Firm growth and productivity in Belarus: New empirical evidence from the machine building industry*

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Abstract

Using a unique dataset comprising information for over 900 firms in the the machine building sector in Belarus, we investigate the determinants of firm growth for an economy where state ownership of enterprises is widespread. We use panel data models based on generalizations of Gibrat's law, total factor productivity estimates and matching methods to assess the differences in firm growth between private and state-owned firms. Our results indicate that labor hoarding and soft budget constraints play a particularly important role in explaining differences in performance between these two groups of firms.

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1 Introduction

Belarus's growth experience is at odds with standard transition paradigms. Relatively early recovery and uninterrupted growth record since 1996 were not the result of opening and structural transformation of the economy. In comparison to other countries in Eastern Europe, which privatized their companies, shed labor and closed unprofitable enterprises, most Belarusian businesses remained state-owned. Belarus's impressive growth was not an outcome of the slow pace of economic reforms, however, but of its dependence on Russia's willingness to provide cheap energy inputs. With comparative advantages in its main export markets (CIS, especially Russia), Belarus enjoyed a 15-year growth run, primarily led by energy-intensive export-oriented state industries. However, these advantages were transitory. Missed opportunities to pursue a structural transformation of the economy in the boom years narrowed the Belarus' possibilities to find new sources of growth and decrease the dependence of its industry on foreign resources.

The future development of the state enterprise sector in Belarus is thus crucial for the overall success of the Belarusian economy. In this sense, a clear understanding of the functioning of state-owned firms is pivotal for the implementation of accurate economic policy measures. This paper provides an in-depth analysis of firm growth and its drivers for the machine building industry in Belarus, constitutes one of the key industries in the economy. Such an analysis allows us to understand the main forces driving firm profitability in Belarus.

We move beyond descriptive statistics to obtain more clear-cut insights on the determining forces of firm growth in Belarus by using the workhorse model of the empirical firm growth literature. Based on firm size convergence, we concentrate on assessing the heterogeneity between state-owned and private enterprises. Our results indicate a significant degree of inefficient resource allocation in state-run firms.

With these results at hand, we investigate the reasons behind the inefficiency in the allocation of production inputs. We obtain total factor productivity (TFP) estimates applying standard modern econometric procedures and compare the resulting TFP measures across different types of firms. Simple mean comparison tests unambiguously reveal that state-owned enterprises produce less efficiently and, more importantly, exhibit lower growth rates of TFP. In a final step, we are interested in unveiling the sources of these observed productivity differences. We estimate TFP convergence models and apply matching estimators in order to assess whether labor hoarding and/or inefficient over-investment in physical capital are able to explain low levels and growth rates in TFP in state-owned companies. Our results indicate that the inefficiencies in state-owned enterprises are at least partly related to the use of input factors which makes them less competitive than their private counterparts.

The paper is organized as follows. Section two gives a descriptive view of firm growth dynamics in the Belarusian machine building industry. Section three estimates panel data models in the framework of Gibrat's law specifications. The estimates of such models allow us to assess differences in the firm growth process between state-owned enterprises and private firms. Section four focuses on the estimation of TFP at the firm level for the machine building industry. The sources of differences in TFP dynamics between state-owned and private firms are studied in section five. Section six analyzes resource misallocation in more detail using matching techniques and section seven concludes.

2 Firm growth in Belarus: Descriptive evidence from the machine building industry

This section provides empirical evidence on the growth process of manufacturing firms active in the machine building industry in Belarus. It relies on a balanced panel dataset spanning the years 2005 to 2010. Machine building has been historically one of the specialization sectors of the Belarusian economy and is quantitatively one of the most relevant industrial sectors in terms of employment and production, accounting for approximately 22% of total industrial output in 2010. Our dataset contains information on 152 firms (727 firm-year observations) for 18 subsectors of the machine building industry.[1]

The employment growth rate for the full sample of firms (see Table 1) indicates that the average firm in the machine building industry reduced its employment by approximately 2.5% yearly over the period considered. Interestingly, however, a small fraction of outlying firms exhibited impressive growth rates, with a maximum amount of more than 200% employment growth. At a more disaggregated level, privately organized firms tended to outperform state-owned and mixed-owned firms in terms of employment growth. Accordingly, privately owned firms reduced their number of employees by 1.8%, on average, although the maximum (annual) increase in employment in this group of firms amounted to 24.3%. The average employment growth rates in the other two groups of firms are -2.6% and -2.5%, respectively. One should be cautious, however, when interpreting these results, given the relatively small number of privately-owned firms in this sample. Similarly, comparing firms directly reporting to the Ministry of Industry with non-ministry-reporting firms, we find that the former group performed significantly worse. The average ministry-reporting firm exhibits an annual growth rate of -4.1% while non-reporting firms, on average, keep their level of employment unchanged.[2] Focusing on different types of firms, such as head companies of vertical chains, affiliates of such chains and independent firms, the descriptive statistics with regard to employment growth do not reveal remarkable differences across these groups. However, these types of firms may differ in other respects that affect their growth pattern. In our econometric analysis we will use this classification in order to analyse the impact of vertical integration on the growth performance in the Belarusian machine building industries.

Disaggregating firm growth by sub-industry within the machine building sector reveals that (average) firm size in terms of employment is relatively heterogeneous across them. The average firm size ranges from approximately 250 employees in the repair of machinery sector to approximately 1,100 employees in automobile production. During the observed time period, the median firm growth rates across all sub-industries imply that the respective firms reduce their number of employees throughout. Here, the only exception is the interdisciplinary production industry, where the median firm does not change its number of employees from 2005 to 2010. These downsizing tendencies are most pronounced in the machine tools sector, with a median firm growth rate of -6.1%.

[1] These are the automotive subsector, bearings, chemical and petroleum engineering, construction and road and municipal engineering, conveying machinery, electrical, industry interdisciplinary productions, industry metalwork, instrumentation, tools, machinery for light industry, food industry and household appliances, metallurgical engineering, mining and mining engineering, production of sanitary and gas equipment, radio industry, repair of machinery and equipment and tractor and agricultural machinery.

[2] For reasons which will be discussed in more detail below, we will focus on the information regarding the obligation to directly report* to the Ministry of Industry as an alternative measure of state-ownership.

