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Sergii Gasanov ORCID ID: https://orcid.org/0000-0002-7454-0419
Ph. D. (Economics), Professor, Director of the Research Financial Institute of the SESE "The Academy of Financial Management", Kyiv, Ukraine, sgasanov@ukr.net

RESEARCH AND DEVELOPMENT (R&D) IN THE NATIONAL ECONOMY STRUCTURE: TRENDS OF EMPLOYMENT, EXPENDITURES AND FUNDING

Abstract. *The article continues the research of the main directions of international comparisons of the R&D sector in the structure of the national economy, published in issues No. 3 (84) and No. 4 (85) of the collection in 2018. The purpose of this article is to reveal the main trends in employment, expenditure and R&D financing in the economy of Ukraine and other countries, to formulate proposals on how to counter negative trends in the R&D sector, which inhibit the processes of innovation, structural transformations and growth of the national economy. Theoretical studies and practices of developed countries indicate a fairly close relationship between the dynamics of the number of researchers, the intensity of R&D with innovation activity, labour productivity, gross value added and the level of gross domestic product per capita. The necessity of a new paradigm of structural transformations of the economy is substantiated. The triad "agrarian sector – industry – services" is a substantial simplification of real structural changes. The production, distribution, exchange and consumption of knowledge "permeate" each of the traditional phases of the economic cycle of goods and services. Further prospects for structural changes will be determined by the scale, quality and efficiency of the use of human, material and financial resources of the R&D sector, its impact on the "scientification" of labour and capital, the gradual transformation of research and development into the leading type of economic activity.*

K e y w o r d s: research and development (R&D), economic structure, types of economic activity, R&D measurement indicators, international comparisons.

JEL classification: J21, O10, O32, O38.

Гасанов С. С. ORCID ID: https://orcid.org/0000-0002-7454-0419
кандидат економічних наук, професор, директор Науково-дослідного фінансового інституту ДННУ "Академія фінансового управління", Київ, Україна, sgasanov@ukr.net

ДОСЛІДЖЕННЯ І РОЗРОБКИ (R&D) У СТРУКТУРІ НАЦІОНАЛЬНОЇ ЕКОНОМІКИ: ТЕНДЕНЦІЇ ЗАЙНЯТОСТІ, ВИДАТКІВ ТА ФІНАНСУВАННЯ

Анотація. *Стаття продовжує дослідження основних напрямів міжнародних порівнянь сектору R&D у структурі національної економіки, що були опубліковані у випусках № 3(84) та № 4(85) збірника у 2018 році. Мета цієї статті – розкрити основні тенденції зайнятості, видатків та фінансування R&D в економіці України та деяких інших країн, сформулювати пропозиції щодо можливостей протидії негативним тенденціям у секторі R&D, що гальмують процеси інноватизації, структурних трансформацій та зростання національної економіки. Теоретичні дослідження та практика розвинутих країн засвідчують достатньо тісний зв'язок динаміки чисельності дослідників, інтенсивності R&D з інноваційною активністю, продуктивністю праці, обсягами валової доданої вартості та рівнем валового внутрішнього продукту на одну особу. Обґрунтовується необхідність нової парадигми струкурних трансформацій економіки. Тріада "аграрний сектор – промисловість – послуги" – суттєве спрощення реальних структурних змін. Виробництво, розподіл, обмін і споживання знань "пронизують"*

кожну з традиційних фаз економічного кругообігу товарів та послуг. Подальші перспективи структурних змін визначатимуться масштабами, якістю та ефективністю використання людських, матеріальних та фінансових ресурсів сектору R&D, його впливом на "онаучювання" праці та капіталу, поступовим перетворенням наукових досліджень і розробок у провідний вид економічної діяльності.

Ключові слова: дослідження і розробки (R&D), структура економіки, види економічної діяльності, індикатори вимірювання R&D, міжнародні порівняння.

Табл. 3. Літ. 41.

