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Using data from official manufacturing censuses, we compare labour productivity in Great Britain and the Russian Empire around 1908. We find that Russia's labour productivity was at 81.9 per cent of the U.K. level. Russia's productivity was on a par with France's and significantly superior to Italy's. We also find that the majority of Russian industries underperformed British ones. However, the industries that had been established or modernised during the state-induced industrialisation policies of the 1890s, such as the Southern metallurgy, performed on a par with their British counterparts. Russia's alcohol, tobacco, and petrochemical sectors outperformed their British equivalents. Our findings suggest a revision of the view that, at the turn of the 20th century, Russian manufacturing was economically underdeveloped.

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1. Introduction

Labour productivity in the early 20th century in major industrialised countries, including the U.S., the U.K., Germany and France, has been extensively studied by economic historians (Broadberry and Burhop, 2007; Broadberry and Irwin, 2006; Burhop, 2008; Crafts, 1984; Dormois, 2006b). However, labour productivity in Russia, the fourth or fifth largest manufacturer in the world (Bairoch, 1982, p. 296; League of Nations, 1945, p. 13), has received only a partial overview. Russia's labour productivity has either been studied on the aggregate country and industry level over time, typically covering the years 1887 to 1913 (Crisp, 1978; Gerschenkron, 1947; Goldsmith, 1961; Gregory, 1982, 1999; Kafengauz, 1994; Nutter, 1962; Strumilin, 1960), or based on small and non-representative samples of individual firms and industries (Kulikov & Kragh, 2019, p. 304). Russia's productivity has never been compared to the levels in other leading industrial countries.

This article provides a new benchmark estimate of comparative labour productivity in British and Russian manufacturing and mining around 1908. We calculate labour productivity using net output data and net output weights. In addition, we calculate productivity levels using net and, separately, gross output data and employment weights in both cases. In order to do so, we collect data from official manufacturing censuses in both countries. In particular, to calculate purchasing power parities (PPPs), we collect data on 37 similar products in the U.K. and Russia. This allows us to compare 32 individual industries. We also provide a new estimate of the number employed in Russian industry as a whole and compare it to the employment in British, German, and French industries.

We find that Russia's labour productivity, calculated based on net output data and net output weights, was at 81.9 per cent of the U.K. level. This estimation pertains to manufacturing and mining, in which medium- and large-size enterprises predominated. Our calculation does not include some of the industries in which small enterprises prevailed, such as clothing, construction, and bakery and restaurant businesses.

We find that Russia's productivity was on a par with France's and significantly superior to Italy's. What helped Russia achieve this relatively high performance was the highly productive and large alcohol industry. Without the alcohol sector, Russia's productivity would have been 74.8 per cent of the British level. However, we cannot consider Russian productivity without this sector because the government had made large investments in it, leading to a strong comparative advantage. Russia was also ahead in the petrochemical and tobacco sectors. Russian productivity was equivalent to British in the industries that had been established or modernised during the state-induced industrialisation policies of the 1890s. This was the case with the Southern metallurgy and, to a lesser extent, with railway carriage and wagon production. Great Britain had a substantial

productivity lead in the remaining industries, including textiles, sugar, paper, clay, stone and mining. In addition, we find that the number of individuals in Russian industry as a whole, which includes small artisanal production, was greater than in British and French industry, but not in German.

Our arguments are built as follows. Section 2 discusses Russian industry and provides an estimate of industrial employment in Russia and other industrialised countries. Section 3 describes our data. Section 4 discusses our methodology for calculating PPPs and weights. Section 5 reports our results. Section 6 compares the performance of individual Russian factories to corresponding British industries. Section 7 concludes.

2. Industry and employment in Imperial Russia

Soviet researchers perceived the development of Imperial Russia's economy as a series of economic setbacks that eventually led to the revolutions of 1905 and 1917 (Gregory, 2003, p. 9). Alexander Gerschenkron (1962) viewed tsarist Russia as a typical latecomer economy that could catch-up to the already industrialised countries only by means of state intervention. Perhaps because the Russian economy was perceived as "backward" (Gerschenkron, 1962) and "non-European" (Allen, 2003, p. 12), economic historians have devoted too little attention to it. As we discuss next, there is little research and no consensus on some fundamental issues about Russian industry, including the scale of its industrial production, its productivity level in comparison to other countries, the size of its workforce, and the role of government in its economic development.

One debatable issue concerns the size of Russian manufacturing. According to the estimates of the League of Nations (1945, p. 13), in 1913, Russia produced 5.5 per cent of global manufacturing output, which ranked it as the world's fifth largest manufacturer. Russia was not far behind France, which produced 6.4 per cent of the global output, but it lagged considerably behind the U.K. (14.0 per cent), Germany (15.7 per cent), and the U.S. (35.8 per cent).

Using the same primary source as the League of Nations, Bairoch (1982, p. 296) calculated that, in 1913, Russia's share of world industrial production was, in fact, higher. At 8.2 per cent, Russia's share surpassed that of France's (6.1 per cent), but fell short of the U.K.'s (13.6 per cent), Germany's (14.8 per cent), and the U.S.'s (32.0 per cent). However, the data used by the League of Nations and Bairoch did not include the findings by Kafengauz (1994). In the 1920s, Kafengauz showed that, in the early 20th century, Russia's manufacturing output was even higher than what was reported in the data used by Bairoch. Including Kafengauz's findings should further raise Russia's share in global output.

Another debatable question relates to the pace of structural transformation. To address this question, some researchers looked at the data on the size of the population by social estates and

the share of the population living in rural areas. According to the only general population census, in 1897, 77.1 per cent of Russia's population were of peasant origin and 85.0 per cent lived in the countryside (Rubakin, 1912, p. 54). Allen (2003, pp. 13, 25) estimated that, in 1913, 75 per cent of the entire population were employed in agriculture and concluded that '(t)he population statistics show little evidence of structural transformation' between 1861 and 1913 (Allen, 2003, p. 25). Cheremukhin et al. (2017, pp. 627, 642) estimated that, in 1913, 85 per cent of the working-age population were employed in agriculture and concluded that between 1885 and 1913, 'the economy did not experience structural transformation from agriculture' into industry and services (Cheremukhin et al., 2017, pp. 627).

However, contemporary and soviet researchers considered the share of agricultural population to be less than 75 per cent. Pogozhev (1906, p. 58) calculated that over 70 per cent of workers in large factories came from the peasant class and lived in rural areas. The special inquiry commission on the welfare of the rural population determined that, in 1900, 23.2 per cent of the working age population, in the rural part of European Russia, were employed in manufacturing, crafts, and seasonal non-agricultural work (Pogozhev, 1906, pp. 15-6). Case studies of individual companies showed that up to 85 per cent of those employed at large textile factories were peasants (Borodkin et al., 2010, p. 58).

We provide our own estimate of industrial employment in Russia, the U.K., Germany, and France. Our data cover the entire industry, including manufacturing and mining, as well as small artisanal production. The only sectors we do not cover are railroads and public services because these data are not available for all four countries. For Russia, our data come from a manufacturing census conducted in 1908, by the Ministry of Trade and Industry (1912a, p. 2). This census predominantly includes medium and large-scale enterprises. We retrieve the data on small and artisanal production from Rybnikov (1922). We take the data on the workers in the construction industry from Rashin (1958, p. 171). The British data are taken from the British manufacturing census of 1907 (Board of Trade, 1913). The German data for the years 1907-1908 and 1910 come from the German industrial census (Kaiserliches Statistisches Amt, 1912, pp. 52-54). The French data, for the year 1906, are from Dormois (2006b, table A6).

Among the four censuses, the German one provides the greatest coverage of firms. It includes large, medium, small, and micro enterprises with just one employee (Kaiserliches Statistisches Amt, 1912). The census specifies the number of workers, managerial staff and owners. It includes the full range of industries, ranging from manufacturing to mining and construction. As shown in Table 1, it covers nearly 10.4 million people, of which 1.95 million are business owners.

As shown in Table 1, the British census covers 5.9 million workers and 0.45 million managers employed in small, medium and large enterprises. Ritschl (2008, p. 547) estimates that the British census should be adjusted upward, by 25-30 per cent, to account for the lack of micro enterprises and company owners. We add 1.0 million individuals who were employed in micro enterprises (Board of Trade, 1913, p. iv). We also assume that the ratio of owners to managers and workers in small, medium and large British enterprises was the same as this ratio in German industry, or 3.0 per cent.[4] This adds 0.191 million owners. The grand total for the British industry comes out to be over 7.5 million individuals. Our adjustments increase the employment reported in the British census by 18.6 per cent, not far from what Ritschl (2008) proposed. Note that another 0.58 million individuals were employed in the British railroad and utility sectors. As noted above, we do not account for these industries because other countries did not provide data for them.

Table 1 also shows that the French industry employed over 6.2 million individuals, including workers, managerial staff, and owners (Ministere du Commerce, 1908, pp. 15-16). Like the German census, the French one covers micro, small, medium, and large enterprises (Dormois, 2004, p. 115), so there is no need to make any adjustments to the French statistics.

Lastly, Table 1 shows that the Russian census includes over 8.5 million workers in micro to large enterprises. It does not include managerial staff and owners. We assume that the ratio of owners to workers, and managers to workers, in small, medium, and large Russian enterprises, were the same as those ratios in British industry.[5] This adds over 0.92 million owners and managers. We then assume that bakery and restaurant businesses employed the same number of individuals as these trades in the U.K., or 0.1 million employees (Board of Trade, 1913, pp. 443-444). The grand total for Russian industry as a whole comes out at 9.5 million individuals.