Table 1: Descriptive statistics: Firm size and firm growth in terms of employment in the machine building industries

	Variable	**Obs.**	**Mean**	**25^{th} perc.**	**Median**	**75^{th} perc.**	**Std. dev.**	**Min.**	**Max.**
Full sample	Employment growth	783	-0.025	-0.073	-0.019	0.024	0.134	-0.780	2.279
	Log(employment)	914	6.239	5.357	6.116	6.948	1.183	2.398	10.263
By ownership structure									
Private	Employment growth	93	-0.018	-0.069	-0.011	0.030	0.101	-0.397	0.243
	Log(employment)	113	5.739	5.176	5.673	6.182	0.791	3.807	7.448
State-owned	Employment growth	324	-0.026	-0.076	-0.019	0.027	0.119	-0.780	0.805
	Log(employment)	393	6.532	5.541	6.657	7.249	1.325	2.398	10.263
Mixed ownership	Employment growth	366	-0.025	-0.073	-0.022	0.019	0.153	-0.356	2.279
	Log(employment)	408	6.096	5.311	5.833	6.751	1.051	4.220	10.027
Ministry-reporting	Employment growth	383	-0.041	-0.082	-0.037	0.011	0.089	-0.377	0.405
	Log(employment)	451	6.733	6.043	6.720	7.203	1.170	4.263	10.263
Non-Ministry-reporting	Employment growth	400	-0.009	-0.054	-0.005	0.035	0.165	-0.780	2.279
	Log(employment)	463	5.758	5.100	5.591	6.269	0.981	2.398	8.412
By type of firm									
Head companies	Employment growth	35	-0.027	-0.073	-0.004	0.017	0.095	-0.332	0.221
	Log(employment)	41	7.921	5.565	8.946	9.243	1.827	4.771	10.053
Affiliates of vertical chains	Employment growth	143	-0.027	-0.078	-0.027	0.034	0.086	-0.296	0.229
	Log(employment)	170	6.669	6.096	6.724	7.240	0.765	4.949	8.514
Independent firms	Employment growth	605	-0.024	-0.071	-0.018	0.021	0.145	-0.780	2.279
	Log(employment)	703	6.038	5.176	5.829	6.799	1.113	2.398	10.263
By subsector									
Electrical	Employment growth	65	-0.045	-0.082	-0.037	0.021	0.088	-0.273	0.127
	Log(employment)	72	6.245	5.817	6.534	6.949	0.909	4.263	7.448
Interdisciplinary production	Employment growth	58	-0.025	-0.058	0.000	0.025	0.181	-0.780	0.805
	Log(employment)	60	6.199	5.566	6.060	7.214	0.881	4.605	7.455
Agricultural machinery	Employment growth	118	-0.017	-0.060	-0.014	0.037	0.084	-0.296	0.283
	Log(employment)	129	6.214	5.17	5.737	6.757	1.425	4.419	10.053
Automobile	Employment growth	111	-0.010	-0.063	-0.006	0.052	0.123	-0.397	0.405
	Log(employment)	123	7.005	5.694	7.181	8.204	1.448	4.5	10.263
Instrumentation	Employment growth	52	-0.056	-0.103	-0.051	0.000	0.088	-0.377	0.103
	Log(employment)	63	6.433	5.951	6.781	7.048	0.982	3.807	8.001
Machine tools	Employment growth	55	-0.076	-0.122	-0.061	-0.021	0.082	-0.342	0.119
	Log(employment)	66	6.602	6.460	6.689	6.881	0.497	5.215	7.366
Repair of machinery	Employment growth	108	0.013	-0.047	-0.007	0.030	0.240	-0.451	2.279
	Log(employment)	111	5.521	4.934	5.303	5.835	0.798	4.554	7.534

Notes: Statistics by subsector are reported for subsectors where at least 50 observations are available.

Table 2: Descriptive statistics: Firm size and firm growth in terms of value added in the machine building industries

	Variable	**Obs.**	**Mean**	**25^{th} perc.**	**Median**	**75^{th} perc.**	**Std. dev.**	**Min.**	**Max.**
Full sample	Value added growth	617	0.128	-0.091	0.140	0.335	0.403	-0.992	2.179
	Log(value added)	742	9.027	8.152	8.931	9.770	1.292	5.714	13.558
By ownership structure									
Private	Value added growth	68	0.175	-0.020	0.139	0.371	0.507	-0.992	1.954
	Log(value added)	83	8.598	7.845	8.751	9.447	1.078	5.714	11.095
State-owned	Value added growth	279	0.113	-0.092	0.132	0.317	0.378	-0.958	2.179
	Log(value added)	348	9.090	8.203	8.993	9.785	1.349	5.858	13.558
Mixed ownership	Value added growth	270	0.133	-0.094	0.150	0.358	0.398	-0.959	1.646
	Log(value added)	311	9.072	8.163	8.804	9.949	1.260	6.040	12.953
Ministry-reporting	Value added growth	307	0.117	-0.087	0.134	0.317	0.361	-0.959	1.646
	Log(value added)	372	9.310	8.585	9.190	9.991	1.291	6.116	13.558
Non-Ministry-reporting	Value added growth	310	0.139	-0.100	0.141	0.361	0.440	-0.992	2.179
	Log(value added)	370	8.743	7.903	8.601	9.555	1.230	5.714	12.020
By type of firm									
Head companies	Value added growth	31	0.126	-0.263	0.213	0.347	0.491	-0.867	1.344
	Log(value added)	38	10.483	7.733	11.208	12.953	2.377	7.006	13.558
Affiliates of vertical chains	Value added growth	110	0.106	-0.084	0.149	0.316	0.357	-0.958	0.923
	Log(value added)	133	9.547	8.961	9.698	10.136	0.780	7.408	11.048
Independent firms	Value added growth	476	0.134	-0.089	0.139	0.346	0.407	-0.992	2.179
	Log(value added)	571	8.809	7.990	8.728	9.514	1.187	5.714	12.218
By subsector									
Electrical	Value added growth	43	0.161	-0.002	0.196	0.352	0.375	-0.992	1.374
	Log(value added)	50	8.638	7.845	8.747	9.540	1.053	6.597	10.011
Interdisciplinary production	Value added growth	48	0.132	-0.016	0.154	0.285	0.308	-0.518	0.878
	Log(value added)	50	8.957	8.280	8.985	10.077	1.169	6.545	10.443
Agricultural machinery	Value added growth	75	0.101	-0.180	0.124	0.331	0.428	-0.959	0.949
	Log(value added)	87	9.199	7.888	8.491	10.298	1.884	6.040	13.558
Automobile	Value added growth	85	0.250	-0.136	0.256	0.505	0.579	-0.817	1.954
	Log(value added)	100	9.514	8.487	9.910	10.577	1.475	5.714	12.218
Instrumentation	Value added growth	49	0.100	-0.072	0.134	0.253	0.298	-0.801	0.929
	Log(value added)	61	8.964	8.464	9.188	9.584	1.201	6.075	11.361
Machine tools	Value added growth	50	0.072	-0.123	0.092	0.275	0.357	-0.958	0.895
	Log(value added)	61	9.183	8.819	9.174	9.505	0.616	7.059	11.440
Repair of machinery	Value added growth	90	0.157	-0.015	0.169	0.368	0.418	-0.858	2.179
	Log(value added)	94	8.836	8.085	8.736	9.375	0.960	7.113	11.524

Notes: Statistics by subsector are reported for subsectors where at least 50 observations are available.

Table 2 reports the same information for value added as a measure of firm size and firm growth.[3] Table 2 shows that the average value added growth rate is positive and well above 10% in most cases. Again, one should stress that these results might be affected by asymmetric changes in overall prices. However, qualitatively they are similar to those obtained for employment. In comparison to their state and mixed-owned counterparts, privately-owned firms exhibit higher value added growth rates. Similarly, non-ministry reporting firms again outperform those firms which report to the Ministry of Industry. With regard to this latter result, the difference in the average value added growth performance is considerably smaller than for employment. Focusing on different types of firms, affiliates of vertical production chains tend to exhibit the lowest value added growth rates on average. Additionally, independent firms also tend to outperform the head companies of the vertical production chains on average (although the opposite is the case if we consider the median growth rate of employment, thus indicating that the distribution of firm growth rates among heads of vertical chains is negatively skewed).