Гасанов С. С.
кандидат экономических наук, профессор, директор Научно-исследовательского финансового института ГУНУ "Академия финансового управления", Киев, Украина

ИССЛЕДОВАНИЯ И РАЗРАБОТКИ (R&D) В СТРУКТУРЕ НАЦИОНАЛЬНОЙ ЭКОНОМИКИ: ТЕНДЕНЦИИ ЗАНЯТОСТИ, РАСХОДОВ И ФИНАНСИРОВАНИЯ

Аннотация. *Статья продолжает исследования основных направлений международных сравнений сектора R&D в структуре национальной экономики, опубликованные в выпусках № 3 (84) и № 4 (85) сборника в 2018 году. Цель этой статьи – раскрыть основные тенденции занятости, расходов и финансирования R&D в экономике Украины и других стран, сформулировать предложения о возможностях противодействия негативным тенденциям в секторе R&D, которые тормозят процессы инноватизации, структурных трансформаций и роста национальной экономики. Теоретические исследования и практика развитых стран свидетельствуют о достаточно тесной связи динамики численности исследователей, интенсивности R&D с инновационной активностью, производительностью труда, объемами валовой добавленной стоимости и уровнем валового внутреннего продукта на душу населения. Обосновывается необходимость новой парадигмы структурных трансформаций экономики. Триада "аграрный сектор – промышленность – услуги" – существенное упрощение реальных структурных изменений. Производство, распределение, обмен и потребление знаний "пронизывают" каждую из традиционных фаз экономического кругооборота товаров и услуг. Дальнейшие перспективы структурных изменений будут определяться масштабами, качеством и эффективностью использования человеческих, материальных и финансовых ресурсов сектора R&D, его влиянием на "онаучивание" труда и капитала, постепенным превращением научных исследований и разработок в ведущий вид экономической деятельности.*

Ключевые слова: исследования и разработки (R&D), структура экономики, виды экономической деятельности, индикаторы измерения R&D, международные сопоставления.

The problems of international comparisons of R&D in the structures of the national economies and in the structures of the national innovation systems are broad and multidimensional, as evidenced by the works of W. J. Baumol [1; 2], W. J. Baumol and G. R. Faulhaber [3], W. J. Baumol and E. N. Wolff [4], W. J. Baumol, R. R. Nelson and E. N. Wolff [5], D. Coe, E. Helpman and A. Hoffmaister [6], G. Dosi [7], G. Dosi, P. Llerena and M. Labini [8], G. Dosi, M. Grazzi and D. Moschella [9], C. Freeman [10], C. Freeman and L. Soete [11], Z. Griliches [12; 13], B. Hall and N. Rosenberg [14], A. Link and J. Scott [15], B.-Å. Lundvall [16], E. Mansfield [17], D. C. Mowery [18], R. R. Nelson [19–22], K. Pavitt [23], N. Rosenberg [24],

T. Scott and J. Scott [25], and others; in Ukraine – O. I. Amosha, A. I. Zemlianikin, & I. Yu. Pidorycheva [26], O. I. Amosha, H. Dzhvihol, & R. Miskievich [27], Iu. M. Bazhal [28; 29], V. M. Heyets [30], I. Yu. Yehorov [31–33], and others.

Despite the abundance of literature related to research and development problems, scholars do not pay enough attention to the new paradigm of modern economy structural changes associated with the R&D sector. The concept of primary, secondary and tertiary sectors of the economy originates in the first third-middle of the last century and remains unchanged until nowadays. The decline in the share of the agricultural sector, industry and the rapid growth of the service sector can hardly be considered in modern conditions to be a sufficient and comprehensive criterion to characterize the nature and prospects of the ongoing structural economic changes. The triad "agrarian sector – industry – services" is a strong simplification of real structural changes. Structural changes in the developed economies have long gone beyond the framework of this triad, if only because, first, there were deep internal transformations of all three components of this triad (for example, the agrarian sector of the European Union is a completely different compared the developing countries agrarian sector; this also applies to industry and services). Secondly, the main structural shift of modernity is the transition from the "service economy" to the "knowledge economy". The traditional four phases of economic reproduction (or circulation) – "production, distribution, exchange and consumption of goods and services" are complemented by production, distribution, exchange and consumption of *knowledge.* The production, distribution, exchange and consumption of knowledge "permeate" each of the traditional phases of the economic cycle of goods and services. Further prospects for structural changes will be determined by the scale, quality and efficiency of the use of human, material and financial resources of the R&D sector, its impact on the "scientification" of labour and capital, the *gradual transformation of research and development into the leading type of economic activity.*

