Cross-National analysis of spatio-temporal characteristics of the technological coefficients.

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The results of calculations of product-by-product input-output tables based on the supply and use tables from WIOD[1] are set forth in this paper. A comparative analysis of different national economic systems' macrostructural characteristics is made with the use of calculated technological matrices.

In recent years the tools for cross-industry macroeconomic explorations is going through a kind of renaissance. Primarily it is caused by the expansion of methodological approaches to construction and analysis of input-output tables. For Russia, the urgency of cross-sectoral macroeconomic researches is principially determined by dynamic structural changes, which largely define the parameters and the potential for economic development. Cross-national analysis of dynamic and structural characteristics of the development is of considerable interest to assess the level of efficiency of production and technology development in the domestic economy compared to most developed countries. Technological coefficients form the basis of input-output models (IO models). Speaking with W. Leontief's words: «Economic systems with identical sets of input coefficients can be said to be structurally identical, and systems with unlike technical matrices structurally different. Structural change, in other words, is a change in the structural (technological - note the authors) matrix of the system» [1]. Thus, changes in technological coefficients is a concentrated expression of the structural changes in the economy. Nevertheless, studies on the changes of technological coefficients in time and space (ie, technological coefficients of various national economic systems) are very rare in scientific literature. Papers [1], [2], can be named among the Russian publications, from the foreign sources one can distinguish [3-5]. The root cause of this fact is the presence of restrictions on the information base of comparable systems of direct input coefficients. These restrictions apply to both spatial and temporal aspects.

In Russia, there are no official time series input-output tables. Detailed input-output tables were compiled for the 1995 year on the basis of one-time survey of the input structure.

[1]World Input-Output Database

From 1996 to 2003, aggregated (22-branch) tables were designed in Russia, based on the OKONKh classifier (All-Russian Classifier of Economy Branches) they virtually spread the cost structure of 1995 for the following years.

Such an information hunger encourages researchers to develop computable input-output tables. Evaluative input-output tables are based on current statistics, indirect and expert information involving cost structure during the years of the one-time survey of input structure.

In recent years global input-output tables have been actively designed by various international organizations and research groups from different countries. World Input-Output Database (WIOD) – is the example of such projects. Database WIOD (http://www.wiod.org) has been built within the official project WIOD, funded by the European Commission. 11 members took part as developers, The University of Groningen, the Netherlands; The Institute for Prospective Technological Studies, Seville, Spain; The Vienna Institute for International Economic Studies (wiiw) are among them. as well as researchers from various institutions in Germany, Belgium, Greece, France. The WIOD database contains information for 40 countries: for the 27 European Union countries and another 13 countries: USA, Canada, Australia, Brazil, Mexico, China, Japan, South Korea, India, Indonesia, Taiwan, Turkey, Russia. Supply and use tables (Supply and Use Tables - SUT) for these countries served as the baseline information. The tables are given in current prices, indices measured in local currency. In general, the time interval for the SUT covers 1995-2011 years., But not for all countries, this interval is filled with no spaces. Russia, for example, is represented only by the year 1995. Missing tables for the rest of the years have been estimated on the basis of the SUT-RAS method using the official national accounts data of countries, which reflect the statistics of outputs and value added by industries, total imports and exports, final use across all categories. In addition to filling the gaps in time series, the developers have also solved the problem of data harmonization. So, there was the need to align supply and use tables to a single classification on 59 products (classifier CPA[2]) and 35 industries (classifier NACE[3]). The problem of translation of use tables from the purchasers' prices to basic prices was also solved. Furthermore, the developers have made symmetric input-output tables with separation of the first and second quadrants onto domestic and imported products. World input-output tables were have been compiled on the basis of symmetric IO tables, combining 40 listed countries and the rest of the world.

[2] CPA - Statistical classification of products by activity
[3] NACE - Nomenclature Generale des Activites Eqomiques dans les Communautes Europeennes

There are symmetric 35x35 industry-by-industry tables for 40 countries from 1995 to 2011, published in the WIOD database. They can be used to calculate the direct input coefficient matrix A or otherwise, technological matrix. The difficulty in the analysis of such 35x35 tables is the high degree of industries aggregation. A special problem for the Russian Federation is the analysis of coefficients of the most important sectors: oil and gas, metal ores, coal and other non-metallic ores - all of these activities are combined into one - Mining and quarrying.

At the same time, there are time series (1995-2011) of supply and use tables for 40 countries published in WIOD. The dimension of the supply and use tables is 59x35, i.e. they are designed for 59 types of products and 35 industries.

Availability of supply and use tables 59x35 makes it possible to calculate 59x59 product-by-product technological matrix A (in the old terminology - matrices for clean industries). The calculation of these matrices is possible on the basis of Industry Technology Assumption (ITA). Simply put, according to this method, the outputs of particular products are assembled from different industries, where they are actually produced. It is assumed that the production technology of various products are the same within one industry. Of course, the approach is quite vulnerable - the assumption of the constancy of the input structure for the production of different products within one industry raises questions.

According to the guide on the development of the UN System of National Accounts 2008 (2008 SNA) [6], the symmetric input-output tables can be calculated by 6 methods. The first method is based on the assumption of the product technology constancy. The second method - the aforementioned ITA, assumes the same production technology for all products in the industry and leads to a symmetric product-by-product table. The third method is based on the assumption of a fixed sales structure of the product, no matter in which industry it is produced. The fourth method involves a fixed industry sales structure, regardless of the composition of the product output, and leads to a symmetrical industry-by-industry table. The problem of negative coefficient matrix technology can also be solved using the fifth method - the hybrid technology and the sixth method - the Almon procedure [7].

