Productivity Spillovers in the Russian Federation: The Case of Chemical Market

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Abstract. Over the last decades, much attention has been drawn to the question of productivity variation across countries. The differences in cross-country productivity could be explained by both foreign and domestic innovation. In order to estimate the influence of the former, the international transfer of technology should be considered. Foreign direct investment (FDI) and international trade are suggested to be major conduits of international technology transfer. The present paper aims to extend the current empirical literature by determining the effect and the source of productivity spillover in Russia in case of chemical industry. In order to find out the existence of FDI and international trade productivity spillover we applied the methodology developed by Ericson and Pakes (1995) and Olley and Pakes (1996). The econometric model was tested on the companies from chemical industry for the period 2007–2012. The empirical results show that FDI and international trade productivity spillovers are present in Russian chemical industry. The size of FDI spillovers is economically more important than imports-related spillovers. Based on the empirical results, we may predict that Russia's accession to the World Trade Organization in 2012 should result in productivity growth. However, further research on this topic will be possible when the statistical data becomes available for several years after accession.

Аннотация. На протяжении последних десятилетий большое внимание уделяется вопросу колебаний производительности в межстрановом аспекте. Различия в уровне производительности можно объяснить внешними и внутренними инновациями. Чтобы оценить влияние внешних инноваций, необходимо рассмотреть вопрос международной передачи технологий. Предполагается, что прямые иностранные инвестиции (ПИИ) и международная торговля в наибольшей степени способствуют международной передаче технологий. Настоящая работа призвана расширить эмпирические знания путем определения эффекта и источников переливов капитала в России на примере химического рынка. Мы применили методологии, разработанные Эриксоном и Пейксом (1995), а также Олли и Пейксом (1996), чтобы выявить присутствие переливов капитала, вызванных как ПИИ, так и международной торговлей. Эконометрическая модель была протестирована на данных компаний химической отрасли за 2007–2012 гг. Эмпирические результаты демонстрируют, что в российской химической промышленности присутствуют переливы капитала, вызванные как ПИИ, так и международной торговлей. Эффект от переливов капитала, вызванных ПИИ, имеет большее экономическое значение. Основываясь на результатах эмпирического исследования, можно предположить, что вступление России в ВТО в 2012 г., вероятно, приведет к росту производительности. Однако дальнейшее изучение данного вопроса будет возможно, как только станут доступны статистические данные за последующие годы после присоединения.

Key words: Productivity spillover, FDI, trade liberalisation, Russia.

* Переливы капитала в Российской Федерации на примере рынка химического сырья.

INTRODUCTION

Over the last decades, much attention has been drawn to the question of productivity variation across countries. The differences in cross-country productivity could be explained by both foreign and domestic innovation (Eaton and Kortum, 1999; Keller, 2002). In order to estimate the influence of the former, the international transfer of technology should be considered. Grossman and Helpman (1991) suggested that foreign direct investment (FDI) and international trade are major conduits of international technology transfer.

FDI is believed to provide recipient countries with knowledge transfer as well as capital. The argument is that multinational corporations (MNCs) establish subsidiaries overseas and transfer knowledge to their subsidiaries. The transferred knowledge has a certain public good quality and may spread through non-market mechanisms over the entire economy leading to productivity spillovers in domestic firms (Blomstrom, 1989).

Expectation of productivity spillovers from knowledge transfers has been a major impetus to policy makers in many countries to provide FDI-friendly regime. In developing countries, policies in favor of FDI have been introduced since the early 1980s. Since then, net inflows of FDI have increased dramatically and FDI has been the most significant part of private capital inflows to developing countries.

Now an important question is whether these huge FDI inflows indeed bring about productivity spillovers for recipient countries, particularly for developing economies. The evidence is fairly mixed so far. Some empirical studies confirm positive productivity spillovers from FDI (for example, Caves, 1974; Chakraborty and Nunnenkamp, 2008; Görg and Strobl, 2005; Javorcik, 2004; Schiff and Wang, 2008), but others find negative or no spillovers (e.g., Aitken and Harrison, 1999; Barry *et al.*, 2005; Djankov and Hoekman, 2000; Haddad and Harrison, 1993). The mixed evidence intuitively implies that there is no universal relationship between FDI and domestic firms' productivity. Some studies, however, argue that the mixed findings may be attributed to domestic firms' characteristics or host countries' ability to absorb productivity spillovers (Görg and Greenaway, 2004; Smeets, 2008). Nevertheless, differences in findings depend significantly on research design, methodological approach, types of data used, estimation strategy, and even on the construction of the spillover variable.

On the other hand, recently many developing countries have experienced dismantling of barriers to trade that has left domestic industry exposed to greater competition while at the same time allowing the most productive firms the opportunity to trade with a larger and more diverse world market. Trade liberalization episodes in the developing world have attracted the interest of much academic research aimed at understanding the extent to which exposure to foreign competition impacts on industry and firm productivity.

A large and growing empirical literature has linked trade to productivity using firm-level evidence, particularly for developing country contexts, and has attempted to disentangle these mechanisms. Tybout *et al.* (1991) find evidence of productivity enhancing effects from increased trade exposure using the case of trade liberalization in Chile in the 1970s. Pavcnik (2002) also finds for Chile that sectors facing new import competition saw faster productivity growth and attributes these effects to both within-firm productivity improvements and reallocations of resources away from the least productive firms. Similarly, Eslava *et al.* (2004) and Fernandes (2007) show that trade, labor and financial reforms in Columbia in the 1990s were associated with aggregate productivity improvements due to a more efficient allocation of resources. Fernandes also links productivity gains under trade liberalization to increases in imported intermediates, skills and machinery investments. Evidence for imported inputs as a channel for productivity growth is also provided by Kasahara and Rodrigue (2008) and Halpern *et al.* (2005) for Chile and Hungary, respectively. Amiti and Konings (2007) estimate the productivity gains associated with tariff reductions in intermediate inputs in Indonesia and find that the productivity gains from tariff reductions are at least as high as the gains associated with lower output tariffs. Moreover, they also show that these gains are achieved through learning, variety and quality effects. Blalock and Veloso (2007) also investigate the impact of imports on productivity growth of firms in Indonesia focusing on supply chain linkages. They find evidence that importing is a source of technology transfer for upstream firms supplying import-intensive downstream sectors. The overall evidence, however, is not conclusive. Van Biesebroeck (2003), for example, finds no evidence that productivity improvements in Columbia are due the use of foreign inputs. Similarly, Muendler (2004) finds limited effects of foreign inputs on productivity in Brazil.

The study proposed could provide a greater depth of knowledge about modern developments in the field of research of productivity spillovers. The results of the study may support the continuing fiscal and investment incentives provided by the Russian government for FDI, as well as stable trade liberalization policy. Moreover, the research topic is of current interest taking into consideration accession of the Russian Federation to World Trade Organization (WTO).

