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Drivers of Firm-Level Productivity in Russia's Manufacturing Sector

Željko Bogetić
Olasupo Olusi

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Abstract

This note presents the results of an empirical analysis of firm-level productivity growth in Russia's manufacturing sector during the period 2003–08 using a rich Amadeus database as well as the recent EBRD/World Bank Business Enterprise and Performance surveys (BEEPs). The results show that productivity grew steadily between 2003 and 2008, with an annual growth rate averaging 4 percent over the period, showing no signs of a slowdown from the previous period after the 1998 crisis.

Firm characteristics such as size, location, age, and the structure of firm ownership are important determinants of productivity, as evidenced by positive effects of scale economies (large firm effect), agglomeration (Moscow-city effect), private ownership, and a firm's industry dominance. Supplemental analysis of the quality of infrastructure—water, electricity, transport, and the internet—using BEEPS data show that infrastructure quality gaps reduce firm productivity with water supply gaps having the largest impact.

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Željko Bogetić and Olasupo Olusi[1]

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1 The authors are lead economist and economist, respectively, in the Poverty Reduction and Economic Management Department (ECSPE) of the Europe and Central Asia Region, World Bank. Corresponding author: Željko Bogetić (e-mail: zbogetic@worldbank.org).

1. Introduction

Russia experienced a well-documented productivity surge over the period 1999-2005, following the 1998 crisis. This contributed to a dynamic growth and poverty reduction. Estimated annual total factor productivity (TFP) growth of 5.8 percent was the driving force behind the observed average annual real GDP growth of 6.5 percent over this period (Alam et al. 2008). Part of the productivity surge is explained by better utilization of excess capacity, especially in the manufacturing sector, a key driver of Russia's growth, but also within-firm factors and inter-sectoral allocation of labor. Productivity in manufacturing itself—an important engine of Russia's growth—grew at a healthy rate of over 4 percent in this period. At the same time, infrastructure constraints began to limit firm activities, as evidenced by several firm surveys. Extending the Alam et al. study, the questions arise whether Russia was able to sustain such productivity growth in a more recent period and how firm-level characteristics and infrastructure gaps affected productivity growth.

This note, with a limited scope, aims to analyze the impact of firm characteristics and infrastructure deficiencies in Russia for the more recent period 2003-08 using the Amadeus database; next, we use the 2004 and 2008 BEEPs data for Russia to explore the firm-level links between infrastructure and productivity. More specifically, we seek to answer the following questions: Did Russia's manufacturing productivity growth slow in the latter part of the past decade, as conjectured by some analysts who attributed Russia's pre-global crisis growth to only high oil prices? What are the firm-specific characteristics that correlate with manufacturing productivity growth? Who are the productive firms in Russia? Which factors contributed most to the observed performance? And, finally, what role infrastructure gaps played in productivity dynamics.

2. The Empirical Approach

(i) Estimating TFP

We estimate total factor productivity (TFP) for Russian manufacturing firms using the Generalized Method of Moments (GMM) model developed in Levinsohn and Petrin (2003) that accounts for endogeneity in productivity functions. This approach recognizes that profit-maximizing firms respond to positive productivity shocks by expanding output via mobilization of additional inputs. By contrast, firms experiencing negative productivity shocks reduce output by reducing the use of inputs. The GMM model is superior in this regard to the alternative OLS functions which yield biased estimates of productivity under these circumstances.

Levinsohn and Petrin (2003) assume a Cobb-Douglas production function of the form:

$$y_t = \beta_0 + \beta_l l_t + \beta_k k_t + \beta_m m_t + \omega_t + \eta_t \tag{1}$$

where y_t is the logarithm of the firm's output, most often measured as gross revenue or value added (measured as gross revenue in this paper); l_t and m_t are the logarithm of the freely variable inputs labor and the intermediate input (materials); and k_t is the logarithm of the state variable capital (fixed assets). The demand for the intermediate input m_t is assumed to depend on the firm's state variables k_t and ω_t;

$$m_t = m_t(k_t, \omega_t) \tag{2}$$

The demand function is assumed to be monotonically increasing in ω_t, allowing the inversion of the intermediate demand function, so ω_t can be written as a function of k_t and m_t:

$$\omega_t = \omega_t(k_t, m_t) \tag{3}$$

Substituting into (1) yields:

$$\widehat{\omega_t} = exp\left(y_t - \widehat{\beta_l} l_t - \widehat{\beta_k} k_t - \widehat{\beta_m} m_t\right) \tag{4}$$

which is solved using GMM.

(ii) Growth and Productivity Decomposition

Using standard growth accounting methodology, we assess the impact of each of the factor inputs (TFP, labor, capital) on the growth of firms' output. Taking logarithms and differentiating a standard Cobb-Douglas, three-factor production function, we obtain the following growth accounting equation, expressed in value-added form (i.e. output less materials):

$$\frac{dY}{Y} = \alpha_i \frac{dK}{K} + \alpha_{ii} \frac{dL}{L} + \frac{dA}{A}, \qquad \text{and,} \tag{5}$$

$$\alpha_i + \alpha_{ii} = 1 \tag{6}$$

This shows that firms' output growth (first derivative of Y) can be decomposed into three sources of growth: (a) the contribution from growth in the physical capital stock (the derivative of *K*), (b) the contribution from growth in the labor force (the derivative of *L*),

and (c) the contribution from growth in TFP. Furthermore, $\alpha_i, and\ \alpha_{ii}$ are the respective coefficients of the factor inputs, which are assumed to be subject to constant returns to scale.

We investigate the allocative efficiency of each industry within the manufacturing sector by decomposing total productivity along the lines of Olley and Pakes (1996):

$$Prod_t = \sum_i \omega_{it} Prod_{it} = \overline{Prod_t} + \sum_i (\omega_t - \overline{\omega}_t)\left(Prod_{it} - \overline{Prod_t}\right)$$

where $Prod_t$ is the total productivity of the industry, $Prod_{it}$ is firm-level productivity, ω_{it} is the share of activity for the firm, and a bar over a variable represents the unweighted industry average of the firm-level measure. The simple interpretation of this decomposition is that aggregate productivity is composed of two terms: un-weighted average firm-level productivity and a cross-term (i.e. the sample covariance between productivity and output share) that reflects the extent to which firms with higher than average productivity have a greater market share. The higher the covariance, the higher the share of output that goes to more productive firms, and the higher is industry productivity. In other words, when efficiency is positive, it means that most productive firms have a larger market share.

To better understand the dynamics of productivity growth, we breakdown the sources of aggregate productivity growth across manufacturing industries into various components using the methodology in Foster et al (2001) as follows:

$$\Delta P_t = \sum_{Continuers} \theta_{it-k} \Delta p_{it} + \sum_{Continuers} \Delta\, \theta_{it}(p_{it-k} - P_{t-k}) + \sum_{Continuers} \Delta\, \theta_{it} \Delta p_{it} + \sum_{Entries} \Delta\, \theta_{it}(p_{it} - P_{t-k}) - \sum_{Exits} \Delta\, \theta_{it-k}(p_{it-k} - P_{t-k})$$

where Δ is changes over the *k*-years' interval between the first year *(t-k)* and the last year *(t)*; θ_{it} is the share of firm *i* in the given industry at time *t* (expressed in output or employment); p_i is the productivity of firm *i*; and P_t is the aggregate (weighted average) productivity level of the firm. The components of the equation can be defined as follows:

- The first term is the *within effect*, which is productivity growth within each firm, weighted by initial output shares. It also reflects the impact of productivity growth in individual sectors on aggregate productivity in the economy.