Taken together, we conclude that Russian industrial employment was considerably larger than in the U.K. and France, but smaller than Germany. Our calculation augments earlier estimates that placed Russian employment between 7 and 9 million workers (Pogozhev, 1906, pp. 11-16; Gukhman, 1926, p. 263; Rashin, 1958, p. 171).

Another understudied issue of great debate is the role of government. Gerschenkron (1962) believed that a key factor in Russia's economic development was the state-led industrialisation of the 1890s. This was a period of protectionist policies, large inflow of foreign capital investments, and massive, multi-year state procurement orders from the Ministries of Finance, Railways, Defence, and Maritime Affairs (Gindin, 2007a). Other scholars are not so sure about the role of government. Gregory (1993, pp. 64-79; 1994, pp. 59-62) contends that the state was not a vital

[4] In Germany, there were 186,203 owners at small enterprises and 28,784 owners at medium and large enterprises (Kaiserliches Statistisches Amt, 1912).

[5] Based on the data in Table 1, the ratio of owners to workers and managers to workers in the U.K. was 3.0 and 7.6 per cent, respectively.

player in the industrialisation of the 1890s. According to him, state expenditure on industrial products, such as military hardware, were too small to affect industrial growth. McKay (1970) goes even further by arguing that the government's role was 'largely one of public relations, propaganda, and the radiation of enthusiasm' (p. 10).

Even before the 1890s, Russian industry was quite large in the production of textiles, food, oil, metallurgy, machinery, and ships (Orlov, 1887). According to Bairoch's (1982, p. 296) estimates, in 1880, the share of Russian industry in global manufacturing was 7.6 per cent, which was only slightly lower than the French share of 7.8 per cent. The state development policies of the 1890s had helped to develop heavy industry, such that by 1900, Russia surpassed France and became the fourth largest manufacturer in the world (Bairoch, 1982, p. 296).

The exceptional growth, between 1893 and 1900, was interrupted by a major financial and industrial crisis that took place between 1899 and 1902, by the disastrous war against Japan in 1904, and by the prolonged nation-wide revolution of 1905-07. This period of economic and social instability was replaced by reinvigorated industrial growth that lasted between 1909 and 1913.[6]

Various researchers calculated that, between 1887 and 1913, Russian manufacturing and mining sectors grew, on average, from a low estimate of 5.1 per cent (Goldsmith, 1961; Suhara, 2018) to a high estimate of 6.65 per cent per year (Gregory, 1999, pp. 487-488; Kafengauz, 1994, pp. 290-297). Accepting Gregory's (1999) higher estimate would mean that Russian industry grew considerably faster than the industry in major industrialised countries, including the U.S., the U.K., and Germany (Gregory, 1999, p. 488). Accepting the more conservative estimate by Goldsmith (1961) would mean that over this 26-year period, Russian industry grew on a par with major industrialised countries (Gregory, 1999, p. 488).

Despite these successes, Russian enterprises operated with substantial friction in the production process and the labour market. Competition between firms was severely distorted by subsidies to key industries, including large loans from the state to specific companies; high tariffs on industrial products from abroad; and state procurement of industrial output (Gindin, 2007a). During the crisis of 1899-1902, the government encouraged firms to form cartels and syndicates (Gindin, 2007b, p. 69). This policy further distanced the industry from perfect competition. According to Cheremukhin et al. (2017), high barriers to entry and widespread monopolies were the most important factors that slowed down Russia's industrialisation; although these factors were also widespread in other industrialised countries (Moody, 1904; Chandler, 1990).

Russian industrialists not only had significant market power, but they also dominated the labour market. Before the Revolution of 1905, workers had little protection from company owners

[6] Calculated from data in Izmesteva (1998), itself based on the data from Kafengauz (1994).

and managers. The latter benefited from a nearly total control over workers' wages and their working and living conditions (Borodkin et al., 2010). Factory inspectors, who resolved the disputes between workers and companies, simply lacked human resources to provide adequate oversight and accountability (Pushkareva et al., 2011, p. 160).

Amidst these distortions, joint-stock corporations and big businesses prospered (Gregg, 2020a; Kulikov & Kragh, 2019). Corporations owned about five per cent of all industrial factories, yet they accounted for over 40 per cent of the total output generated between 1894 and 1908 (Gregg, 2018, p. 8). Several scholars have pointed out that labour productivity in Russian industry was low in comparison to that in Western Europe (Kulikov & Kragh, 2019, p. 304). However, such studies were based on small samples and case studies of individual firms and industries.

3. Russian and British manufacturing censuses

Our data for Russia come from an official manufacturing census conducted in 1908 by the Ministry of Trade and Industry (1912a). This census was primarily compiled from the 1908 census of individual factories (Ministry of Trade and Industry, 1912b). The editor-in-chief of the census is Varzar, one of the leading economists of the time. The census includes factories operating across the entire empire, including European Russia, Siberia, Central Asia, and the Caucasus (Ministry of Trade and Industry, 1912a, p. iii). It covers nearly all sectors, including textiles, metals, chemicals, paper and printing, stone trades, and food, drink, and tobacco. As can be inferred from the census of individual factories, the manufacturing census includes establishments with as little as one worker. However, the census provides a rather limited coverage of small enterprises with about 50 workers and less (Ministry of Trade and Industry, 1912a, p. 35). The census does not fully cover the factories operating in the grain-milling and wood-processing industries and those owned by the Ministry of Defence. It does not include artisanal enterprises that did not own machinery or did not operate from a separate building. It also does not include mining, construction, clothing, food retail, restaurant, and railway industries. For every industry, the census provides detailed statistics on the quantity and the monetary value of output and the cost of materials used in production. It specifies the number of workers employed, but does not report managerial staff and owners. For a variety of individual products, the census reports the monetary value and the physical volume produced.

Overall, the census includes 2,254,503 workers employed by 20,010 factories (Ministry of Trade and Industry, 1912a, p. 2). Because the census does not fully cover the grain-milling trade, we replace the 36,241 workers reported for this industry in the census with the more inclusive data from Lyashchenko (1910, p. 104), who reports 2,416 mills and 214,065 workers. We also add the 387,868 workers in the mining industry, as estimated by the authors of the census (Ministry of

Trade and Industry, 1912a, p. 3). The grand total for the Russian manufacturing and mining comes out at 2,820,195 workers.

You can see that the 2,254,503 workers covered by the census differs from the 2,674,894 workers reported in Table 1 for medium and large manufacturing. This is because the census did not include the 37,301 workers employed at the technical institutions of the Ministry of Defence and the 387,868 workers employed in various mining trades (Ministry of Trade and Industry, 1912a, p. 3). We also excluded the 4,778 workers employed at power stations and water supply businesses from the census because the British census did not report on these businesses.

Our data for the U.K. come from the British census of 1907 (Board of Trade, 1913). We retrieve the 1907 data about railway wagons, trucks, and agricultural machinery from the census of 1924 (Board of Trade, 1931). The British data cover all enterprises across the entire U.K., except for small family-owned workshops and single proprietorships (Board of Trade, 1913, p. iii). Like the Russian census, the British one reports each industry's monetary value and quantity of output produced and the cost of materials used. The census also reports the physical volume and the monetary value for a variety of products manufactured. The census covers manufacturing and mining sectors and also construction and repair industries. It reports information on the number of workers (called wage earners in the census) and managerial staff (called salaried persons in the census), along with their wages and salaries. Overall, the census covers 6,984,976 individuals (Board of Trade, 1913, p. iii). You can derive this number from the data in Table 1 by summing the total number of workers with the workers employed in railways and utilities.

Our choice fell on the Russian census of 1908 because other major industrialised countries, including the U.K. (Board of Trade, 1913), Germany (Kaiserliches Statistisches Amt, 1912), France (Ministere du Commerce, 1908), and the U.S. (Bureau of the Census, 1913), conducted similar comprehensive censuses in this period.

To make sure that we compare the same set of industries in both countries, we exclude some industries from the British and Russian censuses. From the U.K. census, we exclude the following industries: clothing, railway construction and repair, bread and biscuit trades, explosives, ammunition, and fireworks, building and contracting, public utility services, leather, canvas, and India rubber, timber, and miscellaneous trades. As a result, we exclude 2,348,649 workers or 33.7 per cent of the total British manufacturing and mining employment. From the Russian census, we exclude the following industries: timber, animal products, and miscellaneous trades for a total of 161,380 workers or 5.8 per cent of the total Russian manufacturing and mining employment. These data allow us to compare British and Russian industries in which medium- and large-size enterprises predominated. Lastly, to take into account the fact that Russian statistics

reported only the number of workers, while the British data also reported managerial staff, we make sure not to include the latter into the British data.

As shown in Appendix Table A1, we retrieve 37 similar products from both censuses. For each product, we collect data on its physical quantity and monetary value produced. Expanding the list of products poses difficulties because the British census does not specify the quantity produced for a number of products. Also, in some cases, the type or quality of products differed in the two countries, as, for example, in the case of automobiles. Appendix Table A1 also shows the name of each British product as specified in the British census and our translation of the name of each Russian product.

The products we have collected dictate which industries we can compare. As shown in Appendix Table A2, we collect data for 32 British and Russian industries. We collect the number of workers, gross output, and the cost of materials used in the production process. We then calculate net output, which equals to gross output minus the cost of materials, and gross and net output per worker. The British data included in our benchmark industries cover 35.7 per cent of the U.K.'s total net output and 40.5 per cent of total manufacturing and mining employment. The Russian data used for our benchmark cover 72.5 per cent of Russia's total net output and 67.7 per cent of total employment in manufacturing and mining. For comparison, Broadberry & Burhop (2007), examine about 27 per cent of British and 29 per cent of German employment around 1907.