All of these methods have their advantages and disadvantages. However, the ITA method has two indisputable advantages: 1. The possibility to obtain a disaggregated technological matrix **A** of 59x59 dimension (the only method, which allows you to perform such disaggregation). 2. Absence of negative coefficients in the matrix **A**.

We have also carried out a comparative analysis of the data from WIOD and Rosstat on the same named indicators, before making calculations of matrices A by the ITA method and before analyses of technological coefficients. Despite some data inconsistency between WIOD and domestic statistics and incomplete fulfillment of preconditions for method ITA, the set of technological matrices A that we have obtained - is the only one source of information for the comparative analysis of technological coefficients of different countries and comparative analysis of the coefficients' dynamics to date.

This analysis is becomes possible due to identical approaches in WIOD to statistics in different countries: the same classifications, level of aggregation, methodological approaches. Differences between WIOD and Rosstat data are expressed, for example, in outputs' difference: Rosstat data and WIOD for the year 2011 show that the volumes of outputs in these sources varies by 2.1%. In our opinion deviations of indicators for some products, mainly arise from the differences in the classifiers used (NACE and CPA in WIOD and OKVED and OKPD in the Federal State Statistics Service), as well as the permanent adjustments of accounting data carried out by Rosstat. Nevertheless, our position is that these differences are not critical to an expanded comparative cross-national analysis, which is possible due to WIOD database.

In the first step of the analysis we used data of 35x35 industry-by-industry symmetric tables published in the section of national tables in WIOD. The shares of intermediate consumption in output from product-by-product and industry-by-industry tables were compared. This analysis showed the correlation of relevant data in product and industry tables.

We have calculated the series of technological 59x59 product matrices for 1995-2011 years at current prices for the Russian Federation, the United States, China, Poland. The choice of this set of countries allows us to estimate the level of usage of technologies in our country in comparison with economies of various quality and dynamics.

Analysis of the dynamics of technological coefficients required calculations of matrices **A** in comparable prices. For this purpose we calculated the supply and use tables in prices of 1995. In turn, chain price indexes of products were obtained on the basis of supply and use tables in current prices and prices of the previous year up to 2007, inclusive. For 2008-2009 chain price indexes for industries were used. Product chain indexes were obtained as weighted value of industry indexes. Calculation of product matrices A at constant prices was accompanied by a reconciliation with industry matrices in constant prices, especially in certain cases of dispute. This verification did not reveal the contradictions between product and industry tables at constant prices. In addition, we performed a comparative analysis of the technological coefficients obtained on the basis of different sources: Rosstat, WIOD, Institute of Economic Forecasting, and [3].

The results gave no reason for abandoning the use of technological coefficients calculated according to WIOD, in order to analyze the dynamics of structural shifts in the economies of different countries. They also demonstrated a satisfactory quality of technological coefficients calculated according to WIOD.

Analysis of structural changes in outputs

Analysis of structural changes in the Russian economy in comparable prices shows that one of the main structural changes was the replacement of agricultural production by real estate services last 15 years. In the top five activities in all price measurements are invariably oil and gas extraction, wholesale trade and construction.

We should note the sufficient stability of the list of types (all prices and for all the years) of products, directly adjacent to the top five in terms of production volume: electricity, basic metals, retail. It should also be noted that electrical energy and heat are stably included in the top ten industries in terms of production volume. For comparison: for the year 2011 electrical energy in current prices took the 17th place in the USA in terms of production volume, in China – the 10 th in Poland - the 11th.

According to the data in current prices for the year 2011, American and Russian structures have only public administration and defense common in the top five industries by output volumes. Next in the US go: real estate services (8.4%), health services (7.5%), other business services (7.2%), and financial intermediation (6.4%). And in current prices of 1995, the picture is almost unchanged, with the exception of financial intermediation services - in 1995, its place was occupied by retail trade.

A fundamentally different set of products in the first five and significant transformation of the structure over time (Table 1) catch our eyes in the structure of the Chinese outputs.

Table 1

The most important products in the Chinese economy, %

Structure 1995 in current prices		Structure 2009 in 1995 prices		Structure 2011 in current prices	
Agriculture	10,8	Basic metals	7,4	Construction	9,6
Construction	8,1	Construction	7,4	Basic metals	6,8

Food products and beverages	5,6	Machinery and equipment n.e.c.	6,3	Chemicals, chemical products and man-made fibres	5,3
Wholesale trade and commission trade services, except of motor vehicles and motorcycles	5,2	Radio, television and communication equipment and apparatus	5,8	Agriculture	4,9
Basic metals	4,8	Electrical machinery and apparatus n.e.c.	5,3	Food products and beverages	4,6

It is characteristic, that agriculture ranks first in the ranking of the year 1995, but in 2009, in the prices of 1995 this industry is out of the top five. The structure of the economy, measured in constant prices, has changed significantly in favor of the industry, although construction has always been at the forefront. The role of financial intermediation is not so significant: its place even decreased compared to 1995 year (from 10th to 19th place in 2009 and 2011). 25-27 th places are occupied by educational services. The share of health and science is somewhat lower (30-40 th). Extractive industries occupy practically the same position. Public administration and defence services; have a much smaller proportion compared to the Russian Federation and the United States (1.9-2.2%). Chinese clothing, world famous for its prevalence, takes a worthy place: 18th in 1995 and 18th in 2009 in constant prices, the textiles consistently ranked in the top ten.

