fully based on R&D, which is represented in new products or procedures, and enables the initiating market actor to *improve their competitiveness.* At this point, creation of knowledge and competitiveness are truly interlinked in a direct and salient way.

Recently, literature has devoted increasing attention to non-R&D based methods of knowledge creation and innovation. This unfolding change in approaches is party fuelled by the practical experience that many types of innovation may represent only minimal changes to a product, organisation or process, and still considerably improve market chances, without the need for any R&D input. At the same time, there is also an underlying line of thought behind this altered approach: practical devaluation of R&D with reference to the idea that R&D has less economic benefit than believed earlier, if there are considerably less expensive methods of arriving at innovations. Innovations as classified by economic historian *Joel Mokyr* into micro and macro inventions always required R&D in the past – certainly in line with the opportunities and customs of the relevant era – (Mokyr, 2004), and will continue to do so in the future.

The article by *Lundvall* and associates (2007) presents an apparently outstanding new result in terms of the connection between knowledge creation and R&D, which makes a distinction between the two major models of knowledge creation. One is the traditional R&D based model (Science, Technology & Innovation, STI), i.e. a set of relations among science, technology and innovation, including the linear and triple helix models (for more details in Hungarian, see Török, 2006a). The other one is the new DUI (Doing, Using & Interacting) model of knowledge creation, which emphasizes development of work experience into innovation, using network links among market actors.

An important element of the latter model is that in modern industry, many kinds of innovation need to be adopted and improved, instead of being reinvented. At the same time, propagation of this model will necessarily devalue the traditional techniques and procedures of protecting intellectual property. Emphasis is increasingly shifting to in-house innovations and further development of innovations adopted from others by way of experience, which will need no patents, for example. Anyway, a slight amount of aversion is emerging to patents in companies in certain industries, because competitors may conclude courses of research and development from the patents published, and that is how they initiate rival development programmes. What is more – particularly in the pharmaceutical industry – patents may generate ideas to manufacturers (in the far east, for example), with weak enforcement facilities available in Europe, whereas competitors may even deduce the manufacturing procedures of important new products from the patent description, and usurp foreign knowledge to become competitive actors on the global market.

Science, R&D and innovation are thus closely interrelated, but operation of these three areas follows partially different sets of criteria. The scientific set of values is relatively far from the strict and short-term return requirements of the economy, R&D more emphatically represents the considerations of economic cost/benefit, whereas innovation is expressly an economic activity, which is primarily pursued today in a profit-oriented framework of enterprise. The relationship between the operation of scientific, R&D and innovation organisations and competitiveness is different presumably because considerations of competitiveness are represented to varying degrees on assessing the performance of the three areas.

With a certain amount of simplification, we may state that it is reasonable to set criteria of competitiveness and direct return

- in full for innovation,
- in part for R&D,
- and not at all for science – provided we consider science[7] as something only pursued in line with its own requirements, independent from the needs of the economy, and focused on knowledge creation.

According to the set of values that has been increasingly represented in economic policy in the recent years in the EU and in Hungary, and also (in certain periods, vehemently) advocated by the Hungarian governments after 2004, the above statements may even sound as heresy. Although, the position about science does not imply that funding for science may exclusively be provided by the state and exclusively without requirements. Today, science can rarely be pursued as an unpaid hobby, but it does not mean it is necessarily funded from state resources.

In wealthier countries, considerable private capital is used to support even the portion of science that does not guarantee economic results, in the form of foundations or through universities. In those countries, the emblematic question that has been asked many times in Hungary because science has badly needed regular state subsidy in the absence of relevant private resources to meet long-term public interest, and in order to preserve the language and the cultural heritage, does not even emerge. The question is: "How does the economy benefit from the study of medieval scripts?" This question has been mainly asked referring to the fact that in most years research funding was also available to the field of liberal arts within the system of Hungarian R&D funding systems, which have been partly run from the contributions that companies have paid on innovation since 2003.[8]

The obvious answer certainly is that it does not, but on giving a more detailed explanation, a more in-depth picture unfolds. Even abstract science may help improve competitiveness, but often through a number of directly non-quantifiable transfers, which generally cannot be predicted.[9] What is probable, though, is that the formation of attitudes, as well as education not directly developing labour market skills may considerably improve the quality of workforce, which also requires diverse research not necessarily related to the economy.

> Let us add a non-European example to what has been said here: in Japan, huge amounts are spent to develop software in the Japanese language. Such software is certainly much more complicated to manage compared to the English version, and it is much more difficult/expensive to write in Japanese on computers. Would it not be a much more efficient solution for Japanese computer users to shift to using the English language?

For somewhat unclear reasons though, Japanese society and economy, which are otherwise very much efficiency oriented, have still not taken this step – for some reason, they insist on their "low efficiency" language and culture.

SCIENCE, R&D AND EFFICIENCY

Through the Japanese example, we have reached the point of asking what limits are applicable to the possibility and reasonableness of extending the notion of efficiency customary in the economy to fields where other measures of performance – or ones interpreted on a different timescale only – are also used.

> This is illustrated by the "paradox of the string quartet".[10] The paradox illustrates the limits of measuring and interpreting efficiency. The point is as follows: a string quartet produces a CD recording of a piece by Beethoven in year t, which is a 40-minute performance, and it generates USD 100 thousand to the recording company. The same piece is recorded by the string quartet again in year t+5. The duration of the recording is only 37 minutes this time, but the revenue is the same. The paradox is: does the same amount of revenue generated from a shorter recording mean increased efficiency 1. in an artistic, 2. in an economic sense? The answer to the first question is obviously no, but to the second, it is probably 'yes'. The problem is, however, that if a correspondence needs to be found between the two types of efficiency approaches, one of the answers must be wrong. So, the essence of the paradox is that the market in the specific case could not appreciate artistic quality, i.e. product differentiation did not result in a better situation in terms of information for the demand side.

In a more general sense, the "paradox of the string quartet" implies that efficiency-based performance requirements have hard limits even in the economy where output and the quantitative proportion of resources cannot be interpreted, or only in a misleading way. With the paradox extended to science and R&D, it can be established that the efficiency measure customary in the economy is reasonable and permitted to be applied only to cases – fields of science – where the market value of output is applicable at all. Where it is not, strict cost and capacity limits can also be set up – for want of something better –, but one cannot refer to the absence of competitiveness, as absence of a measure does not at all mean the same as absence of performance.

On comparing science and R&D performances on an international scale, the abovementioned fields of science must be ignored; however, it should be repeatedly emphasized that this does not mean their exclusion from funding at the same time. Now, we are proceeding on to the international competitiveness examination of science and R&D, but this time we will be focussing on R&D and innovation, due to the lack of a clean-cut competitiveness measure applicable to science.

In a comparison of countries, two competitiveness approaches are possible for R&D: the first one is competitiveness of each country's R&D and system of innovations, the second the contribution of R&D and the system of innovations to the competitiveness of the whole economy.

❶ In order to measure the competitiveness of international R&D, it is necessary to quantify the international positions achieved on the "input" and "output" sides of R&D and innovation (expenditures and performance). For this, the most frequently used charts are the proportion of the GDP applied to R&D (GERD/GDP) and human resources of R&D on the expenditures side, while performance in terms of publications and patents as the output indicator. In the international R&D rankings produced since the early 2000s, Hungary has occupied positions between 30 and 35,[11] whereas the country ranked 40[12] in the economic development report issued by the World Bank in 2007. These details alone apparently rank Hungarian R&D competitiveness above the average, however, this is not the case. The international ranking of economic development is not a competitiveness ranking; consequently, comparison of the two lists requires great caution. On the other hand, there are a number of developed countries, or ones with high GDP per capita indicators, where no material R&D activity is pursued, or where R&D does not contribute considerably to GDP (such are, for instance, the great oil exporting countries). Accordingly, it is pointless to link R&D and competitiveness in any way in these countries.

