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LABOUR PRODUCTIVITY IN THE METALLURGICAL INDUSTRIES OF RUSSIAN FEDERATION AND THE USA IN 2010–2018

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ABSTRACT

The paper considers the problems of comparison of productivity levels in the metallurgical industries of Russian Federation and the USA. The authors show that the existing methods of productivity measuring in any economical area can't answer the question about the concrete factors influencing on differences in productivity levels. The assertion that all these differences are stipulated by the differences in the level of capital-labour ratio is substantiated of the example of the metallurgical industries of Russian Federation and the USA. The added value parameter is the base for joint measuring of productivity in this case; the authors think that it provides more exact measuring of produced value amount at the concrete enterprise or in the concrete industry in comparison with natural parameters or proceeds in cash per one employee. The article also substantiates the assertion that comparison of produced value in different countries and in different currencies respectively, in order to lead to the united value assessment in USD, requires to use the market exchange rate, not parity rate.

Introduction

The problem of productivity, production efficiency, its competitiveness in the current economical globalization conditions becomes more and more sharp. The global market forms very strict requirements to all capital forms (financial, production, commercial, "human"). Quality of institutional medium where capital operates, also plays very important role. Inclusion in the international division of labour, in the international production relations (production chains) that are based on the market principles, is possible only having definite qualitative and quantitative parameters of a capital and institutional medium.

The paper considers the problem of correlation between the labour productivity levels in the metallurgical industries of Russian Federation and the USA. The authors substantiate the method for joint measuring of the labour productivity levels both between separate countries and between separate industries and corporations; this method is different compares with well-known ones.

Different approaches in determination of the labour productivity levels in the metallurgical industry of Russian Federation

It should be noted that different methods are used for concrete measuring of the labour productivity levels, e.g. at the metallurgical enterprises, and this situation does not provide the definite vision for comparison of the labour productivity levels both between the Russian works and in comparison with the foreign plants. Different measuring units (US dollars, time, tons) are used as the labour productivity indicators. Several examples are presented below.

So, investigation of McKinsey & Company и McKinsey Global Institute (MGI) testified that productivity level in the Russian iron and steel industry made 33 % of USA level (in tpy) in 2007, while the level of capital productivity was 88 % (in tons per capital, USD) [1].

Mr. S. Zaborov, head of the group of consulting services for mining and metallurgical companies of Ernst and Young noted: "Comparison of productivity of the leading Russian metallurgical works (MMK, Severstal, NLMK and other) with productivity of East Europe enterprises (e.g. ArcelorMittal group works) testified that productivity of East Europe plants exceeds productivity of domestic companies appr. by 1.5–2 times. Comparison with more geographically distant works, e.g. in Brazil (Tubarao, Usiminas, Gerdau etc.) shows already 3–4 times difference; the chosen foreign enterprises demonstrate productivity at the level 1,300–1,500 t of steel per employee compared with 300–500 t at the Russian works" [2]. It should be mentioned that only natural indicator of labour productivity level was used in this case.

The same approach to determination of labour productivity can be found also in other publications [3, 4]. So, the journal "Proizvoditelnost. RF" published by the Federal center of competencies in the field of labour productivity, noted in 2019: "The specialists of ChTPZ group suceeded to rise productivity of their works by several times owing to the created system of training of specialists. Electric steelmaking shop "Zheleznyi Ozon 32" with the staff having 345 specialists manufactures at present time 1 mln. tons of steel per year (3,600 tons per employee) [4, 21].

At the same time the Strategy of RF iron and steel industry development for 2014–2020 and prospectively until 2030, approved on May 5, 2014, testifies that labour productivity "of the largest metallurgical works is at present time on the level that is still getting behind the level of the metallurgical plants in the industrially developed countries (labour input per 1 t of steel makes 3.5 man-hours in RF and about 2.5 man-hours at the leading foreign plants). Average labour input at the Russian metallurgical works make 5.5 man-hours per 1 ton of steel, what is apr. by 50 % larger than in the iron and steel industry of the industrially developed countries. The Strategy is aimed on labour productivity rise by 30 % in comparison with 2012 level" [5]. Quite different indicator of labour productivity level is used in this case.