4. PPPs and industry weights

Our next step is to derive PPPs, which can be calculated from either the output or expenditure side. In other words, PPPs can be based on the differences in the output prices of products (producer prices) or expenditure prices (consumer prices). The period we study was characterised by tough protectionist policies and high logistics costs. Because of this, PPPs based on the output side can differ substantially from those based on the expenditure side (Broadberry and Burhop, 2010, pp. 401-2).

In the early 20th century, the majority of countries did not systematically collect producer prices and output volume. Given these data limitations, some scholars suggested using the official exchange rate instead (Dormois, 2006a, pp. 177-78). However, the exchange rate might differ considerably from the PPP in a particular industry. Such was the case in Russia and Great Britain, where in some industries the PPP was considerably higher than the official exchange rate of 9.45 rubles to one pound (Zandberg, 1905, pp. 998-99) and in other industries it was significantly lower, as can be seen from Appendix Table A1.

Throughout the paper, we follow the methodology of Broadberry and Burhop (2007), who compare British and German labour productivity circa 1907. We calculate labour productivity

based on PPPs from the output side. Appendix Table A1 shows the PPPs we have derived for each product. In line with the existing literature (Fremdling, 1991, p. 29), we assume that the prices of these products represent the level of all prices in relevant industries. For example, the price of pig iron and rails is assumed to represent all prices in the iron and steel trades.

The structure of industry was quite different in the two countries. British manufacturing was more oriented towards metal production, while the Russian industry was larger in the foods sector. The U.K. also had a larger share of labour force in mining compared to Russia.

As shown in Table 2, our primary weighting scheme is based on net output. Appendix Table A3 shows the weighting based on employment. We take the following steps in deriving the weights. First, net output is allocated across major sectors, highlighted in bold. Second, within major sectors, we allocate net output among the industries for which we have data available. For instance, the British textiles accounted for 94,334 thousand pounds sterling in net output, or 18.5 per cent, out of 712,135 thousand pounds sterling in the net output in the entire British industry. Among the textiles sector, we are able to collect data on three industries – cotton; wool; and jute, hemp, and linen. The net output for the cotton industry was 45,913 thousand pounds sterling, for wool it was 20,536 thousand pounds sterling, and for jute, hemp, and linen it was 5,253 thousand pounds sterling. The combined net output for these industries was 71,702 thousand pounds sterling, which meant a net output weight of 62.6 per cent for the cotton industry, 28.5 per cent for the wool industry, and 8.9 per cent for the jute, hemp, and linen industry.

5. Results

Table 3 shows our main results of labour productivity comparison, calculated based on net output per worker and weighted on net output. Appendix Table A4 shows the results calculated based on net and gross output per worker, weighted by employment in both cases. According to Broadberry and Burhop (2007, p. 319), the first of the three approaches is the more accurate way to calculate labour productivity. A value below 100 indicates a British productivity advantage, and a value above 100 indicates a Russian productivity lead.

Table 3 reveals that labour productivity in Russian manufacturing was at the level of 87.6 per cent of British manufacturing. This calculation does not include the mining industry, as we do not know its cost of materials for Russia. If we assume that its cost of materials, as a share of gross output, was the same in Russia as in Great Britain, then, overall productivity in Russia would be 81.9 per cent of the British level.

Although we do not have enough price data to calculate the productivity level in the rubber industry in Russia, we know that this industry was considered to be highly productive (Ipatiev, 1945). We use the official exchange rate and estimate that Russia's rubber industry was 148.5 per

cent as productive as the British rubber industry, based on net output and weights. We do not include the rubber industry in our overall productivity calculation, to be consistent in using only PPP.

The level of productivity in Russia should be further adjusted upwards to take into account the negative impact of the worldwide financial crisis of 1907-1908 on the Russian economy. The British data were collected in 1907, when the British economy was not yet affected by the crisis. In addition, the Russian industry was significantly and adversely affected by the nationwide revolution of 1905-1907 (Gregory, 1999, p. 477; Ministry of Trade and Industry, 1912a, p. 4). However, since it is not possible to quantify the exact upward adjustment, we do not make it.

In 1911-12, manufacturing productivity in France was at the level of 81.1 per cent of the British,[7] and Italian productivity stood at 50 per cent of the British level (Dormois, 2006a, p. 188). This means that Russia's productivity was about the same as France's and considerably higher than Italy's.

Appendix Table A4 shows that Russian industry was 71.2 per cent and 52.2 per cent as productive as the British industry based on net and gross output data, respectively, and employment weights in both cases. The difference in results, based on net and gross output data, can be partially explained by the fact that the cost of materials, as a share of gross output, was less in Russian industries than in British ones, with the exception of brewing, spirit distilling, and soap and candle trades.[8] The difference in results is also likely due to the fact that British enterprises were more specialised, while Russian enterprises produced a wider range of products (Holmogorov, 1907).

Productivity varied quite a bit among individual industries. The Russian industries that were established in the 18th and early- to mid-19th centuries had much lower productivity than their British counterparts. These industries included textiles and sugar, as well as the metallurgical factories in the Ural region that used wood fuel in their operations. The British mining industry was also much more productive than the Russian one. However, the Russian industries that were established or modernised with the help of the state in the late 19th and early 20th centuries were about as productive as their British counterparts. The Southern metallurgy, which produced about half of metal output, was 105.7 per cent as productive as British iron and steel factories. The productivity of railway carriage and wagon production was also close to Great Britain's. Finally, the Russian alcohol, tobacco, rubber, and petrochemical industries showed higher labour productivity than the analogous industries in Great Britain.

[7] In 1906-1907, French productivity was 74.1 per cent of the British level (Dormois, 2006a, p. 188).
[8] Concluded based on data in Appendix Table A2.

The alcohol sector deserves a separate discussion. Without the alcohol sector, but inclusive of mining, Russian productivity would have been 74.8 per cent of the British level based on net output data and net output weights. The beer trade in Russia was more than two times less productive than the corresponding industry in Great Britain, and the spirit distilling trade was four times less productive. Russia's comparative advantage was in the bottling industry, which was more than four times as productive as the British bottling industry. Since the 1890s, the sale of alcoholic drinks, as well as the functions of rectifying, blending and bottling, were monopolised by the Russian government (Sorokin, 2003). The making of raw alcohol remained in the hands of a few private-sector firms, which often operated with technologically-outdated machinery. However, the state monopoly was able to generate high added value because of the large investments in the technology it had introduced in the 1890s (Krshizhanovski, 1906; Grigor'eva, 2010). By 1908, the factories owned by the state were among the most technologically and organisationally advanced enterprises in Russia (Garkush, 2007; Vinogradov, 2012).

6. Data on individual factories

In this section, we examine whether our industry-level productivity estimates are representative of the productivity level of individual factories. For that, we plot the performance of individual Russian factories against their respective British industries. Our data on the Russian factories come from the 1908 census of individual factories and plants (Ministry of Trade and Industry, 1912b) and the database of individual factories and companies (Moscow Institute of Physics and Technology, 2019). Our data on British industries come from the labour productivity calculations, as discussed in the previous sections.

Appendix Figures A1-6 plot the relationship between yearly output and the number of workers for individual Russian factories, shown as dots, and a linear trend line representing this relationship for each corresponding British industry. The results shown in these figures confirm our industry-level productivity estimates.

We choose those Russian factories that, based on our reading of business literature, were considered most typical. For example, the Nevskaja Paper Spinning Manufactory was managed and owned by a British multinational firm J. & P. Coats. The manufactory had the same organisational structure and used the same technology as the firm's factories located in Great Britain (Kim, 1995). Appendix Figure A1 shows that the manufactory's productivity lay on the trend line representing the British textile industry. In contrast, the Bogorodsko-Glukhovskaya Manufactory, owned a family of old believers Morozov, was considerably less labour productive than an average factory in the British textile industry.

Appendix Figure A1 shows other textile factories. While the majority of Russian textile factories markedly underperformed their British counterparts, some larger factories performed quite closely to the British ones. A small minority of Russian textile plants outperformed British textile firms. Appendix Figure A2 displays iron and steel factories. The factories, established in the 1890s, in Southern Russia, with the help of foreign investors,[9] were equally or more productive than the British metallurgical factories. However, the factories established in the 18th and early- to mid-19th centuries, in the Ural region,[10] lagged behind British enterprises. Appendix Figure A3 shows engineering, shipbuilding and metal production. The Russian factories in this sector were approximately as labour productive as the British ones. This was true both for the state-owned factories that were supervised by the Ministry of Maritime Affairs[11] and for private-sector factories[12]. Appendix Figure A4 demonstrates chemical factories. Russian petrochemical factories[13] were more productive than the British chemical industry. However, the performance of Russian coke and benzene factories[14] fell behind. Appendix Figure A5 shows alcohol factories. While Russian beer factories[15] underperformed the British alcohol sector, the factories that rectified spirits, outperformed.[16] Appendix Figure A6 plots rubber factories. Typical Russian rubber factories outperformed their British counterparts.

7. Conclusions

To explain the economic growth in czarist Russia, scholars, from Herzen (1907) to Gerschenkron (1962), have used the concept of economic backwardness. Economic backwardness implied that labour productivity in Russia lagged behind other industrialised countries. This paper uses official manufacturing censuses of 1907 and 1908 to show that, in the early 20th century, Russian manufacturing was not economically underdeveloped. The productivity gap between Great Britain and Russia was not that significant. While the British productivity lead was evident in textiles, paper, clay, stone, and mining, Russia was ahead in the alcohol, tobacco, rubber, and petrochemical industries. Although Russia was behind in the metals industry, the gap with Britain was not large. When compared to France, Russia's productivity was on a par with them. This paper also dispels a widespread misconception that Russia's industrial labour force was small. We show

[9] Alexandrovsky Southern-Russian, Dniprovsky metallurgical and Makeevsky.
[10] Votkinskiy and Vyksunskiy.
[11] Baltiisky, Admiralteisky and Izhora.
[12] Putilovsky, Franco-Russian, St. Petersburg metal, Sormovo, Zinger and RBVZ.
[13] Mantashev and Brothers Nobel.
[14] Bereznikovsky, Ushkova and Tentelevsky.
[15] Trekhgorny, Kalinkinsky and Durdin.
[16] Kazennyj spirtoochistitel'ny and Kazennyj vinnyj ochistitel'ny.

that the number of those employed in Russian industry as a whole was greater than in British and French industries, although not in German.