In order to substantiate the new paradigm of structural changes – the gradual transformation of the well-known triad "agricultural sector – industry – services" into the formula "agricultural sector – industry – services – production and knowledge distribution sector – R&D sector", sufficiently accurate measurements and comparisons are needed.

This is an analysis of international comparisons main directions of the R&D sector in the national economy structure: identification of the R&D sector in the structure of economic activities and the institutional structure of the economy; evaluation of the scale of factors of production involved in the R&D sector, primarily the "labor" factor; measuring the volume of financial flows of the R&D sector from relevant sources; determining the economic and social performance of the R&D sector and its contribution to the gross value added created in the national economy.

Beginning from the second half of the last century, scientific achievements and their implementation in new technologies became the main driving force of intensive economic growth. This led to fundamental and comprehensive changes in the structure of traditional production factors: labour and capital. Over the two postwar decades of the XX century (1945–1965) there was a cardinal renewal of physical capital in traditional sectors of the economy; there have occurred branches

that demanded not only large-scale financial and real investments, but also qualitatively new human resources. On the one hand, the quality of the workforce has become directly dependent on the level of education and professional training of workers. On the other hand, a *clear separation of educational and scientific activities of certain professional and economic types within the framework of national and international economies showed the fact of a "structural revolution" in the division of labour.* Individual segments of the workforce began to transform into "human capital" in parallel with the increasing role of the educational component in the workforce quality structure, with the *professionalization and institutionalization of scientific activity as an economic activity in the social division of labour.*

In the fundamental work "The production and distribution of knowledge in the United States" (1962) [34], Fritz Machlup has formulated the assumptions of economic analysis of the production and distribution of knowledge. One of them is that there is a certain difference between the analysis of the production of knowledge in terms of the "sectoral approach" and in terms of increasing the share of "professions producing knowledge" in the total labor force.

Nowadays, there are five main international standards that allow for the measurement and comparison of research and development: *International Standard Industrial Classification of All Economic Activities (ISIC, Rev. 4), Statistical classification of economic activities in the European Community (NACE Rev. 2), System of National Accounts, Frascati Manual, Canberra Manual* [35–39]. Immediately, we note that between them there are certain contradictions that make it difficult to measure the R&D sector in the structures of national economies.

Ukraine has approved the *National Classification of Economic Activities* (NCEA-2010) [40], which is broadly consistent with ISIC, Rev. 4 and harmonized with NACE, Rev. 2-2008). Research and development are referred to **section M** "Professional, Scientific and Technical Activities", **division 72** "Research and Development" (R&D in the field of natural and technical sciences, R&D in the field of social and humanitarian Sciences) both in international and national classifications of types of economic activity.

In our opinion, the structure of **section M,** applied in the international and national classifications of types of economic activity, *does not meet the new requirements for international comparisons of the R&D sector in the context of the formation of a modern innovative economy based on knowledge, and does not adequately identify the R&D sector in the structure of such an economy.*

This is due to the fact that along with **division 72** "Scientific research and development", **section M** includes divisions that cover economic activities that differ significantly in character and objectives from the goals and specifics of activities in the R&D sector, in particular, divisions 69, 71, 73, 74, 75.