In the Polish economy the highest specific weight in outputs in 1995, accounted for food products (8.6%), agriculture (7.7%), construction (7.5%), retail trade (7.5%), real estate services (4.8%). Structural shifts measured in constant prices, in the 15 years form the following picture: the output of the motor vehicles appeared in the top five, instead of real estate services; the specific weight of services in public administration and defense, trade, land transport, products of the chemical industry, basic metals, machinery and equipment are still significant. But share of the following products in a comparable dimension decreased significantly: education services (from 12 th to 23 th place), health services (from 15 th to 27 th place), coal (from 17 th to 42 th places). Among the products and services, whose share in total output has increased, the financial intermediation (from 37 th to 21 th), radio-TV equipment (from 39th to 29th) are worth noting.

Consider structural and technological characteristics, which are important for the Russian oil and gas industry in more detail.

Analysis of the structural and technological characteristics of oil and gas complex

Oil and gas. Unexpected results were obtained for the share of intermediate consumption (PP) in the production of oil and gas production in current and constant prices for the Russian Federation and the United States. Fig. 1 shows the relevant dynamics which indicates that the value of the share of intermediate consumption in constant prices in the output of oil and gas extraction in USA is close to 1.

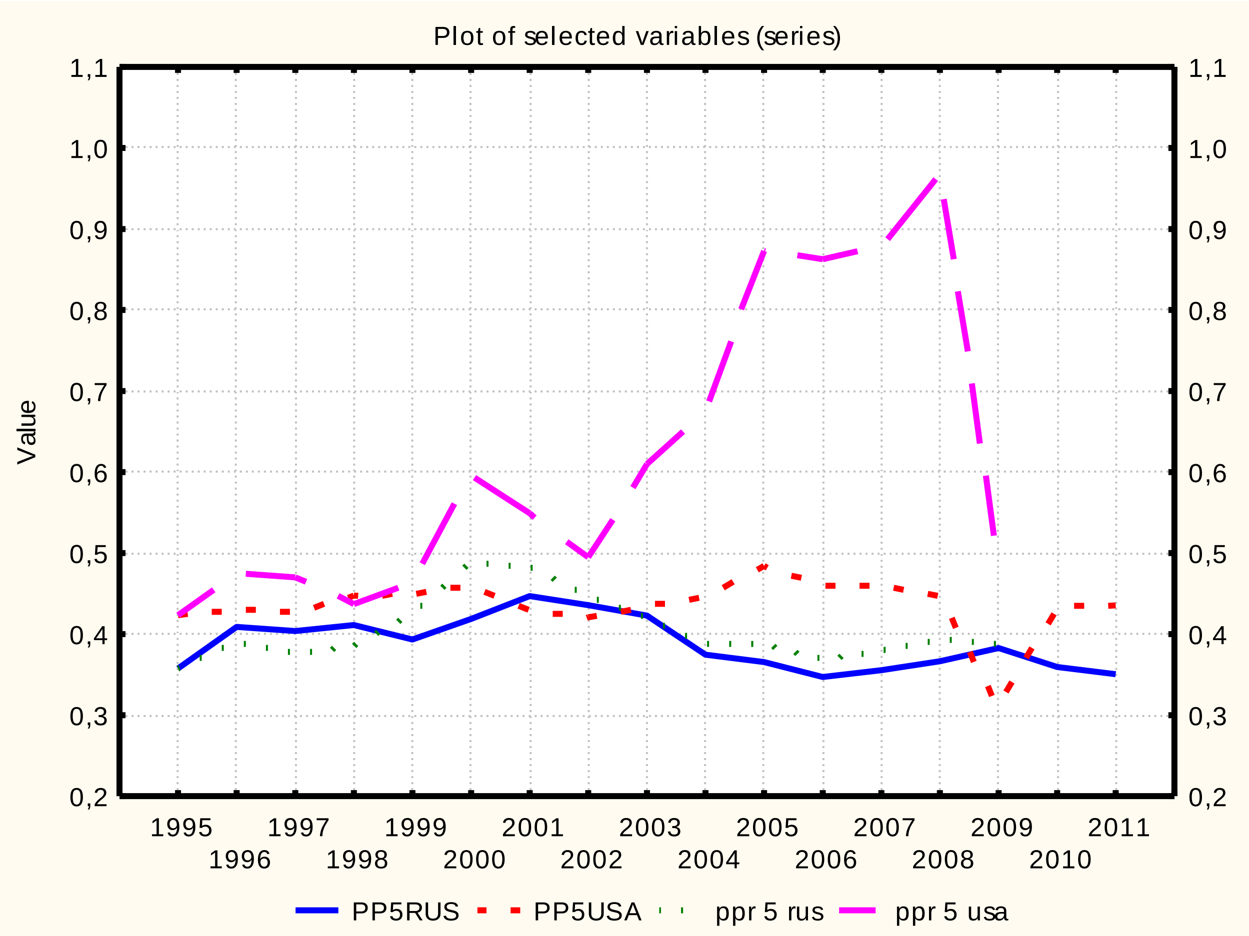

Fig. 1

Where:
PP5rus – the share of intermediate consumption in current prices in the outputs of oil and gas for Russia
PP5usa– the share of intermediate consumption in current prices in the outputs of oil and gas for USA

ppr5rus– the share of intermediate consumption in constant prices in the outputs of oil and gas for Russia
ppr5usa– the share of intermediate consumption in constant prices in the outputs of oil and gas for USA

The reason for such a strange dynamics is associated with the coefficients of the costs in current prices. For example, changes in prices for oil and gas (345% in 2008, relatively to the year 1995) would have lead to a strong change in the direct input coefficients of oil products. Logically, when the prices of oil products and gas are increasing rapidly, the proportion of the cost of their production in the current prices should decrease. But the share of intermediate consumption in current prices in the outputs of oil and gas for the United States detects an enviable constancy (Table 2).