It should be noted that the natural indicator (tons per employee) and cost parameter (rubles per employee) are the main ones both in conventional practice and in special researches (**table 1**) [6–8].

N. A. Zhdankin and S. K, Romanycheva in their research suggested the labour productivity indicator per unit of salary. Analysis of labour productivity dynamics at NLMK during 2007–2014 displayed that "NLMK operating revenue increased practically by two times during this period with the same number of personnel, i.e. labour productivity (output per employee) also rises by two times. However, taking into account increase of the payroll fund also almost by two times, labour productivity on a salary ruble (return of personnel) didn't vary practically [9, 10]. At the same time the main productivity level is also determined in this research via the value of proceeds in cash per one worker.

Starting from 2015, the Federal center of competencies in the field of labour productivity together with RAEX Rating Agency, IPL Consulting company and "Upravlenie proizvodstvom" almanac determine annually in Russian Federation the winners on labour productivity between the enterprises of different economical sectors and production industries.

NLMK Kaluga became the winner among the iron and steel producers in 2018 [11]. It was noted in the methodical clarification that the value of output per one worker at the enterprise (rub. per employee) was used as the calculated indicator of the labour production level. It was equal to 39.05 mln. rub. per employee at NLMK Kaluga (compared with 25.62 mln. rub. per employee at MMK and 18.55 mln. rub. per employee at NLMK Lipetsk. So NLMK Kaluga enters the leading triplet in metallurgical industry for the fourth year running. This company is also the leader on labour productivity in Kaluga region as well as in iron and steel industry. Productivity rise in 2018 made 45 % [12].

Thereby it can be concluded that the common approach to measuring the labour productivity level in the metallurgical industry does not exist. In these conditions it is very difficult to make any conclusions about correlation of productivity levels between the works from different countries, e.g. between RF and USA.

Table 1. **Labour productivity level at several metallurgical works, mln. rub. per employee per year**

	2017	2018	2019
NLMK Group	11.04	14.17	12.94
NLMK Kaluga	26.84	39.05	31.02
MMK	21.88	25.62	24.62
Severstal	9.16	18.91	10.56
EVRAZ	9.00	11.77	10.82
Metalloinvest	7.82	9.89	10.44
RUSAL (Bratsk)	15.10	23.45	16.70

Sources: [7, 8].

The other method of joint measuring which can be applied for reveal of more objective correlation of labour productivity levels is proposed in this work.

Theoretical prerequisites

1. The exchange rate: market rate or based on purchasing power parity (PPP). This research uses market rate as an exchange rate. The authors think that amount of produced values in any country, industry or at an enterprise can be determined only in the case if evaluation in national currency will be expressed in dollars A according to the market exchange rate, not based on purchasing power parity (PPP). Naturally, essential fluctuations in evaluation of amount of produced values are possible in this case, because the ruble exchange rate is often subjected to significant oscillations. This work uses the indicator of average annual exchange rate, but nevertheless evaluation of amount of produced values can vary significantly. However, this is the essence of market relations. The problems of oil and gas industries testify evidently on difference between production volume in natural form and amount of produced values which is measured in money (US dollars). Value of each good can be determined only at definite moment of time, its fluctuations are permanent, it can be only fixed and then compared.

According to the OECD data, GDP volume per one employee (in current prices, in USD, based on PPP) made:

2000: 13,850.7 USD for RF, 73,665.1 USD for USA (retard by 5.32 times);

2018: 25,015.1 USD for RF, 59,605.5 USD for USA (retard by 2.38 times) [11].

Essential decrease of RF retard on this indicator comparing with the USA can be noted for this period. This comparison testifies that Russian Federation can really enter in the five of the most economically developed countries (to speak truthfully, RF was there already in 2013). However it is not correct to consider the Chinese economics larger than the USA one only because Chinese GDP on the base of PPP exceeds US GDP. Thereby it is expedient to use World Bank statistics based as on PPP, as well as on market rates of national currencies. E.g. global GDP on the base of PPP made 135.6 trillion USD in 2019, while GDP based on market rate made 87.7 trillion USD [12].