Thus, it is advisable to make changes to the International Standard Industrial Classification of All Economic Activities (ISIC, Rev. 4.), Statistical classification of economic activities in the European Community (NACE, Rev. 2) and National Classification of Economic Activities (NCEA) of Ukraine in order to isolate a ***separate section*** "Scientific research and development". It will contribute to a clearer identification of the R&D sector in the structure of the national economies.

In the SNA, the R&D sector is represented by units of the institutional sectors of non-financial corporations, general government and households by type of economic activity "Professional, scientific and technical activities". Considering the above, it is impossible to directly estimate the share of the R&D sector in gross value added, based on information from the State Statistics Service of Ukraine given in the National Accounts of Ukraine for 2010–2017. The share of economic activity "Professional, scientific and technical activity" in Ukraine has increased from 2.9 % (2010) up to 3.7 % (2013) of the gross value added created in the national economy. In 2017, this share decreased to 3.4 %.

In average annual terms, this share in 2010–2017 accounted for 3.29 %. For the non-financial corporations sector, it was equal to 3.29 %; for the general government sector – 3.46 %; for the household sector – 3.90 % (Table 1).

The sector of production and distribution of knowledge can be represented by three types of economic activities: "Professional, scientific and technical activity";

Table 1

Dynamics of the share of gross value added by types of economic activity "Professional, scientific and technical activity", "Information and communication, "Education" in the Ukrainian economy, *%*

Year	Institutional sectors of the economy					Total economy
	Non-financial corporations	Financial corporations	General government	Households	Non-profit institutions serving households	
M. Professional, scientific and technical activity						
2010	3.0	–	3.5	2.8	–	2.9
2011	2.6	–	3.9	2.9	–	2.7
2012	4.0	–	3.5	3.0	–	3.5
2013	4.3	–	3.8	3.1	–	3.7
2014	3.5	–	4.1	3.6	–	3.4
2015	2.9	–	3.3	5.0	–	3.3
2016	3.0	–	2.8	5.3	–	3.4
2017	3.0	–	2.8	5.5	–	3.4
J. Information and communication						
2010	5.3	–	0.4	1.7	–	3.5
2011	4.9	–	0.3	2.4	–	3.4
2012	5.2	–	0.0	2.7	–	3.6
2013	5.4	–	0.0	3.2	–	3.8
2014	4.8	–	0.0	4.8	–	3.8
2015	4.7	–	0.0	6.8	–	4.3
2016	4.6	–	0.0	7.5	–	4.4
2017	4.4	–	0.1	8.0	–	4.4
P. Education						
2010	0.2	–	33.5	0.4	7.7	5.6
2011	0.1	–	33.7	0.4	8.0	5.3
2012	0.2	–	35.8	0.5	4.8	5.9
2013	0.2	–	35.9	0.6	5.8	6,1
2014	0.1	–	34.5	0.5	2.8	5.5
2015	0.1	–	33.5	0.4	2,4	4.9
2016	0.1	–	29.9	0.7	3.9	4.4
2017	0.1	–	31.9	0.7	3.3	5.3

Compiled by: State Statistics Service of Ukraine. (2019). *National Accounts of Ukraine for 2017.* Kyiv, pp. 94–96 [in Ukrainian].

Table 2

The share of gross value added of the knowledge production and distribution sector in the economies of some countries, *%*

Country	2010	2011	2012	2013	2014	2015	2016
Austria	13.7	13.7	13.9	14.0	14.1	14.2	14.3
Belgium	19.7	19.9	20.2	20.5	20.6	20.7	20.7
Belarus	10.4	9.0	9.2	10.1	11.1	12.7	13.5
Bulgaria	12.6	12.3	12.7	12.6	13.5	13.5	13.6
China Hong Kong	17.9	17.6	17.9	18.0	18.0	18.1	18.4
Germany	15.0	14.9	15.2	15.3	15.1	15.1	15.2
Poland	14.2	13.8	13.8	14.1	14.2	14.6	14.6
Portugal	14.3	13.9	13.3	13.3	13.4	13.0	13.0
United States	19.6	19.3	19.2	19.3	19.0	19.4	19.5
Ukraine	**11.9**	**11.4**	**13.0**	**13.6**	**12.7**	**12.5**	**12.2**

Compiled by: United Nations (2018). N*ational Accounts Statistics: Main Aggregates and Detailed Tables (Five-volume Set), 2017.* New York: Author.