But the proportion of PP decreased when oil prices fell in 2009, the share of PP = 0.31, when logically the share of PP would have to grow. Of course, there is a hypothesis about the growth of the physical volume of the specific costs involved in the development of more complex fields, with the growth of oil prices. Another possible hypothesis is the actual binding of operating costs in the mining sector to oil price.

At the same time, it should be noted that this situation is not seen in the RF extractive industries, respectively, the proportion of PP dynamics in comparable prices remains within reasonable limits. After 2008, the proportion of PP in the US in extractive industries returned to previous level. In constant prices the share of PP in the United States is higher than that of PP in current prices for the whole period. The share of Russian PP in comparable prices is slightly higher than proportion of PP in current prices. This means that there is no any reduction of costs in the physical dimension, there is even some growth.

In the search of the reasons of PP stability in current prices for oil and gas in United States we have made an analysis of the dynamics of the industry-by-industry 35x35 symmetric table, published in WIOD in the section of national tables (Table 2). In the industry-by-industry table all mining and quarrying production is combined into one industry, oil and gas are 73% of it. But this analysis also shows stability of the PP proportion in the mining sector in the US, despite the faster growth of mining products' prices, compared to the price of the costs.

Table 2

Dynamics of the share of intermediate consumption in the oil and gas outputs in the US

	The share of PP in the product table	The share of PP in the industry table
1995	0,4235	0,4219
1996	0,4293	0,4274
1997	0,4277	0,4254
1998	0,4477	0,4456
1999	0,4501	0,4479
2000	0,4596	0,4570
2001	0,4309	0,4285
2002	0,4209	0,4187
2003	0,4356	0,4329
2004	0,4452	0,4418
2005	0,4843	0,4808
2006	0,4598	0,4563
2007	0,4598	0,4561
2008	0,4461	0,4425
2009	0,3113	0,3088
2010	0,4355	0,4319
2011	0,4355	0,4313

Source: database WIOD, authors' calculations

The same trends are seen in oil and gas production in China - the proportion of PP in the oil and gas outputs in China in constant prices tends to 1, and in current prices it rises within the period of outrunning price increase on mining and quarrying products.

PP dynamics of oil and gas extraction products and of the whole mining industry for the Russian Federation shows less synchrony compared to the US. The explanation lies in the fact that, although the products of oil and gas in Russia make up 77% of the mining industry, it is produced not only by mining industry but also by trade and transport industries in comparable volumes (according to WIOD)[4]. Nevertheless, the dynamics of costs in the mining industry in general and the products of oil and gas are not contradictory.

In refining the situation with PP considered for oil and gas, repeating on a smaller scale for the United States, and to a larger extent for the Russian Federation (Fig. 2).

[4] This phenomenon stems from the fact that a number of large oil and gas holdings have as profiling activity other one than oil and gas production. Among other things, this makes it difficult to assess the real contribution of the mining sector to the development of the Russian economy.