Table 2. **NLMK operating parameter in 2018**

Financial indicators, USD million	Year				
	2014	2015	2016	2017	2018
Proceeds from sales	10396	8008	7636	10065	12046
Net profit	773	967	935	1450	2238
EBITDA	2381	1943	1943	2655	3598
Investments	563	595	559	592	680
Steel production with NBH, thousand tons	16108	16060	16641	17076	17493
Number of NLMK employees, thousand employees	60.1	56.7	54.0	53.2	53.3
Labour productivity, t of steel per employee, Lipetsk	437	463	482	502	503

Sources: [16, 17].

The research devoted to comparison of the labour productivity levels in Russia and other countries noted that «labour productivity in the Russian processing industry corresponded in 2007 to 18 % of the USA level, while for economics in general and for metallurgy these indicators made 24 % and 51 % respectively". It was mentioned that "these evaluations are the most reliable ones which can be got at present time, because they are based on comparable industrial classification (KLEMS database), allowing to take correctly into account the differences in the prices within industries for different countries" [13].

It should be noted that KLEMS Program presents the concrete version of the International Comparison Program (ICP) which was realized by the World bank since 1968 under the aegis of the UN Statistical commission [14]; purchasing power parities of national currencies for the majority of UN countries as well as GDP of these countries are calculated on PPP base within the framework of this program.

At the same time the author notes [13] that evaluations of labour productivity for the processing industry in general for 2007, based on Rosstat and U.S. Bureau of Labor Statistics, are rather more pessimistic. They presented the labour production level only 8 % of the US level in comparison with 18 % in his work [13] which used hour productivity on PPP base. He thinks that it is possible to get the values close to his evaluations when using the exchange rate for conversion [15].

In this research the authors use the definition of cost of manufactures products in the RF metallurgical industry in USD, based on the market currency rate. The following statement can be the definite argument for choosing this rate as an indicator in comparison of the labour productivity levels in the RF and US metallurgical industries. The annual 2018 report of NLMK displayed that "financial information is presented in US dollars or Russian rubles in correspondence with the approved financial reporting system of the Company. If it was required to recalculate the financial data from rubles in dollars, the average weighted exchange rate for 2018 was used: 1 dollar = 62.7078 rubles" (**Table 2**) [16].

2. Proceeds in cash per 1 employee, labour expenses per ton (man-hour), metal amount (tons) or added value per one employee? The indicator of added value per one employee is used in this research as the criterion for comparison of the labour productivity levels in RF and US metallurgical industries. The authors think that this indicator reflects efficiency level of any production facility more exactly. The level of proceeds in cash can contain essential part of added value created by allied manufacturers. Labour expenses don't take into account technological level of production, quality and market assessment of manufactured products. Additionally, it is important to understand that there is comparative statistic data in RF and USA regarding this indicator for metallurgy. It should be noted that this approach was reflected in the research devoting to comparison of the labour productivity levels for steel production in Japan and USA during 1958–1993 [18].

3. Correlation: main capital – added value – labour productivity level. The research used the method of correlation relationship based on the least square method for analysis of mutual relation between labour productivity level (as amount of added value created by one employee in RF and US metallurgical industries) and amount of accumulated main capital per one employee. The methods of statistical analysis, graphic comparison methods for dynamics evaluation of interrelated indicators are used in the research; they allow to make definite logic conclusions on the base of concrete indicators of economical development.

Results of the research

Indicators of the USA metallurgical industry during 2010-2018 are presented in the **table 3** and **fig. 1**.