❷ Contribution of science, R&D and the system of innovations to macroeconomic competitiveness can only be represented in a considerably more complicated system of correlations. Certain simplifying assumptions are indispensable. First, let us assume that improved competitiveness of the national economy is seen in terms of commodity export, or, more directly, the structure of commodity export. This alone cannot be considered a regularity at all, given that improved competitiveness may also be manifest in the structure of services export, similarly to the structure of domestic industry supplying to the export sector. Similarly, it must also be assumed that the achievements of science, R&D and innovations are actually represented in upgraded products, and not left on paper, or sold abroad as intellectual products.

If these assumptions are met, progress in competitiveness can be measured by the speed of improvement in the export structure towards products/services with higher added values. A popular and relevant indicator has been around in the literature, which is rather doubtful in terms of contents: export ratio of "high-tech products".

The details indicated in *Chart 1* are spectacularly complemented by the indicators of a few developing countries for the year 2003: in the Philippines, the export ratio of products deemed as high-tech[13] reached 64 per cent, while the ratio of electronic parts within imports 47 per cent. The corresponding two charts in Singapore were 49 and 35, in Malta 57 and 20, whereas in Malaysia 45 and 44 per cent, respectively, also in 2003 (Srholec, 2007). All the four countries are primarily known as exporters of electronic products, and the high import ratio of parts suggests that a considerable portion of manufacturing is actually assembly.

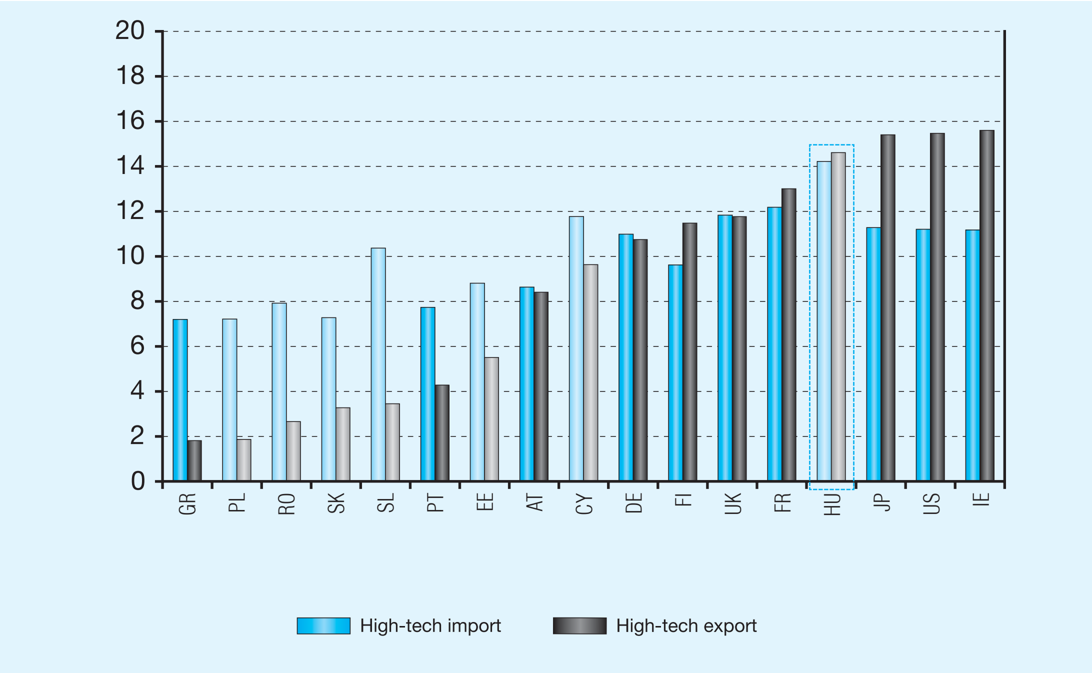
Chart 1 and the numbers reveal that the high export ratio of products considered as high-tech does not, in many cases, reflect the standard of the domestic system of R&D and innovation, if the sector producing state-of-the-art electronic or other products uses foreign technology and parts, and the overwhelming majority of high-tech export derives from multinational companies assembling products in a country, relying on foreign R&D.

The structure of the global high-tech trade does not truly reflect international R&D and innovation activities because details of countries are shown here, whereas the decisions applicable to business sites in terms of R&D, innovation and high-tech industries are increasingly made by multinational companies.

Chart 2 reveals that the share of leading countries and regions in terms of R&D is diminishing in the field of global high-tech export, while the proportion of countries specialising in assembly is continuously on the rise. The same process is presented from a different angle by the fact that the United States of America, the absolute leader in international R&D and innovation rankings has been a net importer of high-tech products for years *(see Chart 3)*.

Chart 1

THE PROPORTION OF HIGH-TECH EXPORT AND IMPORT IN TOTAL EXPORT, 2004

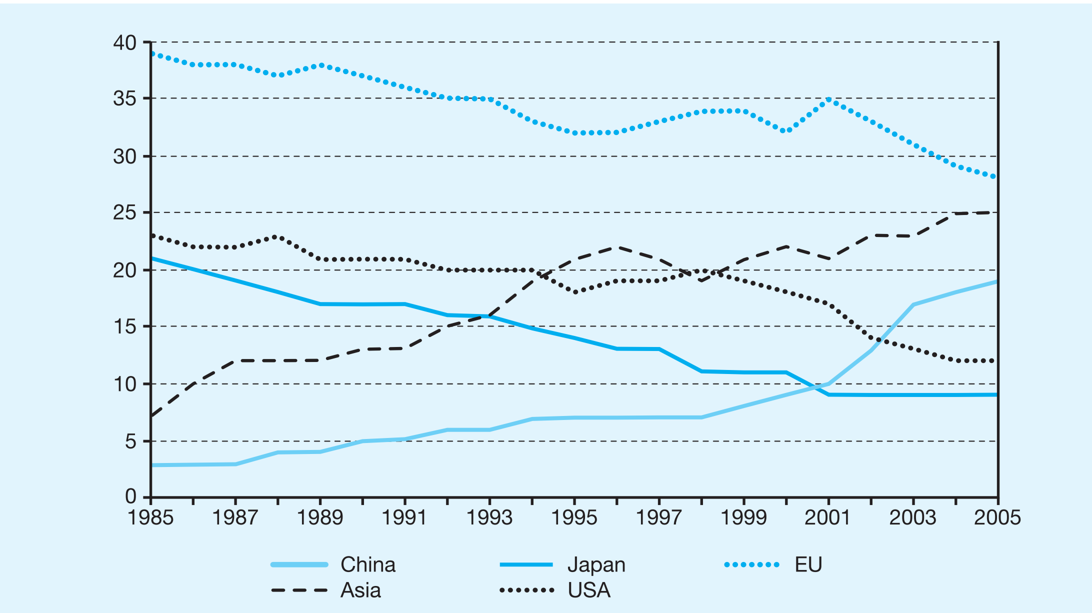


Forrás: GKI-Microsoft Competitiveness Report, 2007, chart 121

Chart 2

SHARE OF KEY REGIONS IN THE GLOBAL HIGT-TECH EXPORT

(1985–2005, per cent)