- The second term, the *between effect*, captures the gains in aggregate productivity arising from the expanding market of high-productivity firms or from shrinking shares of low-productivity firms weighted by the initial shares. Hence a positive between effect means that aggregate productivity rises because the sector displays higher than average productivity and factor inputs are moving into it.
- The third term is the *cross effect* or covariance, which is positive if the firms that are gaining market shares (and increasing factor usage) are also those with above-average productivity growth or negative if the firms that are downsizing are the more productive ones.
- The fourth term is the *entry effect*, which is the sum of the differences between each entering firm's productivity and the initial productivity in the industry, weighted by the market share of the entering firm.
- The fifth and final term is the *exit effect*, which is the sum of differences between each exiting firm's productivity and the initial productivity in the industry weighted by the market share of the exiting firm. [2]

This breakdown of the five components can also be presented differently as three components (see Bartelsmann and Scarpetta, 2007):

- the *within* component;
- a *reallocation* component, which is the sum of the *between-effect* and *cross-effect* components described earlier. It captures the productivity gains from reallocating factor inputs across firms; and,
- the *net entry* component (also known as firm turnover or firm churning) reflects the productivity gains resulting from the creation of new, more productive firms and the exit of obsolete firms, calculated as the sum of the *entries* and *exits* terms.

For the purposes of this study, we analyze growth between two time periods: 2003 and 2008. Therefore, we define *continuing firms* as firms with data in both years; *new entrants* began operation after 2003; and *exiting firms* are firms that left the dataset after 2003.

A caveat on productivity decomposition: One potential problem with our methodologies is that the presence of measurement errors in assessing market shares and relative productivity will yield spurious decomposition. This needs to be given careful consideration here, since we excluded firms in the top (bottom) one percentile of TFP to minimize the impact of outliers. As a result, our calculations of market shares and

[2] One potential problem with this methodology is that the presence of measurement errors in assessing market shares and relative productivity will yield spurious decomposition. This problem is carefully considered here, since we exclude firms in the top (bottom) one percentile of TFP to minimize the impact of outliers. As a result, our calculations of market shares may be distorted, especially as many industries in Russia consist of large market-dominant firms. As a result, we present two results on decomposition, the first using the full sample (i.e. including outliers), and the second without outliers.

aggregate productivity in each sector may be distorted, to the extent that many industries in Russia consist of large market-dominant firms which in many cases recorded large TFPs. Consequently, while we discuss results of the decomposition that excludes outliers, we also present results using the full sample (i.e. including outliers) in the Annex.

(iii) Productivity and Firm Characteristics

Finally, to investigate the basic correlates of firm productivity, we regress the productivity of manufacturing firms on a set of core firm characteristics, as follows:

$$LnTFP = \alpha + \sum_{n} \varphi_n X_{i,t}^{n} + \varepsilon_{i,t}$$

where $TFP_{i,t}$ is the TFP of firm *i* operating at time *t*, which is calculated according to the semi-parametric estimation technique developed by Levinsohn and Petrin (2003); and $X^{n}_{i.t}$ is a vector of *n* firm characteristics, each with coefficient φ .

The vector of firm characteristics includes a rich set of variables relevant for productivity. These include ***size*** (according to the official definition of the Russian government contained in Federal Law #209-FZ, 2007),[3] ***market share*** (the percentage of the firm's revenue relative to total revenue of the sector (NACE level 4 classification)); ***industry structure*** (based on the Herfindahl index of market concentration—NACE level 4 classification); and ***dummy variables*** for each of the following: ***location*** in the capital city (Moscow); ***new entrants*** (ages 0 or 1); ***exiting firms*** (firms that cease commercial operations); a quadratic ***age*** function (defined as the square of firm age divided by 1000, similar to Alam et al 2007), industry (NACE level 4 classification), and ***year*** dummies. The model is estimated with White's (1980, 1982) heteroscedasticity-consistent GLS estimators.

3. The Data

[3] The following are the definition of firm sizes according to the Russian Law: *Micro*–firms with the number of employees less than 15, maximum annual revenue from sales of RUB 60 million (or EUR 1.64 million); *Small*—between 15 and 100 employees, with annual revenue from sales max RUB 400 million (EUR 10.94 million); *Medium-sized firms:* between 101 and 250 employees, and RUB 1 billion (EUR 27.64 million); There are no specific thresholds for large firms but they are implicitly defined as all those above the largest medium-size threshold.

The data on key variables required to compute firm-level TFP, are obtained from the Amadeus database.[4] The sample covers 78,704 manufacturing firms (NACE 10 – 35 i.e. 25 manufacturing sectors divided into 270 four-digit manufacturing sub-sectors) for which data are available for the Russian Federation, over the period 2003 to 2008. Firms' output, capital stock, materials, and labor, are proxied by operating revenue (turnover), tangible fixed assets, cost of goods sold, and the number of employees, respectively. This provides an unbalanced panel of about 204,000 observations. This number of observations is the result of data cleaning procedures similar to those used in Alam et al (2008) that excludes: (i) missing observations on any of the key variables for estimated productivity functions; (ii) observations including a positive number of subsidiaries in order to prevent double counting of firms and also to avoid the inclusion of shell companies which are not directly involved in the production process; (iii) observations involving ratios greater than 1 between material and output; and (iv) observations with TFP (post-estimation) greater (less) than one percent standard deviation to minimize the impact of outliers. Full description of the characteristics of the sample is presented in Annex 1.

4. Results and Discussion

(i) Productivity Dynamics and Output Growth

The Levensohn and Petrin (2003) estimates of the Cobb-Douglas production function for Russian manufacturing firms over the period 2003 to 2008 indicate diminishing returns to scale (results are summarized in table 1). All factor inputs are statistically significant. However, the null hypothesis of constant returns to scale is rejected overall, even at the one percent level of statistical significance i.e., increasing all three factor inputs by 100 percent increases output by less than 100 percent (94 percent in this case).

[4] Amadeus is a database of comparable financial information (in a standardized format) for public and private companies, on over 18 million companies across 43 Western and Eastern European countries. It includes comprehensive information on all main dimensions of firm operations and performance (e.g., the profit and loss account, and the balance sheet). For more detail on this database, please see http://bvdinfo.com/Products/Company-Information/International/AMADEUS.aspx.

Table 1: Levinsohn-Petrin (2003) productivity estimator (dependent variable: ln TFP)

	Coefficients	*z-statistic*
Log of Labour (no. of workers)	*0.09****	*24.83*
Log of Capital Stock (tangible fixed assets)	*0.07****	*8.89*
Log of Materials (cost of goods sold)	*0.78****	*39.11*
Wald test of constant returns to scale: Chi2 = 29.89 (p = 0.0000)		

*** indicates significance at the 1 percent level.

Average productivity of manufacturing firms increased steadily from 2003 to 2008, albeit at an uneven annual growth rate: TFP grew by about 3 percent in 2004, and by nearly 6 percent in 2008 (Figure 1). This results in an average annual TFP growth of 4 percent over the whole period, similar to what was found in Alam et al (2007) for the period 1999-2003. Contrary to conjectures of some analysts attributing Russia's growth mostly to high oil prices, there is no sign of an obvious slowdown in TFP growth in Russia's manufacturing over the entire decade 1999-2008. The result of rising productivity is robust to the effects of "survivorship bias" i.e., both firms within the panel (14,067 firms) (mainly new and exiting firms) and those outside the panel have seen an increase in TFP, although non-panel firms have experienced a faster growth rate averaging 4.5 percent, compared to 2.7 percent for panel firms (Figure 2).

