Chapter 7
Key Tendencies of Scientific and Technological Development in Ukraine and Its International Dimension (Review of Statistical Indicators)

Igor Yegorov

The key elements of the national science and technology (S&T) system of Ukraine were primarily formed during the Soviet Era. In some areas of science and technology, Ukrainian research institutes and design bureaus[1] were leaders in the USSR. This applies in particular for electric welding, new materials, transport aviation, development of specialized software, etc. However, the economic crisis of the 1990s and the disintegration of the Soviet Union brought upon a sharp reduction demand for S&T results from the industrial sector, and entire high-tech industries, such as electronics, disappeared almost entirely.

After the declaration of independence in 1991, the Ukrainian research system remained centralized, with individual regions playing a limited role in policy formulation and implementation. In first years of independence, the governments of Ukraine did not pay adequate attention to research and development (R&D), despite some significant legislative acts being passed in the 1990s and early 2000s. The last important changes have been made recently in the context of euro-integration processes. The law of Ukraine 'On Scientific and Scientific-Technical Activity' was substantially modified. It was approved and passed through Ukrainian Parliament at the end of 2015. Because Ukraine is a unitary state, local budgets are not a primary source for financing R&D. Block grants dominate the system for the allocation of funds devoted to R&D; however, in recent years, more competitive principles of fund distribution have become popular.

[1]Design bureaus are special organisations, which are focused on development and science services.

I. Yegorov (✉)
The Institute of Economics and Forecasting, National Academy of Sciences of Ukraine, Kyiv, Ukraine
e-mail: igor_yegorov1@ukr.net

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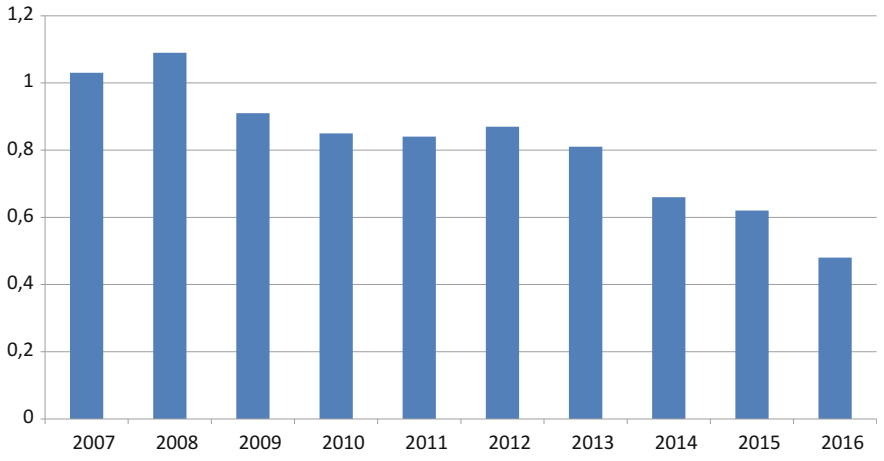
Analysis of Statistical Data

It is still not easy to compare the development of R&D in Ukraine and other countries. It is true that recently Ukraine has developed a system of statistical indicators, most of which are compatible with OECD standards. However, some standards, for instance, the distribution of specific sectors in official Ukrainian statistics, were introduced only recently, meaning that some data for historical periods are not available. A similar situation is with calculations of the scientific personnel. Ukrainian statisticians are not using data in full-time equivalent, as it is done in the OECD countries (Scientific and Innovation Activities in Ukraine 2017).

However, it is possible to conclude that the indicator values concerning R&D activities (e.g. number of researchers, a total volume of financial resources devoted to R&D in real terms) declined two to fivefold since the beginning of the 1990s. The most significant decrease was observed in the 1990s. Since the early 2000s, the situation has largely stabilized and deteriorated in 2014–2016 again. Financing of R&D sector went down both in terms of percentage of GDP (GERD) (see Picture 7.1).

As for resource indicators, the number of researchers has continued to decline but has levelled off at 1–3% decline per year, while nominal expenses on R&D had even a tendency to grow in 2000–2007 and 2011–2013, after the crises of 2008–2010. However, further decline in number of researchers was observed in 2014–2016. While there is no official data on the number of doctoral students across age categories, the total number of Ph.D. holders and Candidates of Sciences is growing. The number of Candidates of Sciences (Ph.Ds) grew from 59,000 in 2000, to 96,000 in 2015. The number of Doctors of Sciences increased from 10.3 thousand to 15.7 thousand during the same period. However, less than 40% of Doctors



Picture 7.1 Level of Ukrainian GERD in 2007–2016, %

of Science and less than 25% of Candidates of Sciences are involved in R&D as their primary means of work. Most holders of scientific degrees work as lecturers in non-research institutes and universities. At the same time, in 2006–2013, the share of Gross Expenditures on R&D (GERD) declined to less than 1%, with no signs of recovery in sight. Almost all other indicators of R&D performance are declining, including the percentages of Ukrainian publications in international journals and the share of patents in USPTO (Yegorov 2009; Yevtushenko and Osadcha 2013).