Finally, the disaggregation of value added growth rates by subsector reveals that value added growth is lowest in more traditional industries such as for production of agricultural machineries and for production of machine tools. To the contrary, the automobile industry shows impressive increases in value added, leading to an annual average growth rate of 25%.

3 Modeling firm growth dynamics in the machine building industry

3.1 Gibrat's law: Firm size dynamics and convergence trends

In his seminal contribution, Gibrat (1931) argues that firm growth is independent of firm size and, consequently, firm size follows a random walk. In the empirical firm growth literature this hypothesis is referred to as *Gibrat's law of proportionate growth*. Formally, this implies that the data generating process for firm growth can be specified as:

$$\ln S_{it} - \ln S_{it-1} = \mu_{it}, \tag{1}$$

where S_{it} denotes the size of firm i at time t (proxied by employment, value added or any other reasonable measure) and μ_{it} is an *iid* random variable assumed to be normally distributed with $E[\mu_{it}] = 0$ and $\text{var}[\mu_{it}] = \sigma^2 > 0$ (see, e.g., Geroski 2005). Accordingly, the growth rate of firm size between time $t-1$ and time t is given by $g_{it} = \ln S_{it} - \ln S_{it-1}$.

In line with Chesher (1979), we might assume that the error term is serially correlated and thus define $\mu_{it} = \rho\mu_{it-1} + \varepsilon_{it}$, where ε_{it} is assumed to be white noise. Additionally, following Goddard, McKillop and Wilson (2002), Goddard, Wilson and Blandon (2002) and Giotopoulos and Fotopoulos (2010), among others, we reformulate a typical Gibrat's law type of equation in its dynamic representation. We also impose a potentially autocorrelated error term structure, additionally include (time-varying) control variables (denoted by $\mathbf{x}_{it}$ with their respective parameters γ), account for individual fixed effects (captured by α_i) and for (common) time-effects

[3] The value added figures are based on nominal values and thus might be affected by annual changes in the overall price level. This might especially be the case if changes in prices for the final goods deviate from price changes for intermediate inputs and raw materials. In our regression analysis, we account for overall price changes by including year fixed effects in our specifications.

(denoted by δ_t). This, in turn, leads to the following formulation of a generalized empirical firm growth equation,

$$g_{it} = \rho g_{it-1} + (\beta - 1)\ln S_{it-1} + \gamma \mathbf{x}_{it} + \alpha_i(1-\rho) + \delta_t + \mu_{it}, \text{ where} \quad (2)$$
$$\mu_{it} = \varepsilon_{it} + \rho(1-\beta)\ln S_{it-2}.$$

The estimation of (2) allows to jointly test whether firm growth is independent of firm size (i.e., $\beta = 1$) and for autocorrelation in firm growth rates (i.e., $\rho \neq 0$). Gibrat's law holds if $\beta = 1$ and $\rho = 0$ simultaneously (see, e.g., Giotopoulos and Fotopoulos 2010). In this case, μ_{it} reduces to ϵ_{it}.

From an econometric point of view, equation (2) is a dynamic panel data model, where typically a large number of cross-sectional units i (firms) are observed over a relatively short time period. For this reason our empirical firm growth equation might most appropriately be estimated using approaches in the spirit of Arellano and Bond (1991) and Blundell and Bond (1998). These methods rely on Generalized Method of Moments (GMM) methods to estimate the model parameters. Indeed, building on previous papers, Oliveira and Fortunato (2006) and Giotopoulos and Fotopoulos (2010), among others, applied such estimators in order to investigate firm growth dynamics.

3.2 Empirical specification

To estimate the effect of the main drivers of firm growth in Belarus, we model firm growth from year $t-1$ to year t as a function of firm growth in the previous period, firm size in period $t-1$ and a set of controls which we measure at period $t-1$.[4] The set of controls contains the log of total wage costs per employee, the log of a firm's exports, the log of previous years' investment and a firm's capacity utilization. Finally, we use fixed-effect estimators in order to control for time-invariant unobserved heterogeneity and year dummies which account for common shocks.[5]

With regard to the potential drivers of growth, per employee wage costs proxy the firms' production cost effectiveness. In this sense, firms with lower per employee wage expenses tend to be more competitive. With regard to a firm's growth performance, this implies that firms with lower wages per employees are expected to grow more rapidly. The specification also includes lagged exports as an explanatory variable to capture the impact of international competition on a firm's performance. Additionally, the inclusion of the level of investments allows to test more directly whether, on average, Belarusian machine building firms tend to substitute factor inputs.

We examine also whether resources are allocated efficiently in the Belarusian machine building industry. For this reason, we incorporate a firm's lagged capacity utilization in our firm growth model. In line with standard neoclassical theories, we thus expect that those firms which appropriately utilize their inputs will have higher incentives to increase their demand for factor inputs. Consequently, we expect a positive impact of capacity utilization on a firm's employment growth performance.

[4]This modeling strategy intends to reduce the potential problem of reverse causality.

[5]Notice that the firm fixed effect also controls for differences across industries as long as the firms do not change the industry where the produce.

We check for the robustness of our results by applying three different estimation strategies: least squares dummy variable (LSDV) estimator, difference GMM estimation based on Arellano and Bond (1991) and a bias-corrected least squares dummy variable estimator (CLSDV) based on Kiviet (1995) and Bruno (2005). The latter approach – which applies an approximation procedure to correct for the Nickell (1981) bias in LSDV estimation of dynamic fixed effects models – should be most appropriate for our application given the relatively small cross-sectional dimension of some of the sub-samples studied (see, e.g., Buddelmeyer, Jensen, Oguzoglu and Webster 2008).

3.3 Estimation results

Table 3 reports our baseline estimation results for employment growth using different sub-samples for privately-owned, mixed-owned and state-owned machine building firms, respectively. The three different estimation techniques lead to inconclusive results concerning the impact of lagged employment growth on the recent growth performance. The LSDV and the GMM estimators tend to show negative but insignificant correlations in the firm growth rates over time. In contrast, the results obtained from the CLSDV estimator point to a positive autocorrelation in firm growth over time, implying that employment growth dynamics tend to be reinforcing. Interestingly, the positive correlation in employment growth is mainly driven by state-owned firms.

With regard to the impact of initial firm size on firm growth, the different estimates commonly point to the fact that small firms tend to grow more rapidly than larger ones. The estimates of $(\beta - 1)$ are all negative indicating that $\beta < 1$. This result is well in line with the empirical firm growth literature which implies that, over time, firms tend to converge in terms of size.[6]

The qualitative impacts of the rest of the controls on firm growth is comparable across all three different types of fixed effects estimators. This points to the robustness of the results obtained. Moreover, utilizing the full sample of machine building firms and applying the preferred CLSDV estimator we are able to identify significant effects throughout. The parameter estimates of the lagged value of investments are positive throughout and significant in the most of cases implying that investments trigger employment growth in Belarusian machine building firms. This effect seem to be most pronounced for privately-owned and mixed-owned firms.