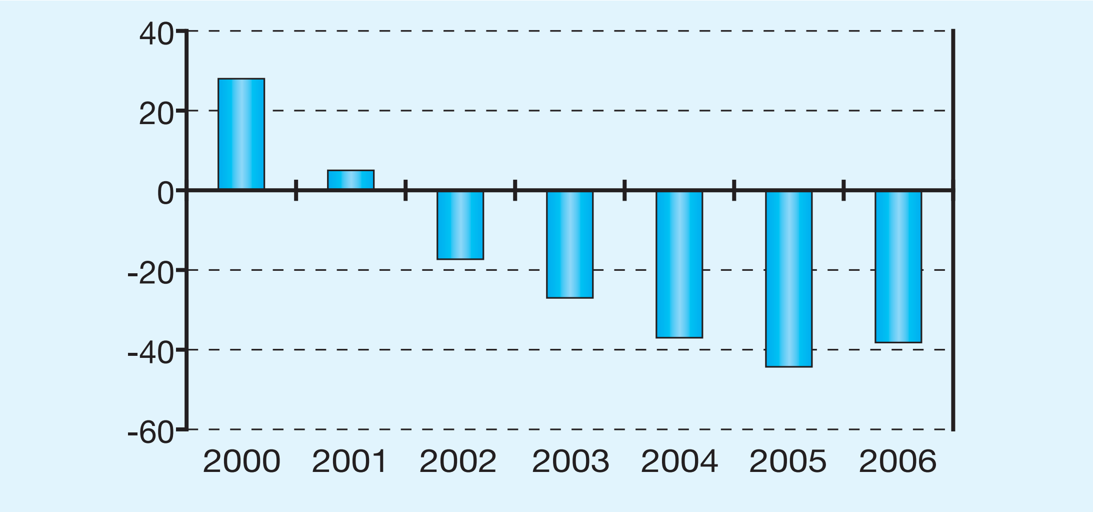


Forrás: NSB, 2008, Chapter 6

Chart 3

BALANCE OF HIGH-TECH PRODUCTS TRADE IN THE UNITED STATES OF AMERICA

(2000–2006, billion USD)



Forrás: NSB, 2008, Chapter 6

The link between R&D, innovation and competitiveness cannot be reliably represented based on foreign trade charts, so to say. The question is what other method would be suitable to show this link, or the economic benefit of science, in a broader sense.

THE "BENEFIT" OF SCIENCE

Representation of the link between R&D, innovation and competitiveness would also be necessary because between 2005 and 2007, multiple forms of statements were voiced in public by leading politicians in Hungary, not always explicitly, which questioned the benefit and point of Hungarian science and R&D and their various institutions from the aspect of economy or competitiveness. They did state that Hungarian science (or R&D), as well as the Hungarian Academy of Science deserve state funding only at times and in fields when and where they have a direct impact on competitiveness for improvement[14].

A part of science (and R&D), however, is incapable of immediately and directly improving competitiveness, not only in Hungary but also in countries dominating the area of R&D. The reason for this is a difference between the content of basic and applied research. Basic research is seen as the portion of R&D that creates new knowledge without a direct or palpable economic benefit, where the end result of research is only presumable but not clearly visible, and, for this reason, evaluation of basic research can only rely on scientific considerations. For applied research, however, the objective is a pre-defined result, and, accordingly, the economic point of applied research is to achieve the goal.

Contrasting basic research with applied research is artificial, because it emphasizes their rivalry for resources, instead of their interdependence and interaction.[15] In case of scarce funding, it must certainly be accepted that such a rivalry is present, but the comparability of results is very doubtful. Results of basic research are generally used by the domestic and foreign community of researchers, while clients of applied research are mostly privately owned economic organisations – although not excluding important government orders for the public good, such as urgent testing of a vaccine.

So, with certain simplification, it may be stated that basic research creates public goods, while applied research creates private goods. Consequently, a comparison of public and private goods immediately raises the issue of pricing for the two types of goods, when no short-term market demand is present for public goods, although they satisfy long-term social needs (such as the study of medieval scripts, cultivation of the language, or proofs of abstract mathematical theorems).

However, the social /economic benefit of basic research must be determined, or at least indicated when one intends to support its funding from public resources. Such benefit may be of many kinds, but generally is not measurable directly the way it is for applied research that is subsequently represented in products and services, and this is why it obviously easily lends itself to political deliberations. The social and/or economic benefit of basic research – and one can state with certainty: the strategic increment – may consist of the following factors:

- maintaining the domestic basic research database in the branches of science where the requirements of return are difficult to interpret, and, consequently, funding cannot be based on revenues from the corporate sector;
- supplying domestically generated R&D results to domestic higher education,[16] and
- creating incentives to prevent migration of researchers. This equally includes migration of researchers abroad, and from research positions to companies, as was seen in transitional European countries in the early 90s (Biegelbauer, 2000).

An indicator corresponding to the GERD/GDP ratio[17] is rarely calculated for basic research, although international comparisons made this way yield rather interesting conclusions. Chart 3 indicates an expressly strong relationship between the portion of the GDP spent on basic research and the development status of R&D, and the economy. The international cutting edge – with outstanding indicators – consists of Switzerland and Israel, followed by the United States, France and a number of Scandinavian and South-East Asian countries. In moderately developed countries, however, this ratio is considerably lower. *(see Chart 4)*

The portion of the GDP spent on basic research alone does not show how important basic research is considered by science policy and R&D policy as opposed to applied research. The proportion of basic research within R&D expenditures is the right indicator to show. It reveals that it is generally the Central European countries (if the region is taken to include Switzerland, in line with a tendency suggested by old geography textbooks) that spend most on basic research within R&D, which implies a kind of central European tradition in patronizing basic research.

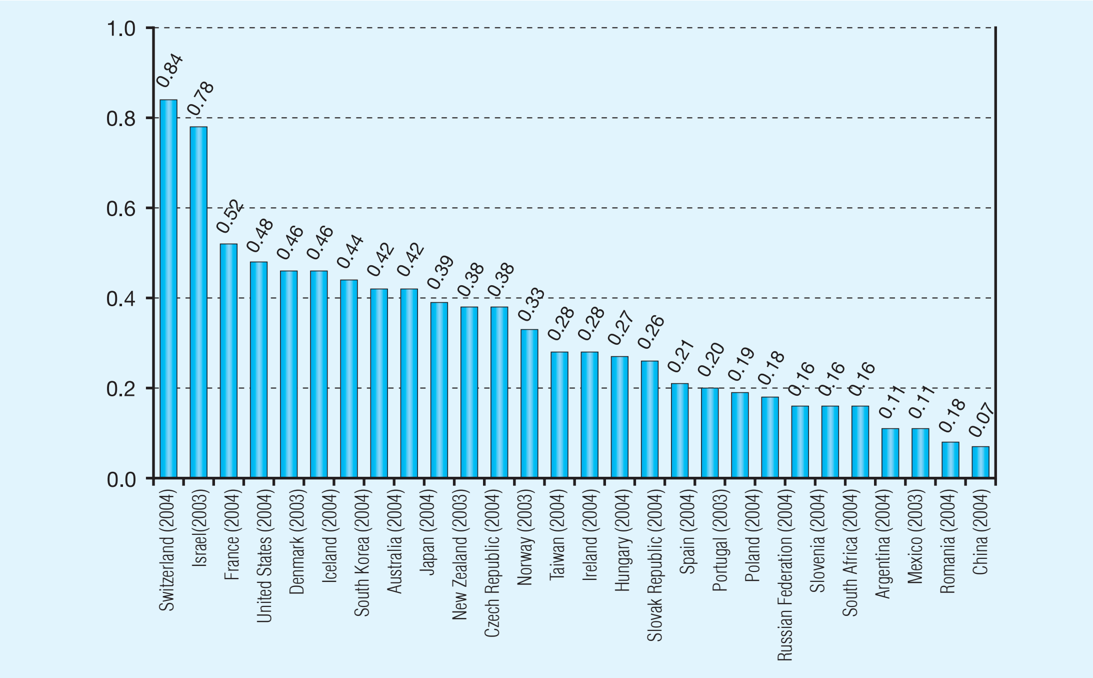
This is shown in *Chart 5,* which is in seeming contradiction with Chart 4; however, this seeming contradiction is easily resolved. Developed countries spend relatively generously on basic research (and also on R&D) *in comparison to their economic performance,* while the economies of central Europe *consider basic research important within R&D.* Tradition alone cannot be responsible for this; the relatively low cost requirement of a significant portion of basic research also supports this trend (given that in many fields of humanities only basic research is available, in the first place)[18], compared to the results that are achievable in the respective limited field of science, such as publication performance.