What were the characteristics of the more labour-productive Russian industries? First, these industries were often highly export-oriented. The high-performing petrochemical, rubber, and butter industries exported a great share of their products, as can be seen from export statistics (Valetov, 2017). Second, these industries tended to invest heavily in research and development, as can be referred from the database of individual companies and the research centers they owned (MIPT, 2019). Successful firms collaborated with leading scientists, including Mendeleev, Ipatiev, Markovnikov, Lebedev, Ostromyslensky, and Byzov (Ostromyslensky, 1913; Ipatiev, 1945). The state often acted as a key facilitator of innovativeness. Authorities provided technical education, funded research projects and helped attract foreign investors (Kojevnikov, 2002). Third, the more labour productive firms often expanded into related industries (Gregg, 2020b). Such was the case with the firms owned by Nobel, Gukasov, Mantashev, Lianozov, and Shibaev, who had initially made large profits in the oil business (Kulikov, 2017; Kulikov and Kragh, 2019). These companies made large investments in electrical engineering, machine-building, shipbuilding, and chemical industries, as a result, forming large vertically and horizontally integrated industrial groups (Bovykin, 2001; Salomatina, forthcoming).

Future research could address the questions that have already been answered with respect to other major industrial nations. Specifically, it would be possible to study the trends in Russia's labour productivity over a long time period, spanning between 1869 and 1917, and to compare these trends to the shifts in workers' real wages.

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Table 1: Number of employees and owners in Russia, Great Britain, Germany, and France, circa 1908

	Great Britain			**France**	**Germany**				**Russian Empire**		
	workers & managers in 1907			**workers & mgrs in 1906**	**workers, managers, & owners in 1907**				**workers in 1908**		
	Salaried persons	Wage-earners	Total	Total	Micro enterprises	Small enterprises	Large & med. enterprises	Total	Small enterprises	Large & med. enterprises	Total
Textiles	42,267	1,210,777	1,253,044	914,000	172,058	181,834	734,388	1,088,280	1,708,500	823,324	2,531,824
Clothing	75,161	681,305	756,466	1,551,000	926,751	209,003	168,099	1,303,853		n/a	
Metals	115,655	1,343,267	1,458,922	856,700	408,703	419,737	1,228,862	2,057,302	421,900	589,258	1,011,158
Food and drink	63,069	400,617	463,686	479,100	615,847	353,745	270,353	1,239,945	364,100	386,814	750,914
Chemical, petro, rubber	20,218	131,663	151,881	124,600	25,999	70,527	168,925	265,451	62,200	117,543	179,743
Paper	38,253	287,222	325,475	176,700	28,225	67,968	134,732	230,925	28,300	88,008	116,308
Glass and porcelain	7,664	111,190	118,854	166,800					66,900	68,889	135,789
Clay and stone	5,031	81,729	86,760	46,600	315,309	615,131	633,154	1,563,594	86,100	66,640	152,740
Construction	37,966	481,660	519,626	550,000					1,500,000		1,500,000
Mining	18,052	947,178	965,230	280,000	67,262	327,779	1,236,425	1,631,466	n/a	387,868	387,868
Leather	6,575	54,110	60,685	376,800	83,961	49,723	73,289	206,973	631,500	52,806	684,306
Timber	24,431	214,764	239,195	704,700	327,148	271,813	172,098	771,059	965,900	93,744	1,059,644
Total	**454,342**	**5,945,482**	**6,399,824**	**6,227,000**	**2,971,263**	**2,567,260**	**4,820,325**	**10,358,848**	**4,335,400**	**2,674,894**	**8,510,294**
Micro enterprises			1,000,000								100,000
Owners			191,824								905,422
Grand Total			**7,591,648**	**6,227,000**				**10,358,848**			**9,515,716**

Notes: In Germany, micro enterprises are those with 5 or less employees, small enterprises are those with 6 to 50 employees, large and medium size enterprises are those with more than 50 employees. In Germany, there were 186,203 owners at small enterprises and 28,784 owners at medium and large enterprises.
For the U.K., we assume that the ratio of owners to managers and workers at small, medium, and large British enterprises was the same as this ratio in German industry, or 3.0 per cent. For Russia, we also assume that the ratio of owners to workers and managers to workers at small, medium, and large Russian enterprises were the same as this ratio in British industry, or 3.0 and 7.6 per cent, respectively. We also assume that bakery and restaurant businesses (adjustment for micro enterprises) employed the same number of individuals as these trades in the U.K.
Sources: Russia: Rashin (1958, p. 171), Rybnikov (1913, 1922, 1923), and Varzar (1912). United Kingdom: Board of Trade (1913). Germany: Kaiserliches Statistisches Amt (1912, pp. 52-54). France: Dormois (2006, table A6).

Table 2: Net output weights in Great Britain and Russia, circa 1908. Industries for which net output data are available.

Industry	U.K. net output weights	Russian net output weights
	net output data	
Textiles	**24.1**	**23.6**
Cotton	64.0	68.4
Wool	28.6	21.9
Jute, hemp, linen	7.3	9.7
Iron and steel, engineering, shipbuilding, and metal	**37.8**	**18.9**
Iron and steel	32.6	43.4
Copper and zinc	3.2	2.3
Iron and steel tubes	2.3	2.1
Railway carriages	3.8	23.2
Engineering trades	58.1	29.0
Food, drink, and tobacco	**19.9**	**40.9**
Flour	10.1	36.2
Sugar	5.2	12.1
Beer	64.8	5.3
Butter and cheese	1.8	2.5
Spirit distilling	2.3	4.3
Animal fat	1.7	1.0
Tobacco	9.1	3.4
Bottling	4.9	35.4
Chemical and allied trades	**5.1**	**9.7**
Chemicals, coal tar products, drugs, and perfumery trades	72.2	30.0
Oils	5.9	65.4
Soap and candle trades	21.9	4.7
Paper, printing, and allied trades	**8.6**	**3.6**
Paper	100.0	100.0
Clay, stone	**4.4**	**3.4**
Cement	26.4	40.4
Bricks	73.6	59.6
Mines and quarries	**n/a**	**n/a**
Salt mining	n/a	n/a
Coal mining	n/a	n/a
Iron ore mining	n/a	n/a
Total	**100.0**	**100.0**

Notes: Excluded the following UK industries: clothing; railways construction, repair; bread and buscuit trades; explosives, ammunition, and fireworks; building and contracting; public utility services; miscellaneous trades; leather, canvas, and indiarubber; timber; and mines and quarries. Excluded the following Russian industries: miscellaneous trades, timber, animal products, and mines and quarries..
Sources: See Appendix 1.

Table 3: Labour productivity based on net output data and net output weights in Great Britain compared to Russia, circa 1908

	U.K. / Russia net output (U.K. = 100)
Textiles	**62.2**
Cotton	57.1
Wool	80.4
Jute, hemp, linen	47.4
Iron and steel, engineering, shipbuilding, and metal	**67.5**
Pig and cast iron	54.6
Copper and zinc	58.9
Iron and steel tubes	98.6
Railway carriages	90.8
Engineering trades	70.4
Food, drink, and tobacco	**142.1**
Flour	54.3
Sugar	6.8
Beer	43.1
Butter and cheese	105.8
Spirit distilling	22.2
Animal fat	26.8
Tobacco	411.7
Bottling	421.4
Chemical and allied trades	**76.5**
Chemicals, coal tar products, drugs, and perfumery trades	64.2
Oils	109.3
Soap and candle trades	35.8
Paper, printing, and allied trades	**47.8**
Paper	47.8
Clay, stone	**45.9**
Cement	52.9
Bricks	42.4
Mines and quarries	**44.9**
Iron ore mining	n/a
Coal mining	n/a
Salt mining	n/a
Total	**87.6**

Sources: See Appendix 1.