Figure 1: Average Productivity of Russian Manufacturing Firms.

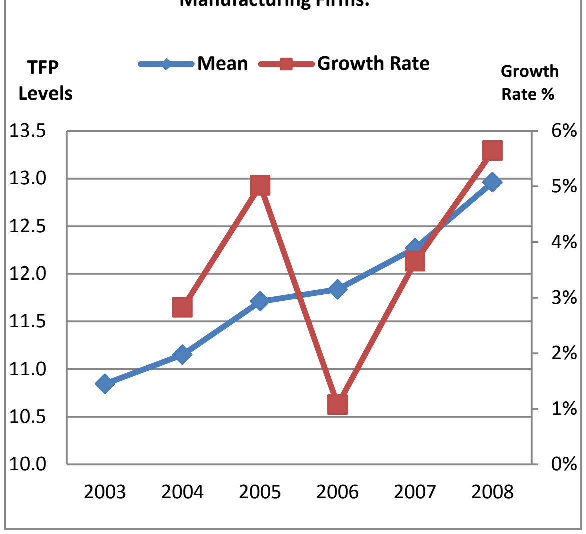
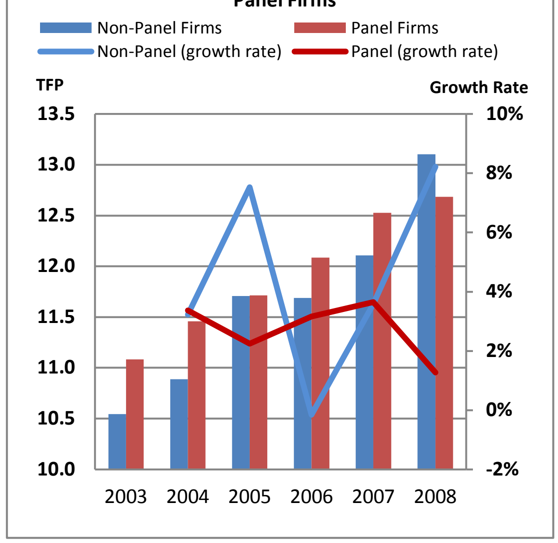
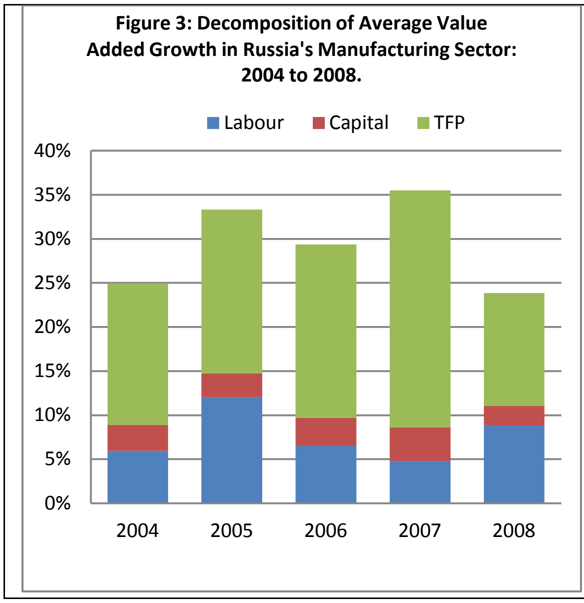
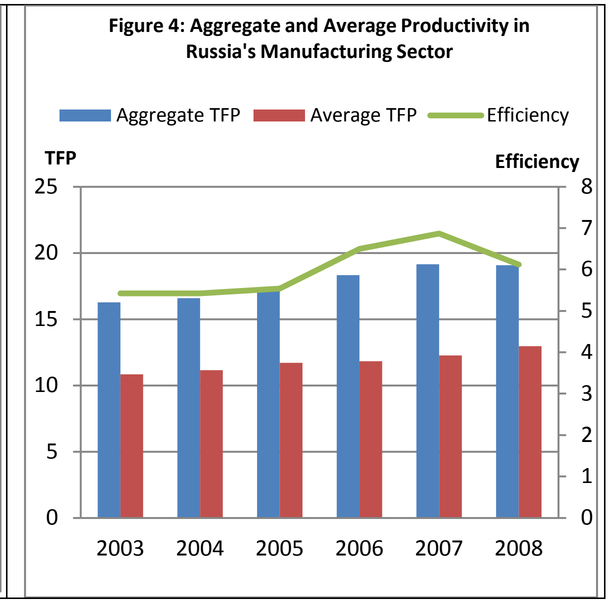


Figure 2: Average Productivity - Panel Vs. Non-Panel Firms



The result of the growth accounting decomposition shows that output growth within the manufacturing sector has been driven primarily by TFP gains: TFP accounted for an average 63 percent of the annual growth in output (value-added) from 2004 to 2008 as shown in Figure 3. The contribution of labor and capital accumulation to Russia's manufacturing output remains low, in line with evidence from Alam et al (2008).





(ii) Productivity Decomposition

The most productive manufacturing firms are found to have a larger market share. The result of the Olley-Pakes decomposition shows, in the first instance, that efficiency is positive in the aggregate (see Figure 4). Moreover, the efficiency increased during the period of observation, slowly at first (between 2003 and 2005), then sharply from 2005, peaking in 2007 – meaning that there was a persistent increase in the share of output from the most productive firms in the entire manufacturing sector until the economic crisis that started in 2008. However, at the industry level (2-digit), the efficiency dynamics varied slightly (see Table 2). While efficiency estimates in all industries are positive through the years, indicating a higher productivity of market-dominant firms, the scale of efficiency in a number of industries –

Table 2: Olley-Pakes (1996) Decomposition of Allocative Efficiency (i.e. Aggregate TFP minus Average TFP) by NACE 2-digit Industry Classification of Manufacturing Firms.

NACE 2 Industry	2003	2004	2005	2006	2007	2008
Food Product	4.64	3.66	4.43	5.21	4.27	5.19
Beverages	6.23	7.02	7.79	8.44	8.39	5.83
Tobacco	5.96	3.80	4.66	5.94	6.38	4.76
Textiles	1.26	1.49	1.59	2.10	2.89	3.93
Apparel	3.21	2.56	2.75	3.52	3.77	6.55
Leather	2.49	2.52	2.52	3.40	3.54	3.37
Wood	3.08	2.91	2.92	4.39	4.52	5.21
Paper	4.24	4.52	4.92	4.62	3.97	4.85
Printing	2.76	2.82	3.16	3.15	3.12	3.66
Coke & Refined Petrol Products	6.52	5.80	8.92	10.37	12.68	11.87
Chemicals	4.43	5.81	6.13	5.90	6.87	4.79
Basic Pharmaceutical	9.27	9.48	9.94	11.74	10.62	9.80
Rubber	4.18	3.69	3.29	4.20	4.48	5.84
Non-metallic	3.23	3.07	3.11	4.46	4.77	4.92
Basic Metal	10.52	12.52	9.40	10.72	9.63	6.29
Fabricated Metals	3.62	3.38	2.99	3.66	4.58	4.43
Computer	2.37	2.24	2.24	3.07	3.51	3.35
Electrical	3.20	3.06	2.84	4.38	4.12	4.25
Machinery & Equipment	2.12	2.92	2.90	4.01	4.27	4.72
Motor Vehicles	3.89	4.03	4.72	6.70	8.77	7.71
Other Transport	4.14	2.36	3.12	3.50	2.77	3.26
Furniture	2.20	2.26	2.17	3.06	3.00	3.32
NEC	4.74	3.38	3.65	5.04	5.80	6.00
Machine Repair & Installation	1.55	1.25	1.90	2.94	2.45	3.37
Utilities	4.30	4.39	4.21	5.60	7.89	6.97

Beverages, Tobacco, Basic Metal, and other Transport – had declined through 2008, by 6.4%, 20.2%, 40.2%, and 21.1%, respectively, suggesting a decrease in the share of output of the most productive firms in these sectors. On the other hand, efficiency in some sectors, like Textiles, Apparels, Machinery and Equipment (including Repair and Installation), more than doubled over the period.[5]

[5] See the Annex for results using the full sample.