This relatively strong commitment to basic research can actually be considered a European peculiarity, in comparison with the highly developed overseas or English speaking countries. This is certainly not meant to suggest that

Chart 4

AMOUNTS SPENT ON BASIC RESEARCH FROM GDP

(percentage, 2003 or 2004)



Forrás: NSB, 2008, Chapter 4

basic research is pushed to the background outside Europe – in the United States, for example –, as financial support for research has quite different dimensions in developed overseas countries, which concludes that the absolute amounts devoted to basic research are considerably higher.

> It is illustrated by the size of R&D budgets for 2006 at certain leading U. S. universities:[19] Among American universities, it is Johns Hopkins University that spends most on R&D: it was USD 1500 million in 2006, which is approximately an amount equal to the Hungarian GERD. University of Michigan with a USD 800 million budget for R&D, Boston-based MIT with USD 600 million, and Harvard University with USD 450 million correspond to the GERD charts of European countries between the size of Slovakia and Slovenia.

International R&D statistics present it as a solid fact that Europe lags behind the United Stated in terms of the R&D competition; this was also referenced in the documents of the Lisbon Agenda (Rodrigues, 2003; Deli, 2004; Török, Borsi and Telcs, 2005; Török, 2006a; NSB, 2008b). There is an apparent understanding in the trade concerning the causes of this lag. Looking into it deeper, however, the explanation is not so simple.

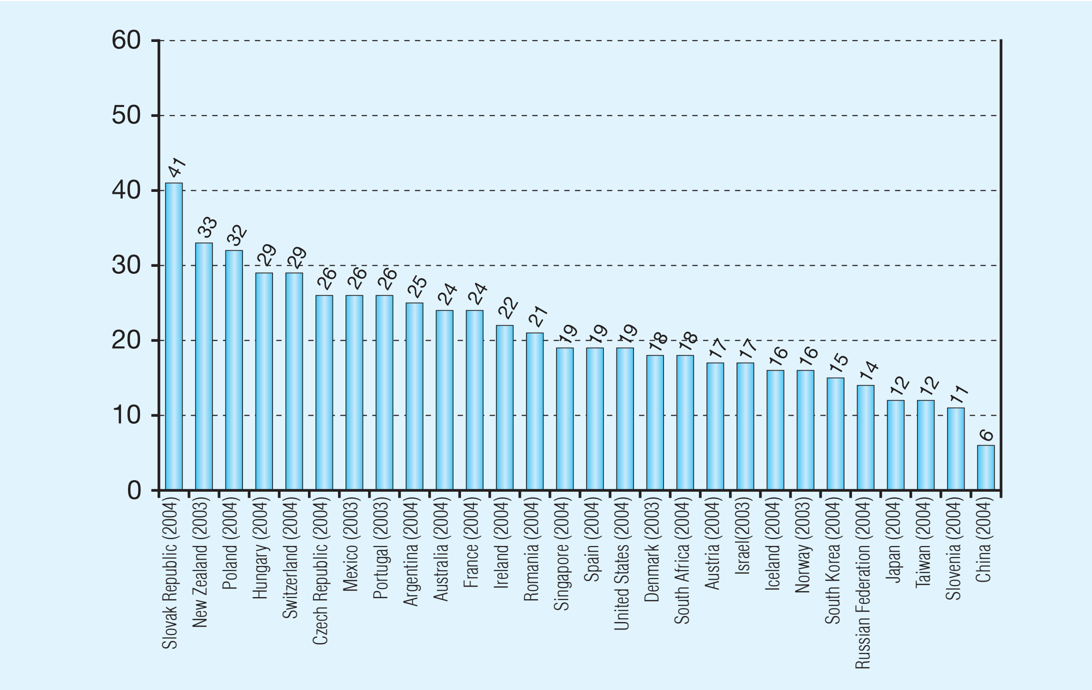
EUROPE'S R&D LAG

Out of the factors that cause the EU to lag behind the US in terms of R&D and innovation, two are most frequently highlighted. One is already known to us: on the supply side of R&D competitiveness, the GERD/GDP ratios measured are truly low in comparison with the

Chart 5

"CENTRAL EUROPEAN TRADITION": THE PROPORTION OF BASIC RESEARCH WITHIN R&D

(percentage)



Forrás: NSB, 2008, Chapter 4

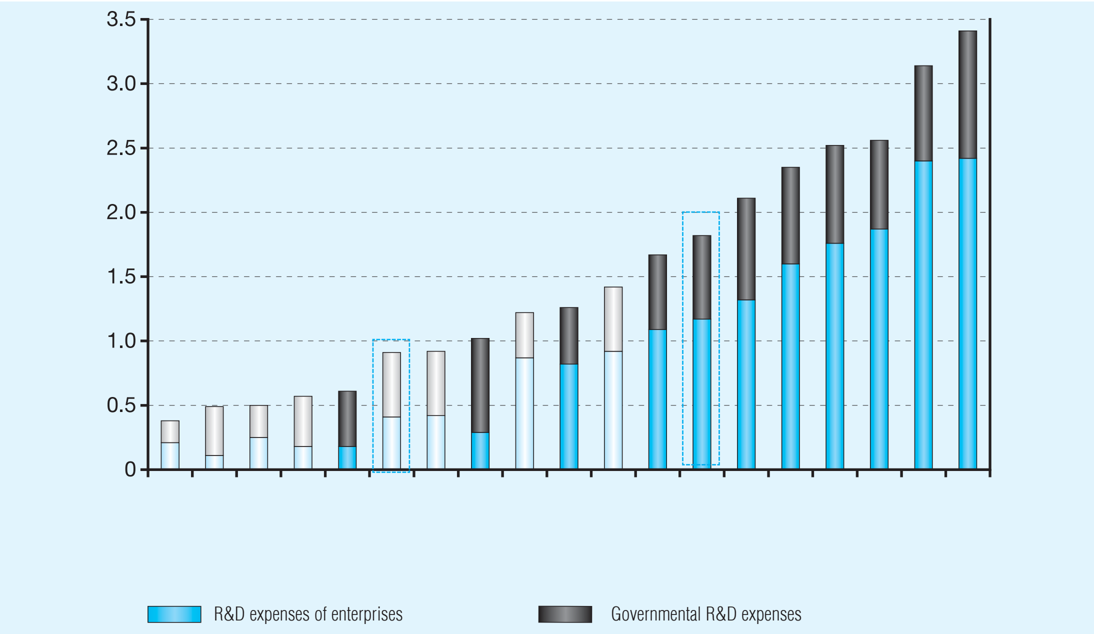
EU average. The actual charts fluctuated between 1.8 per cent and 2.0 per cent in the period 2002–2007[20], which is more than one percentage point below the USA chart. When considering the EU as a single country, the chart is certainly undoubted, but when splitting the Community into individual countries, the field is much more differentiated. Considerably above the American chart – on the financing side –, Sweden and Finland are seen as the two leading R&D powers globally, while in a number of EU countries GERD/GDP indicators do not exceed 0.5 percent. This, on the other hand, is a chart characteristic of the marginal participants of the R&D competition (Török, 2006a).

The GERD/GDP indicator *(Chart 6)* is widely used in both the scientific and the business literature, to compare the R&D potentials and performance of individual countries. In the meantime, certain, otherwise empty threshold values of the indicator gain almost mythical significance (2 per cent for the EU, and 1 per cent for Hungary), and many endeavour to disguise meeting these as strategic objectives. However, international R&D comparisons based on the GERD/GDP alone are pointless, as the GERD/GDP ratio could only be considered as a performance indicator in case of equal levels of distribution for use and efficiency of R&D expenses (which certainly is an illusion). It is precisely the Hungarian R&D system that may prove to have still better publication performance indicators than expected based on the GERD/GDP ratio (Török, 2006a), which, surprisingly, suggests a relatively high average efficiency of Hungarian R&D.