The state sector continues to play a paramount role in the funding of R&D in Ukraine. The bulk of this state funding is used for supporting the system of academies of sciences, including National Academy of Sciences of Ukraine. The role of the business sector, regarding both the financing and implementation of R&D, is decreasing. To date, the higher education sector and the private non-profit sector has not played a significant role in the funding of R&D. Development in these areas has exhibited small fluctuations but seems to be declining overall. The higher education sector, regarding research performance, is still extremely dependent on public funding, with shares fluctuating 68–75% over the past decade. However, the role of the higher education sector appears to be growing, although growth rates have not exceeded 7% of funding over the last 20 years. The share of foreign sources of R&D financing is relatively high in Ukraine, although statistics provided by the state excludes information on the distribution of funding according to countries of origin. However, it is known that substantial part of the financing comes from Russia, the USA, the EU and China. In 2006–2007, both the relative and absolute reduction in the volume of foreign R&D financing occurred despite stable economic growth; however, in 2009–2014, the share of foreign-financed R&D activities increased once again to one-quarter of the total R&D expenditures. The private non-profit sector showed no substantial changes with its share well below 1% of total R&D expenditures in recent years.

From examining the statistics, it is evident that the levels of R&D expenditures in Ukraine, both absolute and relative, are substantially lower than in developed EU countries. This is likely because registration with the State Statistical Service (SSS) of Ukraine[2] is obligatory for all state organizations and business enterprises, while foreign companies conducting research in Ukraine are exempt. This means that the real R&D funding and expenditures in Ukraine are likely higher, with the share of business enterprises and the private non-profit sector underestimated (Yegorov et al. 2010).

Ukraine inherited a relatively well-developed educational system from Soviet times and still preserves several positive features of the Soviet system. However, the quality of education in the technical and natural sciences declined in the 1990s and 2000s. To some extent, this can be explained by the recent economic crisis, and the collapse of whole industries (electronics, precise mechanics and some others), related to military needs. In the mid-2010s, the share of graduates in natural sciences declined to 25%, and technical sciences to 21%, while the number of

[2]State Committee of Statistics (SCS) before 2011.

graduates in humanities and arts grew to 5%, and in social sciences, and in business and law to 44%. The remaining students fell into the categories of agriculture, health care and related services. No particular policy supporting education in engineering and the natural sciences exists in Ukraine. On the other hand, Ukrainian universities are trying to update their curricula in these disciplines following the international standards. In some leading universities, students receive special stipends for advances in sciences from the state. Private foundations sometimes provide similar stipends. The level of these stipends varies, from approximately €100 to several thousand Euros per year, but the highest level is the exception rather than the norm.

In general, a career in science is not viewed as prestigious. The standard of income in science is much lower than in business sector, especially in the banking and insurance spheres (Vashulenko et al. 2010). The government has no long-term human resource policy in R&D. The existing policy could be defined as 'inertial' rather than targeted, despite the fact that different types of special stipends for scientists have recently been introduced. Also, a growing number of Ukrainian scientists are of pension age. The average age of Doctors of Sciences is 63, while the average age of Candidates of Sciences[3] is over 50 (2016). These figures are increasing at a rate of one age-year every three years. This is mainly because the growth in career possibilities for young scientists is limited, particularly since the state permits to combine job preservation with obtaining a full pension in the government sector.

The results of the policy, aimed at attracting talented youth to the R&D sector, remain modest, although the state is trying to stimulate interaction between research and education. Several state stipends for young scientists increased between two-fold and fourfold from 2008 to 2013. State awards for advancements in science have also been growing, showing that the government is trying to support and encourage the most talented scientists within the country. However, the proposed measures are still not adequate to stimulate young scientists to work for Ukrainian science, as the level of salaries available in foreign laboratories remains much higher than in Ukrainian ones.