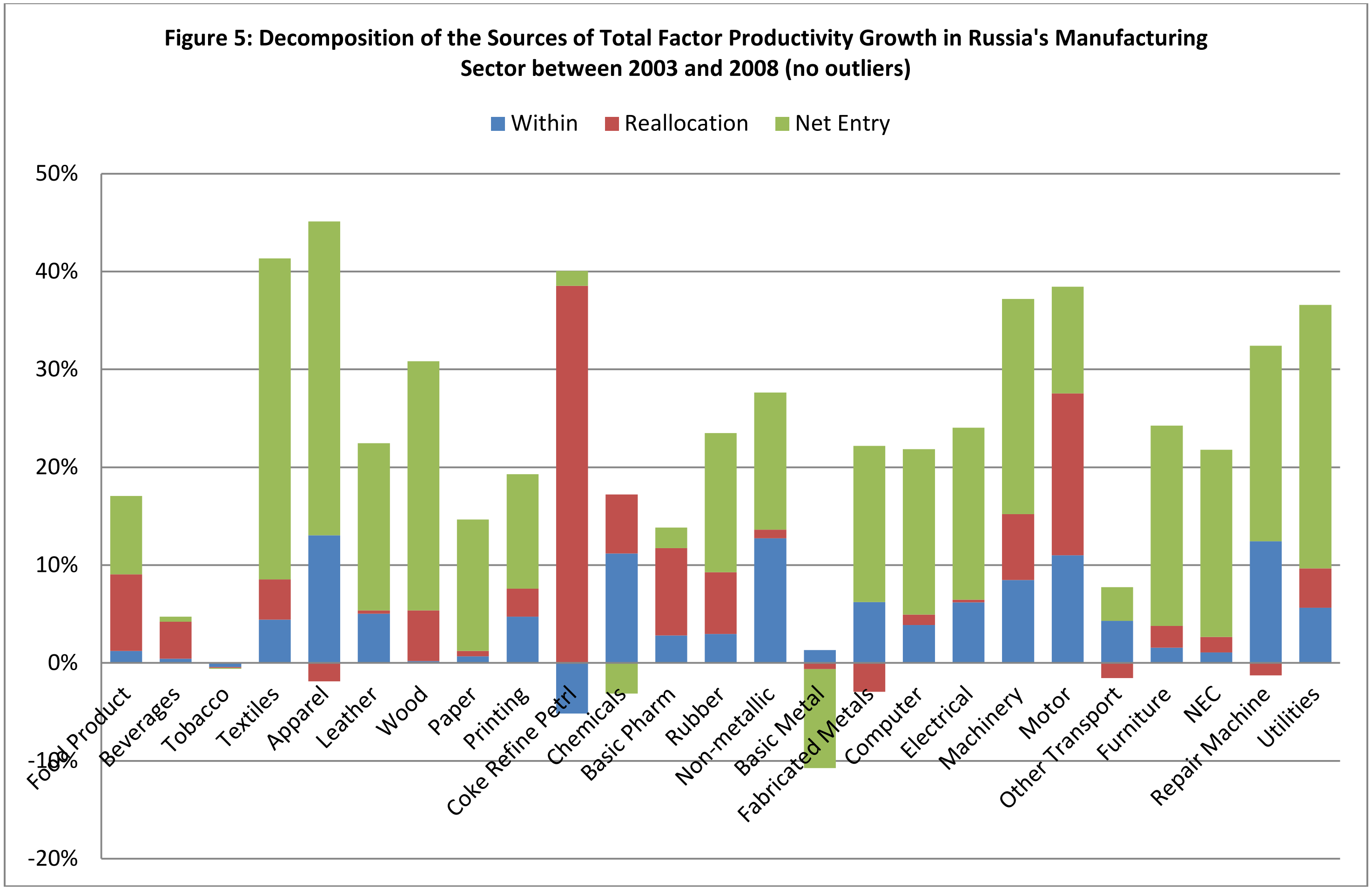


Figure 5: Decomposition of the Sources of Total Factor Productivity Growth in Russia's Manufacturing Sector between 2003 and 2008 (no outliers)
Within
Reallocation
Net Entry
50%
40%
30%
20%
10%
0%
-10%
-20%
Food Product
Beverages
Tobacco
Textiles
Apparel
Leather
Wood
Paper
Printing
Coke Refine Petrl
Chemicals
Basic Pharm
Rubber
Non-metallic
Basic Metal
Fabricated Metals
Computer
Electrical
Machinery
Motor
Other Transport
Furniture
NEC
Repair Machine
Utilities

Interestingly, TFP growth in most industries is attributable to *new entrants*. This is indicated by the results of the Foster et al (2001) decomposition method (see Figure 5), which shows that with the exception of a few industries (i.e. beverages, coke and refined petroleum, chemicals, basic pharmaceuticals, and motor vehicles manufacture) reallocation of capital and labor play a key role in productivity growth (which, given the structure of the dataset, also includes old firms i.e. registered before 2003, but for whom data became available between 2003 and 2008).[6]

(iii) Productivity and Firm Characteristics

The results of the empirical analysis of firm characteristics are statistically strongly significant; they are also broadly consistent with earlier analyses of theoretical and empirical literature using the Russian data (e.g., Alam et al. 2007). All independent variables, except measure of the industry structure, are statistically significant at the 1 percent level). Results are summarized in Table 3.

The following principal findings are of particular interest.

- First, **firm size** matters for productivity, with all size variables statistically and strongly significant (relative to micro-sized firms) and large firms being the most efficient, followed by medium-sized firms, indicating the existence of economies of scale and scope.

- Second, the **"primary city effect"** of Moscow, reflecting agglomeration effects of Moscow city on productivity, is statistically and quantitatively significant although the effect is weaker for medium-size and large firms. In other words, it matters more for productivity if a firm has grown over a threshold size than that it is located in Moscow per se (Figure 6). Intuitively, this finding means that once a firm grows to a certain size, locating in the capital—while certainly an advantage—becomes less critical to its productivity.

- Third, **younger firms** tend to be more efficient than older ones, suggesting that firm old age makes knowledge, abilities, and skills obsolete and induces organizational decay (as in Agarwal and Gort, 1996 and 2002). There is a quadratic effect in the relationship between age and productivity i.e., there is a *decline* in average TFP from the first quintile of the age quadratic until the fourth quintile (the threshold), then *rising* sharply to the fifth quintile.