Recently, attempts have been made to prove the lag of the whole EU in terms of R&D and innovation using the distribution of R&D per-

Chart 6

THE GERD/GDP INDICATORS IN INDIVIDUAL COUNTRIES IN 2005



Forrás: GKI-Microsoft, 2007, Chart 106.

formance by product, instead of the GERD/GDP indicator regarded to be low on average. The notion of the "European paradox" has been adopted in the collective awareness of the trade in this context (Papanek, 2003).

According to a widely spread interpretation of this paradox, Europe spends relatively much on science and R&D, but it only has a limited effect on increasing competitiveness, because results are represented more in publications than in patents.

On the other hand, there are certain more recent research results that make this conclusion seem simplistic. Mostly because the assumption whereby a scientific result must be published first (to conclude the basic research phase, so to say), and then the applied research phase built on basic research would be crowned with patenting, follows the logic of the old linear model of the innovation process rejected by so many. The problem is that in the globalized innovation systems of the 2000s, highly exposed to strong competition, often there simply has been no time to comply with theoretically strict sequence of steps applicable to the linear innovation process. Calderini and associates (2007) believe that patenting and publishing results are often alternatives to each other ("activities in complementary distribution"), i.e. – with certain simplification – a result is either patented or published. In this case, the absence of patenting does not necessarily mean that the given result will not become an innovation.

The "European paradox" is built on the assumption that innovations are necessarily patented. It has been known for almost two decades now that this is not the case (Griliches, 1990). Patenting new products or procedures also entails publishing the essence of results, which may facilitate competitors' efforts to discover the new courses of research.

The strong doubt about the "European paradox", however, is only aimed at the paradox itself, that is, the quoted explanation to the European lag in terms of R&D and innovation. The fact of lagging behind – in respect of the whole EU – is indisputable, nevertheless. Not even despite the fact that the publication performance of the EU has slightly improved since the early 90s, and that of the United States slightly deteriorated between 1995 and 2005. In 1995, 564 645 articles were published on natural and technical sciences globally, of which 193 337 were authored by Americans and 195 897 by nationalities of the subsequent EU-27. In 2005, these three charts were 709 541, 205 320 and 234 868, respectively (NSB, 2008b, Appendix Table, 5–34),[21] i.e. the number of American publications grew by only 0.8 per cent on average, as opposed to the 2.3 and 1.8 per cent for global and EU averages, respectively. Nevertheless, this only seems to indicate the relative deterioration of American performance; the charts rather reflect a shift in strategies. Of all channels of knowledge creation, the United States increasingly prefers "producing" innovations that can be used in the economy, as well as higher education, and in this sense – but not simply through contrasting patenting and publication performance – the EU can be actually shown to lag behind in the international field.

Instead of the reviewed European paradox – which is not even expressly solid in terms of validity due to flexible management of the success criterion (publication or patenting?) –, other proofs weight more when measuring the EU's lag. A particularly strong proof is the American advantage in terms of good quality higher education, which is undoubted, as is also supported by a number of international university rankings.[22] At least three factors can be distinguished within this advantage, and none of them belong to the area of R&D policy when taken in the narrow sense.

The first factor is that not only universities but also their support enjoy a higher social status in the USA, compared to Europe. Concurrent provision for the future and independence of universities is a public cause, and multiple examples can be quoted (for instance, the case of Princeton University and the associated Institute for Advanced Study) where one of the world's strongest universities and research sites were created with social cooperation within a couple of decades. To this end, generous funding was provided to reputable scientists, leaving their full professional and political independence, and not requiring them to meet short-term and detailed reporting obligations in exchange for support of their research. Distribution of support was much rather determined by a value judgement of the professional community.

The second crucial element is that in the United States – and elsewhere in the English speaking countries – university funding is strongly dependent on institutional contacts with *alumni*. Organisations of alumni are involved in the governance of universities, and they are virtually imposed a moral obligation to achieve that companies or other organisations managed by alumni provide regular support or mandates to universities – as backed by centuries of tradition.

The third reason is that the autonomy and scope of authority of European accreditation systems are considerably smaller than customary in North-America. Higher education accreditation in the EU countries is generally linked to the government in charge of education, i.e. the state even participates in running and funding accreditation institutions termed as autonomous, in determining their composition, and the rules or criteria for accreditation are also developed by the government alone. This may reduce accreditation to formal, as often the point is not the capability of an institution to provide truly high standard education as judged by the trade, but its capability to meet the requirements literally (and maybe only at the moment of disclosing the data).

> It is rather frequent in the Hungarian accreditation system to have a head tutor who holds a scientific degree (which is necessary, for example, to head a department), and has not produced a single publication (which is only a requirement in the form of "relevant publication activities") in the recent years or maybe decades (!). This generates a lot of debate: the person formally meets the requirements, however, by higher professional standards, they would obviously be unsuitable to perform the respective assignment.

As opposed to this, the American system is a two-tier one, which represents a clear-cut distribution of roles among the stakeholders in the state and in the trade. The first tier is at the state level, which in the United States means federal states and accreditation consortia of certain member states (such as the Midwestern States). At this level, not the professional quality of education is assessed but the availability of technical conditions of higher education. Practically, this is where operating licences are issued to institutions of higher education. This does not yet mean accreditation, but ensures state recognition of the degrees issued by them.

Accreditation itself is performed at the second level by bodies organised by higher education institutions, and in line with rules set up in cooperation. This is where the professional contents of education is judged, the value is rated, as well as determining whether it can be recommended to students. Institutions are not required to participate at this level of accreditation, but they are still strongly recommended to do so in order to acquire or retain their professional ranks. This level of accreditation is open on an international scale; this is why foreign institutions may apply as well (in Hungary, for example, a number of departments at the Central European University hold such American accreditation).

The two-tier system provides a facility also for weaker colleges to obtain operating licences, but, in the formal sense, it still does not make them become rivals to stronger universities, as the case was, for example, in Hungary in the 2000s. This is how the accreditation system of American higher education facilitates coexistence of quantitative and qualitative education besides officially recognising outstanding quality, and also helps to create a balance between education and R&D at universities.

The three factors listed above probably have much to contribute not only to the outstanding competitiveness of American higher education but also the system of R&D and innovation. Concurrently, it also alludes to the fact that the competitiveness of science and R&D is far from being a mere question of funding.

FUNDING SCIENCE AND R&D

Financial background to science and R&D is generally considered as the key factor to competitiveness. This is not disputable, whereas the exaggeration of this assumption is. As discussed earlier, the scientific and R&D performance or even capacity of individual countries cannot be compared using the charts of GERD/GDP alone. Strictly speaking, it cannot be proved, but it is held valid in international terms that higher R&D expenses yield more scientific and R&D results, but the results are visible only after a lead time of years (Crespi and Geuna, 2008). Representation of results often outspans the customary reporting or return cycles of government or corporate funding, and this shift in time may also be the reason why return occasionally appears to be poor.

Dynamics of the GERD/GDP indicator show close correlation with the development level of the economy.[23] *Chart 7* illustrates this correspondence displaying charts of 18 countries. Two economies deemed as successful, Finland and Japan spend considerably more on R&D than expected in proportion to their GDP per capita indicator, while German, Hungarian and Czech charts are slightly above the expected values. As opposed to that, American, British and Austrian economies devote relatively less to R&D – at least in this comparison.

