Effects of Robotization on productivity in Russian firms[1]

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1. Introduction

Industrial robotics has long been a widely known technology in the world. At the same time, there is still a significant gap in the level of robotization of the pioneer countries from the follower countries. In Russia there is low integration is related to the non-obvious effects of robotization on production. Previous studies have not evaluated the value of robot adoption effects – scale and specificity, which is primarily necessary for company management. We aimed to fulfill this research gap by providing an empirical study that answers main research question: What are the effects of robot adoption in Russian firms?

2. Theoretical Background and Literature Review

Country-level studies are mostly based on databases from the IFR, WIOD, and EU-KLEMS databases and cover mostly developed European countries. Among them *(Stiebale et al., 2020)* find a positive effect of industrial robotics on productivity raising markups and overall profits, but declining aggregate labor income. Confirming previous effects of robotics *(Graetz and Michaels, 2018)* argue that the contribution from robotization increases labor productivity and total factor productivity. Nascent and rapidly growing empirical literature discusses the effects of robots' adoption at the micro level using mainly data from a few EU countries - Germany, France, Italy and Spain *(Acemoglu et al., 2020; Bonfiglioli et al., 2020; Koch et al., 2021)*. Much less is known about the effects of robot adoption in the new EU member states and former transition economies including Slovenia, Slovakia, Czech Republic and Hungary *(Cette et al., 2021)* as well as other developing and transition economies, where evidence is mainly represented by China *(Huang et al., 2022).*

3. Research Design, Methodology and Data Analysis

Our data comes from Ruslana Bureau van Dijk database and includes 81794 firms that were active in 2011-2018 in Russian manufacturing sector. For each firm, we have data on revenue, fixed assets, costs of goods sold, number of employees, industry and region of operation, year of establishment and ownership structure. We combine this dataset with data from the Customs service of the Russian Federation and identify 295 that purchased industrial robots during 2011-2018. We use two proxies for robots' adoption, the first is the ratio of (cumulative) value of imported robots to fixed assets and the second is a simple dummy if firms imports robots

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in respective years. In addition, we use the Customs service data to identify exporters and for each exporting firm in our sample we add the data on values of exports to calculate the export intensity. The research design of our study is quantitative based on secondary data analysis. Estimation procedure includes now-standard panel data estimation technique with random effects model for sector *i;* at time *t*.

4. Results/Findings and Discussion

First, we find that robots contribute to increasing in labour productivity. From the literature there is a perception that robotization in the Russian context is not always aimed at increasing labour efficiency, because it can lead to job cuts while companies are under constraints of releasing employment. However, we see that implementation of robots leads not only to higher TFP, but also to higher labour productivity. That if why there are effects associated with increased labour productivity.

Second, our empirical estimations show a significant presence of substantial lags, that is why effects are not constraint through the time. In this case, the support tools from the government should be aimed for a medium-term perspective (at least 3 to 5 years). In addition, we observe that the coefficients are decrease over time: the effects for TFP gradually diminish and becomes totally insignificant in the 5th period. The effect of robotization does not transfer to productivity all at once but with some delay effect: it is strong at first period and then it becomes increasingly weaker. This means that the use of robots in the baseline period will reduce the impact on TFP unless a constant level of technological upgrading is maintained. In addition, the robots themselves begin to become obsolete. As a possible solution of this problem there is a necessity in long-term increase in level of technological upgrading that bring to a constant increase in productivity. In this case, government support of robotization through incentives (tax reductions, subsidies and other benefits) should be last for medium-term perspective.

Third, non-exporting companies (companies with lower productivity) benefit more from the introduction of robots in production. As a possible explanation, we see a lower base effect for companies with a low share of exports: they tend to be less productive. Importing robots for them has a much greater effect than for exporters who have a lower development potential. In this way, the introduction of robotics contributes to convergence in the economy, because we see a strong productivity gap between exporters and non-exporters. Here robotization plays as a "catching-up" effect for companies with lower TFP. For these companies, the use of robots creates an additional chance of overcoming the level of productivity that would allow them to become an exporters and enter international markets, thereby integrating into the GVC. If non-exporting companies receive governmental support in the form of robotized production they receive a modernized base and productivity increases more quickly, thereby gaining greater potential for the expansion and becoming an exporter.

The effects of robots do not differ between domestic and foreign owned companies. The one difference between this sub-samples is that for companies that have domestic ownership and high export activity such companies have higher productivity then similar foreign owned companies.

Finally, we found negative impact of size: TFP is greater in smaller companies. At first glance, findings on

effects from the size of the company might be controversial. However, in our opinion when a large company imports robots it does not affect the structure and business model much. In the case of a small business, when a company starts using robotics, the whole production cycle begins to change, the whole ideology of production changes. In this respect the effect may be greater. Any technological upgrading at a large business occurs more smoothly than at a small business. In this case, small companies have a more dramatic leap in productivity than large market players, which have to gradually change the structure of production by gradually replacing old technologies and introducing new ones.

5. Conclusion, Contribution and Implication

Our paper provides one of the first portray of robots' adoption in Russian manufacturing sector and discusses effects on labour productivity and TFP. Our results uncover specifics of robots' adoption and provide some policy implications which are important for technology upgrade and productivity growth in a lagging country as Russia. We find that robots import leads to higher labour productivity and TFP. These suggests that robot adoption is a part of technology upgrade programs. The results are highly relevant for policymakers and show that to fully benefit from robotization it's not sufficient to attract technologically advanced foreign firms, but it's also important to stimulate robotization in domestic firms.

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