"Information and communication"; "Education". Table 1 shows that the share of this sector in the gross value added of the national economy increased from 12.0 % (2010) to 13.1 % (2017). It is the third position after the "Wholesale and retail trade, repair of motor vehicles and motorcycles" (16.3 %) and "Manufacturing" (14.3 %) in 2017. The share of "Agriculture, forestry and fisheries", as well as "Mining and quarrying" was 12.1 % and 7.0 %, respectively.

The share of the production and distribution of knowledge in the gross value added of the economies of Austria, Belgium, Belarus, Bulgaria, Hong Kong, Germany, Poland, Portugal, United States and the Ukraine is presented in Table 2.

The main trend is increasing the share of the knowledge production and distribution sector in the total gross value added created for the period 2010–2016. This share has practically not changed in the United States and has decreased in Portugal. The difference between the maximum level of Belgium and the minimum level of Ukraine was quite large and amounted to 8.5 percentage points in 2016. The corresponding difference in the type of economic activity "Professional, scientific and technical activities" amounted to 6.2 percentage points.

The identification of the R&D sector in the structure of the national economy is complicated by a certain discrepancy between the institutional classification of the Frascati Manual and the classification of the institutional sectors of the SNA-2008.

SNA-2008 identifies five institutional sectors of the economy: Non-financial and Financial corporations (CS); General government (GGS); Households (HS); Non-profit institutions serving households (NPISH) [37, p. 65]. Frascati Manual identifies such institutional sectors for measuring employment, expenditure, and R&D financing [38, p. 89]: Business enterprise; Government; Higher education; Private non-profit; Rest of the world.

Corresponding relations between Frascati and SNA institutional sectors can be represented as follows.

The business sector includes non-financial and financial corporations (private and public, as SNA), but does not include higher education institutions in the corporate sector. In addition, the Frascati business sector includes some units of the household sector (SNA), such as self-employed (most likely quasi-corporations).

The higher education sector includes institutional units from three SNA sectors: institutions of higher education in the Corporations sector, the General government sector, and the NPISH sector.

The private non-profit sector includes institutional units from two SNA sectors: same as SNA NPISH sector, except for the institutions of higher education in the NPISH sector; same as SNA Households sector, except for the households "enterprise-like self-employed" [38, p. 90].

According to Frascati the *Business enterprise sector* comprises: all resident corporations, including not only legally incorporated enterprises, both private business enterprises (both publicly listed and traded, or not) and public business enterprises (i.e. government-controlled enterprises); the unincorporated branches of non-resident enterprises; all resident non-profit institutions (NPIs) that are market producers of goods or services or serve the business.

The main aggregate statistic used to describe R&D performance is Business enterprise Expenditure on R&D (BERD). BERD is the measure of intramural R&D expenditures within the Business enterprise sector.

The Government sector comprises: units of central or federal, regional or state, local or municipal government, social security funds, except those units that corresponds the description of higher education institutions; other government bodies: performing and/or funding agencies and all non-market NPIs that are controlled by government units, and that are not part of the Higher education sector.

The main aggregate statistic used to describe R&D performance within the Government sector is Government Expenditure on R&D (GOVERD). It is the measure of intramural R&D expenditures within the Government sector.

The Higher education sector comprises: universities, colleges and other institutions providing formal tertiary education programs, whatever source of their funding or legal status; research institutes, centres, experimental stations and clinics that have their R&D activities under the direct control of, or administered by, tertiary education institutions.