It can be seen after calculation of the correlation relationship that the correlation level between the main capital

Table 3. **Indicators of the USA metallurgical industry**

Indicator	2010	2011	2012	2013	2014	2015	2016	2017	2018	2010–2018[1]
	Totally, USD billion									
Added value	170.8	189.7	203.1	203.9	208.0	206.9	202.3	207.6	223.7	201.8
Main capital	324.0	336.8	347.5	357.5	362.7	362.7	365.6	376.2	390.4	358.2
Investments	22.6	27.8	31.9	31.2	29.1	27.4	29.1	29.9	31.6	29.0
Number of employees, thousand	1681.9	1776.8	1816.6	1839.2	1874.2	1824	1781.9	1816.6	1875.7	1809.7
	Per one employee, USD thousand									
Added value	101.6	106.8	111.8	110.9	111.0	113.4	113.5	114.3	119.3	111.4
Main capital	192.6	189.6	191.3	194.4	193.5	198.8	205.2	207.1	208.1	197.8
Investments	13.4	15.6	17.6	17.0	15.5	15.0	16.3	16.5	16.8	16.0

Sources: [19, 20]. [1] Average annual parameters.

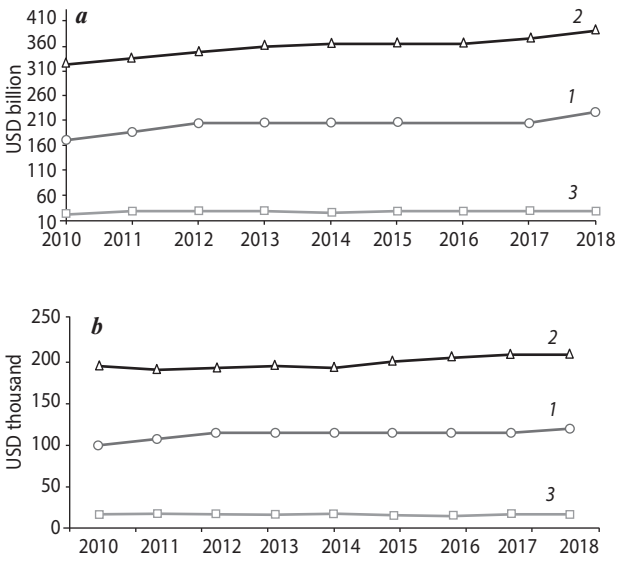

Fig. 1. Indicators of the USA metallurgical industry — totally (*a*) and per one employee (*b*):
1 — Added value; *2* — Main capital; *3* — Investments [19, 20]

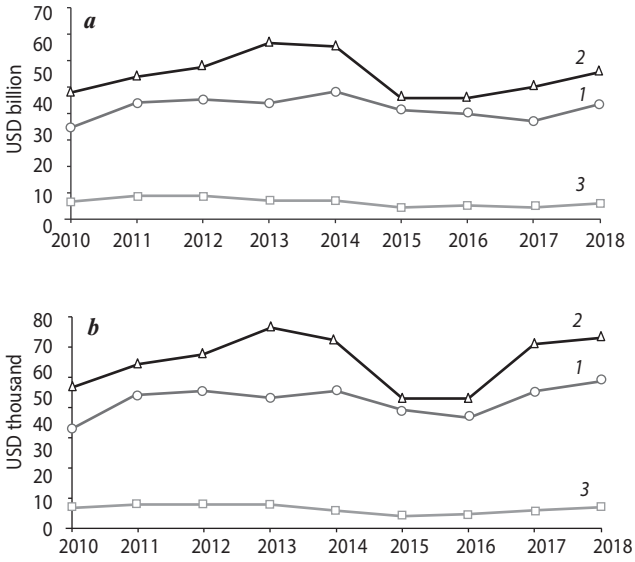

Fig. 2. Indicators of the RF metallurgical industry — totally (*a*) and per one employee (*b*):
1 — Added value; *2* — Main capital; *3* — Investments [table 4]