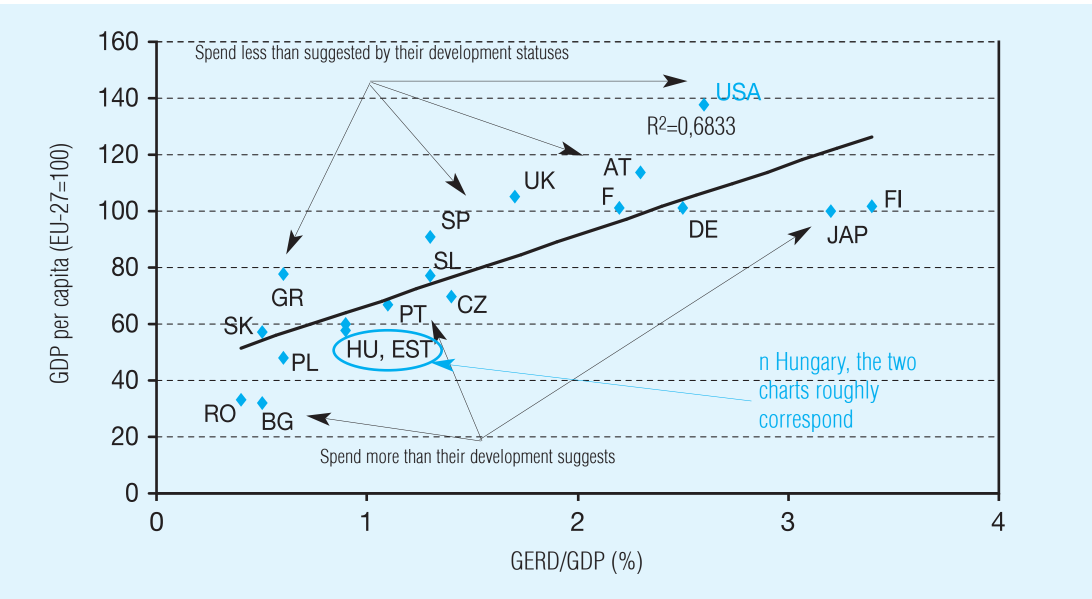
The GERD/GDP chart that is seemingly high for Hungary and low for America here in this comparison may provide food for thought concerning whether increasing the GERD can really mean a reserve for increasing R&D competitiveness and performance. The answer is presented by another indicator or its relation to GERD/GDP.

BERD (Business Expenditure on Research and Development) denotes R&D expenditures in the business sector, i.e. R&D expenses of enterprises. Its ratio to the GDP is also frequently used in comparative R&D statistics. This indicator shows an even closer correlation with economic development than GERD/GDP, and, practically, also positively correlates with the GERD/GDP ratio. In general, it can be stated that higher GERD/GDP-indicators go together with higher BERD/GERD ratios[24] (Török, 2006a). In countries that spend relatively the highest amount on R&D, countries with GERD/GDP indicators above 2 per cent, the BERD/GERD ratio is 65-80 per cent, while in the mid-list of GERD/GDP featuring 1–2 per cent it is around 50 per cent, and in the group of countries with a GERD/GDP below 0.5 per cent, it is not more than 25 per cent (NSB 2008b, Appendix Tables 4–37,4–39). The BERD/GERD ratio grew from 51.8 per cent to 62.2 per cent on average in the OECD between 1981 and 2004 (NSB 2008b, Appendix Table 4–39).

What all this means is that the proportion of R&D financed by enterprises at the level of the national economy rises in both time and space

Chart 7

CORRELATION BETWEEN ECONOMIC DEVELOPMENT (GDP PER CAPITA) AND PROPORTIONATE R&D EXPENDITURES, BASED ON 2005 CHARTS



Forrás: the author's calculations based on NSB charts with economic development. In more developed countries, the engine of development is technological upgrading, instead of using always additional resources of invariable quality. In this way, it is reasonable to expect the state to increase the total expenditures on R&D (GERD/GDP) only if it has an actually perceivable impact of developing the economy, because in that case the GERD/GDP ratio is expected to continue rising along with increased corporate spending on R&D.

In this case, political economic debates reminiscent of the "chicken or egg" dilemma and standpoints full of politically motivated simplifications are common. According to a typical opinion, the key task of the government's R&D policy is to encourage enterprises to raise their R&D expenses, which is primarily conceivable by fiscal means. A partial counterexample to this concept is the Hungarian corporate contribution to innovation introduced in 2004, which the majority of enterprises are required to pay unless they use it for research. A number of companies give mandates of R&D for contents indifferent to them to "friendly" R&D organisations, as a form of self-help. This is a way to drive up the Hungarian BERD indicator at least nominally. The counter-example, however, is only partially valid because the amount of contributions paid by companies for innovation should have been complemented by the government to double in amount every year, which the government never did. Consequently, the expected impact on stimulating expenses was only partial.

The other major concept is that the state is supposed to re-establish Hungarian R&D using funds from the central budget, and once its chronic financial undernutrition has been eliminated, it will become more competitive, and may better facilitate competitiveness of enterprises. The logical error here is that the Hungarian system of R&D needs intervention not only financially but also regarding its institution and operation. I do not wish to recall here the frequent attacks against the Hungarian Academy of Sciences and basic research – including various articles by *Béla Darvas, György C. Kálmán, Csaba Szabó* and *István Polónyi* between 2006 and 2008 –; nevertheless, a purposeful and sensible renewal of the HAS (not necessarily a *reform*, as suggested by the platitudinous expression) is surely in the best interest of the scientific community. The efficiency of the Hungarian system of science and R&D would be very difficult to improve until clear criteria for efficiency are set up for science and R&D, the absence of which is discussed in this paper.

With sufficient political courage and determination, however, a number of operating disorders could be eliminated. Only a few examples:

- on reforming the Hungarian system of scientific ratings in the early nineties, responsibility for rating was uncritically assigned to universities; however, excessive respect for university autonomy considerably prevents truly thorough and regular monitoring of the contents and standards of PhD courses.[25] The Hungarian system of scientific ratings would require an in-depth reconsideration, resulting in stricter measures for PhD degrees at most universities, and national standardisation of certain components of such measures;
- performance evaluation of Hungarian research sites is primarily at an institutional level, i.e. in the shadow of a few well-performing associates, a number of others may get by without any acceptable products. Truly individual performance appraisal would be necessary;
- on appraising researcher performance, spectacular new "panaceas" that often turn out to lack contents should be eliminated, such as involving foreigners in evaluating Hungarian research institutions. In gener-

al, it is an unnecessary burden for foreign researchers to perform external appraisal (or other) tasks in Hungary on a courtesy basis, and if the appraisal is made on a reciprocity basis (in as many as three or more steps)[26], the result can be predicted with good probability. This method (or requirement) does not promise success because it is built on the illusion that the cohesion of domestic researcher networks and, consequently, its effect on distorting evaluation, is necessarily much stronger than that of international ones with Hungarian participation;

- not contrary to the above remark, an effort should be made to break the often gravely adverse circles of inside references, appraisals and promotion in Hungary – even at the cost of breaching vested interests.[27]

Solution to a portion of all institutional and operating problems, however, cannot make up for the pressure to select a strategic path. Beyond all this, the core question ("chicken or egg?") of the Hungarian government's R&D strategy is ultimately whether it is a higher GERD/GDP that accelerates economic development, or higher economic development that facilitates more R&D and scientific expenses. It would be reasonable to take a balanced stance on this issue, because the correspondence between R&D expenses and economic development, or competitiveness is necessarily bidirectional.

In the longer term – but due to the nature of scientific research, only partly in line with the strict and time-restricted requirements of return customary in business – it is certainly true that a higher level of scientific and R&D expenses improves the competitiveness of the whole economy. Consequently, funding for R&D must also be increased in Hungary, and the role of the state in that cannot be neglected.[28] Rising R&D spending at companies cannot be achieved simply by the government taking a toll on the business world also in this area, quoting the shortage of its resources. Such company resources may indeed be received on a charity basis by research foundations, for example. This, however, is a much lower order of magnitude compared to a situation where the actors of the Hungarian business sector spend on R&D truly keeping their own economic interests in mind, similarly to companies in more developed countries.