The main aggregate statistic used to describe R&D performance within the Higher education sector is Higher education Expenditure on R&D (HERD). It is the measure of intramural R&D expenditures within higher education.

The Private non-profit sector comprises: non-profit institutions serving households (NPISH), as defined in the SNA 2008, except those classified as part of the Higher education sector; households and private individuals engaged or not engaged in market activities.

The main aggregate statistic used to describe R&D performance within this sector is Private Non-profit Expenditure on R&D (PNPERD). It is the measure of intramural R&D expenditures within the Private non-profit sector [38, pp. 32–35].

Statistics of employment in the research and development sector have a long history. In order to adequately record the number of scientific personnel, a special Canberra Manual was developed. But in reality, the basic provisions on personnel in the field of research and development are spelled out in sufficient details in the Frascati Manual. Moreover, following the revision of the Frascati Manual, the Canberra Manual itself needs to be revised. The problem of measuring the number of personnel performing R&D remains relevant. The recommendations are given in

the Frascati Manual concern ways to estimate of labor costs for R&D both in terms of the number of employed in this field and in terms of time actually spent on the relevant activity. The methodological differences that characterize the practice of measuring various countries do not allow in many cases to obtain sufficiently accurate data for international comparisons. First of all, it concerns the data on the full-time work equivalent in science. Another problem is the registration of persons who are not employees of scientific institutions, but who take part in scientific activities (students, graduate students, etc.). Note that in the process of revising the Manual, experts tried to achieve greater consistency between the terminology used in the OECD standards for labor statistics and for R&D statistics. According to international standards, indicators characterizing scientific personnel are calculated using two aggregates, namely, the personnel engaged in carrying out research and development, and its most important component – researchers. The key problem of the scientific personnel statistics in many countries remains the calculations in full-time work equivalent (FTE). The fact is that in many developing countries (including some Asian and post-Soviet countries), the number of people engaged in research and development, which is determined by headcount (HC), is lower than the number calculated in full-time equivalent. The source of the problem lies in the fact that the general system of accounting for employment in science and education in these countries differs from the similar system in the developed countries.

The following R&D personnel groups are distinguished according to Frascati:

Researchers are professionals engaged in the conception or creation of new knowledge. They conduct research and improve or develop concepts, theories, models, techniques instrumentation, software or operational methods.

Technicians and equivalent staff are persons whose main tasks require technical knowledge and experience in one or more fields of engineering, the physical and life sciences, or the social sciences, humanities and the arts. They participate in R&D by performing scientific and technical tasks involving the application of concepts and operational methods and the use of research equipment, normally under the supervision of researchers.

Other supporting staff includes skilled and unskilled craftsmen, and administrative, secretarial and clerical staff participating in R&D projects or directly associated with such projects [38, pp. 162–164].

The dynamics of the number of researchers (full employment equivalent) in the economies of OECD countries and some other countries is presented in Table 3.

The total number of researchers (full employment equivalent) in OECD countries increased from 1990 to 2017 by 2.32 times, and in EU-28 by 2.02 times. The greatest rates of increase in the number of researchers during this period were observed in Turkey (9.97 times), Portugal (5.73), Greece (5.65), Ireland (4.24), Denmark (3.94), Korea (3.81), China (3.69), Spain (3.54), Austria (3.50), Chinese Taipei (3.29), the Czech Republic (3.28), and Iceland (3.26).

The number of researchers (full employment equivalent) in Sweden (2.84), the Netherlands (2.65), Norway (2.55), Slovenia (2.48), France (2.33), the United Kingdom (2.18), Poland (2.03) more than doubled.