Table A1: Purchasing power parity for matched British and Russian products

Product	**Country**	**Source** page number	**Unit of measure**	**Quantity** units of measure 1000s	**Value** local currency 1000s	**Unit value** local currency per kg	**PPP by value weight** rubles to £	**PPP geometric** rubles to £
Textiles								
Yarn, twist and weft	UK	337	lbs	1,487,367	78,304	0.12	11.62	
Plain and twisted cotton yarn	Russia	20	poods	7,104	156,166	1.35	11.62	11.62
Sheep and lamb's wool, and other sorts	UK	342	lbs	31,395	1,453	0.10	9.30	
Soft and rugged wool	Russia	42	poods	343	5,307	0.95	9.30	9.30
Jute and twist yarn, hemp yarn and tow, linen yarn and flax tow yarn	UK	348	lbs	369,454	6,226	0.04	13.94	
Ruffled and combed flax; ruffled hemp; jute, hemp, linen yarn and tow	Russia	70	poods	3,002	25,370	0.52	13.94	13.94
Food, drink, and tobacco								
Wheat flour and meal and offals	UK	492	cwt	117,400	51,708	0.01	10.73	
Wheat and rye flour and bran	Russia	52, 104	poods	1,286,244	1,951,232	0.09	10.73	10.73
Sugar	UK	521	cwt	8,995	8,995	0.02	14.30	
Refined sugar	Russia	457	poods	148,033	148,033	0.22	14.30	14.30
Beer	UK	524	barrels	34,505	58,580	0.01	6.31	
Beer	Russia	457	bucket	78,024	64,265	0.07	6.31	6.31
Butter, made or blended & cheese	UK	509	cwt	1,175	6,033	0.10	7.22	
Cheese and butter	Russia	409	poods	92	1,098	0.73	7.22	7.22
Plain spirit	UK	527	gallons	48,086	3,709	0.02	12.18	
Plain spirit	Russia	457	poods	22,035	74,144	0.21	12.18	12.18
Grease, tallow, animal fat, and stearine	UK	577	tons	55	1,459	0.03	13.12	
Fish and seal fat; lamb, beef, and bone fat; stearin	Russia	353	poods	1,065	6,042	0.35	13.12	13.12
Snuff tobacco	UK	538	cwt	14	307	0.43	0.02	
Snuff tobacco	Russia	457	poods	258	1,354	0.32	0.03	
Manufactured tobacco	UK	538	cwt	628	12,987	0.41	0.97	
Tobacco	Russia	457	poods	4,987	33,152	0.41	0.96	0.99
Wines, bottled	UK	532	gallons	3,052	1,342	0.10	10.45	
State-monopoly wine	Russia	457	poods	19,664	323,838	1.01	10.45	10.45

Table A1: Purchasing power parity for matched British and Russian products (continued)

Product	**Country**	**Source** page number	**Unit of measure**	**Quantity** units of measure 1000s	**Value** local currency 1000s	**Unit value** local currency per kg	**PPP by value weight** rubles to £	**PPP geometric** rubles to £
Chemical and allied trades								
Sulphuric acid	UK	571	tons	475	861	0.002	10.30	
Sulfuric acid	Russia	481	poods	2,362	1,174	0.03	2.38	
Nitric acid	UK	571	tons	6	91	0.02	0.71	
Nitric acid	Russia	481	poods	90	243	0.16	0.32	
Hydrochloric acid	UK	571	tons	198	241	0.00	4.43	
Hydrochloric acid	Russia	481	poods	1,548	793	0.03	2.47	
Coal tar, crude, refined, and varnish	UK	571	tons	46	80	0.002	0.93	
Coal tar	Russia	482	poods	674	309	0.03	0.61	
Toilet soap	UK	572	tons	2	126	0.08	1.37	
Toilet soap	Russia	482	poods	279	5,727	1.25	10.54	17.01
Crude oil	UK	74	tons	177	357	0.002	1.58	
Oil extracted	Russia	489	poods	456,983	96,311	0.01	5.68	
Lubricating oils	UK	74	tons	29	117	0.00	1.03	
Lubricating oil	Russia	489	poods	15,085	12,640	0.05	1.48	
Lamp oils	UK	74	tons	76	376	0.00	1.59	
Light and heavy kerosene, paraffin	Russia	489	poods	87	43	0.03	0.00	
Paraffin wax and candles	UK	74	tons	25	601	0.02	9.82	
Paraffin and paraffin candles	Russia	489	poods	4	35	0.57	0.01	10.03
Glycerine, crude and distilled	UK	583	tons	16	604	0.04	1.10	
Glycerin	Russia	353	poods	200	2,014	0.62	0.94	
Candles	UK	583	tons	48	1,829	0.04	4.57	
Tallow, paraffin, stearin, and wax candles	Russia	353	poods	1,396	19,595	0.86	12.60	
Soap, household and laundry	UK	583	tons	287	6,194	0.02	7.59	
Soap, tallow, olive and other types	Russia	353	poods	2,297	8,955	0.24	2.83	
Soft soap	UK	583	tons	29	432	0.02	0.76	
Liquid soap	Russia	353	poods	1,175	4,607	0.24	2.08	16.08

Table A1: Purchasing power parity for matched British and Russian products (continued)

Product	Country	Source	Unit of measure	Quantity	Value	Unit value	PPP by value weight	PPP geometric
		page number		units of measure 1000s	local currency 1000s	local currency per kg	rubles to £	rubles to £
Iron and steel, engineering, ship-building, and metal								
Pig and cast iron	UK	171	tons	9,092	40,336	0.004	5.40	
Cast iron	Russia	273	poods	55,586	24,195	0.03	3.18	
Rails	UK	171	tons	777	4,655	0.01	1.07	
Rails	Russia	273	poods	21,403	21,538	0.06	4.85	7.21
Copper, unwrought	UK	264	tons	40.90	3,422	0.08	9.59	
Copper	Russia	273	poods	1,289	16,858	0.80	9.59	9.59
Iron and steel tubes and pipes and fittings	UK	179	tons	300.00	6,040	0.02	10.83	
Iron and steel pipes	Russia	274	poods	2,760	9,805	0.22	10.83	10.83
Railway wagons, trucks, and parts	UK	328, 329	units	55.88	17,349	310.45	8.17	
Wagons and spare parts	Russia	275	units	10.41	26,410	2,536.01	8.17	8.17
Argicultural machinery and parts	UK	231, 233	tons	43.00	1,144	0.03	10.44	
Argicultural machinery and spare parts	Russia	276	poods	3,445	15,592	0.28	10.44	10.44
Mines and quarries								
Iron ore	UK	76	tons	6,802	1,987	0.0003	11.16	
Iron ore	Russia	480	tons	5,391	17,574	0.003	11.16	11.16
Coal	UK	66	tons	266,588	119,553	0.0004	10.54	
Coal and anthracite	Russia	475	tons	25,904	122,483	0.005	10.54	10.54
Rock and white salt	UK	81	tons	1,244	576	0.0005	11.17	
Rock and other types of salt	Russia	489-490	tons	1,872	9,679	0.005	11.17	11.17
Paper, printing, and allied trades								
Various paper	UK	624	tons	812	11,960	0.01	14.52	
Various paper	Russia	120	poods	14,261	49,716	0.21	14.52	14.52
Clay, stone								
Cement	UK	775	tons	2,877	3,439	0.001	15.00	
Cement, romanesque, portland and other types	Russia	313	poods	55,087	16,095	0.02	15.00	15.00
Bricks, of brick-earth and fireclay	UK	775	pieces	4,760	6,329	1.33	9.76	
Bricks, ordinary, slag and silicate	Russia	313	pieces	1,401	18,191	12.98	9.76	9.76

Notes: Geometric mean for tobacco products comes out to be 0.99. In our calculations of labour productivity, we use the foreign exchange rate of 9.46. 1 UK lbs = 0.453 kg; 1 Russian pood = 16.3 kg; 1 UK cwt = 50.8 kg; 1 UK barrel = 160 liters; 1 Russian bucket = 12.3 liters; 1 UK gallon = 4.55kg; 1 degree (gradus) of spirit = 0.00595 poods

Sources: Board of Trade (1913) for all British products and Varzar (1912) for all Russian products. With the exception of the Russian data on (1) wheat and rye flour that come from Lyashchenko (1910), (2) iron ore, (3) coal and anthracite, and (4) salt that come from Kafengauz (1994).
The UK data on (1) railway wagons, trucks, and parts and (2) argicultural machinery and parts that come from Board of Trade (1931).

Table A2: British and Russian censuses of production data

Industry	**Country**	**Source**	**Employment**	**Gross output**	**Cost of materials**	**Net output**	**Gross output per worker**	**Net output per worker**
as specified in the primary source		page number	1000s	1000s local currency			rubles	
	UK		1253.044					
Textiles	Russia		823.324					
Cotton trade	UK	337, 339	559.573	174,610	128,697	45,913	3,625	953
Cotton-processing (all industries)	Russia	10, 11	492.33	958,478	690,345	268,133	1,947	545
Woollen and worsted trades	UK	324, 346	254.378	75,905	55,369	20,536	2,774	751
Wool-processing (all industries)	Russia	30-31	142.049	241,781	156,098	85,683	1,702	603
Jute, hemp, and linen trades	UK	349, 350	79.856	18,747	13,494	5,253	3,272	917
Jute, hemp, and linen-processing (all industries)	Russia	60-61	87.720	94,329	56,181	38,148	1,075	435
	UK		353.344					
Food, drink, and tobacco	Russia		564.638					
Grain-milling trade	UK	492, 493	29.112	65,322	58,869	6,453	22,436	2,216
Flour-milling production	Russia	104	214.065	1,951,232	1,693,670	257,563	9,115	1,203
Sugar and glucose trades	UK	521, 522	5.836	12,315	9,024	3,291	30,184	8,066
Sugar-refining production; sugar production; beetroot-sugar	Russia	426-429	157.337	289,283	203,318	85,965	1,839	546
Brewing and malting trades	UK	524, 525	68.996	67,250	25,833	41,417	6,151	3,788
Brewing and mead	Russia	420-421	22.959	67,339	29,893	37,446	2,933	1,631
Butter, cheese, and margarine trades	UK	509, 510	7.754	10,164	8,996	1,168	9,465	1,088
Canned food, cheese, dairy and butter production; oil and oil extraction	Russia	366-369	15.456	93,577	75,798	17,779	6,054	1,150
Spirit distilling trade	UK	527	5.632	4,833	3,352	1,481	10,450	3,202
Distillery; yeast-distillery production	Russia	410-413	42.899	112,637	82,182	30,455	2,626	710
Oil and tallow trades	UK	577, 578	4.6	6,603	5,490	1,113	18,834	3,175
Intestinal-washing, intestinal-string, albumin; tallow; stearin; bone	Russia	324-326, 328, 330-331	8.092	32,426	25,543	6,883	4,007	851
Tobacco trade	UK	538	33.88	23,870	18,053	5,817	697	170
Tobacco production	Russia	430-431	34.209	58,145	34,238	23,907	1,700	699
Bottling trades	UK	532, 533	16.753	12,795	9,655	3,140	7,985	1,960
State wine warehouses	Russia	432-433	30.473	344,925	93,319	251,606	11,319	8,257