Finally, in line with our expectations, an increase in capacity utilization contributes to employment growth. Focusing again on the different sub-samples, it becomes obvious that this result is mainly driven by firms with mixed ownership, while for purely state-owned firms the point estimate is negative but statistically insignificant. This implies that changes in employment in state-owned enterprises tend to be decoupled from the labor demand which is driven by capacity enhancement.

Given the conflicting results for different types of ownership, a more in-depth investigation of the role of state ownership seems justified. For this reason, Table 4 provides additional estimation results for different types of firms and for an alternative measure of state ownership.

Firstly, the information used hitherto on different types of ownership might not provide a representative picture of private ownership. To give an example, in the sub-sample under study a firm with a direct state-ownership of less than 50% and with the rest of the shares being in the hands of other state-owned companies would be classified as a private firm. Put

[6]A more detailed analysis of differences in fixed effect estimates may shed more light on this issue.

Table 3: Estimation results: Drivers of firm growth in the Belarusian machine building industries

	LSDV estimator				Difference GMM estimator				Corrected LSDV estimator			
	Full sample	Private	State	Mixed	Full sample	Private	State	Mixed	Full sample	Private	State	Mixed
Lagged growth	−0.004	−0.103	−0.007	−0.009	−0.033	−0.160	0.011	−0.040	0.069**	0.036	0.107*	0.036
	(0.017)	(0.173)	(0.041)	(0.018)	(0.032)	(0.139)	(0.074)	(0.035)	(0.028)	(0.171)	(0.056)	(0.034)
Lagged employment	−0.549***	−0.706***	−0.437***	−0.494***	−0.842***	−0.851***	−0.711***	−0.813***	−0.553***	−0.661***	−0.478***	−0.489***
	(0.071)	(0.185)	(0.086)	(0.079)	(0.087)	(0.144)	(0.109)	(0.083)	(0.037)	(0.216)	(0.060)	(0.061)
Lagged wages per employee	0.084*	−0.087	0.314***	0.013	0.048	−0.002	0.258***	0.009	0.084***	−0.074	0.314***	0.013
	(0.045)	(0.144)	(0.077)	(0.014)	(0.030)	(0.102)	(0.066)	(0.011)	(0.018)	(0.112)	(0.036)	(0.020)
Lagged exports	−0.004**	0.003	−0.006**	−0.001	−0.004***	−0.010	−0.009***	−0.003	−0.003	0.003	−0.005	−0.001
	(0.002)	(0.016)	(0.003)	(0.003)	(0.002)	(0.011)	(0.002)	(0.002)	(0.003)	(0.025)	(0.005)	(0.005)
Lagged investment	0.004**	0.018***	0.002	0.006**	0.003**	0.013***	0.002*	0.001	0.004*	0.016*	0.002	0.006**
	(0.002)	(0.006)	(0.002)	(0.003)	(0.001)	(0.003)	(0.001)	(0.002)	(0.002)	(0.009)	(0.003)	(0.003)
Lagged capacity utilization	0.098**	0.089	−0.080	0.128**	0.114***	0.091	−0.020	0.126***	0.094**	0.077	−0.092	0.129**
	(0.042)	(0.207)	(0.072)	(0.107)	(0.039)	(0.183)	(0.062)	(0.046)	(0.041)	(0.133)	(0.074)	(0.061)
Year fixed-effects[a]	10.83***	2.39	11.55***	7.75**	36.82***	13.43***	40.74***	32.40***	75.61***	7.97**	126.53***	12.59***
Observations	563	60	239	264	420	45	171	204	563	60	239	264

Notes: Robust standard errors in parenthesis. *(*)[***] stands for significance at the 10%(5%)[1%] level. All specifications include firm fixed effects. [a]Based on χ^2-tests with 3 degrees of freedom.

Table 4: Estimation results: Firm type, state-reporting and employment growth

	LSDV estimator					Difference GMM estimator					Corrected LSDV estimator				
	Main	Affil.	Indep.	Ministry	Non-Min.	Main	Affil.	Indep.	Ministry	Non-Min.	Main	Affil.	Indep.	Ministry	Non-Min.
Lagged growth	0.291	0.070	−0.009	0.088	0.001	0.161	−0.110	−0.021	−0.051	0.004	0.448*	0.198*	0.059	0.200***	0.064
	(0.388)	(0.066)	(0.019)	(0.066)	(0.027)	(0.259)	(0.072)	(0.036)	(0.047)	(0.049)	(0.254)	(0.112)	(0.038)	(0.061)	(0.044)
Lagged employment	−0.348	−0.447***	−0.596***	−0.493***	−0.656***	−0.342	−0.565***	−0.912***	−0.683***	−1.013***	−0.394**	−0.438***	−0.603***	−0.494***	−0.667***
	(0.294)	(0.059)	(0.088)	(0.075)	(0.118)	(0.213)	(0.061)	(0.104)	(0.074)	(0.132)	(0.182)	(0.071)	(0.058)	(0.049)	(0.065)
Lagged wages per employee	0.355*	0.152***	0.077*	0.045	0.093	0.411***	0.173***	0.042	0.038	0.054	0.354*	0.148***	0.078***	0.043	0.093***
	(0.162)	(0.048)	(0.046)	(0.032)	(0.056)	(0.111)	(0.056)	(0.029)	(0.026)	(0.037)	(0.201)	(0.047)	(0.023)	(0.027)	(0.022)
Lagged exports	−0.011	−0.008*	−0.002	−0.005**	−0.003	−0.004	−0.012***	−0.002	−0.005***	−0.003	−0.011	−0.007	−0.002	−0.004	−0.003
	(0.007)	(0.004)	(0.002)	(0.002)	(0.004)	(0.008)	(0.003)	(0.002)	(0.002)	(0.003)	(0.010)	(0.005)	(0.003)	(0.003)	(0.006)
Lagged investment	0.033*	0.000	0.005***	0.003	0.006**	0.036***	0.000	0.004***	0.000	0.006***	0.034	0.000	0.005**	0.003	0.006**
	(0.014)	(0.002)	(0.002)	(0.002)	(0.003)	(0.008)	(0.002)	(0.002)	(0.001)	(0.002)	(0.021)	(0.003)	(0.003)	(0.002)	(0.003)
Lagged capacity utilization	−0.158	0.042	0.119**	0.097**	0.086	−0.246**	0.069	0.126***	0.091**	0.135**	−0.177	0.037	0.118**	0.092*	0.082
	(0.109)	(0.077)	(0.048)	(0.048)	(0.067)	(0.093)	(0.072)	(0.045)	(0.043)	(0.061)	(0.176)	(0.074)	(0.057)	(0.050)	(0.069)
Year fixed-effects^{a}	8.15**	13.9***	7.84***	17.22***	5.52***	48.84***	52.20***	28.69***	67.42***	16.45***	7.63*	32.16***	53.77***	54.71***	50.24***
Observations	28	109	426	281	282	21	81	318	210	210	28	109	426	281	282

Notes: Robust standard errors in parenthesis. *(*)[***] stands for significance at the 10%(5%)[1%] level. All specifications include firm fixed effects. ^{a}Based on χ^2-tests with 3 degrees of freedom.

differently, if the state owns less than 50% of a firm directly, it is classified as privately owned irrespective of whether the other owners are state or private companies. Evidently, in an economy which is characterized by widespread state ownership this approach may lead to a massive misclassification of firms.