The present paper aims to extend the current empirical literature by determining the effect and the source of productivity spillover in Russia in case of chemical industry. In order to achieve the stated aim and answer research questions, the paper is organized as follows. Section 1 presents the conceptual framework for exploring the mechanisms through which FDI as well as international trade might impact the productivity of firms. Section 2 describes the role of chemical manufacturing sector in Russia. In Section 3 empirical approach and research design are discussed. Section 4 presents the results. Finally, conclusions are made.

1. CONCEPTUAL FRAMEWORK FOR PRODUCTIVITY SPILLOVERS

The concept of productivity spillovers embodies the fact that foreign enterprises own intangible assets such as technological know-how, marketing and managerial skills, international experience or reputation, which can be transmitted to domestic firms, raising their productivity level. Productivity spillovers diffusion is thus a matter of externalities from established foreign producers to domestic ones. As mentioned previously, there are two main sources of productivity spillovers, namely FDI and international trade. In the following sections, the mechanisms of such sources will be considered.

1.1. PRODUCTIVITY SPILLOVERS: GENERAL OVERVIEW

Foreign firms are presumed to have inherent advantages, particularly in scale and technological knowledge and in access to international markets that allow them to overcome the cost of setting up in a different country and to produce more efficiently (Blomstroem & Kokko, 1997; Hymer, 1976). Often, these advantages take the form of proprietary assets, technology or management and marketing practices (what Markusen (2002) terms as "knowledge capital"). These imply higher productivity of foreign-owned firms themselves. Moreover, productivity spillovers may have positive effects on local firms. Productivity spillovers generally take place when the entry or presence of multinational firms leads to efficiency or productivity benefits for local firms that are not fully internalized by the foreign firm (Blomstroem & Kokko, 1998).

There are several mechanisms through which these spillover effects occur. These can be split into competition and demonstration effects (Girma, Greenaway, & Wakelin, 2001). The presence of more efficient foreign firms in an industry may increase competition in domestic industries as foreign firms tend to populate industries where the initial cost of entry is high (Caves, 1974). They may also break up domestic monopolies by lowering excess profits and generally improving allocative efficiency. Local firms can also improve their productivity by copying technology from multinational firms in their industry. Foreign firms may not be able to internalize all the gains of their technology and domestic firms may benefit through their contact with foreign firms, either as suppliers, consumers or competitors. On the other hand, entry of foreign firms may crowd out domestic firms, reducing their scale and thus their productivity. The extent to which spillovers occur helps determine the productivity effect for local firms from the presence of foreign firms in the same or related industries.

In a seminal study of Venezuela, Aitken and Harrison (1999) find that positive productivity effects are confined to plants with foreign equity participation, and then only small ones, but that domestic plants are negatively affected, with a very small overall positive effect. In a study of Lithuania, Smarzynska & Javorcik (2004) find evidence consistent with spillovers from foreign affiliates to their local suppliers in upstream industries, although only for projects with shared domestic and foreign ownership, not for wholly owned foreign subsidiaries. Liu (2008) distinguishes between a level and a growth effect of foreign presence on total factor productivity (TFP). Learning advanced foreign technology is costly and requires that scarce resources be devoted to the effort, which is why a short-term negative effect on the level of TFP is expected, and a long-term positive effect on the growth rate of TFP. Panel data on Chinese manufacturing firms confirms the theoretical expectations.

This paper joins the literature exploring the effect of trade liberalization on productivity, for example, Bernard and Jensen (2009) for the US, and Trefler (2004) for Canada. Except for these studies testing data on developed countries, more evidence has been found in developing countries, such as Bustos (2009) for Argentina, Schor (2004) for Brazil, Tybout *et al.* (1991) and Pavcnik (2002) for Chile, Fernandes (2007) for Columbia, Krishna and Mitra (1998) and Topalova & Khandelwal (2010) for India, Amiti and Konings (2007) for Indonesia, Iscan (1998) for Mexico and Levinsohn (2003) for Turkey. These studies find that lower output tariffs have boosted productivity due to "import competition" effects, whereas cheaper imported inputs can raise productivity via learning, variety, and quality effects. Moreover, these studies were extended by Haichao Fan (2012) by introducing endogenous quality and endogenous number of imported varieties.

1.2. PRODUCTIVITY SPILLOVERS FROM FDI

In the recent years, the attraction of FDI has been an important topic on the agenda of many governments. Policy mechanisms such as tax reductions for foreign firms tempt to stimulate inward FDI. The main reason for this growing interest stem from the positive externalities the presence of foreign multinational affiliates may generate in the host country. Accordingly, the entrance of foreign MNCs is often seen as a conduit for transfer of technology and knowledge within and across sectors. The linkages between foreign MNCs and local host-country firms can be distinguished between horizontal and vertical spillovers. On the one hand, technology from foreign MNCs may spill over to local competitors within the same industry (horizontal spillovers). On the other hand, productivity enhancing knowledge may be absorbed by local client firms or supplier firms across industries due to vertical linkages (vertical spillovers).

The results of studies analyzing spillover effects due to inward FDI are rather inconclusive, ranging from negative to positive depending on the data and method used. Mainly focusing on horizontal spillovers, the earliest empirical industry-level analyses found positive evidence of FDI externalities in Australia (Caves, 1974) and Canada (Globerman, 1975). Both analyses concerned sectoral (rather than firm-level) production functions and found a positive correlation between the local firms' productivity growth on industry-level and FDI inflows. Other studies discussed the effects of FDI using well-elaborated case studies (Rhee and Belot, 1989; Larrain *et al.,* 2000), but the results of these studies lack the potential to be generalized into clear-cut policy implications. More recently, some cross-sectional studies at the firm level have confirmed the existence of intra-industry spillovers using data from UK and Greece respectively (Driffield, 2001; Dimelis and Louri, 2002). As highlighted by Görg and Strobl (2001), technology diffusion is a dynamic phenomenon making panel data analysis the most appropriate method to estimate improvements in host-country firms' productivity. Recent econometric studies using panel data find positive effects on of FDI spillovers on productivity performance for host country firms (Keller and Yeaple, 2003; Haskel *et al*., 2002). Based on a micro-level study of US manufacturing firms, Keller and Yeaple estimated that the share of productivity growth during the sample period 1987–1996 accounted by FDI spillovers at 14%. Similarly, Haskel *et al.* found that the foreign-affiliate presence in an industry, measured by the industry share of employment accounted by foreign firms, is positively correlated with the domestic firms' total factor productivity (TFP) in that industry. Their estimations indicate that spillovers from inward FDI explain about five percent of the ten percent rise of TFP in local UK manufacturing firms during the period 1973–1992. On the other hand, other studies have reported inconclusive or even negative effects of FDI on host country firm productivity (Girma and Wakelin, 2001; Barrios and Strobl, 2002).