Table A2: British and Russian censuses of production data (continued)

Industry	**Country**	**Source**	**Employment**	**Gross output**	**Cost of materials**	**Net output**	**Gross output per worker**	**Net output per worker**
as specified in the primary source		page number	1000s	1000s local currency			rubles	
	UK		115.098					
Chemical and allied trades	Russia		107.491					
Chemicals, coal tar products, drugs, and perfumery trades	UK	572, 573	46.04	24,025	14,448	9,577	8,875	3,538
Chemical production; gas (coal tar); cosmetics and pharmacy	Russia	458-459, 464-465	18.872	68,902	26,015	42,887	3,651	2,273
Shale oil works	UK	74	3.043	2,371	1,594	777	7,811	2,560
Oil extraction; oil refineries; oil products	Russia	485-486	33.422	199,729	106,207	93,522	5,976	2,798
Soap and candle trades	UK	583, 584	15.596	12,218	9,312	2,906	12,597	2,996
Soap and tallow candles production; stearin and stearin candles production; wax production and wax candles	Russia	326-329, 332-333	6.224	43,720	37,042	6,678	7,024	1,073
Rubber trade	UK	687, 688	21.556	8,908	5,932	2,976	3,905	1,305
Rubber products	Russia	466-467	14.068	64,797	37,537	27,260	4,606	1,938
	UK		1412.048					
Iron and steel, engineering, shipbuilding, and metal	Russia		551.957					
Iron and steel trades	UK	174, 175	247.404	105,322	74,815	30,507	3,068	889
Iron-smelting, iron-casting, and iron and steel plants	Russia	206-207	183.139	202,363	113,516	88,847	1,105	485
Copper and brass trades	UK	264, 265	19.956	17,285	14,321	2,964	8,307	1,425
Copper plants	Russia	208-209	5.601	10,000	5,298	4,702	1,785	839
Wrought iron and steel tube trade	UK	179	18.907	6,548	4,359	2,189	3,749	1,253
Tube-rolling	Russia	164-165	3.559	9,275	4,878	4,397	2,606	1,235
Railway carriage and wagon trades	UK	226, 227	27.105	9,850	6,274	3,576	2,969	1,078
Locomotive and railway carriage	Russia	170-171	48.672	85,306	37,682	47,624	1,753	978
Engineering trades	UK	191, 192	422.427	102,952	48,535	54,417	2,544	1,344
Production of agricultural machinery; mechanical and electrical engineering	Russia	166-167, 170-173	62.678	109,908	50,560	59,348	1,754	947

Table A2: British and Russian censuses of production data (continued)

Industry	**Country**	**Source**	**Employment**	**Gross output**	**Cost of materials**	**Net output**	**Gross output per worker**	**Net output per worker**
as specified in the primary source		page number	1000s	1000s local currency			rubles	
	UK		965.23					
Mines and quarries	Russia		387.868					
Iron mines and quarries	UK	76	11.046	1,999	251	1,748	2,020	1,766
Iron ore industry	Russia	480	29.705	17,574			592	
Coal and ironstone mines	UK	66, 67	824.822	122,637	16,547	106,090	1,568	1,356
Coal industry	Russia	475	174.061	122,483			704	
Salt mines, brine pits, and salt works	UK	81	4.433	667	348	319	1,680	804
Salt industry	Russia	489-490	11.514	9,679			841	
	UK		325.475					
Paper, printing, and allied trades	Russia		88.008					
Paper trade	UK	624, 625	38.642	13,621	9,079	4,542	5,120	1,707
Paper industry	Russia	90-91	32.300	59,218	32,854	26,364	1,833	816
	UK		205.614					
Clay, stone	Russia		135.529					
Cement trade	UK	775	13.86	3,735	1,780	1,955	4,041	2,115
Cement production	Russia	288-289	8.964	16,481	6,454	10,027	1,839	1,119
Brick and fireclay trades	UK	769, 770	65.866	8,324	2,867	5,457	1,234	809
Brick and tile	Russia	294-295	43.109	19,781	4,984	14,797	459	343

Sources: Board of Trade (1913) for all British industries and Varzar (1912) for all Russian industries. With the exception of the data on the Russian plour-milling industry that come from Lyaschenko (1910) and the data on the Russian iron ore, coal, and salt industries that come from Kafengauz (1994).

Table A3: Employment weights in Great Britain and Russia, circa 1908. Industries for which data on net / gross output data are available.

Industry	U.K. employment weights	Russian employment weights	U.K. employment weights	Russian employment weights
	gross output data		net output data	
Textiles	**27.1**	**31.0**	**34.2**	**36.3**
Cotton	62.6	68.2	62.6	68.2
Wool	28.5	19.7	28.5	19.7
Jute, hemp, linen	8.9	12.1	8.9	12.1
Iron & steel, engineering, shipbuilding, & metal	**30.5**	**20.8**	**38.5**	**24.3**
Iron and steel	33.6	60.3	33.6	60.3
Copper and zinc	2.7	1.8	2.7	1.8
Iron and steel tubes	2.6	1.2	2.6	1.2
Railway carriages	3.7	16.0	3.7	16.0
Engineering trades	57.4	20.6	57.4	20.6
Food, drink, & tobacco	**7.6**	**21.2**	**9.6**	**24.9**
Flour	16.9	40.7	16.9	40.7
Sugar	3.4	29.9	3.4	29.9
Beer	40.0	4.4	40.0	4.4
Butter and cheese	4.5	2.9	4.5	2.9
Spirit distilling	3.3	8.2	3.3	8.2
Animal fat	2.7	1.5	2.7	1.5
Tobacco	19.6	6.5	19.6	6.5
Bottling	9.7	5.8	9.7	5.8
Chemical & allied trades	**2.5**	**4.0**	**3.1**	**4.7**
Chemicals, coal tar products, drugs, & perfumery trades	71.2	32.2	71.2	32.2
Oils	4.7	57.1	4.7	57.1
Soap & candle trades	24.1	10.6	24.1	10.6
Paper, printing, and allied trades	**7.0**	**3.3**	**8.9**	**3.9**
Paper	100.0	100.0	100.0	100.0
Clay, stone	**4.4**	**5.1**	**5.6**	**6.0**
Cement	17.4	17.2	17.4	17.2
Bricks	82.6	82.8	82.6	82.8
Mines and quarries	**20.8**	**14.6**	**n/a**	**n/a**
Salt mining	1.3	13.8	n/a	n/a
Coal mining	98.2	80.9	n/a	n/a
Iron ore mining	0.5	5.3	n/a	n/a
Total	**100.0**	**100.0**	**100.0**	**100.0**

Notes: Excluded the following UK industries: clothing; railways construction, repair; bread and buscuit trades; explosives, ammunition, and fireworks; building and contracting; public utility services; miscellaneous trades; leather, canvas, and indiarubber; and timber. Excluded the following Russian industries: miscellaneous trades, timber, and animal products.
Sources: See Appendix 1.

Table A4: Labour productivity based on net and gross output data and employment weights in Great Britain compared to Russia, circa 1908

Industry	U.K. / Russia gross output (U.K. = 100)	U.K. / Russia net output (U.K. = 100)
Textiles	**53.3**	**61.7**
Cotton	53.7	57.1
Wool	61.4	80.4
Jute, hemp, linen	32.9	47.4
Iron and steel, engineering, shipbuilding, and metal	**51.4**	**65.3**
Pig and cast iron	36.0	54.6
Copper and zinc	21.5	58.9
Iron and steel tubes	69.5	98.6
Railway carriages	59.0	90.8
Engineering trades	68.9	70.4
Food, drink, and tobacco	**70.4**	**118.6**
Flour	40.6	54.3
Sugar	6.1	6.8
Beer	47.7	43.1
Butter and cheese	64.0	105.8
Spirit distilling	25.1	22.2
Animal fat	21.3	26.8
Tobacco	244.0	411.7
Bottling	141.8	421.4
Chemical and allied trades	**54.6**	**73.2**
Chemicals, coal tar products, drugs, and perfumery trades	41.1	64.2
Oils	76.5	109.3
Soap and candle trades	55.8	35.8
Paper, printing, and allied trades	**35.8**	**47.8**
Paper	35.8	47.8
Clay, stone	**38.6**	**44.2**
Cement	45.5	52.9
Bricks	37.2	42.4
Mines and quarries	**44.8**	**n/a**
Iron ore mining	29.3	n/a
Coal mining	44.9	n/a
Salt mining	50.0	n/a
Total	**52.2**	**71.2**

Notes: Excluded the following UK industries: clothing; railways construction, repair; bread and buscuit trades; explosives, ammunition, and fireworks; building and contracting; public utility services; miscellaneous trades; leather, canvas, and indiarubber; and timber. Excluded the following Russian industries: miscellaneous trades, timber, and animal products.
Sources: See Appendix 1.