This is partly because Ukraine has no national schemes aimed at stimulating the mobility of scientists. The stimulation of science immigration is not an issue for the country at the moment, despite the fact that the science sector is in decline in Ukraine, with research conditions that do not meet international standards. While there are modest attempts to establish cooperation among those specialists who left

[3]Ukraine has inherited the Soviet system of scientific degrees. Candidate of Sciences is the person, who finished his (her) post-graduate education, passed 3–4 special exams, published several articles in scholar journals (usually, 3–10) and defended dissertation in the special meeting of the scientific council on his specialization. This decision of the council has to be approved by the State Certification Commission, which consists of independent experts. Doctor of Sciences has to have a proven contribution to modern science (plus individual book and not less than 20 articles in scholar journals), to defend doctoral thesis and to receive an approval from the State Certification Commission of Ukraine.

the country during the past two decades, the country still cannot provide a corresponding level of salaries and attracting working conditions, making return a frequently unattractive option. Emigration, on the other hand, is a more alarming issue. Existing statistics for scientific emigration in Ukraine do not reflect the real magnitude of the outflow of specialists from the country. According to the official data, only 13 researchers with doctorate and candidate of sciences degrees emigrated from Ukrainian research sector in 2009, 21 in 2010 and approximately 40 in 2016, a stark contrast with the early 1990s, when the number of emigrants reached several hundred persons per year. In recent years, the age of emigrants decreased, as more and more graduates and postgraduate students leave the country. These people are not considered scientists, despite the fact that they often possess substantial intellectual potential. The second problem is with shuttle migration, a more pressing matter than that of 'pure' emigration of researchers, as up to one thousand scientists are involved in it every year. The Ukrainian government has recently introduced new methods of statistical control to reflect this type of migration more adequately. Now, questionnaires administered by the State Service of Statistics include more questions relating to long-term visits abroad. This is crucial for the correct measurement of shuttle migration among Ukrainian scientists.

The state budget plays a crucial role as a source of R&D funding. Parameters of R&D funding had tendency to decline in real terms in 2014–2016, when inflation processes are taken into consideration. Data from recent years show that the level of R&D funding as a proportion of GDP declined to 0.75% in 2012 to 0.48% in 2016, the lowest level ever reached since Ukraine gained independence. R&D expenditures grew in current prices in 2006–2008 and in 2010–2012. However, the real level of spending growth on R&D in pre-crisis years was modest and significantly lower than the overall rate of GDP growth. In 2009 and in 2014–2015, the standard of R&D expenditures declined even in current prices. The state typically uses three key forms of funding for R&D. The first of these is direct funding of R&D organizations. Overall, more than 90% of state funding to the government and higher education sectors is channelled through direct funding. The second way of distributing money is through state R&D and development programs, which are allocated on a competitive basis. Relatively small amounts of money—less than 1% of the state R&D budget—are distributed through such individual grant schemes, or through state-sponsored foundations for support of basic research.

In 2016, up to 25% of R&D funding came from abroad, a substantially larger portion than in 2008 (15.6%), yet on par with figures from 2000 (23.3%). The growth of the share of foreign financing can be explained by two possible factors. First, R&D financing from internal sources tends to contract more substantially than financing from abroad does. The second reason is a quick depreciation of the national currency against the Dollar and the Euro.

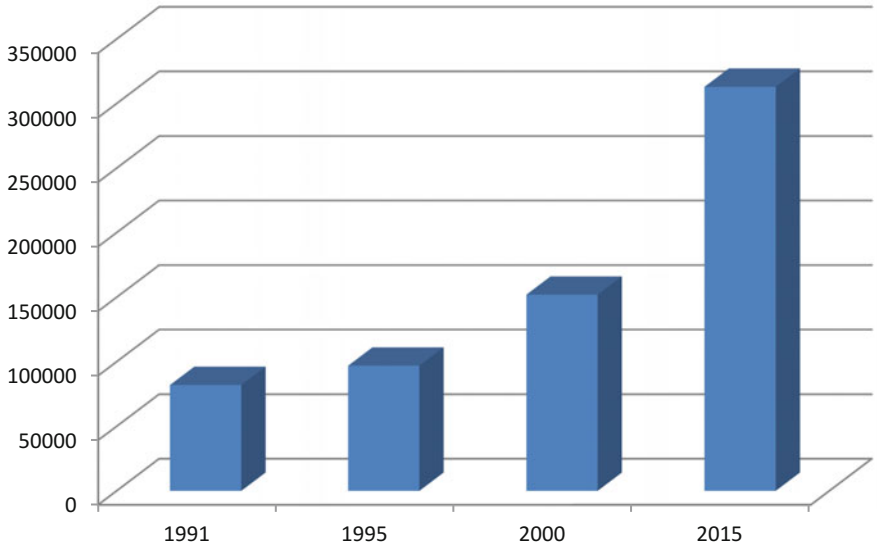
As a result of the general decline of science in the country, Ukraine has a relatively low place in respect to the number of internationally recognized publications (see Table 7.1).