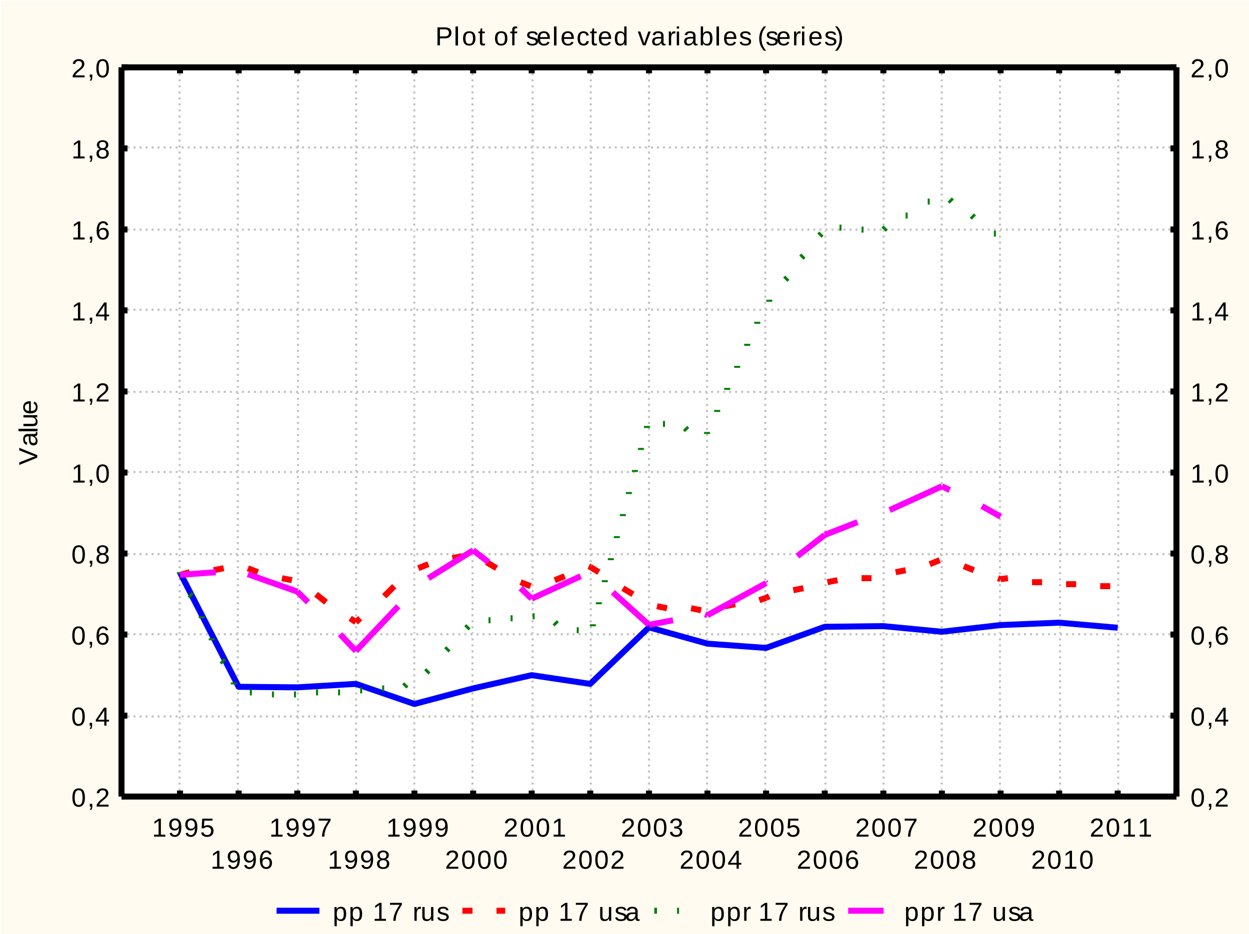

Fig. 2

Where:
pp 17 rus– the share of intermediate consumption in current prices in the production of refined petroleum products in Russia
pp 17 usa– the share of intermediate consumption in current prices in the production of refined petroleum products in the USA
ppr 17 rus– the share of intermediate consumption in constant prices in the production of refined petroleum products in Russia
ppr 17 usa– the share of intermediate consumption in constant prices in the production of refined petroleum products in the USA

In current prices PP in the US is at about the same level, despite the price hikes for mining products, which is possible, since the prices of petroleum products rose even more. On the other hand, due to the costs of products of other industries, whose prices rose less, share of PP would have to fall by 2008, but this did not happen.

When interpreting the results, we used the data of [8], whose authors note the steady growth in operating and capital costs for production of one ton of oil in Russia. We calculated operating costs per unit of product oil in terms of value (US $ 1). Unit operating costs do not form a a trend, but, as expected, vary in antiphase with fluctuations in oil prices. Synchronous oscillations of unit operating costs and of PP share in oil production for Russia should also be noted. However, there remain questions regarding the proportion of PP in the oil and gas outputs in the United States, as well as in China. Analysis of the dynamics of specific operating costs for refined petroleum in Russia (Table 3, designed by us according to Article [8]) sheds some light on the issue. As shown in Table 3, a sharp jump in the costs per unit of output of oil refining (an increase of almost five times) occurred in the year 2005.

Table 3

The dynamics of costs per unit of output of refined petroleum in Russia

Years	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Costs per unit of output of refined petroleum, $/$	0,08	0,12	0,13	0,11	0,14	0,67	0,44	0,54	0,45	0,66	0,64	0,54

Moreover, the jump was due to increased costs of external services. Regardless to the nature of the services of other organizations, such costs do not lead to a decrease in the proportion of PP (leads to some increase), even in periods of soaring prices for oil and oil products. The latter, in turn, leads to the excess of PP proportion in the calculations in constant prices. One can only assume that something similar is happening in oil and gas production of the USA and China, particularly against the background of complicating conditions offshore production, an increase in the role of shale deposits, etc.

Cross-country comparisons of technological coefficients

For general comparative analysis of the level of production efficiency, consider the structure of production costs, mainly taking into account the top-products in the ranking in terms of output volumes.

Public administration and defence services (abbreviated as "public administration") in the United States is consistently in the top five in the ranking in terms of output volumes; in our country, public administration is also in the top ten. Therefore, a comparative analysis of cost structures for these services is undoubtedly of interest. For Russia and the US costs of public administration vary greatly, especially in the types of services consumed in this activity. In general, the consumption of goods is higher in the RF (0.17 - RF and 0.12 - US). In Russia the share of trade and transport services is twice higher. Moreover, the trade services part is higher, than transport ones, although one would assume higher transport costs because of the size of the territory. Also, the share of real estate services is significantly higher (more than double) in the Russian Federation. With regard to the consumption of services by public administration in the US, it may be noted, that the list of consumed services is more diverse and the volumes are higher. Thus, the share of costs of the consumed services (which includes research services, services related to computer equipment, and other services) in the United States exceeds the share of consumption of goods more than three times.

Although healthcare only in the US is among the top five in terms of output volumes, however, this sector, due to its importance deserves a special analysis. From 1995 to 2009. in constant prices the industry output growth in Russia amounted to 18% in the US - 50%. If we turn to substantial costs in medicine, in both countries expectedly chemical industry (including the pharmaceutical industry) and medical equipment play an important role. Further, the cost structures are significantly different: in Russia a significant place is occupied by food, electricity and thermal energy, construction, trade and real estate services. Differences in the structures of costs of health services are determined, apparently, by price ratios and by nature of medical services, as well as by the system-specific role of this sector in the US economy. The cost structure in this sector of the US economy is probably unique and reflects the existing system of health care financing.