Most empirical studies have mainly focused on the intra-industry spillover effects on domestic firms' productivity, while little attention was given to inter-industry spillovers through customer and supplier linkages with foreign multinationals. The first studies analyzing the effect of backward and forward spillovers on host-country firms' productivity dynamics have focused on developing countries (Blalock, 2001; Javorcik, 2004; Kugler, 2006). These studies could not find any evidence for the existence of forward spillover effects, but report significant productivity-enhancing backward spillovers to local upstream firms. Positive horizontal spillover effects due to the presence of foreign-owned affiliates within the sector were found, but these results were not robust across all different specifications of the models. The failure to find evidence for horizontal spillovers may not be surprising, as foreign multinationals will have strong incentives to protect their superior technology by patenting mechanisms or secrecy in order to prevent leakages to local competitors (Veugelers and Cassiman, 2004). Moreover, at least in the short run, the entrance of foreign multinationals may also be harmful to local firms through increased competition effects. Foreign MNCs may reduce growth opportunities and the potential to reap scale economies by domestic firms, and they may attract the most qualified employees (De Backer and Sleuwaegen, 2003), which may have negative productivity consequences for domestic firms. Eventually, this may drive less cost-efficient host-country firms out of the market.

The presence of foreign MNCs is not likely to affect the productivity performance of domestic firms equally. A number of studies have suggested that the gains from spillovers due to FDI are conditional on the absorptive capacity and catching-up capabilities of local firms and on the geographical proximity to foreign affiliates (Görg and Greenaway, 2004). According to the absorptive capacity argument of Cohen and Levinthal (1989) domestic firms need to possess a certain level of human capital and technological knowledge in order to understand, assimilate and use incoming spillovers from foreign affiliates. Domestic firms are better able to catch-up with superior technologies of foreign firms when the technology gap between both parties is not too large (Findlay, 1978). Following this reasoning, different empirical studies have analyzed the correlation between the domestic firms' technological capabilities and their ability to benefit from FDI spillovers. In a panel data study on 4000 UK manufacturing firms covering the period 1991–1996, Girma *et al.* (2001) analyses the conditional effects of intra-industry FDI spillovers on labor productivity according to the skill intensity and competitiveness in the sector and the technology gap between firms and the productivity frontier. The results show that FDI spillovers benefit domestic firms with a relatively small technology gap relative to the technology leader in a positive way, irrespective of the competition and skill level in the sector.

1.3. PRODUCTIVITY SPILLOVERS FROM INTERNATIONAL TRADE

International trade is one of the primary avenues for the diffusion and adoption of new technologies worldwide. This is particularly true and important for developing nations where it is believed that importing new technologies is a significant source of productivity and economic growth. Trade liberalization is considered to be one of the ways of promoting international trade and, therefore, increasing productivity.

Trade liberalization may affect productivity through several mechanisms. Firstly, the competitive pressure arising from increased imports may result in plants eliminating slack and using inputs more efficiently (Holmes and Schmitz, 2001). In contrast, infant-industry arguments sustain that protection may lead to productivity gains when learning-by-doing is important. Secondly, liberalization may boost within-plant productivity by allowing for international technology diffusion as predicted by the endogenous growth models of Grossman and Helpman (1991) and Rivera-Batiz and Romer (1991). When technological knowledge is embodied in goods, an increase in the access to imported intermediate inputs of higher quality and broader variety, and to more efficient capital goods improves plant productivity. The exposure to export markets may also bring technological spillovers. Thirdly, liberalization may alter plant's incentives to invest in productivity-enhancing technology. Goh (2000) finds that liberalization increases these incentives by reducing the opportunity cost of technological effort (the foregone profits from the ensuing delay in output commercialization). In contrast, Rodrik (1992) shows that liberalization decreases these incentives when it reduces the plant's market share. Finally, when productivity is heterogeneous across plants, liberalization may increase industry productivity even with unchanged within-plant productivity. Melitz (2003) shows that increasing an industry's exposure to trade leads to the exit of less productive plants and the reallocation of output to more productive plants, contributing to industry productivity growth. In sum, most theoretical models predict that trade liberalization results in productivity gains.

However, the empirical evidence of the impact of trade is fairly mixed. For example, Pack (1988) has concluded that there are no systematic differences in cross-country TFP growth rates for countries that have different trade orientations. Young (1994), in his study for large number of countries, also finds no positive relationship between open policy regime and TFP growth rate.

At the industry level, Gokcekus (1995) finds that the technical efficiency of the Turkish rubber industry improved significantly during a period of substantial trade liberalization in the early 1980s. Cornwell *et al.* (1990), in their study of the US airlines industry, find an improvement in the productivity of firms after the industry was deregulated. In the case of India, studies looking into the impact of liberalization on productivity have yielded contradictory results. It needs to be mentioned that the period considered for liberalization in most of these studies is after the mid-1980s, when Indian industry was gradually opening up. Pushpangadan and Babu (1997) in their review of various studies conclude that there is no systematic relationship between liberalization and productivity growth. Srivastava's (1996) estimates based on a production function find significantly higher TFP growth after the mid-1980s than in the pre-reform period. The results match the widely held belief that liberalization increases efficiency as demonstrated by Ahluwalia (1991). Srivastava's analysis, however, finds that there exists virtually no price competition during the post-reform period as the price-cost margin shows a higher value for most sectors.

Balakrishnan and Pushpangadan (1994) adopt a double-deflation procedure instead of a single deflation methodology as employed by Ahluwalia and other researchers and find results opposite to these studies. They find that the TFP growth is slower after 1980s liberalization than in the previous decade. A study conducted by Krishna and Mitra (1998), using a methodology similar to Srivastava's, examines mark-ups and productivity growth after 1991 reforms for four industry groups: electrical machinery, non-electrical machinery, electronics and transport equipment. The study finds evidence of increased productivity except for the transport equipment sector.

Summarizing this section it is possible to conclude that there is some evidence confirming the impact of FDI and international trade on the host-country productivity. However, the study of the Russian economy is limited. So in order to fill such a gap, in the next section we will introduce the model that would allow estimating the effects of foreign presence in Russia.