Secondly, it is worth noting that the largest state-owned firms in the Belarusian machine building industry operate as *de facto* vertically integrated corporate groups. Thereby, in most of the cases a number of subcontracting state-owned firms produce intermediate goods which are then assembled by the large and prestigious producers, such as e.g., *Minsk Automobile Plant (MAZ)* or *Minsk Tractor Works (MTW)*. Vertical integration, on the one hand, intends to strengthen governance structures within companies and ensures reliable supply of intermediate inputs (see, e.g., Williamson 1971, Helpman and Krugman 1985). On the other hand, vertical production chains might help hiding inefficiencies within the production chain. Thereby, internal transactions of goods and services at non-market prices may allow for cross-subsidization of inefficient sub-units within the vertical conglomerates.

In order to analyze these issues explicitly, we utilize additional characteristics of the firms. We are able to distinguish between main companies of the vertical chains, the affiliate firms and a third group of independent firms. In addition, we use information on whether a firm directly reports to the Ministry of Industry and, thus, is directly influenced by the state in its activities. Table 4 reports the results of the standard firm growth equations for five different classifications of firms. Among them are main companies of vertical chains, affiliates within a vertical chain, independent companies and ministry versus non-ministry reporting firms.

Our estimation results again reject Gibrat's law, implying that smaller firms exhibit, ceteris paribus, higher employment growth rates. With regard to average wage costs, firms within the vertical production chains tend to have higher growth rates, while they are less cost-efficient. Interestingly, when focusing on the results obtained by the CLSDV estimator, this effect is insignificant only for the ministry-reporting firms. Overall, this somehow surprising result might be explained with unobserved differences in human capital of the employed labor force. Put differently, if firms employ more skilled workers, they tend to be pay higher wages, but may also become more competitive. This in turn, might increase the demand for goods produced by the respective firms leading to higher employment growth rates. More detailed data on the educational attainment of employees, which are not available, would be necessary in order to assess this hypothesis empirically.

The negative internationalization effect of exports seems to be most important for affiliates of vertical conglomerates and ministry-reporting firms. This result supports the view that those firms which are rather inexperienced in being involved in international markets are more negatively affected by an increase in worldwide competition.

Interestingly, the positive impact of investment activities on firm growth does not hold for affiliates of vertical production chains and ministry-reporting firms. Consequently, the employment growth performance of these firms is independent from an increase in capital inputs. To the contrary, for all other types of firms (i.e. head of vertical chain and independent firms) an increase in capital leads to a subsequent increase in employment growth.

With regard to capacity utilization, we are only able to identify positive effects for independently organized firms, while in vertical production chains we tend to find negative effects especially for the main firms. This result suggests that head companies with lower capacity utilization tend to experience higher increases in their number of employees. Evidently, this result once more supports the view that the approach taken for the organization of production in the Belarusian machine building industries leads to inefficient resource allocation. Thereby, the role of the relatively large vertical production chains seems to be especially questionable.

4 Total factor productivity in the Belarusian machine building industry

4.1 Estimating total factor productivity

To investigate productivity differentials between purely state-owned and non-state owned firms, we specify a functional form for the firm-specific production function. For the sake of simplicity, we apply a Cobb-Douglas production function, which is given by

$$Y_{it} = A_{it} L_{it}^{\alpha} K_{it}^{\beta}, \tag{3}$$

where Y_{it} is a measure of output (e.g., value added) of firm i at time t and L_{it} and K_{it} denote labor and capital inputs, respectively. Finally, A_{it} captures firm-specific TFP, which simultaneously affects the marginal products of both inputs. Taking logarithms of the Cobb-Douglas production function yields

$$\log Y_{it} = \alpha \log L_{it} + \beta \log K_{it} + \log A_{it}, \tag{4}$$

which forms the basis of our empirical specification.

Equation (4) implies that the residuals of the estimation of the (log) production function can be used as a measure of each firm's TFP. Theoretically, a firm (at least partly) knows its TFP and accordingly chooses its level of labor and capital inputs (e.g., more productive firms tend to produce larger quantities of a good and, consequently, utilize more capital and labor inputs). Formally, this implies that $\log A_{it}$ comprises a systematic component and a true (random) error term, which modifies the (log) production function to

$$\log Y_{it} = \alpha \log L_{it} + \beta \log K_{it} + \omega_{it} + \epsilon_{it}, \tag{5}$$

where ω_{it} represents a firm's TFP known only to itself and ϵ_{it} is an iid error (see, e.g., Arnold 2005). Since ω_{it} is correlated with the choice of labor and capital inputs, ordinary least squares (OLS) estimation of (5) *inter alia* suffers from the so-called simultaneity bias (or transmission bias), leading to inconsistent estimates of α, β and $\log A_{it}$, respectively.

To successfully cope with the simultaneity problem when estimating TFP at the firm leve,l the econometric literature offers various methodologies.[7] In case that the firm-specific systematic component in the error term is time-invariant (i.e. $\omega_{it} = \omega_i$), standard fixed-effects estimation would allow to consistently estimate α and β and thus, TFP would be accurately measured. However, in case of low within-firm variation the parameters of the production function would be only weakly identified and in case of ω_i varying over t the fixed-effects estimates would also be inconsistent.

Olley and Pakes (1996) and Levinsohn and Petrin (2003) developed alternative (semi-parametric) estimation procedures, which explicitly deal with the simultaneity bias when estimating pro-

[7]For a recent survey on the estimation of TFP at the macroeconomic and the microeconomic level, see Del Gatto, Di Liberto and Petraglia (2011).

Table 5: Estimation results: Cobb-Douglas production function in machine building industries

	Model			
	OLS	FE	OP[a]	LP[b]
Labor	0.583***	0.263***	0.417***	0.314***
	(0.044)	(0.064)	(0.097)	(0.088)
Capital	0.391***	0.158**	0.414***	0.569***
	(0.038)	(0.065)	(0.144)	(0.171)
Returns to scale	0.974	0.421	0.834	0.883
Wald test[c]	2.10	53.09***	1.19	1.21
Observations	914	914	759	914

Notes: Standard errors in parenthesis.*(*)[***] stands for significance at the 10%(5%)[1%] level. All regressions inlclude year fixed effects.
[a]OP indicates the Olley and Pakes (1996) approach.
[b]LP indicates the Levinsohn and Petrin (2003) approach, where material costs proxy for unobserved productivity shocks. [c] The Wald test assumes constant returns to scale (i.e., $\alpha + \beta = 1$) as the null hypothesis.

duction functions. The former utilizes a firm's investment decision to proxy for differences in ω_{it}, while the latter one proposes the use of intermediate inputs in order to consistently estimate the production function. The Olley and Pakes (1996) estimation procedure can only be applied to firms with non-zero investments and therefore this approach typically excludes a large number of firms. In contrast, the Levinsohn and Petrin (2003) approach can be applied to all firms with a non-zero demand of intermediate inputs such as e.g., materials.