Construction by definition takes a high place in the ranking by output volumes in all countries. The construction works in the Russian Federation in terms of output volumes are in the top five. In the United States this industry is directly adjacent to it. Significant direct input coefficients of the construction work can be seen in Table 4. The main differences are observed in other non-metallic mineral products, basic metals and fabricated metal products. These differences show that in the Russian Federation in the cost structure of construction, unlike the US, the most common elements are of not the last stage of processing. Figuratively speaking, there is a lot of industry in the construction of the Russian Federation, that is, building, design and components are subject to industrial rework by construction companies. Remember that the cost structure for construction services is identical to the cost structure of construction, considered as an economic sector. It is known that the Russian construction companies are mostly vertically integrated structures, including enterprises producing construction materials.

Table 4

Significant direct input coefficients in construction for the year 2011 (in current prices)

	USA	**RF**
Coke, refined petroleum products and nuclear fuels	0,0575	0,0399
Rubber and plastic products	0,0144	0,0189
Other non-metallic mineral products	0,0396	0,1089
Basic metals	0,0063	0,0543
Fabricated metal products, except machinery and equipment	0,0478	0,0198
Machinery and equipment n.e.c.	0,0204	0,0148
Electrical machinery and apparatus n.e.c.	0,0195	0,0222
Motor vehicles, trailers and semi-trailers	0,0032	0,0232
Wholesale trade and commission trade services, except of motor vehicles and motorcycles	0,0254	0,0507
Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods	0,0451	0,0313

Source: database WIOD, authors' calculations

We start a comparative analysis of technological coefficients of the Russian Federation and China from the chemical industry. This activity plays a vital role in the economy of the United States and Poland (it does not fall below 20 place in the ranking in terms of output volumes in any of the countries concerned, in China it is in the top five). The share of PP in the chemical industry is quite high, both in current as well as in constant prices, especially in China. In general, a higher compared to other countries, proportion of PP in the output is typical for most manufacturing sectors of Chinese industry. Accordingly, a lower share of value added is explained primarily by cheap labor and the low share of profits. For China, a proportion of internal turnover in the costs is high, and it tends to grow. In Russia, the proportion of PP is substantially lower than in China, besides, the physical volume of expenditures (in constant prices) is somewhat reduced, internal circulation, in contrast to China, is also not growing.

The Russian chemical industry is one of the most energy-intensive. However, electricity and heat capacity of the chemical industry in constant prices in the Russian Federation and China have opposite trends: a decline is in the Russian Federation and growth is in China. The latter in fact shows that the growth of production in this sector in Russia is more qualitative in nature. The most important source of resources for the chemical industry is oil refining. Trends in consumption of petroleum products in the physical dimension are opposite in Russia and China. Levels of cost coefficients of petroleum products in 1995, in Russia and China are almost identical. Taking into account the higher prices of oil products in China, the corresponding direct input coefficient in the physical dimension in China in 1995, was lower. However, further growth of this coefficient in China (three times) can not be explained only by the price proportions. In our opinion, they reflect dynamic changes in the structure of chemical industry and technologies used in it. In Russia, there is a conservation of the actual structure of the chemical industry, which is accompanied by an increase in output, but does not lead to the development of productions, which are innovative to the national economy.

A comparative analysis of technological coefficients of metallurgical industry of Russia and China, an important industry for both countries (in China - first place in terms of output volumes in constant prices) is also of great interest. Material consumption levels remain high for both countries. In China, it is higher and is growing in current prices with a decrease in constant prices. (National industry tables for China, published in the section of national tables WIOD, show practically the same high level of material consumption). Internal turnover makes up the lion's share of PP proportion for both countries, it is growing in Russia, and it is consistently high for China (remember diagonal elements are independent of price ratios and can be interpreted as a physical volumes). Consequently, an increase in the depth of the of raw materials processing is observed in Russia, while in China the figure is stable high. A significant part of the costs of the industry is made up by metal ores. The cost of the primary raw materials in Russia in early 2000 decreased to the level of the Chinese due to changes in relative prices and further were stable. In general, it seems that the level of production efficiency of Russian metallurgy, is at least not less, than Chinese one.

China is the world's largest exporter of textile products, in Russia, this sector is one of the outsiders among manufacturing industries. The proportion of PP is reduced in Russian textile industry in current and constant prices, and in Chinese textiles it is not reduced in constant prices, furthermore it is increased in current prices. On close examination the cause of reducing of the share of PP in textiles outputs in Russia is fabrication level reduction, It means that reduction of the diagonal elements' values occures, such a reduction is usually an indication of degradation of the industry. In China, the figure shows a significant growth and is half of the PP, which is a consequence of growth in the depth of processing of raw materials. The dynamics of the cost of agricultural raw materials in the textile industry in China and in the Russian Federation in constant prices is also quite eloquent. In China, the figure is reduced, but the direct input coefficient of agricultural raw materials in the textile industry in China is still an order of magnitude higher than the corresponding Russian coefficient. The situation of the textile industry is completely repeated in wearing apparel, with the only difference that the costs of textiles for the production of wearing apparel are considered instead of the diagonal elements. Thus, the Russian light industry unlike the Chinese do not show any dynamic development or positive technological changess, which once again describes it as one of the most depressed sectors of the domestic economy.