2. OVERVIEW OF THE RUSSIAN CHEMICAL INDUSTRY

Before starting construction our econometric model and discussion of the results, it is important to make an overview of the chemical industry because the understanding of the background allows us to interpret the model outcomes better. Chemicals are an integral part of daily life in today's world. There is hardly any industry where chemicals are not used and there is no

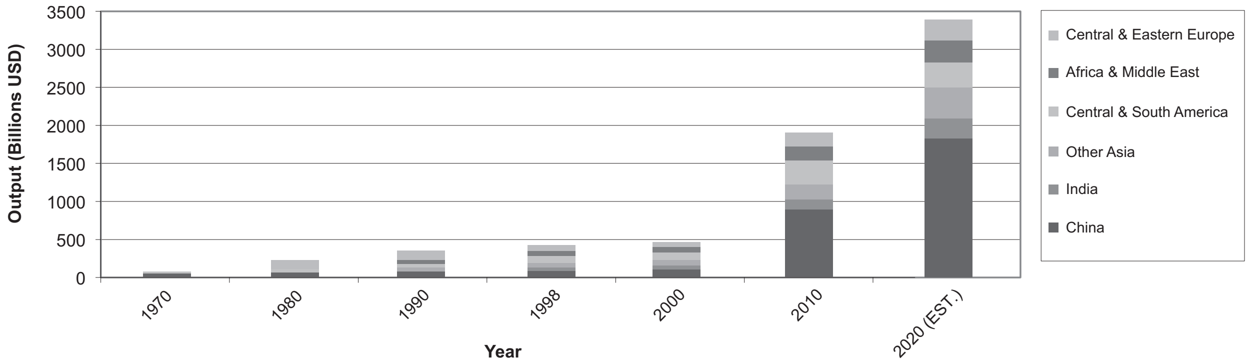

Figure 1. Chemical industry output: developing regions & countries with economies in transition.
Source: UNEP, 2012. Global Chemicals Outlook: Towards Sound Management of Chemicals. GPS Publishing, p. 10.

single economic sector where chemicals do not play an important role.

Industries, which produce and use chemicals, have a significant impact on employment, trade and economic growth worldwide, but chemicals can have adverse effects on human health and the environment. A variety of global economic and regulatory forces influence changes in chemical production, transport, import and export, use and disposal over time. In response to the growing demand for chemical-based products and processes, the international chemical industry has grown dramatically since the 1970s. Global chemical output (produced and shipped) was valued at US$171 billion in 1970. By 2010, it had grown to $4.12 trillion (UNEP, 2012). Figure 1 illustrates the chemical industry output trend from 1970s, and shows estimated numbers for 2020.

2.1 CHEMICAL MARKET PERFORMANCE

According to the Ministry of Industry and Energy of Russian Federation, the chemical complex comprises 1.8% of the Russian GDP, 6.8% of the industrial production, and about 10.4% by the volume of products shipped to all enterprises in the structure of the manufacturing sector. By 2020, it is planned to increase the share of the chemical industry in the GDP by 1.5 times. This increase will particularly result from growth in the overall chemical production (more than 50% growth is expected compared with 2011, while by 2030 this figure is expected to increase by 2.4 times). The main factors hindering the development of the industry include technological backwardness in several sectors of the chemical industry, high depreciation of fixed assets due to a lack of investment activity and restriction of access of Russian chemical products to the markets of certain countries, and the deterioration of the world market under increased competition. Russia's accession to the WTO in 2012 has made it possible to remove access limitations for Russian chemical companies to a number of foreign markets. However, the WTO membership, the planned subsequent accession to the Organization for Economic Cooperation and Development (OECD), and the adoption of a series of Russian long-term strategies for the development of domestic industry will require fundamental changes in most industries.

Generally, the evolving Russian economy, new technologies and global market fluctuations have resulted in the following sector trends:

- growth of Russian industrial output;
- rapid increase of end-users;
- sharp competition among chemical suppliers;
- increased investment;
- new project development;
- high demand for new/updated equipment.

Nearly 8000 companies (not more than 10% are large or medium-sized) owning almost 7% of all of the country's industrial capital assets work in the chemical and petrochemical industries in Russia (Enterprise Europe Network, 2012). Table 1 contains the list of major chemical producers in Russia.

Moreover, chemical industry is an integral part of Russian export. Its share in total exports equaled to 6% in 2012.

2.2 OVERVIEW OF THE CHEMICAL MARKET STRUCTURE

As the Russian market stands right now, the strength of buyers is reaffirmed by the ability of customers to procure similar materials from more than one producer. As a consequence, end users have become very price-conscious. There are only a few isolated cases where a certain chemical product can be purchased from only one manufacturer. The producer's control over the entire supply chain is common on the Russian market. The market segment of commodity chemicals in particular exhibits pronounced vertical integration. Enterprises engaged in natural resources extraction add value to the raw materials they acquire through the process of chemical production.

Table 1. Major chemical producers.

Name	Focus
Sibur Holding (Moscow)	Petrochemical
Gazprom Neftekhim Salavat (Salavat, Republic of Bashkortostan)	Petrochemical
Nizhnekamskneftehim (Republic of Tatarstan)	Petrochemical
EuroChem (Moscow)	Fertilizer Production
Uralkali (Berezniki, Permsky region)	Potassium Fertilizer
Akron (Veliky Novgorod)	Mineral fertilizer

Source: Enterprise Europe Network. 2012. Chemical Industry in Russian Regions, p. 2.

The process of entering the Russian chemicals market is capital intensive. Trying to enter the Russian market on a small scale will not lead to good results in the long term. Companies should be prepared to invest in large-capacity processing facilities.

Competition is intense, because companies are mostly selling unbranded products. Product substitution is unlikely to occur, as consumers need to purchase products of particular chemical composition, available only from local producers. The main product categories on the Russian market are base chemicals, including both inorganic and organic solutions, specialty chemicals, pharmaceutical products, and chemicals for use in the agricultural industry.

Key buyers in the Russian chemicals market include manufacturers of plastic products, pharmaceuticals, consumer chemical manufacturers, as well as utility companies. Oil and gas companies are considered to be key suppliers for the sector. The buyers are large-scale to medium businesses that have good negotiating positions with respect to key producers.

Chemical products are traditionally divided into two groups: base chemicals and specialty chemicals.

Traditionally, bulk base chemicals are not differentiated and are referred to only on the basis of their composition. At the same time, in view of the myriad of different applications of base chemicals, the number of potential clients for these products is high. It is not uncommon for base chemical manufacturers to operate in several regional submarkets. Regional variety and diversity of product application, in turn, can work to curtail buyer power. Base chemicals are usually essential supply materials for the buyers. Chemical production is very often contracted for on a long-term basis.

Specialty chemicals constitute one more set of chemicals industry products that have a diverse application across several industries and that are highly priced. Specialty chemicals are generally derived through innovative processes, and are sold on the basis of their specially designated purpose. It only matters what a particular compound can do, not what chemicals it contains. The versatility of application of specialty chemicals means that these products are easy to sell, or to transform for other uses. The cost of remaking one specialty chemical product into another may include expenses associated with the loss of time from waiting until a previous unprofitable contract expires. The power of buyers in this market segment is well-balanced by the leverage that the producers enjoy.

2.3 SUPPLIER OF CHEMICAL PRODUCTS AND MARKET ENTRANCE CONDITIONS

The chemicals industry is heavily reliant on the oil and natural gas sector for basic materials that are combined to produce both carbon-based chemicals and inorganic substances. Suppliers are strong and few in number, as the Russian oil and gas industry is very centralized.