4.2 Estimation results for total factor productivity

In order to verify the robustness of our TFP results, we apply four different estimation strategies: OLS, fixed-effects as well as both approaches proposed by Olley and Pakes (1996) and Levinsohn and Petrin (2003). Output is measured in terms of value added, defined as revenues minus costs for material inputs. Table 5 reports the corresponding estimation results for α and β.

Evidently, with regard to the labor and capital elasticities the five different estimation strategies lead to deviating results. To give one example, the input elasticities obtained from simple OLS estimation indicate that the Belarusian machine building industry produces using a rather labor intensive technology, while the Levinsohn and Petrin (2003) procedure suggests the opposite.

Regarding the measurement of TFP, the residuals of the various production function estimates are of major interest. In contrast with the estimates of input elasticities, the TFP measures obtained form the four different procedures are very similar, with the correlation exceeding 0.95 in almost all cases. The only exception is the fixed effects estimator, which leads to a relatively poorly correlated TFP measure. However, in our application this latter estimator suffers from low within-firm variation leading to weakly identified input elasticities. For this reason, we use the TFP measures based on all four different estimation results in order to compare TFP between state-owned and non-state owned Belarusian machine building firms.

Table 6: T-Test for Differences in TFP between different types of firms

	State-owned[a]	Non-State-owned[a]	Diff.	Privately-owned[b]	Non-Privately-owned[b]	Diff.	Ministry-reporting[c]	Non-Ministry-reporting[c]	Diff.
Levels in TFP									
OLS	1.054	1.377	−0.323***	1.574	1.198	0.376*	0.988	1.494	−0.506***
FE	2.009	1.522	0.487***	1.225	1.791	−0.566***	2.065	1.389	0.676***
OP	17.232	20.784	−3.552***	22.014	18.941	3.073	16.937	21.641	−4.704***
LP	4.703	5.824	−1.121***	6.522	5.201	1.321*	4.513	6.189	−1.676***
Growth in TFP									
OLS	0.032	0.173	−0.141**	0.268	0.096	0.172	0.124	0.104	0.020
FE	0.029	0.170	−0.141**	0.276	0.092	0.184	0.119	0.104	0.015
OP	0.082	0.247	−0.165**	0.326	0.161	0.165	0.193	0.164	0.029
LP	0.043	0.201	−0.158**	0.287	0.117	0.170	0.150	0.122	0.028

Notes: *(*)[***] stands for significance at the 10%(5%)[1%] level.
[a]The groups of state-owned and non-state-owned firms comprise 369 and 512 firm-year observations, respectively.
[b]The groups of privately-owned and non-privately-owned firms comprise 102 and 779 firm-year observations, respectively.
[c]The group of firms directly reporting to the Ministry of Industry and the group of non-reporting firms comprise 439 and 442 firm-year observations, respectively.

Our results indicate that TFP in non-state-owned Belarusian machine building firms exceeds the corresponding level of productivity in state-owned enterprises (see Table 6).[8] This finding is robust for all four different estimation procedures for the Cobb-Douglas production function, with the exception of the fixed effects estimator. Moreover, during our observation period (2005 to 2010), the difference in TFP levels across state- and non-state-owned firms has increased. The latter result is based on the comparison of TFP growth rates in the respective groups of firms. Again, this result is robust with regard to alternative estimation strategies for our simple production function.

In order to investigate differences in productivity, we additionally compare privately-owned firms with purely state-owned and mixed-ownership firms. The corresponding findings are reported in columns 4, 5 and 6 of Table 6. For this latter classification of different firm groups our results are somewhat weaker. The group of privately owned firms only consists of 102 firm-year observations, which considerably lowers the power of our statistical tests. Qualitatively, our results are in line with the view that, in comparison to privately-owned firms, state-owned and mixed-owned firms have lower levels of TFP. In this regard, the fixed effects estimator again deviates from all other estimated models. Focusing on TFP growth rates, we are not able to obtain any significant differences across privately-owned and non-privately-owned firms. However, column 6 in Table 6 indicates that the average TFP growth rate for the former group always exceeds the ones for average mixed-owned and state-owned firms.

Following the discussion from above, we are also interested in analysing the impact of (potential) misclassification of firm ownership on our TFP results. For this reason, columns 7 and 8 of Table 6 report our TFP results for the groups of ministry-reporting and non-ministry-reporting firms, respectively. Column 9 provides the results of various t-tests for both groups of firms. Here, an additional advantage of the ministry-reporting information for state ownership is that both types of firm groups are of similar size (439 and 442, respectively) and thus our simple mean-comparison tests are well equipped with statistical power.

Excluding the unreliable fixed effects estimation results from our discussion, the upper parts of columns 7 and 8 clearly indicate that, on average, non-ministry reporting firms exhibit higher levels of TFP. Indeed, according to the results obtained from the other three estimation procedures (OLS, Olley and Pakes 1996 and Levinsohn and Petrin 2003), the TFP levels of non-ministry reporting firms substantially exceed the corresponding figures of their ministry-reporting counterparts. Some TFP estimators even indicate that the productivity levels for non-state-influenced firms are approximately doubled.

The results presented in the lower parts of columns 7 and 8 again do not provide significant differences with regard to TFP growth across ministry-influenced firms and the non-influenced counterparts. All results taken together, the simple mean comparison tests unambiguously document that state-owned and state-influenced firms exhibit lower levels of TFP. Moreover, when focusing on a comparision of state-owned and non-state-owned firms this TFP gap has widened during the period from 2005 to 2010.

[8] Table 6 provides the results of simple t-tests with unequal variances in the sub-populations for different types of firms. The upper part compares the level of TFP, while the lower part focuses on differences in TFP growth rates across the respective groups. The first two columns compare state-owned and non-state owned firms.

5 Unveiling the source of productivity differences

The results in the previous section indicate that large productivity differences exist between state-owned enterprises and private firms in the Belarusian machine building industry. In this section, we investigate this issue further using models that aim at identifying the determinants of TFP differences across firms. We start by estimating convergence equations for TFP to assess whether the observed dynamics in productivity lead to corrections in the observed differences in TFP. In particular, we estimate a model given by

$$\Delta \log A_{it} = \rho_0 + \rho_1 SOE + \lambda \log A_{it-1} + \varepsilon_{it}, \tag{6}$$

where a negative estimate of λ indicates convergence. The presence of convergence dynamics would point to the fact that, on average, firms with low productivity levels tend to increase their productivity more than their high-productivity counterparts. We include a dummy variable for state-owned enterprises in the specification, whose parameter estimate informs us about whether state-owned firms converge in the long-run to higher, lower or similar productivity levels as compared to privately- and mixed-owned firms.[9]

Since we are interested in unveiling convergence dynamics between firms, we do not include firm-specific fixed effects in the specification at this point.[10] The results of the estimation of (6) are presented in Table 7 for the different TFP data obtained using the methods described above.