[6] Results when outliers are included are slightly different (See Figure A2 in the Annex).

Table 3: Manufacturing Productivity and Firm Characteristics (Dependent variable: Ln TFP).

Variables	**(1)**	**(2)**
Small Firm	0.13 *** (0.001)	0.13 *** (0.001)
Medium Firm	0.21 *** (0.003)	0.21 *** (0.003)
Large Firm	0.30 *** (0.004)	0.30 *** (0.004)
Moscow	0.12 *** (0.003)	0.11 *** (0.003)
Firm Age	-0.006 *** (0.000)	-0.006 *** (0.000)
Age Squared/1000	0.03 *** (0.001)	0.03 *** (0.001)
New Entrants (age 0 -1)	-0.02 *** (0.002)	-0.02 *** (0.002)
Exiting Firms	-0.065 *** (0.003)	-0.06 *** (0.003)
Federal/State-Owned	-0.22 *** (0.011)	-0.22 *** (0.011)
Municipal-owned	-0.28 *** (0.008)	-0.25 *** (0.009)
Market Share (of NACE level-4 subsector total)	0.98 *** (0.054)	0.98 *** (0.054)
Industry Structure Herfindhal Index	-0.003 (0.009)	-0.01 (0.01)
Year Dummies (2004 – 2008)	Yes	Yes
Industry Dummies	No	Yes
Constant	2.3*** (0.002)	2.2 *** (0.000)
Number of Observations	170,554	170,554
Number of Firms	524,87	52,487
Adjusted R sq	0.20	0.23

Note: Column (1) excludes sector dummies, whereas column (2) includes them. dependent variable calculated is ln (TFP) calculated according to the technique of Levinsohn and Petrin(2003). Standard errors adjusted for clustering on firms are noted in parentheses. The industry dummies are defined at 2-digit NACE level for manufacturing (10 – 35). *** significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level.

- Fourth, **state and municipal ownership** shows strong negative and statistically significant relationships with productivity, perhaps reflecting the weak commercial incentives in state and municipal firms compared with private firms (see Figure 7).

Figure 6: Firm Productivity in Moscow Vs Other Cities

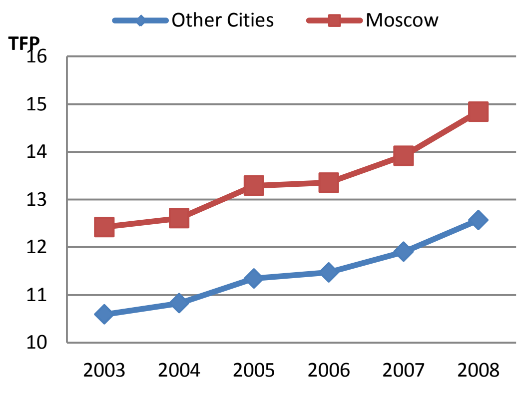
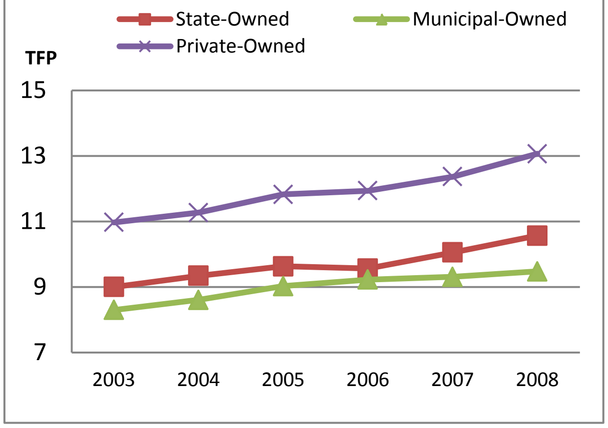


Figure 7: Firm Productivity By Ownership Type



- Fifth, productivity is negatively correlated with both **very young firms** (under the age of one year) **and exiting firms.** This suggests that *existing (or incumbent) firms enjoy certain advantages*, which may be due to either weak competition or other productivity and competitiveness advantages. But with many existing firms consisting of state and municipal companies with lower productivity than in private firms, it appears that firm survival is not correlated with high productivity. Internal managerial incentives in incumbent firms may not be strongly favoring productivity in the presence of weak competitive pressures. Managers of existing firms can maintain sub-optimal use of factor inputs. By contrast, intensified competition pressures force managers to speed up the adoption of new technologies in order to survive.

- And sixth, **market share** (at the NACE industry level four) matters and is correlated with productivity. This is corroborating empirical evidence in Szegedi et al (2009) that firms can increase productivity by raising the market share. In fact, market share has the largest coefficient and in our model is the single most important driver of manufacturing productivity in Russia. But the estimated effect of the broader measure of industry concentration, the Herfindahl index, while having the theoretically correct negative sign, is not significant.

(iv) Productivity and Infrastructure

In the next stage of this analysis, we shift the attention to the infrastructure-productivity link as infrastructure has emerged as a major constraint to Russia's firms in many recent firm surveys. The 2008 BEEPS survey highlights the severity of the infrastructure challenge, relative to other countries within the region. About 14.2 percent of Russian firms identify insufficient water as a major or severe constraint, compared to a regional average of 9.6 percent. Likewise, more firms in Russia complain about electricity and telecommunication facilities than in Ukraine, Romania, and Belarus (see Figures 8 to 11). Recent analyses of infrastructure and productivity growth, especially those based on detailed firm-level data and a wider menu of infrastructure measures (e.g., Fedderke and Bogetic 2009) have shown strong association between infrastructure and productivity that has sometimes proven elusive in more aggregated studies.