Table 4. **Indicators of the RF metallurgical industry**

Indicator	2010	2011	2012	2013	2014	2015	2016	2017	2018	2010–2018[1]
	Totally, USD billion									
Added value	33.7	44.7	44.9	43.5	46.0	38.9	36.7	44.9	49.1	42.5
Main capital	47.0	54.5	57.8	66.3	63.2	42.8	41.9	61.0	63.0	55.3
Investments	7.1	8.2	8.3	7.9	6.5	4.7	4.8	5.5	6.8	6.6
Number of employees, thousand	969.9	998.2	995	991	954.3	926	910.9	1204.4	1124.7	1008.3
	Per one employee, USD thousand									
Added value	34.7	44.7	45.2	43.8	48.2	42.0	40.3	37.3	43.6	42.2
Main capital	48.4	54.6	58.1	66.9	66.2	46.2	46.0	50.6	56.0	54.8
Investments	7.3	8,.2	8.4	7.9	6.8	5.0	5.3	4.5	6.1	6.6

Sources: calculations made by the authors based on the data of RF Statistic Agency and RF Central bank; [1] Average annual parameters.

and added value is rather high: 0.93 for metallurgy in general and 0.75 for production per one employee.

The same approach can be applied for comparison of the labour productivity levels in Russian metallurgy. Its production results were determined on the base of average annual currency exchange rate, as it was mentioned earlier (**table 4, fig. 2**).

It should be noted that correlation coefficients for RF metallurgical industry are also rather high: 0.8 for added value / main capital and 0.7 for added value / main capital per one employee. Now let's compare the labour productivity levels in the USA and RF metallurgical industries.

The added value per one employee in the USA was higher by 2.7 times in average during 2010–2018; however, the value of the main capital was higher by 3.6 times during the same period. Thereby it can be concluded that labour productivity in Russian Federation is higher by 1.3 times (3.6:2.7), taking into account its capital-labour ration in RF (**table 5**).

The labour productivity level can be evaluated in different ways, what is seen from comparison of activity results of NLMK Lipetsk and NLMK Kaluga in 2018 (**table 6**).

The table testifies that operating revenue per one employee at NLMK Kaluga is by 2.1 times higher compared with NLMK Lipetsk; that's why this enterprise became a winner of the All-Russian award "Labour productivity. Russian industry leaders 2019" in nomination "Iron and steel industry".

However, it should be mentioned that capital-labour ratio per one employee at NLMK Kaluga is by 4.1 times higher than at NLMK Lipetsk. Thereby, based on approach of the authors of this research to measurement of the labour productivity level and taking into account its capital-labour ratio, it can be concluded that labour productivity at NLMK Lipetsk is higher almost by 2 times in general (4.1:2.1). In other words, operating revenue per one employee at NLMK Kaluga should be higher than this indicator at NLMK Lipetsk more than by 4.1 times to provide more high labour productivity level at NLMK Kaluga. At the same time it should be mentioned that the higher level of the capital-labour ratio allows to reach higher production volume per one employee. Thereby, to decrease retard of Russian metallurgy in its production volumes per one employee in comparison

Table 5. **Indicators of the USA and RF metallurgical industries per one employee, USD thousand**

Indicator	2010	2011	2012	2013	2014	2015	2016	2017	2018	2010–2018[1]
	USA									
Added value	101.6	106.8	111.8	110.9	111.0	113.4	113.5	114.3	119.3	111.4
Main capital	192.6	189.6	191.3	194.4	193.5	198.8	205.2	207.1	208.1	197.8
	Russian Federation									
Added value	34.7	44.7	45.2	43.8	48.2	42.0	40.3	37.3	43.6	42.2
Main capital	48.4	54.6	58.1	66.9	66.2	46.2	46.0	50.6	56.0	54.8
	Correlation, times									
Added value	2.9	2.4	2.5	2.5	2.3	2.7	2.8	3.1	2.7	2.7
Main capital	4.0	3.5	3.3	2.9	2.9	4.3	4.5	4.1	3.7	3.6

Sources: table 3, table 4, calculations made by the authors; [1] Average annual parameters.