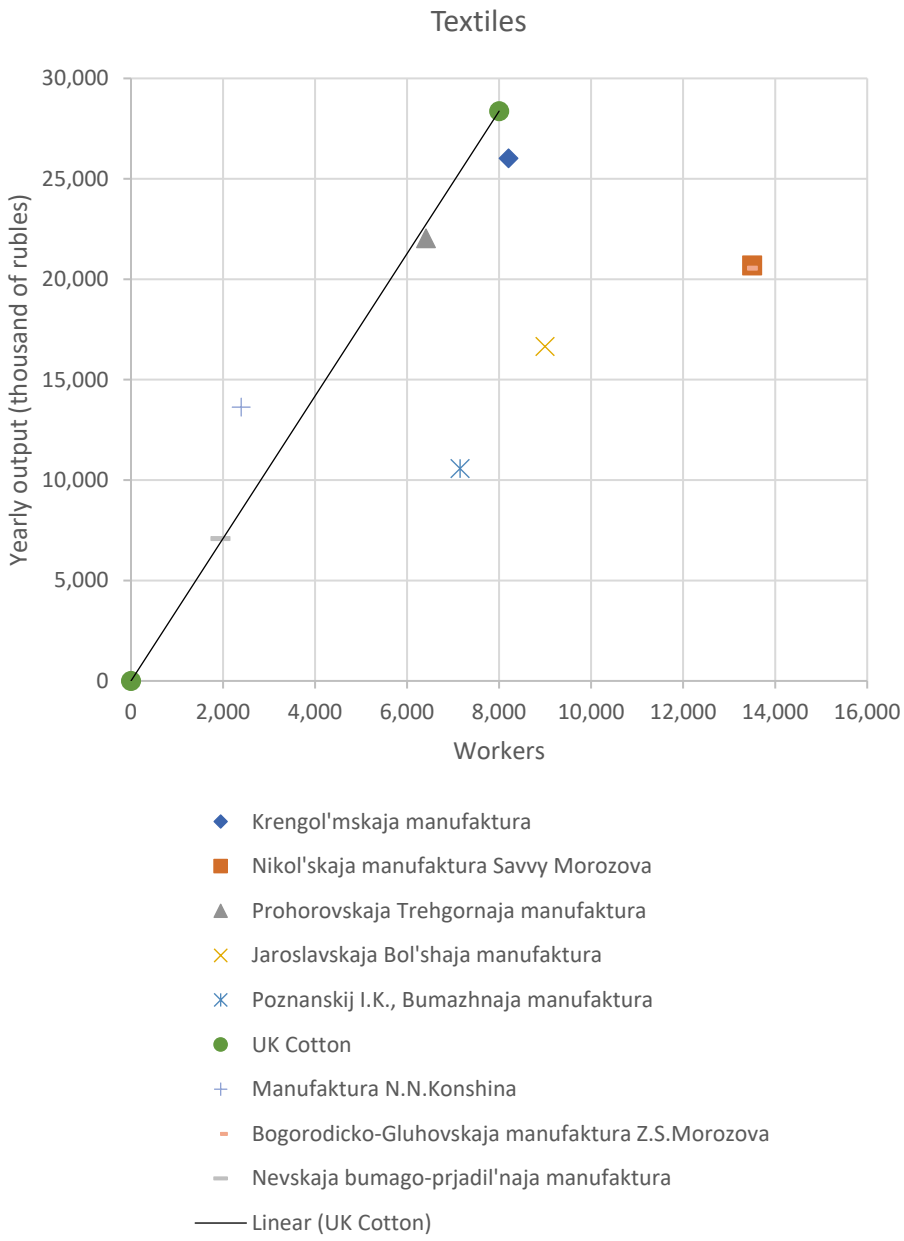

Figure A1. Labour productivity of individual Russian textile factories and a corresponding British industry.
Sources: Ministry of Trade and Industry (1912b); Moscow Institute of Physics and Technology (2019).

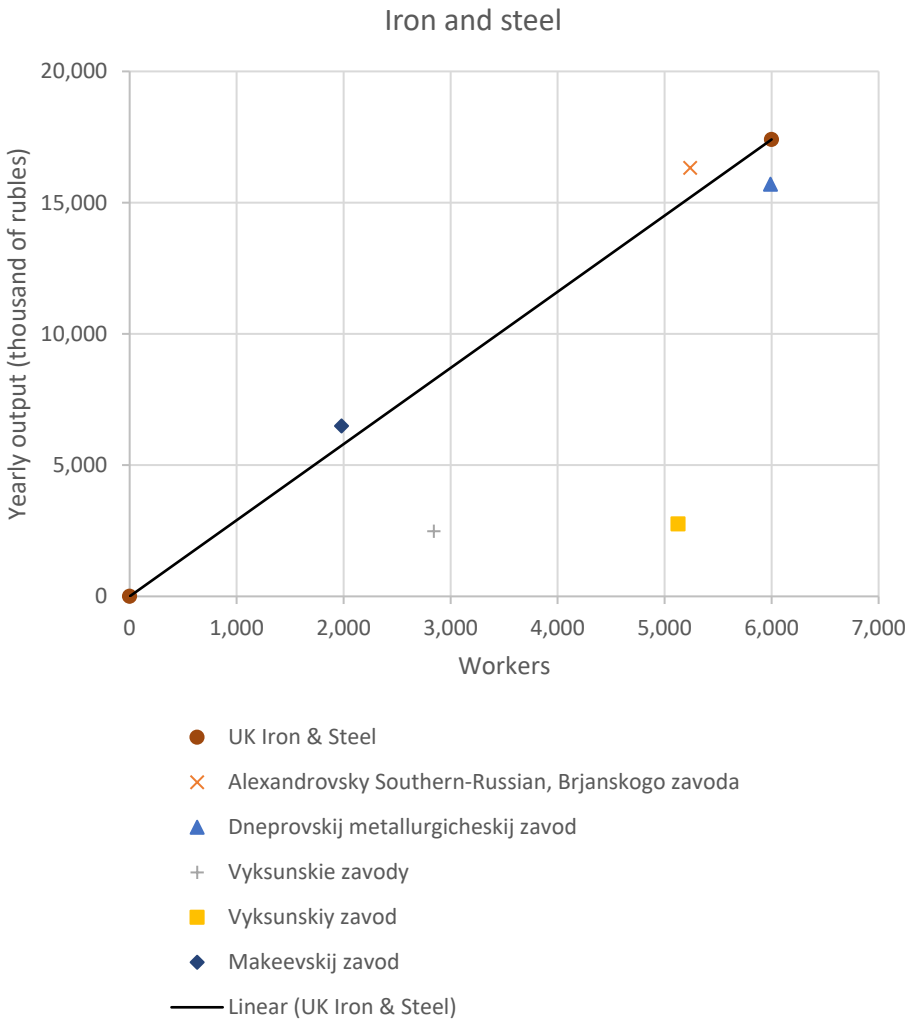

Figure A2. Labour productivity of individual Russian iron and steel factories and a corresponding British industry.
Sources: Ministry of Trade and Industry (1912b); Moscow Institute of Physics and Technology (2019).

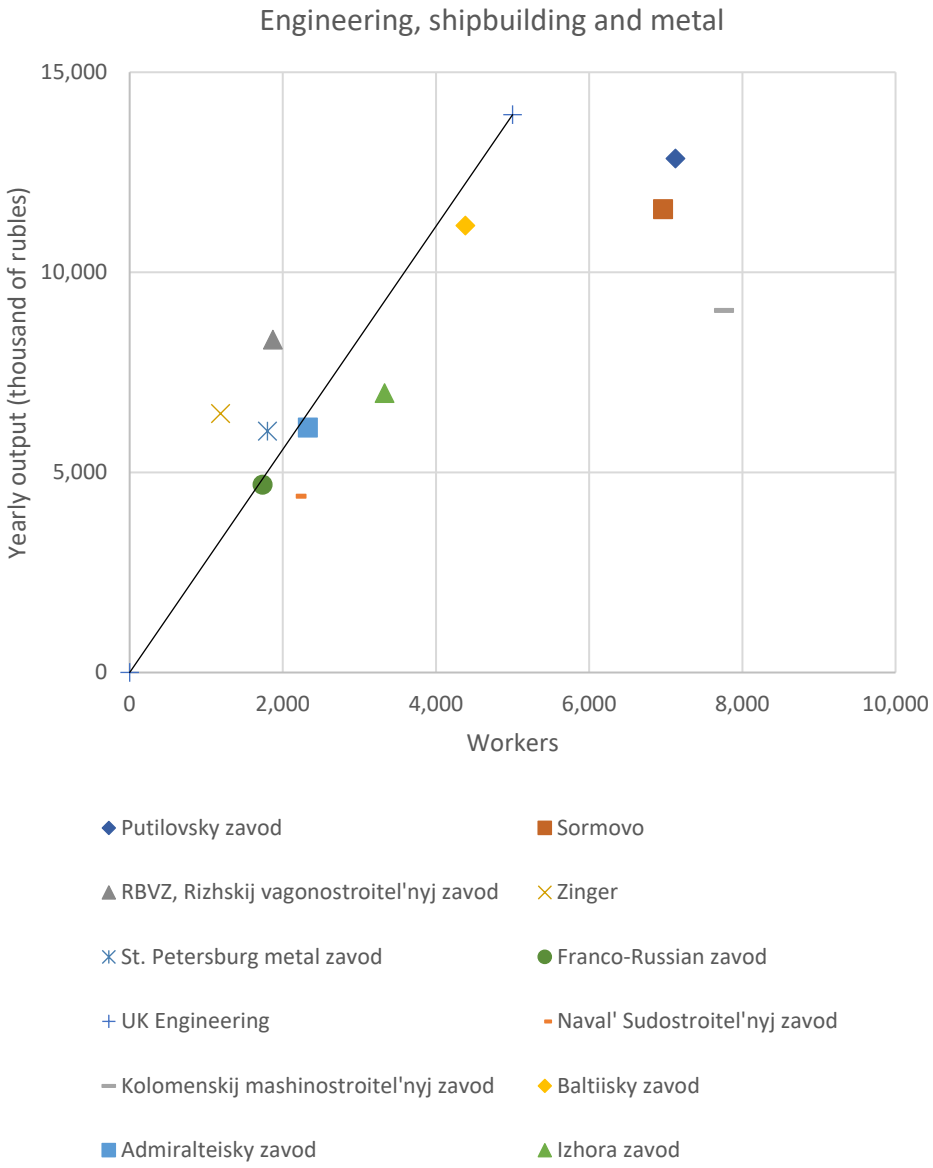

Figure A3. Labour productivity of individual Russian engineering, shipbuilding, and metal factories and a corresponding British industry.
Sources: Ministry of Trade and Industry (1912b); Moscow Institute of Physics and Technology (2019).