The positions of suppliers are even stronger, as the price of hydrocarbons continues to rise. Chemical producers have formed strong relationships with the suppliers of their raw materials in a struggle for profitability. Additionally, a number of key suppliers in the oil and gas industry have chemical and petrochemical manufactures. Thus, the influence of suppliers over downstream chemical producers that do not have their own natural resources is strong.

The power of suppliers, on the other hand, is constrained due to the lack of differentiation in raw materials supplies. The materials a particular chemical manufacturer would buy from one hydrocarbons producer would be the same that it would get from another oil or gas producer.

Still, as the raw materials are bought and sold on an open market, manufacturers are not able to control the price. Strategies for hedging risk and reducing the instability of prices are necessary.

There also are chemicals that are not dependent on oil, but rather require certain minerals or water. Sodium chloride, for instance, can be formed by evaporating sea water or extracted in mining operations. The chemical is then used to create other sodium compounds. Another element from the periodic table, sulfur, is also critical to the production of many base chemicals.

Existing economic conditions have forced many chemical producers to reduce output volumes. These reductions negatively affected the suppliers of raw materials.

While chemicals do have inherent value and may have immediate uses and applications (i.e. cleaning chemicals), more frequently, chemicals are used as a starting point in a production chain that ends with the manufacture of valuable goods. Therefore, chemicals are produced in bulk quantities in order to enable manufacturers to profit from the sale of large volumes.

Accessing the Russian chemicals market therefore entails significant commitments. Large scale production facilities would be required for a foreign player to rise to the challenges of the Russian market. Therefore, the intensity of investment and the size of most chemical operations in Russia narrow the class of companies that would be capable of entering the country.

A number of factors, however, make the Russian market attractive. The products of the chemical industry are sold as unbranded commodities. As a result, marketing strategies are greatly simplified. Absent contractual commitments, a consumer would be just as likely to buy from a new player on the market as from an established producer. The processes and formulas used to manufacture chemicals used by the Russian industry have been around for decades, in many cases without intellectual property restrictions.

Many large and middle-size companies are present on the Russian chemicals market. Because producers of chemicals sell commodities, it is not easy for market participants to offer tangible incentives not to seek a better deal from a different manufacturer. Overall, the market requires high capital outlays and infrastructural investment. The dominant players on the Russian market are local producers, such as Nizhnekamskneftekhim, Togliattiazot Chemical Company, and Uralkali.

The combination of all the factors outlined above naturally breeds competition. Competition is generally tolerable at times of market growth, but can be very aggressive during periods of economic slowdown.

3. MODEL AND ESTIMATION FRAMEWORK

In academic world, the problem of FDI and international trade spillovers is examined with the help of different econometric models that allow analyzing huge amount of data and eliminating the influence of possible bias. We generally employ Olley-Pakes model with some modifications due to lack of information. Model specification and data description will be presented in the next section.

3.1 MODEL SPECIFICATION

Since there is no consensus on the existence of strong spillovers, we take a broad view on how FDI and imports might affect the productivity of domestic firms. Instead of modeling a particular mechanism, our approach is to ask whether there is evidence for higher productivity of domestic firms when there is more foreign activity in terms of FDI and imports. Based on the previous research we might conclude that this is the question that has been asked so far, with the answer being non-affirmative.

Our analysis relies on correctly measuring firm productivity. To this end we employ the methodology developed by Ericson and Pakes (1995) and Olley and Pakes (1996).[1] These authors develop a framework for dynamic industry equilibrium analysis where firms optimally choose sales and investment, as well as entry and exit. For our purposes, two aspects of the Olley and Pakes approach are most important: firstly, it allows for firm-specific productivity differences that exhibit idiosyncratic changes over time, and secondly, the model endogenizes the firm's liquidation decision by generating an exit rule. These features address two major concerns that have afflicted productivity calculations for a long time: simultaneity and selection biases. To see this, consider the following equation:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_m m_{it} + \beta_k k_{it} + u_{it} \quad (1)$$

where y_{it} is the logarithm of output of firm i at time t, and correspondingly, l_{it}, m_{it}, and k_{it} are the firm's (log of) labor, materials, and capital inputs. The last term, u_{it}, is an error representing all disturbances that prevent (1) from holding exactly. Let this term be composed of two parts,

$$u_{it} = \omega_{it} + \eta_{it} \quad (2)$$

Consider the case when neither ω_{it} and η_{it} are observed by the econometrician, whereas the firm cannot observe η_{it}, but it does know ω_{it}. The term η_{it} could be capturing unpredictable demand shocks while ω_{it} could be firm productivity, for instance. If ω_{it} is known to the firm, the optimal labor input choice will be a function of ω_{it}, and simple ordinary least squares (OLS) estimation will suffer from a simultaneity bias because $E\left[u_{it} \middle| l_{it}\right] \neq 0$.[2] If the term ω_{it} is constant over time,

[1] The following introduces only the most salient features of their approach. See also Griliches and Mairesse (1995) for more discussion of the relative strengths and weaknesses of the Olley-Pakes approach.

[2] The existence of this bias depends on the possibility that input choice can be varied; this explains why we use the example of labor as an input, which is generally considered to be not subject to large adjustment costs. In the multivariate case, the OLS bias can usually not be unambiguously signed. However, if labor and capital are positively correlated, and labor is more strongly correlated with ω_{it} than capital, then OLS will tend to overestimate β_l and underestimate β_k.

$\omega_{it} = \omega_i$, all t, taking time- or within-firm differences of (1) and proceeding with OLS on the transformed data can lead to consistent parameter estimates. But in our framework, ω_{it} is firm productivity, and how this changes in relation to imports and FDI is exactly the question we are asking. This strategy is therefore removed from consideration. As shown below, we will identify ω_{it} from the firms' investment choices. Knowing ω_{it} allows us to control for the simultaneity of input choices, and thus to avoid this bias.

We now turn to the selection problem. The firm maximizes the expected discounted value of its future net cash flows. At the beginning of the period, the firm learns its productivity ω_{it}, which is assumed to evolve according to an exogenous Markov process. Then, the firm makes three choices. It decides whether to exit or not, it chooses variable factors (labor and materials), and how much to invest in capital. For a sufficiently low value of ω_{it}, a firm's value of continuing in operation will be less than some (exogenous) liquidation value, and it will exit; call the threshold level at which a firm is indifferent between exiting and staying ω_t.

One can show that if the firm's per-period profit function is increasing in k, the value function must be increasing in k as well, while ω_t is decreasing in k. The reason is that a firm with a larger capital stock can expect larger future returns for any given level of current productivity, so that it will remain in operation at lower realizations of ω_{it}. Relatively small firms exit at productivity draws for which relatively large firms would have continued to operate, so that the relatively small firms that stay in the market tend to be those that received unusually favorable productivity draws. The correlation between ω_{it} and k_{it} is negative, and failing to account for the self-selection induced by exit behavior will lead to a negative bias in the capital coefficient. The Olley and Pakes approach generates an exit rule, so that we can account for this self-selection and avoid the associated bias.