Figure 8: % of firms experiencing insufficient water

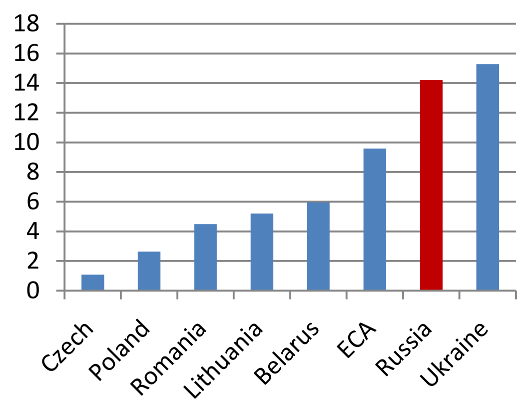
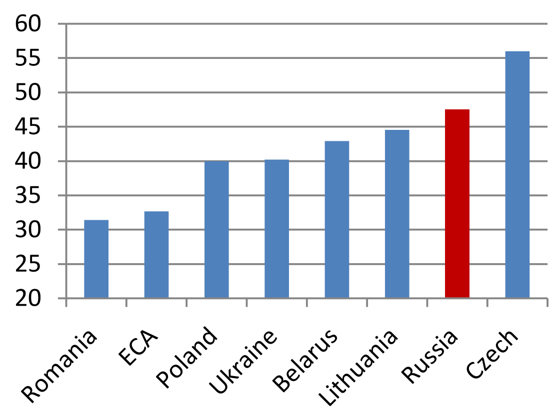
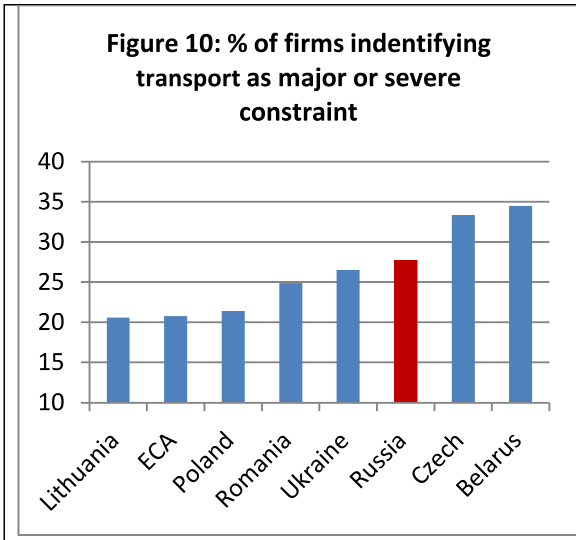
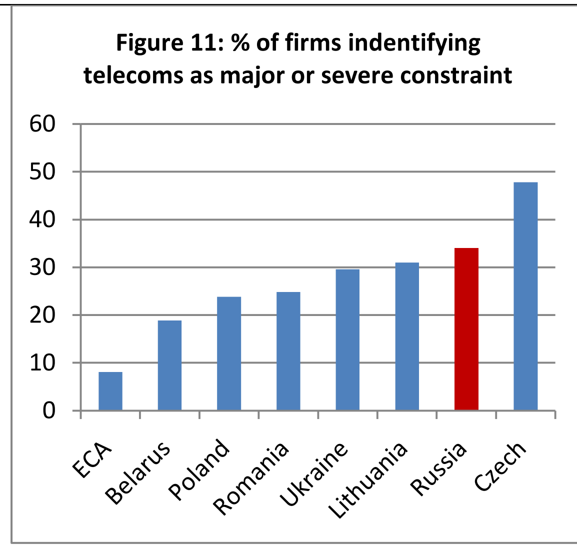


Figure 9: % of firms indentifying electricity as major or severe constraint



Source: BEEPs 2008.

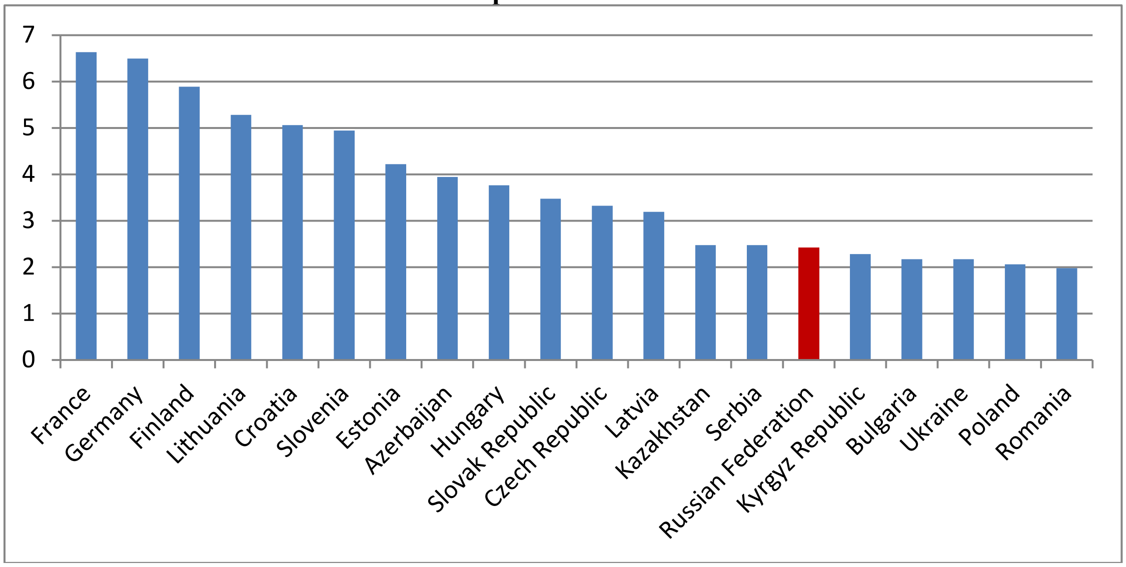




Source: BEEPs 2008.

Both Russian and other international data suggest a major deterioration of transportation infrastructure (World Bank 2011a, b). The state of Russia's transport infrastructure is generally poor, especially for a high-income country and has been declining because of underinvestment in maintenance and rehabilitation. According to the 2010 Enabling Trade Index (World Economic Forum), Russia ranks 48th on the availability and quality of transport infrastructure (Figure 12). The index measures the state of transport infrastructure across all modes of transport in each country, as demonstrated by the density of airports, the percentage of paved roads, and the extent to which they are congested, as well as the transshipment connections available to shippers from each country.

Figure 12: The quality of road infrastructure index (from 0 (worst) to 7 (the best)) in select countries of Europe and Central Asia



Source: Enabling Trade Index, 2010, The World Economic Forum

While the quality of transport infrastructure in Russia varies significantly across different modes of transport—and different parts of the country—the *road* infrastructure is estimated to have deteriorated the most. According to the World Economic Forum's 2010 Enabling Trade Index (ETI), Russia's railway infrastructure quality ranks 33rd in the world, relatively good but still significantly behind the Western European levels to which the country aspires. But its ranking on the quality of road infrastructure is 111th, among the world's worst; this—in a vast country that is heavily resource-intensive and that depends on transport of goods and services for its exports. The quality of port and air infrastructure is also comparatively poor—Russia ranks 82th and 87th, respectively. These differences are also evident in comparing the asset deterioration in recent years, by transport modes. According to Rosstat, the asset deterioration rate reached 48 percent for air transport, roads and maritime port infrastructure in 2008. The deterioration in railways was much lower—24 percent. A recent survey of quality of the federal road network indicates that the majority of roads do not meet the minimum riding quality requirements (Table 4).

Table 4: Length and percentage of federal road network not meeting standards (2009)

	Length (km)	Percentage
Failing to meet minimum riding quality requirements	28,500	57.1
Failing to meet minimum grip requirements	12,200	24.4
Failing to meet minimum strength requirements	24,900	49.9
Failing to meet minimum defects requirements	35,100	70.3

Source: Avtodor, Long-Term Program of the Russian Motor Roads Public Company (2010-2015), December 31, 2009.

Given these findings based on descriptive statistics, the question arises whether they can be corroborated by econometric analysis and to what extent infrastructure deficiencies affect firm productivity. This is the question we take up by explicitly modeling changes in TFP productivity growth using a vector of infrastructure variables from the BEEPs surveys, combined with firm characteristics.

Since BEEPs surveys are infrequent, and in this case were conducted in 2004 and 2008 only, results in this section use data for 2004 and 2008 only. Following Escribano and Gausch (2004) and Alam et al (2008), we postulate the general regression model, with changes in productivity being the dependent variable, and include controls for firm characteristics.

$$\Delta \ln TFP_{ijt} = \alpha + \beta_1 \Delta \mathbf{infrastructure}_{t-1} + \sum \boldsymbol{\varpi_n X^n_{i.t}} + \varepsilon_{i,t}$$

For each of Russia's regions, and for each sector (2-digit NACE classification), we calculate firm size (micro, small, medium, and large) and sector responses to each of the following infrastructure variables:

(a) *Electricity*: number of days of power outage, percentage losses from power outage, and response to the question: Did you experience power outage?

(b) *Water*: frequency of insufficient water supply, and a dummy on whether the firm experienced insufficient water supply.