Finally, consider the structure of production costs of office equipment and computers in China and Russia. Output of this type of product in China for the years 1995-2009 in constant prices in the ranking by output volumes moved from 43rd place to 12th, in current prices in 2011, it occupies 20th place. In Russia, the volume of output of office equipment and computers in 1995-2009. steadily occupies 47th and 46th - in 2011, the year. The share of PP in outputs is high in both countries, in constant prices in China it shows a decline, in Russia - instability. The major part of cost in China is accounted for radio, television and communication equipment and apparatus (direct input coefficient in China in 2009 was 0.29, in Russia the same coefficient is 0.001). In Russia, the main cost is accounted for steel products, the corresponding ratio in 2009 was equal to 0.19. It appears that the conclusions are obvious: product structures of outputs differ in the countries. In the Russian Federation - it is mainly office equipment in China - computers.

Analysis of important technological coefficients and total requirements coefficients

There are different approaches to the establishment of important technological coefficients. The approach that we have used lies in determination of threshold values for changes of technological coefficients that lead to changes in the output of at least one industry of more than a predetermined value m x100% (m is usually given as equal to 0.01 or 0.05). The threshold values of increment coefficients are determined by the formula

$$\Delta a_{kl} = \frac{m}{\left(\text{по } i \max \frac{b_{ik}}{X_i}\right) * X_l \ + m * b_{lk}}$$

where X_i – output volume of the *i*-th product;

b_{ik}– total requirements coefficient of the *i*-th product per unit of final demand of the *k*-th product;

m– predetermined value of the maximum allowable changes of output $\frac{\Delta X_i}{X_i} \leq m$, i=1,…,n

This condition allows one to determine the value of maximum allowable change Δa_{kl}, for each element of the matrix A, the excess leads to violation of the ratio $\max\frac{\Delta X_i}{X_i} \leq$ m. Thus, one can select a group of direct input coefficients, doubling of which can cause a change in output volumes, exceeding a threshold value of at least one industry.

There are only 36 important coefficients, which are common for all aforementioned countries. In fact, the list includes well-known significant direct input coefficients, such as costs of agricultural products in the food production, crude oil - refined petroleum, chemical products - plastic, building materials - construction, metals - machinery and equipment, as well as the diagonal elements in the food, textile, chemical productions, basic metals, machinery, etc.

In Russia, oil and gas production takes the first place in terms of number of important coefficients, further, services of public administration and trade share the 2nd and the 3rd places (13 coefficients), and the 4th place is occupied by construction work - 11 important coefficients. Note that the total output of these productions is almost one third of the national output. (For reference: in the US oil and gas production has only 4 important coefficients in column). In Russian oil and gas production the following inputs coefficients are important: costs of coal; refined petroleum; chemicals; rubber and plastics; machinery and equipment; electrical machinery and equipment; motor vehicles; other transport equipment; electricity and heat; land transport and pipelines; air transport services; auxillary transport services; communication services and other business services. At the same time, important in the United States cost of basic metals is not important in Russia.

Electricity and heat should be specially noted, because there are 6 important coefficients in the line (inputs of the product) and 7 - in the column (production costs of this product) of Russian table, but 0 - in the line and only 3 in the column of the US table. In Russia electricity and heat production has a significant share of the total output (4.3%), though there are no important direct input coefficients, common to all countries both at line and at column. At the same time the Russian Federation ranks low among the countries analyzed in terms of energy consumption per capita, and only 2.1% (Table 5) electricity and heat produced in the country is consumed by households (in the United States - 55.4%). Of course, the share of household consumption in the distribution of the produced electricity and heat for the RF is understated due to the low (compared with the prices for production purposes) price of electricity for the population. But the greatest (among the compared countries) share of intermediate consumption of electricity in the total intermediate consumption (Table 5) tells us about an energy-intensive nature of production in the Russian Federation. Therefore there is nothing surprising in the fact that Russian electricity and heat production has 6 important coefficients in the line (including the direct input coefficients of electricity and heat to oil and gas production, refining, chemicals and basic metals).

Table 5

Production and consumption of electricity and heat

Year		Russia	USA	China	Poland	Germany	Canada	UK
2011	Share of electricity and heat in total output	4,3%	1,6%	3,1%	3,3%	1,8%	1,5%	2,9%
2011	Share of intermediate consumption of electricity and heat in total intermediate consumption	8,5%	1,7%	4,4%	4,1%	2,3%	1,8%	3,4%
2011	Share of intermediate consumption of electricity and heat in total output	4,1%	0,7%	3,0%	2,2%	1,1%	0,8%	1,6%
2011	Share of household consumption in the production of electricity and heat	2,1%	53,4%	4,3%	32,4%	34,2%	38,1%	44,3%
2010	Electricity consumption per capita, kWh / person	7147	14189	2762	4089	7408	16771	6192

In the power industry of China one can observe to some extent similar situation (similar to the Russian situation). There's also a fairly high proportion of industrial consumption of electricity and heat. Also, tbere is a lot of the important coefficients in the line of electricity - chemical production, construction materials, basic metals, construction and the production of electricity and heat (diagonal). At the same time there is a significant difference between technological coefficients of electricity and heat production in the two countries. The difference relates to the structure of not only the fuel used, but also to the intraindustry power consumption. Since 2002 to 2007 the diagonal technological coefficient in China increased from 0.04 to 0.30. Accordingly, the share of PP in the output increased from 0.52 to 0.72. It should also be noted that the production of electricity and heat, measured in constant prices rose more than three times for the same period. At the same time there isn't observed any significant technological change, expressed in terms of other technological coefficients. One can assume that the change occurred in the diagonal elements is a result of changes in the accounting system. In addition, such a peculiarity of China's power industry as the distance between energy sources and load centers, (it is typically 800-3000 km, and undoubtedly increases the diagonal direct input coefficient) should also be taken into account.