In terms of estimation, we take the following steps. In equations (1), (2), we assume that labor and materials are variable inputs so that their choice is affected by ω_{it}, whereas capital k_{it} is only determined by past values of ω, not the current one. Dropping the firm subscript for ease of notation, let it be the firm's optimal investment choice at time t. Provided that $i_t > 0$, it is possible to show that investment is strictly increasing in ω_t for any k_t.[3] This means that the investment function can be inverted to yield

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

Substituting (3) and (2) into (1) gives

$$y_t = \beta_l l_t + \beta_m m_t + \varphi_t\left(i_t, k_t\right) + \eta_t, \tag{4}$$

with $\varphi_t\left(i_t, k_t\right) = \beta_0 + \beta_k k_t + h_t(i_t, k_t)$. Because φ_t (.) contains the productivity term $\omega_t = h_t$ (.) that is the source of the simultaneity bias, equation (4) can be estimated to obtain consistent estimates β_l and β_m on the variable inputs, labor and materials. Equation (4) is a partially linear regression model of the type analyzed by Robinson (1988), and we use a fourth-order polynomial in investment and capital to capture the unknown function φ_t (.).

With consistent estimates of β_l and β_m in hand, we proceed to estimating the effect of capital on output, β_k, which is not identified in (4) because it is combined with capital's effect on investment. We assume for simplicity that k_t is uncorrelated with the innovation in ω_t, $\xi_t = \omega_t - \omega_{t-1}$ or, ω_t is a random walk[4]. Substituting this into (4) gives

$$y_t - \hat{\beta}_l l_t - \hat{\beta}_m m_t = \beta_k k_t + \hat{\varphi}_{t-1} - \beta_k k_{t-1} + \xi_t + \eta_t, \tag{5}$$

where $\hat{\varphi}_{t-1}$ comes from estimating (4), and $\hat{\varphi}_{t-1} - \beta_k k_{t-1}$ is an estimate of ω_{t-1}.

The probability of survival to period t depends on ω_{t-1} and ω_{t-1}, the unobserved level of productivity that would make a firm shut down its operations, which can be shown to depend only on capital and investment at time t-1. We generate an estimate of the survival probability by running a probit regression[5] on a fourth-order polynomial

[3] The requirement that investment must be positive may be limiting for some applications. Levinsohn and Petrin (2001) propose therefore a variant of Olley and Pakes' approach in which productivity is identified from materials inputs (which is usually greater than zero). In our sample, the zero-investment problem is negligible.
[4] A random walk is a mathematical formalization of a path that consists of a succession of random steps.
[5] In statistics, a probit model is a type of regression where the dependent variable can only take two values.

in capital and investment (lagged by one period); the estimated survival probability is denoted by $\hat{P}_t$. The final step is to estimate β_k from the resulting equation:

$$y_t - \hat{\beta}_l l_t - \hat{\beta}_m m_t = \beta_k k_t + g(\hat{\varphi}_{t-1} - \beta_k k_{t-1}, \hat{P}_t) + \xi_t + \eta_t. \quad (6)$$

Here we approximate the unknown function g (.) by a fourth-order polynomial in $\hat{\varphi}_{t-1} - \beta_k k_{t-1}$ and $\hat{P}_t$; β_k is then estimated non-linearly across all terms that contain it.

Using the estimates of coefficients of labor, materials, and capital, we estimate log total factor productivity as $tfp_{it} = y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_m m_{it} - \hat{\beta}_k k_{it}$. Our empirical analysis relates firms' TFP, it is tfp_{it}, to the degree of foreign activity through imports (it IM_{it}) and FDI (it FI_{it}):

$$tfp_{it} = \beta X'_{it} + \gamma_1 IM_{it} + \gamma_2 FI_{it} + e_{it}, \quad (7)$$

where X'_{it} is a vector of control variables, and e_{it} is an error term; the exact definitions of IM_{it}, it FI_{it}, and X'_{it} are discussed in the following data section.

3.2 DATA DESCRIPTION

This study is based on data sample of chemical manufacturing firms in Russia from Standard & Poor's Capital IQ database. Capital IQ database includes only publicly traded companies and publishes data from the companies' balance sheets according to legal reporting requirements. Unlike census data, the Capital IQ database has the advantage of being publicly available. However, our sampling is rather small as Russian companies do not usually provide statistical agencies with required financial and non-financial data.

Our sample consists of a total of 18 Russian-owned firms that were active between the years 2007 and 2012, which represent the Russian chemical industry. From Capital IQ database, we obtain data on the firms' (log) output y, as well as (log) labor, materials, and capital inputs (l, m, and k), where our output measure is net sales. In some cases we have had to fill in small amounts of missing data, typically for the firms' number of employees. These data were hand-collected from firms' annual reports.

Our primary interest is whether productivity is related to the importance of imports and foreign-owned affiliates in the firm's relevant economic environment. We measure the importance of imports for a given firm by the amount of imports; this variable is denoted by it IM. This information was collected from Russian customs database. Correspondingly, the importance of FDI is measured by the number of foreign affiliate employment in total employment of the firm (denoted by it FI). Data on foreign employment comes from Rosstat annual surveys. However, the number of foreign employees is estimated as the report provides only average rate of foreign employees by industry.

These measures of imports and FDI broadly capture the prevalence of foreign economic activity in a particular chemical industry. If specialized imports are important in triggering technology spillovers, or if foreign affi liates of MNEs generate positive externalities for Russian firms by building up more efficient supplier chains or a pool of highly skilled technicians, it is plausible that this is correlated with our measures of foreign presence in that industry.

Additional variable will be employed to better isolate spillover effects (see Table 2 for variable construction). Previously, we have noted that it is important to control for changes in the degree of market competition that might be associated with changes in foreign activity. We follow Nickell (1996) and others and use the firm's mark-up to capture these effects (denoted by FM). To the extent that a higher firm mark-up indicates less competitive pressures, we expect that a firm's productivity growth slows down.

Finally, we employ the following linear panel regression to estimate the spillover effects:

$$Y_{it} = \beta_0 + \beta_1 L_{it} + \beta_2 K_{it} + \beta_3 M_{it} + \beta_4 FM_{it} + \beta_5 IM_{it} + \beta_6 FI_{it} + \beta_7 Inv_{it} + u_{it}, \quad (8)$$

where i denotes firm, t implies year and u_{it} is the disturbance term.

First of all, we need to provide by some descriptive statistics to define the characteristics of our data. Particularly, for panel data it is important to know whether variability is mostly across individual (entity) or across time. If we focus on the three main variables of interest which are sales, measured by net sales, import share and FDI share, the main observations are the following.