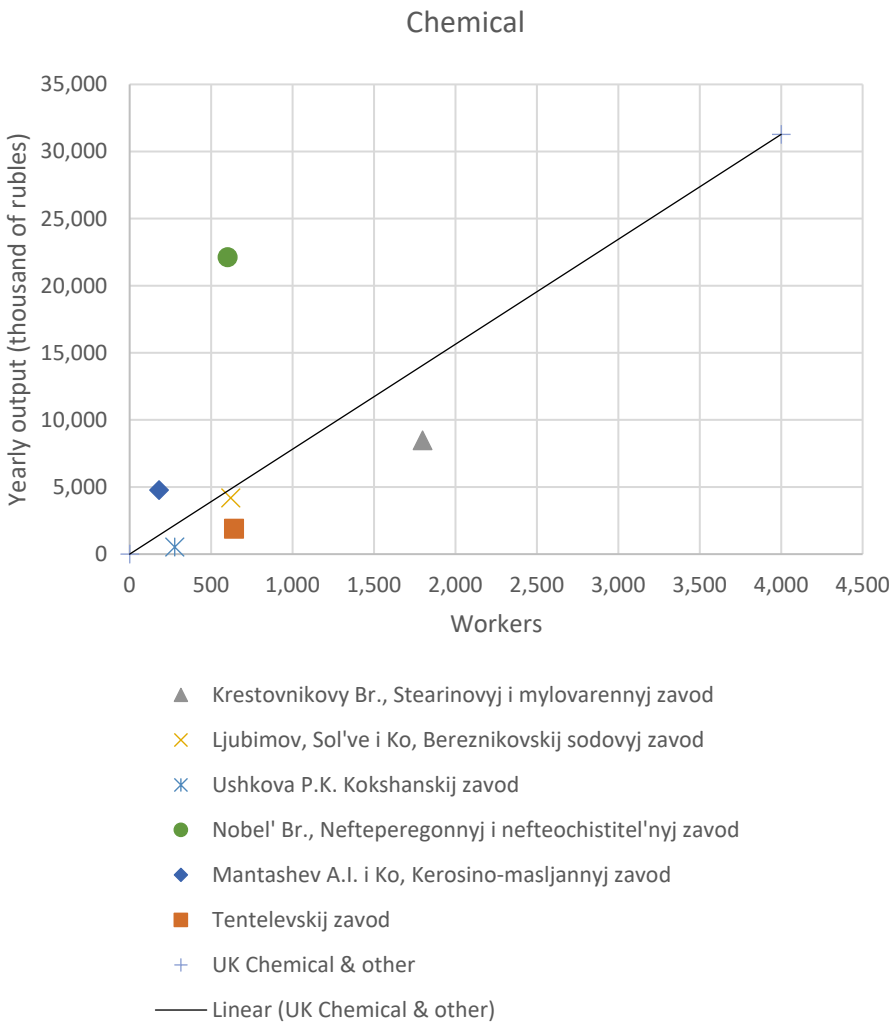

Figure A4. Labour productivity of individual Russian chemical factories and a corresponding British industry.
Sources: Ministry of Trade and Industry (1912b); Moscow Institute of Physics and Technology (2019).

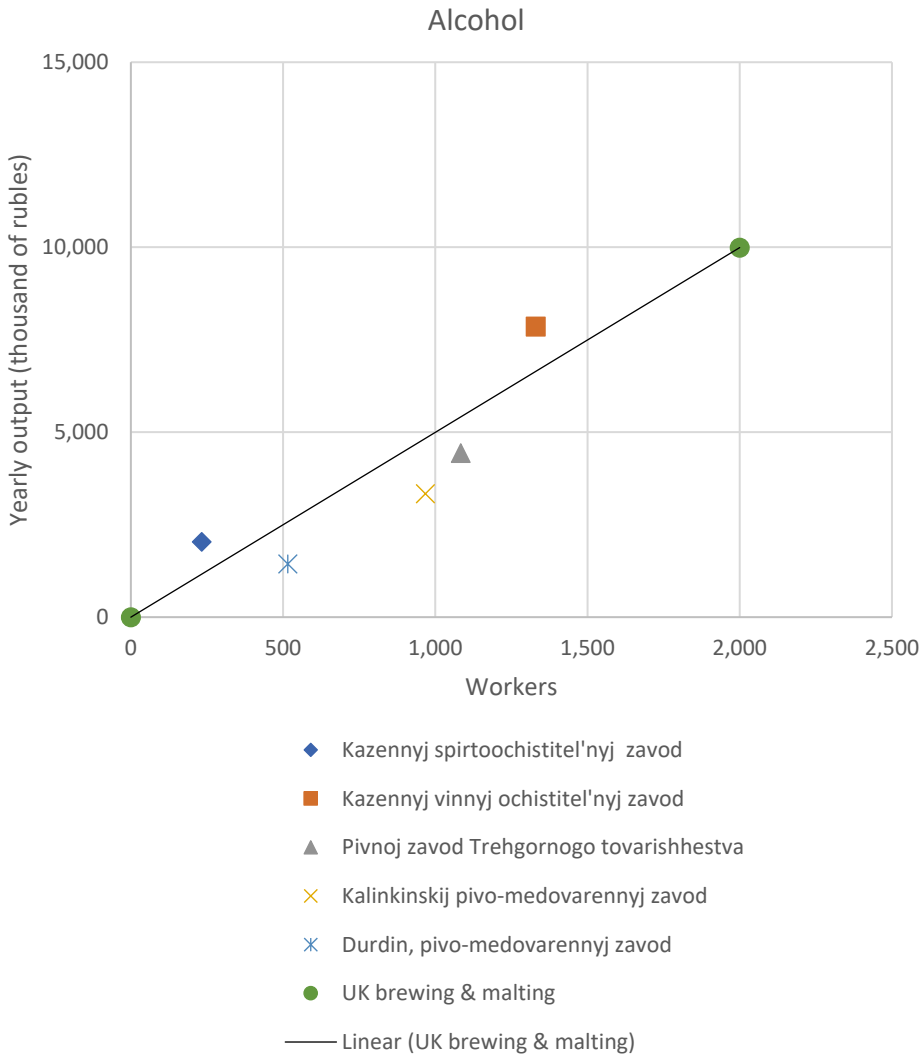

Figure A5. Labour productivity of individual Russian alcohol factories and a corresponding British industry.
Sources: Ministry of Trade and Industry (1912b); Moscow Institute of Physics and Technology (2019).

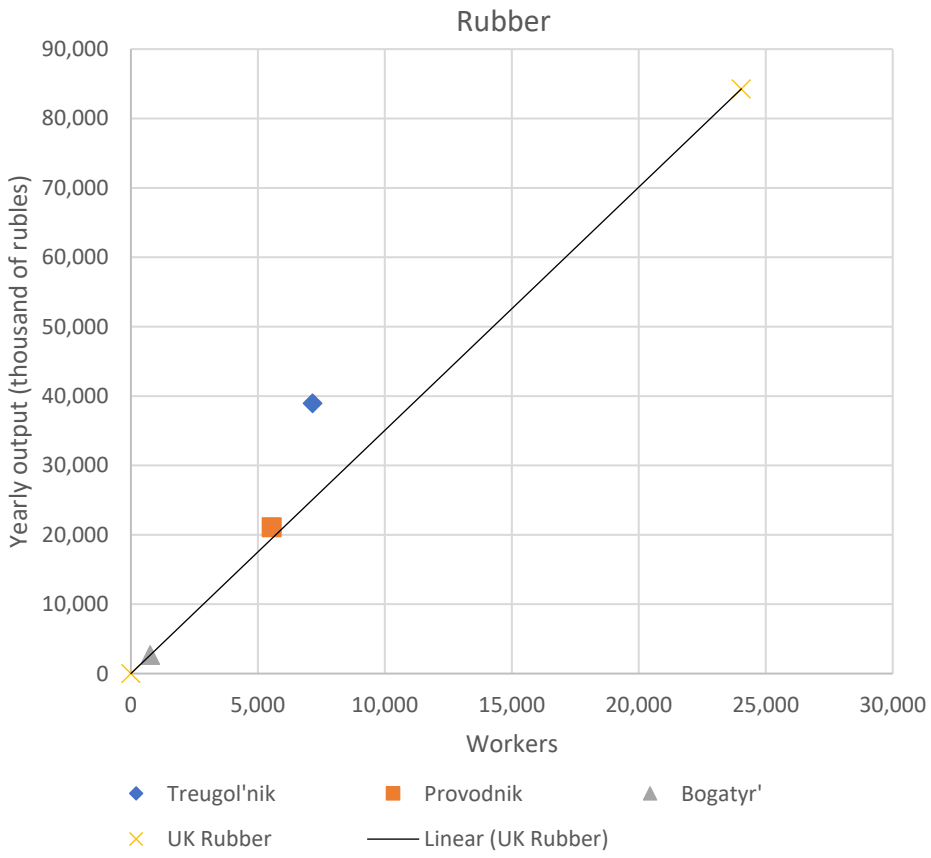

Figure A6. Labour productivity of individual Russian rubber factories and a corresponding British industry.
Sources: Ministry of Trade and Industry (1912b); Moscow Institute of Physics and Technology (2019).

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