Level of citations calculated with the help of H-index also remains low (see Picture 7.1).

Table 7.1 Key indicators of publication activities of different countries, 1996–2012, Scopus data

Country	Average growth rate for 1996–2012 (%)	Share of country's publications in the world publications (%)	
		2012	1996
USA	3.0	22.09	28.98
China	17.5	16.12	2.51
UK	3.7	6.28	7.28
Germany	4.2	5.89	6.35
South Korea	12.2	2.78	0.87
Brazil	11.8	2.29	0.76
Russia	1.5	1.63	2.77
Iran	26.3	1.62	0.07
Turkey	11.5	1.39	0.49
Poland	6.3	1.31	1.01
Czech Republic	7.6	0.68	0.42
Ukraine	3.0	0.36	0.48

Source Scopus (2013)



Picture 7.2 Number of 'internal' scientific publications in Ukraine, 1991–2015. *Source* State statistical service of Ukraine, various years

On the other hand, a number of 'internal publications had a strong tendency to growth (see Picture 7.2).

International Dimension of S&T and Innovation Activities

The discrepancy between the tendency of internationalization and the sharp growth of internal publications could be explained by the heritage of the 'closed Soviet-type system' and existed practice of stimulating these publications at the expense of international publications for more than two decades.

Although Ukraine took part in Framework Programme 7 (FP7) and Horizon-2020, access to participation in some calls was restricted. This means that, although Ukrainian institutes were members of certain networks and research consortia, the government did not make a contribution to the FP7 budget. In addition, Ukraine had no access to the European Development Fund. Ukraine signed an agreement on association with the EU Horizon-2020 Programme in March, 2015. This opened the way for a more active cooperation with the EU countries in R&D.

The impact of the participation in the EU FPs and Horizon-2020 Programme is positive, as Ukrainian scientists received valuable new experience and knowledge, and they have strengthened their contacts with Western partners. On the other hand, this impact is limited as the number of participants was not high. Cooperation between Ukrainian and EU researchers remains relatively low. Additional support from the Ukrainian government for the promotion of international activities is needed as well as additional links between Ukrainian researchers and their EU counterparts to forge partnerships in future projects. As a non-EU member, Ukraine cannot participate (at least, as a leading partner) in some initiatives. Another problem is that existing internal taxation practices do not support international project implementation, despite there being some clauses in EU–Ukraine agreements on special financial conditions for R&D projects. This creates serious barriers to cooperation.

In 2000-first half of 2010s, Ukraine received between 1 and 2 million dollars from NATO research programmes annually. In the mid-1990s, the EU, Japan, Canada and the USA established special fund entitled the Scientific and Technological Centre of Ukraine (STCU), with an annual financing budget of 10 million USD. The funding was designated especially for scientists involved in military-oriented R&D projects (STCU 2014).

Ukraine has no particular policy aimed at enhancing the mobility of researchers. In recent years, the state has tried to keep young researchers by establishing various stipends and awards, but as mentioned, these measures have not been very effective. In fact, national statistics do not provide data on immigration of researchers, as the majority of experts assume the number of immigrants is insignificant. Several dozen foreign researchers remain in leading Ukrainian universities; however, they tend to be mainly involved in teaching. Other researchers are engaged in think-tank activities, particularly in sociology and economics. No exact data on the number of such researchers have been published.

Conclusions

Statistical data show that currently, science in Ukraine is in a complicated situation. The country requires urgent actions, aimed at the transformation of the research system. Among the major measures are the following:

1. Government could stimulate those economic sectors, which are key customers of the research results;
2. Criteria of evaluation of scientific work have to be in line with international practice (however, some 'national components' could be preserved in some way);
3. International programs have to play a greater role in Ukraine in the context of European integration policy, and
4. Ukrainian national programs need further improvement in management, including the creation of the system of independent evaluation with the participation of foreign experts, where it is possible.

In this chapter, I dealt with the analysis of current situation in R&D and innovation sphere in Ukraine. It is important to stress that innovation and R&D systems in Ukraine were 'internally oriented', and not all internationally recognized indicators were used in the national statistics. As to the qualitative assessment, it is worth to note, that Ukrainian S&T policy has not changed substantially in recent years. Up to now, the main focus of government policy mix is on direct support of R&D in selected sectors (state-sponsored academies of sciences, some branch institutes and universities) and provision of financing to specific innovation programmes. The gap between the higher education sector and the industry remains substantial, while international cooperation is clearly underdeveloped, despite some positive changes in recent years.

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