(c) *Transportation:* The proportion of firms reporting that transportation is a major or severe constraint, derived from the question: "How much of an obstacle is transportation?"

(d) *Telecommunications:* The proportion of firms reporting that telecommunications is a major or severe constraint, derived from the question: "How much of an obstacle is telecommunication"?

(e) *The Internet*: Firm response to the question: "Do you have high-speed broadband internet?"

We then calculate the regional, sectoral, and firm-size averages for each variable.

The model is estimated using the principal component analysis. Results are presented in the table 5 below. We highlight two main findings.

- First, access to good infrastructure such as telecommunications, transportation, broad band services, and water supply are important drivers of productivity in the manufacturing sector. Conversely, an increase in the **proportion of firms with difficulty in accessing infrastructure services is significantly correlated with lower productivity**.

- Second, **water supply deficiencies exert the largest negative impact on firm productivity**. This is not a variable that is often associated with firm productivity in middle-income countries where basic water supply issues are resolved although it has come up in a recent analysis of South Africa and SACU countres (Bogetic and Fedderke 2006); nor has it been highlighted in recent analyses for Russia. But, interestingly, this finding is consistent with an independent result in an ongoing analysis of the Human Opportunity Index (HOI) for Russia, which identifies water supply as one of the infrastructure sectors where, despite broad coverage, there remain problems of quality and equity of access across Russia's vast territory and income groups.

Table 5: Regression Results with BEEPs Variables (years 2004 and 2008 only)

Variables	*(1) Beeps Variable Only*	*(2) Including Firm Characteristics*
Δteleobs	*-0.08* ** *(0.035)*	*-0.09* ** *(0.037)*
Δ transobs	*-0.06* * *(0.037)*	*-0.07* * *(0.039)*
Δbroadband	*0.06* * *(0.032)*	*-0.06** *(0.032)*
Δwaterfreq	*-0.104* * *(0.058)*	*-0.12* ** *(0.059)*
Constant	*9.17* *** *(3.287)*	*10.2* *** *(3.563)*
Observations	*19,385*	*19,385*
R-squared	*0.03*	*0.04*

*** significant at the 1 percent level, ** significant at the 5 percent level, * significant at the 10 percent level. Δteleobs = How much of an obstacle is telecommunications?, Δ transobs= How much of an obstacle is transportation? Δbroadband= do you have high-speed broadband internet? Δwaterfreq= frequency of insufficient water supply?

5. Conclusion

This note presents the results of an empirical analysis of firm-level productivity growth in Russia's manufacturing sector during the period 2003-08 using a rich Amadeus database as well as the recent BEEPs surveys. The principal conclusions are as follows:

First, productivity grew steadily between 2003 and 2008, with an annual growth rate averaging ***4 percent*** over the period, showing ***no signs of a slowdown*** from the previous period after the 1998 crisis.

Second, ***firm characteristics*** like size, location, age and the structure of firm ownership are important determinants of productivity. Specifically

- **Firm size matters**: large firms tend to be most productive, followed by medium-size firms, and small firms, reflecting the economies of scale and scope.

- **Location is important**: the "primary city effect" of Moscow—capturing the Moscow city agglomeration effects on productivity—is statistically and quantitatively significant although it is weaker for medium and large firms. In other words, while location matters, size matters even more.

- **Younger firms tend to be more productive**: over time, a firm's old age may make its knowledge, capacities, and skills obsolete and could result organizational decay in (for related evidence, see Agarwal and Gort, 1996 and 2002). But after a certain threshold of age (fourth quintiles in the firm sample), firm productivity rises sharply, suggesting that the oldest and most established firms tend to maintain a productive edge despite the potential downsides of firm age.

- **State and municipal ownership show strong, negative, and statistically significant relationships with productivity**, perhaps reflecting the weak commercial incentives in state and municipal firms compared with private firms. At the same time, state firms tend to be more productive than municipal firms.

- **A firm's dominance in an industry is key to productivity in Russia.** A firm's market share of an industry's sales exerts the most significant influence on firm productivity.

Third, based on the analysis of BEEPs data, firms that complain about access to and/or the ***quality of infrastructure***– particularly water, electricity, transport, and the internet– tend to show lower productivity; this corroborates other recent analyses showing rising infrastructure gaps in Russia and their impact on firm investment and economic activity.

Fourth, ***water supply*** deficiencies exert the largest negative impact on firm productivity.

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ANNEX 1

Data Description

Although data on 78,708 firms were obtained from Amadeus, the number of firms ranges from 25,561 in 2003 to 41,516 in 2008. Only 14,067 firms have data in all six years i.e. panel firms. Noteworthy to mention however, that this does not only reflect a high exit or entry rate of firms into the manufacturing sector, but also an improvement in the data collection processes of the data provider (Amadeus). Micro-sized, small, and medium-sized enterprises (MSMEs) form the bulk of the firms, although they account for only 18 percent of total output of the sample, and 32 percent of total workforce.

Year	No. of firms per year	Exits	New Entrants	Moscow
2003	25,561	498	1644	3573
2004	30,794	1347	2517	5643
2005	31,069	1322	3231	5890
2006	38,553	7064	4298	7498
2007	37,319	8292	4402	6825
2008	41,516	n/a	3605	7191
Total	***204,812***			

Firm Size	2003	2004	2005	2006	2007	2008	Total
Micro	11,749	14,129	11,351	13,330	13,026	9,946	73,531
Small	6,914	9,682	12,695	17,193	16,798	22,271	85,553
Medium	3,163	3,281	3,505	3,989	3,602	4,264	21,804
Large	3,735	3,702	3,518	4,041	3,893	5,035	23,924
Total	***25,561***	***30,794***	***31,069***	***38,553***	***37,319***	***41,516***	***204,812***

	Ownership:		
Year	**Federal/State**	**Municipal**	**Private firms**
2003	568	812	24,181
2004	595	910	29,289
2005	535	876	29,658
2006	579	918	37,056
2007	470	844	36,005
2008	456	887	40,173

The list of Manufacturing sectors (NACE 2-digit classification) provided is below. These are further broken down into 270 sub-sectors, used in computing market shares.

2-Digit NACE	2003	2004	2005	2006	2007	2008	Total
Food Product	3,924	4,461	4,408	5,145	4,741	5,181	27,860
Beverages	658	779	723	885	839	902	4,786
Tobacco	23	21	23	25	24	33	149
Textiles	587	714	746	908	841	902	4,698
Apparel	1,340	1,517	1,328	1,686	1,620	1,504	8,995
Leather	261	288	287	327	288	283	1,734
Wood	1,182	1,460	1,427	1,927	1,921	1,964	9,881
Paper	428	524	553	664	659	718	3,546
Printing	1,101	1,426	1,365	1,798	1,749	1,783	9,222
Coke Refine Petrol	114	126	146	185	170	217	958
Chemicals	940	1,172	1,209	1,469	1,428	1,615	7,833
Basic Pharmaceutical	334	405	400	463	397	445	2,444
Rubber	1,263	1,619	1,743	2,222	2,259	2,622	11,728
Non-metallic	1,648	1,952	2,010	2,511	2,534	3,148	13,803
Basic Metal	348	424	445	551	523	681	2,972
Fabricated Metals	2,130	2,639	2,722	3,511	3,532	4,081	18,615
Computer	1,524	1,889	1,856	2,386	2,195	2,407	12,257
Electrical	1,056	1,259	1,327	1,612	1,605	1,838	8,697
Machinery	3,020	3,670	3,720	4,587	4,466	4,892	24,355
Motor	444	501	527	621	610	729	3,432
Other Transport	371	446	451	563	537	681	3,049
Furniture	773	956	989	1,268	1,238	1,341	6,565
NEC	402	510	519	728	664	690	3,513
Repair Machine	41	50	54	60	66	80	351
Utilities	1,649	1,986	2,091	2,451	2,413	2,779	13,369
Total	***25,561***	***30,794***	***31,069***	***38,553***	***37,319***	***41,516***	***204,812***

ANNEX 2:

Productivity Decomposition, using full sample i.e., including outliers.