More developed countries are able to spend more on science and R&D also *in the short term*, precisely due to stronger average orientation towards R&D, but they have laid the foundations of this higher level of development not only through expanding R&D resources in advance, but also through other investments into improving competitiveness with no short-term return. In particular, such areas of investment are education, healthcare and infrastructure, for example. In the first decade of the 2000s, it is a widely known and undoubted fact that countries that developed in line with a permanent "consensus on convergence"[29] (Finland, South Korea, Israel, Singapore) spent above the international average on education, healthcare and infrastructure, in addition to science and R&D. With an expression borrowed from *Béla Kádár*, the elimination of permanent economic and social deficits is necessary also in the abovementioned areas to initiate fast convergence (Kádár, 2008), and particularly in order to improve the quality of human resources.

SCIENCE AND COMPETITIVENESS

The international positions of Europe and Hungary have indeed deteriorated in the scientific and R&D competition within the past one or two decades, but neither of them are inferior to the respective positions of the EU and

Hungary in the global economic competition. A certain decrease of R&D competitiveness of the EU and within it Hungary is currently the case, increasing the that – maybe in one or two decades – the centres of high-quality knowledge production will gradually disappear from Europe. The process is currently underway, which is conclusively proved by international higher education rankings, despite their methodological mistakes.

The science and R&D policies of the EU, including Hungary should find a strategic response to make up for this loss of R&D competitiveness. In a competitiveness approach, however, it is to be seen that such a strategic response cannot be limited to the national innovation system in a narrow sense. In order to improve the competitive performance[30] of science and R&D, the best possible set of tools should be determined within economic and social policy.

In addition to support for actors and areas that promise direct improvement in competitiveness, an expedient strategic response would also represent improvement to institutional and financial conditions. In this context, it would be reasonable to quit the traditional notion of "technology" as restricted to solutions or procedures of natural sciences and technology, and acknowledge the key importance of developing "social technologies" (Nelson, 2008). This consists of R&D, education and healthcare, but development of "social technologies" also includes upgrading public administration, and even the development of transport systems and housing conditions.

Observing considerations of competitiveness in science and R&D is justified where an actual objective measure of competitiveness is available. Nevertheless, we must be cautious not to accept these competitiveness comparisons as serious competitiveness rankings[31] immediately once they exist. If we actually possess methodologically acceptable competitiveness surveys on science and R&D, a kind of competitiveness measure may really be set up for the R&D policy, certainly considering long-term effects and requirements of efficiency.

Selection in the field of R&D policy should indeed "suppress" areas of weak competitiveness, and not the ones where competitiveness is not even measurable, strictly speaking. The latter includes basic research, in the first place. It should be considered as a positive externality from the perspective of the economy and the whole R&D, whose funding constitutes a public cause, and whose control should not have financial criteria in the foreground.

NOTES

1 A non-exhaustive list: Nyíri (1996), Török (1996), Török (1997), OMFB (1999), Biegelbauer (2000), Török (2000), Braun et al (2002), Nikodémus (2003), Siegler (2003), Borsi – Telcs (2004), Hohl – Holczer – Pál (2004), Báger – Goldperger – Varga (2005), Török – Borsi – Telcs (2005), Török (2006a)

2 Nevertheless, in other publications he discusses the competitiveness problems of the American economy (Krugman, 1996).

3 Potential interpretations are, for example, related to the field of "game theory" (one can only improve one's position to the debit of others), the "neoclassical" interpretation (assuming pure and perfect competition), "classic social sciences" (one can only seek to improve one's position until it breaches others' rights), or the "shorthand" interpretation as suggested by Bork (competition is an ideal state in the market, when consumers' welfare cannot be further improved through state intervention). It is easy to see the material differences among these.

4 A conceivable option for a solution is to try and link the notion of competitiveness to the theory of comparative advantages, or, more broadly speaking, the theory of foreign trade advantages. For such an attempt, see Török (2008a).

5 For simplicity's sake – due to the nature of our subject – only cases of analysing international competitiveness will be addressed in the continuation.

6 The reason why it is important to examine the correlations between R&D and competitiveness is that innovation capacities of social sciences may be proved this way.

7 In terms of contents, basic research is referenced here, but this term will not be used until fully clarified.

8 The indirect benefit of research into social sciences – economics, law, sociology, regional science and others – is generally less argued even among the followers of science funding on a profit-oriented basis.

9 An example that is considered classic today: research into number theory was not regarded serious and worthy of state support until its economic benefit was revealed in terms of developing methods of encoding and cryptography (Török, 2006a).

10 The author has a number of encounters with it on conferences, however, has not managed to find a reference to it in the literature.

11 For details on the methodology of international R&D rankings and the possible results of ranking, see Deli (2004), Török, Borsi and Telcs (2005); Török (2006a).

12 Source: www.worldbank.org.

13 This rating is generally based on the OECD's system, which, in turn, classifies broader product groups in so-called high, medium or low level high-tech products. This system of classifications is considered to be rather lax in terms of defining high-tech.

14 These statements have been mostly made by various executives at the Ministry of Economy. See, for example, Kóka: The work of Nobel laureates is made more difficult by the fact that most of them are dead". Index, 2 May 2005 ; Schermeier, Quirin: Hungary's science academy slammed as 'obsolete'. Nature, 29 June 2006.

15 Contrast probably dates back to the older, "linear" model of innovation systems, where innovation is a three-stage linear process (basic research › applied research › experimental development). More up-to-date models, particularly the "triple helix" model emphasize the shared features and constant interweaving of the three stages.

16 Here a peculiar version of the free-rider problem. Where domestic basic research withers, higher education is increasingly forced to work from curricula adopted from abroad, because they have no bespoke scientific results to use. This ultimately leads to a lower quality of Ph. D., subsequently of M. A. level higher education, followed by an increased migration of students abroad.

17 GERD (Gross Expenditure on Research and Development) compares all R&D expenses to GDP.

18 An illustrative and relevant expression in American English is blackboard sciences, referring to research that only requires paper, books and pencils – but they still do not denote basic research only, because this illustrative definition is assigned on the basis of tools and not objectives.

19 Source: NSB, 2008b, Appendix, Table 5-11

20 Source: www.cordis.lu.

21 In this period, the annual number of articles registered by the NSB rose from 1764 to 2614 (NSB, 2008b, Appendix Table 5-34).

22 Full acceptance of international university rankings is hindered by a number of methodological problems. Within the narrow group of leaders, however, the dominance of US universities is undoubted (Török, 2006b).

23 For a detailed explanation, see (Török, Borsi and Telcs, 2005; Török, 2006a).

24 The share of the business sector in the total R&D expenditures of the country.

25 This remark also applies to the Hungarian system of accreditation in place in 2008 and for one and a half decades prior to that, but there is no space here to explain in more detail. Nevertheless, the custom that lecturers are allowed to obtain PhD degrees at their own universities and continue working there needs urgent revision. This practice is termed "endogamy" in jargon. In North-America, the custom is not to obtain a PhD degree where one teaches or will teach after obtaining the degree, while "endogamy" is more typical of continental Europe. The ratio of university lecturers with internal PhD

degrees is 69 per cent in Spain, 63 in Belgium, 58 in Sweden, 49 in Ireland, 40 in Germany and only 8 per cent in the United Kingdom (Aghion et al., 2007, table 3).

26 I.e.: A appraises B, B appraises C, and C gives an opinion on A.

27 Only one example of this from the author's own experience: Department IX of the Hungarian Academy of Sciences (the Department of Economics and Legal Studies) has operated a committee since 1998 for preliminary assessment of applications for the title D. Sc (Doctor of Sciences, a Hungarian academic equivalent of tenured professorhip)., with the participation of almost 25 representatives holding academic doctorate degrees in economics. However, D.Sc. theses can also be submitted to Department IV of the HAS (the Department of Agricultural Studies), to the Agricultural Economics Committee, and these theses are ultimately judged by way of voting by the agricultural researcher members of Department IV. Until 2008, all efforts made by Department IX failed to achieve that the two departments establish shared standards to D. Sc. theses in economics. Similarly, they failed to put through that the majority of academic representatives of economics in Department IX can vote on D. Sc. theses in agricultural economics.