The number of researchers increased by almost a third (32.2 %) in the EU from 2006 to 2016, from 1.42 to 1.88 million. Almost half (49.3 %) of researchers in the

Table 3

Number of researchers (full employment equivalent) in OECD countries and some other countries

Countries	1990	2000	2005	2010	2015	2016	2017	2017/ 1990
OECD Economies								
Australia	43,176.00	66,001.40	81,191.50[1]	100,413.90[e]	...	...	...	2.33*
Austria	12,821.00[7d]	24,124.10[2d]	28,469.60[de]	36,580.90[de]	43,562.00[d]	44,933.00[dp]	...	**3.50***
Belgium	18,105.00[8de]	30,539.64	33,146.01	40,832.47	53,178.00[b]	54,280.00[e]	56,483.58[p]	3.12
Canada	65,730.00	107,900.00	136,700.00	158,660.00	162,952.00	155,128.00	...	2.36*
Chile	...	...	...	5,440.00[dm]	8,175.33[d]	8,992.52[dp]	...	1.65*
Czech Republic	11,936.00[9]	13,852.00	24,169.07[b]	29,227.88	38,081.00	37,337.72	39,180.64[p]	3.28
Denmark	11,505.00[d]	19,453.00[3d]	28,179.01	37,435.10	42,826.00	44,815.00	45,277.00[p]	3.94
Estonia	...	2,666.00	3,331.00	4,077.00	4,187.00	4,338.00	4,674.00	1.75*
Finland	...	...	39,582.00	41,425.04	37,515.80	35,908.20	35,185.00[dp]	0.89*
France	123,938.00	172,070.00[b]	202,506.79	243,533.23[b]	277,631.50	...	288,579.00[e]	2.33
Germany	241,869.00[8b]	257,874.00[e]	272,148.00	327,996.46[e]	387,982.00	399,605.00	413,542.00[e]	1.71
Greece	6,230.00[8d]	14,371.31[3e]	19,592.78[d]	24,674.25[4bd]	34,708.00[d]	29,403.00[d]	35,185.00[dp]	5.65
Hungary	17,550.00[d]	14,406.00[d]	15,878.00	21,342.00	25,316.00	25,804.00	28,426.00[p]	1.62
Iceland	676.00	1,859.40[3]	2,154.90	2,258.30[4b]	1,944.44[b]	2,206.00	...	**3.26***
Ireland	4,618.20	8,516.00[e]	11,587.00	14,176.00[e]	22,259.00	19,791.00	19,559.00[p]	4.24
Israel	...	...	...	55,184.00[4d]	63,521.27[5de]	...	...	1.15*
Italy	77,876.00	66,110.00	82,488.90	103,424.30	125,875.00	133,706.00[b]	136,204.00[p]	1.79
Japan	477,866.00[e]	647,572.00[d]	680,631.00[d]	656,032.00[d]	662,071.00[d]	665,566.00[d]	676,292.00[d]	1.42
Korea	100,456.00[9d]	108,370.00[d]	179,812.43[d]	264,117.94	356,447.29	361,291.53	383,100.28	3.81
Latvia	3,999.00[7d]	3,814.00[d]	3,282.00[d]	3,896.00[d]	3,613.00[d]	3,152.00[d]	3,482.00[dp]	0.87
Lithuania	7,532.00[10]	7,777.00	7,637.00	8,599.00	8,167.00	8,525.00	8,691.00	1.15
Luxembourg	...	1,645.60	2,227.00	2,613.08	2,539.00	2,505.00[p]	2,732.00[p]	1.66
Mexico	14,103.00[7]	23,390.31[3]	43,922.00	38,496.85	29,920.62[6]	...	...	2.12*
Netherlands	32,190.00[7]	42,194.00	47,854.00	53,703.00	79,155.00	81,117.00	85,300.00[p]	2.65
New Zealand	4,893.00	10,328.50[3b]	12,986.00	16,300.00[4]	18,700.00	...	...	**3.82***
Norway	13,460.00[8d]	19,685.00[3]	21,200.30	26,451.00	30,632.00	31,913.00	34,367.00[p]	2.55
Poland	47,433.00[11]	55,174.00	62,162.20	64,511.10	82,594.00	88,165.00	96,497.00[p]	2.03
Portugal	7,736.30[d]	16,738.31[e]	21,126.25	41,523.40	38,672.00	41,349.00	44,322.00[p]	5.73
Slovak Republic	10,249.00[11d]	9,955.00	10,920.60	15,182.80	14,405.50	14,149.00	15,226.00	1.49
Slovenia	3,745.00[e]	4,336.00	5,253.00	7,703.00	7,900.00	8,119.00	9,293.00[p]	2.48
Spain	37,676.00	76,669.70	109,720.30	134,653.00[d]	122,437.00[d]	126,633.39[d]	133,195.00[dp]	3.54
Sweden	26,515.00[8de]	45,995.37[3]	55,001.00[be]	49,312.00[e]	66,734.00[e]	70,372.00[p]	75,247.00[p]	2.84
Switzerland	17,710.00[12]	26,105.00	25,400.00[1]	35,785.00[5]	43,740.00	...	...	2.47*
Turkey	11,225.00	23,083.00	39,138.98	64,340.96	95,160.76	100,158.00	111,893.00	9.97
United Kingdom	133,000.00	170,554.39[e]	248,599.30[be]	256,584.96[e]	284,483.00	288,922.00[e]	289,674.00[p]	2.18
United States	736,907.00[e]	984,965.00[e]	1,104,019.00[e]	1,200,535.00[e]	1,369,267.00[e]	1,371,290.00[e]	...	1.86*
EU28	968,406.42[9e]	1,113,947.56[e]	1,374,761.87[e]	1,601,114.88[3]	1,843,563.70[e]	1,890,546.76[e]	1,957,773.45[e]	2.02
OECD	2,077,788.08[e]	3,142,417.27[e]	3,707,553.45[e]	4,176,177.11[e]	4,769,438.95[e]	4,829,816.75[e]	...	**2.32***
Non-OECD Economies								
Argentina	24,804.00[13]	26,420.00	31,868.00	46,199.00[p]	52,970.00	54,045.50	...	2.18*
China	471,400.00[8dm]	695,062.00[bd]	1,118,698.00[d]	1,210,840.80	1,619,027.70	1,692,175.80	1,740,442.20	3.69
Romania	38,612.00[7]	20,476.00	22,958.00	19,780.00	17,459.00	18,046.00	17,518.00	0.45
Russian Federation	621,790.00[11]	506,420.00	464,577.00	442,071.00	449,180.00	428,884.00	410,617.00	0.66