Table 6. **NLMK activity results at Lipetsk and Kaluga sites in 2018**

	Operating revenue, billion rub.	Number of employees	Operating revenue per one employee, mln. rub.	Fixed assets, bln. rub.	Fixed assets per one employee, mln. rub.
NLMK Lipetsk	493.8	27,502	17.96	139.3	6.1
NLMK Kaluga	46.4	1,250	37.12	30.9	24.8

Sources: [17, 21].

with US metallurgy, it is necessary to diminish this retard in the level of the capital-labour ratio. Growth of investments is the main factor of increase of the capital-labour ratio. It can be mentioned that the gap of investments slightly lowered in general (based on the data from tables 3 and 4): from 6.9 times in 2010 to 6.2 times in 2018. At the same time, the gap of investments per one employee increased from 1.8 times in 2010 to 2.8 times in 2018.

Enlargement of a deviation in the volume of investments can have very unfavourable effect on operation of the RF metallurgy in general. It is stipulated by the tendency that the current investments are often connected with transition to the new metallurgical technologies (e.g. elimination of blast furnace practice with use of hydrogen). This tendency does not provide production growth at present time, but can become necessary in the future due to possible bans and restrictions for use of technologies connected with essential carbon dioxide emissions in the atmosphere. The German company Salzgitter Flachstahl GmbH that is specialized in flat rolled metal production inaugurated the project SALCOS in one of its affiliates; this project is aimed on development of "green" hydrogen metallurgy. It is suggested that hydrogen will be produced using renewable energy sources and will be applied at the designing iron direct reducing (DRI) plant together with natural gas. This project is accompanied by substantial financial difficulties, because the cost of such hydrogen and electric power is too high in comparison with coal which is used in the iron and steel industry at present time.

Thereby it is proposed to vary the operating conditions for the German iron and steel industry, announcing climate protection as the main goal. It will be connected with applying the special measures based on investing the required financial budget for this purpose. General director of Salzgitter AG noted that "SALCOS can't be realized without significant initial state financial support, and it should be announced quite sincerely. This request seems not to be any unusual, because other successful companies have already received public state investing support for their large state-of-the-art projects" [22].

Another German iron and steel producer – Thyssenkrupp AG – has plans to build DRI plant in Duisburg; it will have integrated melting production facilities based on hydrogen and ecologically clean energy. This project is resulted from the requirements of the hydrogen strategy which was accepted by the German government in the beginning of June 2020 and later approved by the iron and steel industries in Germany. This strategy will include transition to wide use of "green" hydrogen for steel making [23].

It should be noted that the general European program "green hydrogen" will be invested by Euro 430 billion until 2030 [24].

Of course, the disputes about climate varying issues can be continued, but if the decision about banning of production processes using "gray" power engineering will be taken, very high "carbon tax" will be established. It will finalize, in its turn, in very serious effect on development possibilities of RF iron and steel industry (e.g. standards for used fuel, noise level of airplane engines etc.) [25, 26]. That's why the required volume of current investments at present time should be considered as the base for possibility to continue production processes tomorrow.

Conclusions

The conducted analysis with comparison of the labour productivity levels in the RF and US metallurgical industries displayed that there is a tight correlation between the labour productivity level and degree of its capital-labour ratio [27]. The added value per one employee during 2010-2018 was larger in the USA in average by 2.7 times [28]. At the same time the main capital of USA exceeds the Russian main capital during the same period by 3.6 times. It can be concluded in this connection that RF labour productivity (taking into account its capital-labour ratio) is higher than in USA by 1.3 times (3.6:2.7) [29].

However, to reduce the retard of production volumes per one employee in Russian metallurgy compared with the USA, it is necessary to decrease the retard in capital-labour ratio. But we can see that this retard reduced slightly during last ten years, while it even increased if we shall calculate per one employee. It is predicted that transition to the new metallurgical technologies will have negative effect on the competitiveness level of the Russian metallurgy and will finalize in dangerous retard. As it was noted in one recent research, "Russian producers should solve the problem of rising their competitiveness with maximal speed. They can realize opportunity to restore their positions a the global market and provide serious competition to other countries only based on the complex and comprehensive approach to efficiency rise" [30].

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