Table 2. Variable definitions.

Variable	Measurement
Sales (Y)	Net sales
Labor (L)	Number of employees
Capital (K)	Value of property, plant and equipment, net of depreciation
Materials (M)	Firm-level year-end materials inventory stocks
Firm mark-up (FM)	Firm's sales over sales minus profits; profits is measured by net income
Import share (IM)	Value of imported goods
FDI share (FI)	Number of foreign affiliate employment
Investment (Inv)	Capital expenditures

Table 3. Descriptive statistics of the data.

Variable		Mean	Std. Dev.	Min	Max	Observations
ynetsa~s	overall	16282.94	37104.5	40.9	141452	N = 108
	between		37227.03	380.1	117998.7	n = 18
	within		7460.019	-20632.73	39736.27	T = 6
imimpo~e	overall	3.01	2.734568	.01	11.4	N = 108
	between		2.731948	.5	9.75	n = 18
	within		.6025656	1.463333	4.66	T = 6
fifdis~e	overall	1300.214	5655.03	59.52	41871	N = 108
	between		2321.141	62.22667	7286.343	n = 18
	within		5181.064	-5914.75	35884.87	T = 6

The averaged mean of the net sales is USD 16282,94 mln., import amount — USD 3,01 mln., number of foreign affiliate employment — 1300 persons. Concerning the variability around these means we can say that for sales and import share mostly of it is attributed to between individual variations compared to a weak variability across time, and vice versa for FDI share. Indeed we see that the total variability of netsales is 44687,059 (44687,059 represents the standard error).This variability decomposes itself as an individual variability of 37227,030 and only a variability across time of 7460,019. We can do the same conclusions concerning the amount of import since almost 82% of its total variation is attributed to a cross section variation. As for FDI share, the situation is opposite. Here only 31% of its total variation is attributed to a cross section variation. We can finally notice that the variability is much higher for the net sales than amount of import and number of foreign-affiliated employees.

The analysis methodology as well as the results of the estimation will be discussed in the next section.

4. ANALYSIS METHODOLOGY AND RESULTS

The analysis of panel data allows the model builder to learn about economic processes while accounting for both heterogeneity across individuals, firms, countries, and so on, and for dynamic effects which are not visible in cross sections. Modeling in this context often calls for complex stochastic specifications. In order to analyze the panel data, several econometric models were employed, namely OLS regression, regression model with fixed effects and random effects. Then the most appropriate model was chosen to estimate the panel data.

4.1. MODELS CONSTRUCTION

Often the distribution of econometric value has an asymmetry. Going to the logarithm allows reducing it. Furthermore, the transition to the logarithm in some cases allows bringing the distribution of residuals to normal. Therefore, for our estimation we used logarithmic values of all the variables. All econometric models were constructed with the help of STATA 11.2 software package.

Several possibilities are offered to estimate these panel data. We can choose to use a restrictive pooled OLS model without taking into account the special features of the data. On one hand, the graphics below show that the distribution of the net sales according to amount of import and number of foreign employees is not dispersed and that the OLS seem to be appropriate.

However, it is just a first approach. If we want to be more precise and take into account the unobserved individual heterogeneity we can estimate a fixed effects model or a random effects one, provided that this unobserved heterogeneity is time invariant.

Firstly, the OLS regression model was built. It is a generalized linear modelling technique that may be used to model a single response variable which has been recorded on at least an interval scale. The technique may be applied to single or multiple explanatory variables and also categorical explanatory variables that have been appropriately coded. The results are presented below:

Table 4. OLS regression model.

Source	SS	df	MS	
Model	302.192893	7	43.1704132	Number of obs = 104
Residual	6.45854026	96	.067276461	F(7, 96) = 641.69
				Prob > F = 0.0000
				R-squared = 0.9791
				Adj R-squared = 0.9775
Total	308.651433	103	2.99661585	Root MSE = .25938

lynetsales	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lllabour	-.1087084	.0935847	-1.16	0.248	-.2944726	.0770558
lkcapital	.4583853	.057005	8.04	0.000	.3452313	.5715392
lmmaterials	.4237243	.076147	5.56	0.000	.2725737	.5748749
lfmfirmmar~p	.3868898	.2095575	1.85	0.068	-.0290785	.802858
limimports~e	.086404	.090191	0.96	0.340	-.0926236	.2654317
lfifdishare	.3805763	.0792214	4.80	0.000	.2233232	.5378295
linvestment	.0327922	.0142688	2.30	0.024	.0044689	.0611156
_cons	.4223255	.6080333	0.69	0.489	-.7846112	1.629262

R^2 is high (97,90%). It means that varies in X explain 97,9% of varies in Y. Prob > F is less than 0,05, therefore R^2 is not random and quality of specification of econometric model is high. However, one of the most important variables is not significant (0,340 > 0,050), namely amount of import.

Secondly, regression model with fixed-effects (FE) was constructed. It is used when it is needed to analyze the impact of variables that vary over time. FE explores the relationship between predictor and outcome variables within an entity (country, person, company, etc.). Each entity has its own individual characteristics that may or may not influence the predictor variables (for example, the business practices of a company may influence its net sales).

When using FE we assume that something within the entity may impact or bias the predictor or outcome variables and we need to control for this. This is the rationale behind the assumption of the correlation between entity's error term and predictor variables. FE removes the effect of those time-invariant characteristics from the predictor variables so we can assess the predictors' net effect.

Another important assumption of the FE model is that those time-invariant characteristics are unique to the entity and should not be correlated with other individual characteristics. Each entity is different, therefore the entity's error term and the constant (which captures individual characteristics) should not be correlated with the others. If the error terms are correlated then FE is no suitable, since inferences may not be correct and it is needed to model that relationship (probably using random-effects); this is the main rationale for the Hausman test, which will be discussed further.

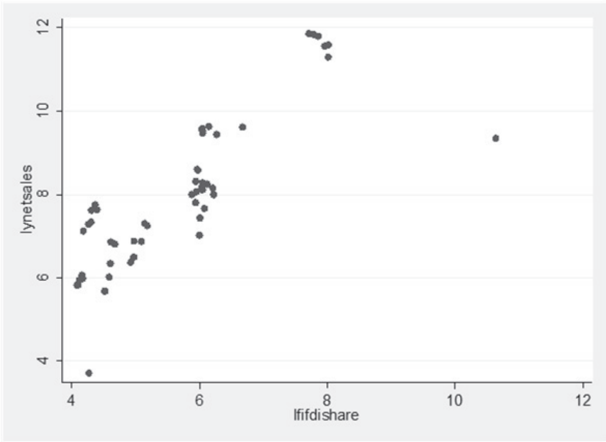

Figure 2. Scatter diagram: net sales and FDI share.