Table 7: Convergence equations: TFP

	OLS	FE	OP	LP
Lagged TFP	-0.099^{**}	-0.025^{***}	-0.008^{**}	-0.027^{**}
	(0.042)	(0.009)	(0.003)	(0.011)
State-owned	-0.159^{**}	-0.113^{*}	-0.159^{**}	-0.160^{**}
	(0.068)	(0.063)	(0.072)	(0.070)
Intercept	0.377^{*}	0.297	0.552^{**}	0.483^{**}
	(0.224)	(0.212)	(0.260)	(0.246)
R^2	0.015	0.008	0.023	0.020
Obs.	727	727	727	727

Notes: Each column refers to a different TFP estimate, abbreviations as in preceding section. Robust standard errors in parenthesis. *(*)[***] stands for significance at the 10%(5%)[1%] level.

The qualitative conclusions from the estimation results appear independent from the TFP data used. In all cases, the results indicate convergence dynamics in total factor productivity, as can be inferred from the negative and significant parameter estimates attached to the lagged TFP level. However, the long-run equilibrium towards which productivity levels converge is significantly lower for state-owned enterprises as compared to privately owned firms, as reflected in the negative and significant coefficient estimate attached to the dummy variable which identifies state-owned firms.

[9] The long-run equilibrium for private firms according to equation (6) is given by $\rho_0/-\lambda$, while state-owned enterprises converge to $(\rho_0+\rho_1)/-\lambda$.

[10] All specifications include year fixed effects.

Once differences in TFP dynamics have been discovered, the question remains concerning where such differences come from. labor hoarding, overinvestment or unproductive investments are potential explanations for such a result. In our next modeling step, we expand equation (6) adding new explanatory variables with the aim of explaining the source of productivity differences across firm groups. The general specification which we estimate is given by

$$\Delta \log A_{it} = \rho_0 + \rho_1 SOE + \lambda \log A_{it-1} + \lambda_1 SOE \log A_{it-1} + \gamma_1 \Delta \log L_t + \gamma_2 \Delta \log K_t + \varepsilon_{it}. \quad (7)$$

In this specification, we allow for a different speed of convergence for state-owned and privately-owned firms, which is captured by the interaction between the SOE dummy and $\log A_{it-1}$, and include employment growth and the growth rate of capital as extra determinants of TFP growth. The explanatory power of employment growth and/or physical capital growth should indicate which input dynamics can explain different productivity developments across enterprises in the machine-building industry. If state-owned firms performed poorly in terms of productivity growth because of labor hoarding, differences in employment growth should be able to account at least partly for TFP growth differences. On the other hand, if unproductive investments were responsible for these differences, the growth in capital stock should be a significant determinant of TFP growth gaps between firms.

Table 8 presents the results of the estimation of (7) using standard OLS methods (where between-firm differences are the dominating source of variation) and fixed effects estimation (which aims at explaining within-firm changes in productivity). Starting with the OLS results, the most remarkable result in Table 8 is that, once that model (6) is expanded to the specification given by (7), the SOE dummy loses its significance for all TFP estimates with the exception of those obtained using the FE method, whose characteristics, as seen in the previous section, appear to be different from those from all other methodologies.

This result, together with the estimates of the covariates included in the specification, implies that the differences in TFP growth between state-owned and private firms can be explained by (a) their different dynamics in terms of adjustment to the equilibrium (mirrored in some significant parameters for the interaction of SOE and $\log A_{it-1}$) and (b) differences in the accumulation of production factors. One of the specifications indicate that the lower TFP growth emanates from the fact that firms have increased employment in a framework where production was either decreasing or increasing at a lower rate than labor input. The specification based on the Levinsohn and Petrin (2003) method indicates that the source of productivity growth differences is based on unproductive investment on physical capital. The conclusion that can be inferred from the OLS results in Table (8) is thus that growth of inputs factors might at least partially explain lower TFP growth rates in state-owned enterprises.

Focusing on the fixed effects results, each firm is assumed to converge to an enterprise-specific level of productivity and the results indicate that in the period under study productivity decreases slightly tended to take place in parallel to increases (or relatively low decreases) in capital. This is indicated by the negative point estimates, which are however insignificant. Furthermore, with the exception of the results based on FE estimates of TFP, our estimates show that state-owned enterprise adjusted their productivity levels at a higher speed than private firms.

Taking into account the developments in aggregate production during the period considered, which have been marked by the effects of the global recession, our results indicate that the

Table 8: Convergence equations: TFP

	OLS estimation				Fixed effects estimation			
	OLS	FE	OP	LP	OLS	FE	OP	LP
Lagged TFP	−0.090**	−0.057**	−0.008**	−0.026**	−0.217***	−0.212***	−0.018***	−0.058***
	(0.044)	(0.023)	(0.004)	(0.013)	(0.044)	(0.054)	(0.004)	−0.058***
Lagged TFP × State-owned	−0.043	0.051**	0.001	−0.003	−0.503***	0.009	−0.028***	−0.099***
	(0.050)	(0.023)	(0.004)	(0.014)	(0.100)	(0.052)	(0.006)	(0.025)
Employment growth	−0.058*	0.019	−0.012	−0.001	−0.053	0.033	0.002	0.009
	(0.033)	(0.038)	(0.041)	(0.036)	(0.039)	(0.046)	(0.046)	(0.038)
Capital growth	−0.050	0.013	−0.050	−0.086**	−0.028	0.007	−0.029	−0.054
	(0.039)	(0.049)	(0.046)	(0.043)	(0.042)	(0.049)	(0.047)	(0.048)
State-owned	−0.106	−0.201**	−0.172	−0.138	.	.	.	.
	(0.104)	(0.094)	(0.124)	(0.120)	.	.	.	.
Intercept	0.379*	0.340	0.563**	0.497**	.	.	.	.
	(0.221)	(0.223)	(0.262)	(0.246)	.	.	.	.
R-squared	0.016	0.011	0.023	0.021	0.049	0.035	0.054	0.049
Obs.	727	727	727	727	727	727	727	727

Notes: Each column refers to a different TFP estimate, abbreviations as in preceding section. Robust standard errors in parenthesis. *(*)[***] stands for significance at the 10%(5%)[1%] level.

likely reason for the polarization in firm productivity between state-owned enterprises and private firms is related to a potential missallocation of resources at the firm level. The loss of productivity in state-owned enterprises can thus at least partly be explained by sub-optimal decisions when it comes to labor allocation and capital investments during the period 2005-2010.