Relative to the results reported in the text, the impact of outliers is quite substantial. Both aggregate productivity and average productivity are not only higher than those reported previously in Section 4, but also efficiency is lower on aggregate (negative in some cases), particularly between 2004 and 2007 (see Figure A1). At the sectoral level, results are mixed (see Table A2).

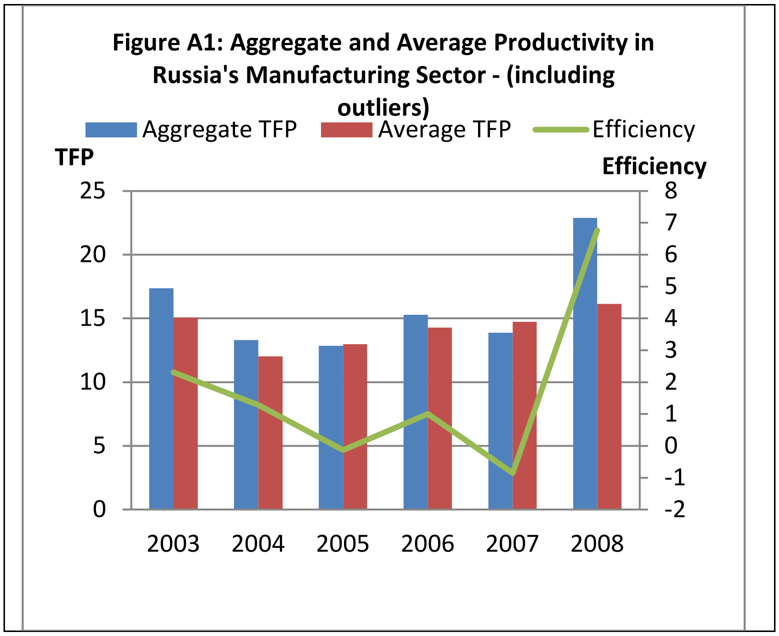
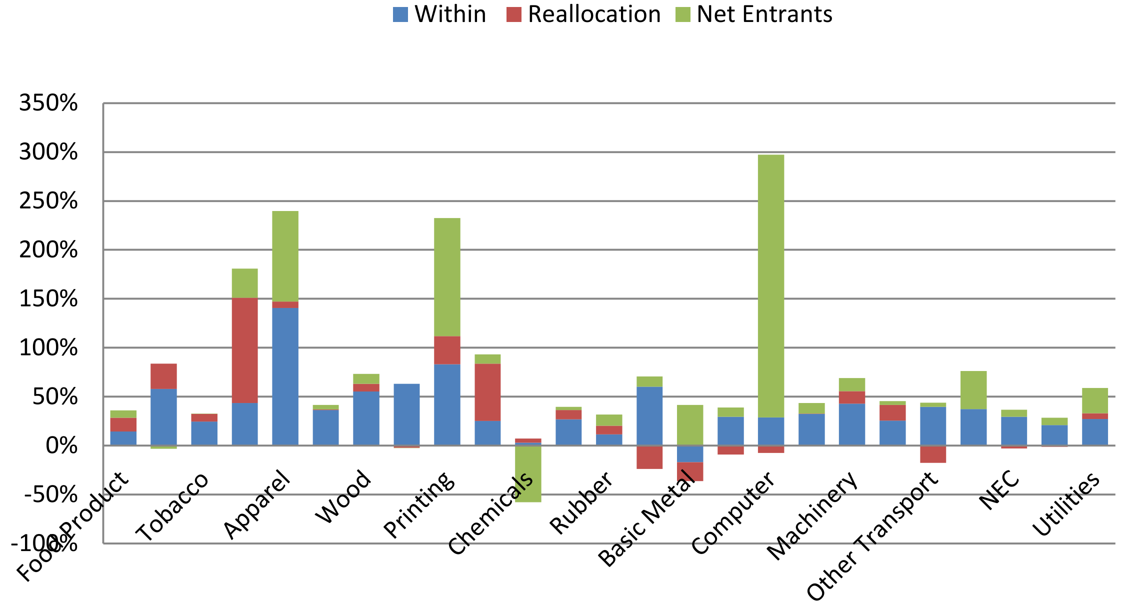


Table A2: Olley-Pakes (1996) Decomposition of Allocative Efficiency (i.e. Aggregate TFP minus Average TFP) by NACE 2-digit Industry Classification of Manufacturing Firms – Including Outliers

Sector	2003	2004	2005	2006	2007	2008
Food Product	3.04	0.00	-0.82	-0.85	-2.20	4.91
Beverages	3.71	-0.73	-0.78	0.84	0.36	13.14
Tobacco	5.96	-4.98	-4.98	-5.68	-5.38	10.92
Textiles	-3.24	-5.52	-2.50	-2.32	-1.18	5.27
Apparel	0.89	-2.18	-1.28	-0.78	-1.79	9.20
Leather	-0.06	1.44	1.47	-2.37	-0.48	1.10
Wood	1.00	-0.54	-1.61	0.42	-2.23	2.55
Paper	2.29	2.49	1.92	0.94	-5.85	-0.71
Printing	-3.32	-1.45	-2.40	-5.24	-6.55	5.47
Coke & Refined Petrol Products	-4.76	1.70	-16.15	3.65	5.76	16.18
Chemicals	-63.89	1.56	2.07	-3.57	1.11	10.52
Basic Pharmaceutical	7.42	6.94	4.57	9.93	0.47	-3.65
Rubber	3.16	-0.88	-1.22	-3.02	-1.09	5.63

Non-metallic	2.63	-0.52	-1.75	-0.32	-0.46	4.02
Basic Metal	10.28	9.71	6.88	15.40	6.43	8.83
Fabricated Metals	1.80	-0.63	-3.20	-1.62	-2.48	3.30
Computer	-0.97	-5.09	-3.35	-5.75	-5.55	28.01
Electrical	0.06	-2.08	-5.32	-4.11	-4.74	-1.66
Machinery	-1.87	-2.97	-3.23	-1.71	-7.45	0.86
Motor	3.39	0.30	-1.84	-0.26	0.01	5.52
Other Transport	1.36	-3.02	-2.56	-4.54	-6.01	1.89
Furniture	-2.28	-2.17	-0.91	-2.40	-3.83	2.16
NEC	3.25	-4.49	-5.36	-24.85	-5.23	4.56
Repair Machine	-1.52	-0.29	1.41	1.29	-0.51	2.24
Utilities	4.09	2.23	-4.80	1.44	2.14	7.06

Figure A2: Decomposition of the Sources of Total Factor Productivity Growth in Russia's Manufacturing Sector between 2003 and 2008



When outliers are included in the sample, it appears that much of the growth in TFP can be linked to within-firm effects.