28 By analysing Spanish data, and also processing sources on other EU member states, González and Pazó (2008) show that the displacement effect is generally not valid for state financing of R&D. Growing state support of R&D does not result in diminishing corporate R&D expenses.

29 This term is not used in the literature in a generally accepted sense. In our understanding, it means cooperation underlying the economic and social convergence among political forces, involving broad social strata. This agreement does not exclude daily political struggles, but assumes continuous and strong cooperation among actors in politics in terms of strategic issues of convergence.

30 Referring to the previously mentioned "string quartet paradox", the term "effectiveness" is on purpose avoided here.

31 For bad examples, see Hungarian higher education rankings (in more detail: Török, 2008b).

Literature

Aghion, Ph. – Dewatripont, M. – Hoxby, C. – Mas-Colell, A. – Sapir, A (2007): Why reform Europe's universities? *Bruegel Policy Brief, Issue 4. September*

Arocena, R. – Sutz, J. (2001): Changing knowledge production and Latin American universities, *Research Policy, 30., pp. 1221–1234*

Báger, G. – Goldperger, I. – Varga, Gy. (2005): From research to innovation – the situation of R&D activity, and certain correlations with efficiency and funding in Hungary, *Research and Development Institute of the State Audit Office, Módszertani Füzetek [Methodological Brochures], Budapest, October*

Biegelbauer, P. S. (2000): 130 Years of catching up with the West. A Comparative Perspective on Hungarian Industry, Science and Technology Policymaking Nince Industrialization. Contemporary Trends in European Social Sciences, *Ashgate, Aldershot, p. 250.*

Bork, R. H. (1993): The Antitrust Paradox. A Policy at War with Itself, *The Free Press, New York, 479, (first edition 1978)*

Borsi, B. – Telcs, A. (2004): International comparison of R&D activities based on country statistics, *Közgazdasági Szemle [Economic Review], Volume LI, February, pp. 101–126*

Braun, T. – Glänzel, W. – Némethné, Kovács É. – Peresztegné, Szabad, Zs. (2002): The position of Hungary in the world of natural science basic research – Scientometrics landscape at the end of the second millennium, *Magyar Tudomány [Hungarian Science], No. 7. pp. 935–945*

Calderini, M. – Franzoni, Ch. – Vezzulli. A. (2007): If star scientists do not patent: The effect of productivity, basicness, and impact on the decision to patent in the academic world, *Research Policy, Volume 36, Issue 3, April, pp. 303–319*

Crespi, G., A. – Geuna, A. (2008): An empirical study of scientific production: A cross country analysis, 1981-2002, *Research Policy, Volume 37, Issue 4, May, pp. 565–579*

DELI, ZS. (2004): International rankings of R&D activities, *Fejlesztés és Finanszírozás [Development and Financing], No. 2, pp. 41–50*

GONZÁLEZ, X. – PAZÓ, C. (2008): Do public subsidies stimulate private R&D spending? *Research Policy, Volume 38., Issue 3, April, pp. 371–389*

GRILICHES, Z. (1990): Patent Statistics as Economic Indicators: A Survey, *Journal of Economic Literature, Volume, XXVIII (December): pp. 1661–1707*

HOHL, F. – HOLCZER, M. – PÁL, A. (2004): A comparative examination of the situations in the European research region and Hungary, *EU-tanulmányok [EU Studies], II. Nemzeti Fejlesztési Hivatal [2nd National Development Agency], Budapest, pp. 981–1037*

KÁDÁR, B. (2008): Our deficits, *Pénzügyi Szemle [Financial Review] No. 2, pp. 171–182*

KRUGMAN, P. – OBSTFELD, M. (2003): International Economics. Theory and Economic policy, *Panem, Budapest*

KRUGMAN, P. (1994): Competitiveness: a dangerous obsession. *Foreign Affairs, No. 2, pp. 28–44*

Krugman, P. (1996): The Age of Diminished Expectations, *The MIT Press, 1994 (Revised and Updated, 1996). p. 239*

LUNDVALL, B.-A. – BERG JENSEN, M. – JOHNSON, B. – LORENZ, E. (2007): Forms of knowledge and modes of innovation, *Research Policy, Volume 36, Issue 5, June, pp. 680–693*

MOKYR, J. (2004, originally 1990): The Lever of Riches. Technological Creativity and Economic Progress, *Nemzeti Tankönyvkiadó [National Textbook Publisher], Budapest, p. 487*

NELSON, R. R. (2008): What enables rapid economic progress? What are the needed institutions? *Research Policy, Volume 37, Issue 1, February, pp. 1–11*

NIKODÉMUS, A. (2003): Perspectives of domestic innovation on the eve of our accession to the EU, *Külgazdaság [Foreign Economy], Volume XLVII., No. 12, pp. 37–52*

NSB (2008a): Science and Engineering Indicators. Volume 1., *National Science Board, Washington, D. C.*

NSB (2008b): Science and Engineering Indicators. Volume 2., Statistical Appendix, *National Science Board, Washington, D. C.*

NYÍRI, L. (1996): Lagging behind or keeping up with knowledge intensive development, Domestic R&D as reflected in OECD processes, *Közgazdasági Szemle [Economic Review], Volume 43., No. 6*

OMFB (1999): Major correlations in the Hungarian system of innovations, *Országos Műszaki Fejlesztési Bizottság [National Technical Development Committee], Budapest, p. 149*

PAPANEK, G. (2003): The "European paradox" in the Hungarian R&D sector, *Fejlesztés és Finanszírozás [Development and Financing], No. 4, pp. 40–47.*

RODRIGUES, M. J. (2003): European Policies for a Knowledge Economy, *Edward Elgar, Cheltenham, UK – Northampton, MA, USA, p. 169.*

SCHUMPETER, J. A. (1980, originally 1912): Theory of Economic Development, *KJK, Budapest, p. 320*

SIEGLER, A. (2003): The European research region and Hungary, *Európai Tükör [European Mirror]. No. 2, pp. 33–53*

SRHOLEC, M. (2007): High-Tech Exports from Developing Countries: A Symptom of Technology Spurts or Statistical Illusion? *Review of World Economics – Weltwirtschaftliches Archiv, Volume 143, Number 2., pp. 227–255*

TÖRÖK, Á. (1996): Diffusion system of R&D in Hungary, *Külgazdaság [Foreign Economy] 40, No. 5, pp. 63-72*

TÖRÖK, Á. (1997): The first comprehensive project evaluation attempt in Hungary, *Közgazdasági Szemle [Economic Review, No. 1, pp. 69–82*

TÖRÖK, Á. (2000): Is position 20 held by Hungarian science in the (imaginary) global ranking realistic? *Magyar Tudomány [Hungarian Science], No. 11, pp. 1307–1328*

TÖRÖK, Á. (with Balázs Borsi and András Telcs, 2005): Competitiveness in R&D. Comparisons and Performance, *Edward Elgar, Cheltenham, UK – Northampton, MA, USA, p. 251*

TÖRÖK, Á. (2006a): A strategic sector with no strategy? Performance and competitiveness of Hungarian research and development in international comparison, *Savaria University Press, p. 252*

TÖRÖK, Á. (2006b): Competitiveness of European higher education and Lisbon objectives. How credible are international university rankings? *Közgazdasági Szemle [Economic Review], Volume LIII, April. pp. 310–329*

TÖRÖK, Á. (2008a): Export competitiveness and the catch-up process in Hungary (1996–2001): a comparative analysis with some reflections on trade theory, *Competitiveness Review, An International Business Journal, Volume 18, No. 1–2, pp. 131–153*

TÖRÖK, Á. (2008b): Performance measurement and ranking in Hungarian higher education, *Educatio*, (in preparation).