In China, the biggest number of important coefficients is in the cost of construction - 21 coefficients; chemical production - 15; basic metals and wholesale trade - 12 important coefficients at both columns. It is noteworthy that the total output of these 4 products is more than a quarter of the national output.

But the sums of total requirements coefficients by columns are the most notable for China. Let us remind, that the sum of the j-th column of total requirements matrix shows total requirements of output per unit of final demand of the j-th product. These values are the largest in China, among the compared countries for almost all products. Manufacturing industries are the most distinguishing. As seen from Table 6, in China these industries have PP proportions in outputs significantly higher than the same indicators in Russia. Consequently, the corresponding direct input coefficients, on average, are higher than the Russian coefficients. Chinese total requirements coefficients and correspondingly the sums by columns of total requirements matrix are higher than similar Russian indicators. High values of PP per unit of output lead to low value added in outputs.

Table 6

Total requirements in manufacturing industries of Russia and China

№	Product name	Russia		China	
		The share of intermediate consumption in output	Total requirements per unit of final demand	The share of intermediate consumption in output	Total requirements per unit of final demand
11	Textiles	0,58	2,21	0,79	3,58
12	Wearing apparel; furs	0,58	2,21	0,79	3,58
13	Leather and leather products.	0,62	2,30	0,80	3,52
18	Chemicals, chemical products and man-made fibres	0,64	2,40	0,79	3,48
19	Rubber and plastic products	0,73	2,63	0,81	3,75
21	Basic metals	0,67	2,43	0,80	3,56

22	Fabricated metal products, except machinery and equipment	0,67	2,43	0,80	3,57
23	Machinery and equipment n.e.c.	0,65	2,50	0,77	3,64
24	Office machinery and computers	0,64	2,45	0,84	4,02
25	Electrical machinery and apparatus n.e.c.	0,64	2,45	0,84	4,02
26	Radio, television and communication equipment and apparatus	0,64	2,45	0,84	4,02
27	Medical, precision and optical instruments, watches and clocks	0,64	2,45	0,84	4,02
28	Motor vehicles, trailers and semi-trailers	0,79	3,09	0,80	3,86
29	Другое транспортное оборудование Other transport equipment	0,79	3,09	0,80	3,86

Conclusions

Analysis of technological coefficients of various industries and countries has shown that direct input coefficients in the estimated product symmetric tables depend not only on production technology, but also on assortment of products that make up a particular type of product (from the so-called sub-sectoral structure of production), and a number of other factors that greatly affect the level of production efficiency. However, a comparative analysis of technological coefficients in different countries is an important element of a level analysis of economic development:

1. The analysis showed a low elasticity of costs in the oil industry under consideration of a change in oil prices, which suggests quite unique principles of pricing in this segment of the world economy, which must be considered during the forecasting and analytical calculations;

2. Comparative analysis of technological coefficients in the manufacturing industries of the Russian Federation, with the same coefficients of the US, China and Poland, allowed to detail information about the relative level of development of the domestic manufacturing industry. For example, the structure of the cost of fabricated metal products confirmed the thesis of a relatively low level of processing in this sector of the Russian economy. The diagonal elements of the technology matrix for such industries of the Russian Federation, as basic metals, chemical and light industries, also show their lagging behind in the depth of processing of raw materials from similar industries in China.

3. Comparison of cost structures for the construction of the Russian Federation and the United States also showed their significant difference. Figuratively speaking, there is a lot of manufacturing in the Russian construction industry, that is, the Russian construction performs a number of functions on completion of building materials and designs.
4. A comparative analysis of the scope of services the US and Russia is of great interest. Public Administration and Defence Services in the United States occupy 9.4% of total output and are significantly different from the Russian in terms of cost structure. It indicates a different nature and the list of services in this sector in the two countries. The structure of health services costs also vary significantly, while in the US the costs inherent in a sector profile are dominating.
5. An analysis of total requirements coefficients shows that the sums by columns of total requirements matrices (total costs per unit of final demand) have maximum values in the manufacturing industries of China. This fact, in turn, is a consequence of the large values of intermediate consumption per unit of the Chinese manufacturing industries' outputs and the relatively small values of added value in the outputs, which confirms the idea that most part of value added produced in China, is redistributed in favor of the most developed countries.
6. The cross-national analysis of important technological coefficients showes different lists of them in different countries. The differences are determined by industry specialization of national economies. The specialization in Russia - is the oil and gas production, in the US - public administration and defense, in China - building, metallurgy, chemical industry. There are 36 coefficients common to all the observed countries, which include well-known significant direct input coefficients, such as costs of agricultural products in the food industry, crude oil - petroleum products, chemical products - for plastic, building materials for construction, mechanical engineering metals and also the diagonal elements in the food, textile, chemical industry, metallurgy, machine-building productions, etc.

In conclusion, it can be said that such calculations of coefficients of different types - direct inputs and total requirements, for products and industries, in current and constant prices, important and less important - and subsequent analysis of them certainly let one to get new information about economic systems of different countries, sectors, technologies, interbranch relations, to substantiate previously expressed assumptions about a comparative performance of different countries.

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