End of Table 3

Countries	1990	2000	2005	2010	2015	2016	2017	2017/ 1990
Singapore	6,518.60[11]	16,632.81	23,789.31	32,030.57	...	...	...	**4.91***
South Africa	12,102.00[8m]	14,182.00[3]	17,303.02	18,719.55	26,159.40	...	...	2.16
Chinese Taipei	45,778.00[10dm]	55,460.47[dm]	88,858.99	128,347.31	145,380.83	147,709.83	150,383.58	3.29

[1]2004; [2]2002; [3]2001; [4]2011; [5]2012; [6]2013; [7]1993; [8]1991; [9]1995; [10]1996; [11]1994; [12]1992; [13]1997.

* Data "last year / first year". For example, for Australia: 2010/1990; for Chile: 2016/2010 etc.

Standard footnotes: b – time series break; d – definition differs; e – estimated value; m – underestimated or based on underestimated; p – provisional value.

Compiled by: OECD. Stat. (n. d.). *Main Science and Technology Indicators.* Retreived from https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB.

EU worked in business enterprises, 38.6 % in higher education and 11.2 % in government in 2016. More than 78 million people in the EU-28 were employed in science and technology occupations in 2016; this made up almost one third (32.1 %) of the total labour force aged 15–74 [41].

A new paradigm of structural changes is that changes in the composition of the labor force occur due to an increase in its share, which is engaged in the production, distribution, and application of new knowledge, in the total number of employees.

A continuation of the article will be published in the next issue of the collection.

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