6 Soft budget constraints and inefficient resource allocation

The results from the previous section indicate the existence of inefficiencies in state-owned firms due to labor hoarding and/or unproductive investments. This section provides results using an alternative method to investigate this issue further. We focus explicitly on potentially prevailing soft budget constraints (SBCs) in the sample of firms. SBCs in state-owned enterprises might arise if the government favours these companies *vis-à-vis* private competitors. Such SBCs may take the form of access to below cost energy inputs, preferential tax treatment, preferential access to financing, subsidy of interest rate payments or preferential access to procurement tenders.[11]

In order to empirically analyze whether SBCs are observable in the Belarusian machine building industry, we apply a simple matching approach. State ownership cannot be credibly considered to be comparable with a treatment which is applied randomly across firms. Some (eventually unobservable) firm characteristics tend to affect both the probability of being state-owned and their economic performance, so sample selection is a potential statistical problem in our empirical application. For our study, we draw on existing theoretical contributions related to matching estimators for average treatment effects by Abadie and Imbens (2006) and implement the corresponding estimators as discussed in Abadie, Drukker, Herr and Imbens (2004).[12] Matching estimators are well established in the so-called program evaluation literature, which intends to identify the economic impact of certain policy measures. In our case, the policy variable (treatment) of interest is state-ownership, measured with the information on firms reporting to the Ministry of Industry, and our aim is to assess whether labor hoarding and/or unproductive investments are present in these firms. The two most commonly used estimators for treatment effects of policy intervention are the *average treatment effect* (ATE) and the *average treatment effect on the treated* (ATT). The former estimates the average effect of the policy program for a randomly drawn firm from the whole sample while the latter only considers the sub-sample of state-owned firms. Formally, these two estimators are given by (see, e.g., Wooldridge 2010)

$$\tau_{\text{ATE}} = E(y_1 - y_0), \text{and} \tag{8}$$

$$\tau_{\text{ATT}} = E(y_1 - y_0 | w = 1), \tag{9}$$

where $w = 1$ if a firm is state-owned and $w = 0$ otherwise. y_1 and y_0 denote the outcome under treatment and non-treatment, respectively. The problem in this setting is that for each firm only one outcome is observable. If a firm is state-owned, we only observe y_1; while for non-state-owned firms only y_0 is available. The matching approach (among other methods) intends to identify the counterfactual unobservable outcome for each firm. Here, the basic idea is that the most similar firms with regard to the outcome-relevant characteristics in the control group

[11] Kornai et al. (2003) provide an excellent survey on SBCs.

[12] Literature reviews on matching estimators are provided by Cobb-Clark and Crossley (2003), Imbens (2004), Blundell and Costa Dias (2009) and Imbens and Wooldridge (2009).

constitute the best estimate for the unobservable counterfactual outcome. If for example two firms, one state-owned and the other private, are equal in all determinants of the final outcome an observable difference between these two can be traced back to state-ownership.

In our empirical application, we are interested in phenomena such as labor hoarding and inefficient investment in physical capital. We evaluate the existence of SBCs taking explicitly the vertical organizational structure of firms into account. Our first analysis focuses on subsidiary firms of these vertical chains as well as on independent firms.[13] We restrict our matching procedure to only consider firms which are of the same type as the respective firms, and thus, we compare our outcomes of interest only for subsidiary firms or independent firms.

Table 9 provides our results. The upper part of Table 9 presents the results when we average our log-differences for the ATE and ATT over both types of firms while the second and third parts individually focus on the sub-samples of subsidiary and independent firms, respectively. For all three different matching estimators the counterfactual outcome for each firm is based on the three nearest neighboring firms based on the matching variables. Finally, the lowest part of Table 9 reports the matching results for the head companies of the vertical production chain. Due to the lack of a proper control group (i.e. no head firms which are not state-owned), we are forced to modify our matching procedure. We define the group of privately-owned independent firms as the most similar group of firms. However, we are aware that many of the independent firms are not really comparable to the group of head companies, which tend to be very large firms. Consequently, in order to compare somehow similar firms we restrict our matching approach for the head firms to only the single nearest neighboring firm out of the control group.

Our various matching estimators commonly restrict the comparison to the same type of firms in the same year. This guarantees that we only compare subsidiaries of vertical production chains and independent firms with each other, respectively. Moreover, due to the cyclical behavior of the whole economy during our observation period, we only compare labor and capital inputs within the same years. Additionally, for our analysis of employment and physical capital, we match firms based on their level of TFP, TFP growth, profits, value added, revenues and the firm's industrial sub-sector as well as its regional location. Here, TFP is calculated as the average of our four different measures.

With regard to these two input variables, our results are well in line with what we have obtained so far. In particular, as indicated by both the ATEs and the ATTs, state-owned firms with most similar characteristics employ more workers as compared to private enterprises. To give one example, the average subsidiary or independent state-owned firm employs 46.7% more workers than it would employ as privatized company. Similarly, the ATT including both types of firms indicates that for the same level and growth rate of TFP and all other matching variables, the capital input of state-owned enterprises is roughly double of that in private firms. This reinforces our argument that not only labor hoarding but also overinvestment is important in the Belarusian machine building industry.

[13]Unfortunately, all head firms of the large networks report to the Ministry of Industry and, thus, our dataset lacks a proper control group for this subset of firms.

Table 9: Matching Estimates for SBCs

	Employment[a]	Physical capital[a]
Subsidiaries and Independent Firms (3 nearest neighbours)		
ATE	0.443***	0.785***
	(0.099)	(0.128)
ATT	0.467***	1.000***
	(0.103)	(0.108)
Subsidiaries Firms (3 nearest neighbours)		
ATE	0.680**	0.196
	(0.281)	(0.205)
ATT	0.732***	0.256
	(0.282)	(0.206)
Independent Firms (3 nearest neighbours)		
ATE	0.832***	0.797***
	(0.125)	(0.152)
ATT	0.989***	1.104***
	(0.100)	(0.125)

Notes: Robust standard errors in parenthesis. *(*)[***] stands for significance at the 10%(5%)[1%] level.

[a] Matching is based on level of TFP, TFP growth, profits, exports, value added, sub-industry and time fixed effects.

7 Concluding remarks

This paper evaluates the economic performance of state-owned versus non-state-owned firms in the Belarusian machine building industry. Empirically, the focus is on the firm growth performance and on total factor productivity. We apply standard modern methods from the empirical firm growth literature and our results indicate that firm growth (in terms of employment) in state-owned firms might be unsustainable and driven by inefficient resource allocation. Our results also indicate that vertical production chains might be particularly important to explain the source of such misallocation of resources. We use matching techniques to investigate the instruments used to enable such resource misallocation. Soft budget constraints appear to be in place in the sector. The group of state-owned subsidiaries of vertical networks tends to benefit most from such soft budget constraints.

From an economic point of view, these unsustainable firm growth trends can have very relevant effects on firm productivity dynamics. Using estimates of total factor productivity (TFP), which account for the simultanity bias, we unambiguously reveal that state-owned firms are less efficient than their private counterparts. Moreover, TFP convergence equations show that the dynamics and long-run level of productivity is substantially lower for this group of firms. labor hoarding and unproductive overinvestment are possible explanatory factors for these differences. With the aid of extended TFP convergence equations, we are able to demonstrate that for the Belarusian machine building industry the unsustainable increases in input factors might be responsible for the low level of productivity in state-owned firms. These results are further confirmed using matching methods where potential sample selection issues are accounted for.

In the long-run, the inefficiencies which have been identified are likely to lead to adverse economic consequences. In a globalized world economy, inefficient firms will not be competitive in the long-run and, thus, Belarusian machine building firms will find it hard to successfully participate in international markets. Relying exclusively on local demand would lead these firms to fail to produce at the minimum efficient scale. The results presented in this study indicate that policy measures aimed at correcting such inefficiencies should be high in the industrial policy agenda of policy actors in Belarus.

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