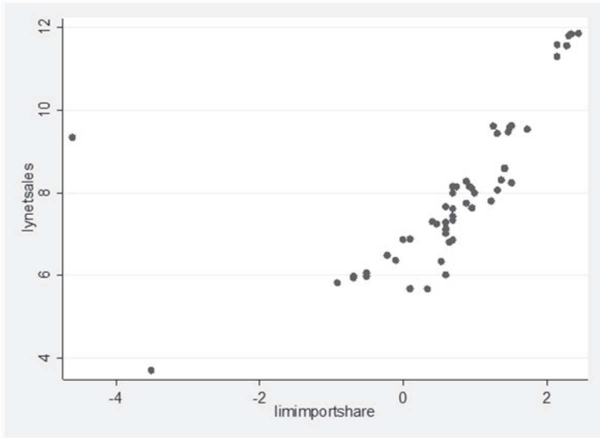

Figure 3. Scatter diagram: net sales and import share.

The equation for the FE model becomes:

$$Y_{it} = \beta_1 L_{it} + \beta_2 K_{it} + \beta_3 M_{it} + \beta_4 FM_{it} + \beta_5 IM_{it} + \beta_6 FI_{it} + \beta_7 Inv_{it} + \alpha_i + u_{it}, \quad (9)$$

where α_i is the unknown intercept for each entity (n entity-specific intercepts). Table 5 shows the results of the FE model.

Table 5. Regression model with fixed effects.

Fixed-effects (within) regression		Number of obs	= 104
Group variable: company		Number of groups	= 18
R-sq: within	= 0.7698	Obs per group: min	= 5
between	= 0.9620	avg	= 5.8
overall	= 0.9543	max	= 6
		F(7,79)	= 37.75
corr(u_i, Xb)	= -0.6427	Prob > F	= 0.0000

lynetsales	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lllabour	-.0654411	.1897335	-0.34	0.731	-.4430962	.312214
lkcapital	.1492522	.1201148	1.24	0.218	-.0898305	.3883348
lmmaterials	.3996918	.1140372	3.50	0.001	.1727065	.6266771
lfmfirmmar~p	.778163	.2081864	3.74	0.000	.3637782	1.192548
limimports~e	.5103775	.1592608	3.20	0.002	.1933768	.8273782
lfifdishare	.7677402	.1285814	5.97	0.000	.5118053	1.023675
linvestment	.0109556	.0125719	0.87	0.386	-.0140681	.0359794
_cons	.2298174	1.915348	0.12	0.905	-3.582587	4.042222
sigma_u	.43975151					
sigma_e	.18265759					
rho	.85285775	(fraction of variance due to u_i)				

F test that all u_i=0: F(17, 79) = 6.74 Prob > F = 0.0000

The overall R^2 is also high and constitutes 95,43%. It means that the quality of the model is good. Moreover, the test (F) to see whether all the coefficients in the model are different than zero has been passed. Unlike the previous model, the variable which demonstrates the influence of imports on sales is significant (0,002 < 0,05). Rho is known as the intraclass correlation. 85,29% of the variance is due to differences across panels.

It should be also mentioned that FE model controls for all time-invariant differences between the individuals, so the estimated coefficients of the fixed-effects models cannot be biased because of omitted time-invariant characteristics. One side effect of the features of FE models is that they cannot be used to investigate time-invariant causes of the dependent variables. Technically, time-invariant characteristics of the individuals are perfectly collinear with the entity dummies. Substantively, FE models are designed to study the causes of changes within an entity. A time-invariant characteristic cannot cause such a change, because it is constant for each person.

Finally, regression model with random effects (RE) was constructed (results are presented in Table 5). The rationale behind random effects model is that, unlike the FE model, the variation across entities is assumed to be random and uncorrelated with the predictor or independent variables included in the model. Green (2008) argued that the crucial distinction between fixed and random effects is whether the unobserved individual effect embodies elements that are correlated with the regressors in the model, not whether these effects are stochastic or not.

If there is reason to believe that differences across entities have some influence on the dependent variable, then RE model should be used. An advantage of RE is that time invariant variables can be included. In the FE model these variables are absorbed by the intercept. The RE model is:

$$Y_{it} = \beta_1 L_{it} + \beta_2 K_{it} + \beta_3 M_{it} + \beta_4 FM_{it} + \beta_5 IM_{it} + \beta_6 FI_{it} + \beta_7 Inv_{it} + \alpha_i + u_{it} + \varepsilon_{it}, \tag{10}$$

where u_{it} – between-entity error, ε_{it} – within-entity error.

RE assumes that the entity's error term is not correlated with the predictors which allows for time-invariant variables to play a role as explanatory variables. In RE it is important to specify those individual characteristics that may or may not influence the predictor variables. The problem with this is that some variables may not be available, therefore leading to omitted variable bias in the model. RE allows generalizing the inferences beyond the sample used in the model.

Table 6. Regression model with random effects.

```
Random-effects GLS regression                Number of obs      =       104
Group variable: company                      Number of groups   =        18

R-sq:  within  = 0.7304                      Obs per group: min =         5
       between = 0.9837                                     avg =       5.8
       overall = 0.9744                                     max =         6

                                             Wald chi2(7)       =   1492.84
corr(u_i, X)   = 0 (assumed)                 Prob > chi2        =    0.0000
```

lynetsales	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lllabour	-.1169475	.1233432	-0.95	0.343	-.3586958	.1248008
lkcapital	.3232325	.0797434	4.05	0.000	.1669384	.4795267
lmmaterials	.408037	.0943266	4.33	0.000	.2231603	.5929137
lfmfirmmar~p	.6573192	.2083416	3.16	0.002	.2489771	1.065661
limimports~e	.2679408	.1194744	2.24	0.025	.0337753	.5021063
lfifdishare	.490643	.0951408	5.16	0.000	.3041704	.6771156
linvestment	.0162339	.0128974	1.26	0.208	-.0090445	.0415123
_cons	.9876227	.8314596	1.19	0.235	-.6420082	2.617254
sigma_u	.15851608					
sigma_e	.18265759					
rho	.42959236	(fraction of variance due to u_i)				

The overall R^2 is higher than in FE model and constitutes 97,44%. It means that the quality of the model is good. Moreover, the test (F) to see whether all the coefficients in the model are different than zero has been passed. In the model both variables that reflect FDI and international trade spillovers are significant (0,000 and 0,025 respectively). However, Rho is lower than in the previous model and demonstrates that only 42,96% of the variance is due to differences across panels.

In the next section we will perform several tests to determine the most appropriate model for the analysis of FDI and international trade spillovers on Russian chemical market.

4.2. SELECTION OF THE MOST APPROPRIATE MODEL

Three main regression models, namely OLS regression, RE and FE regression models, have been estimated. In this section all these models will be tested to choose the most adequate for our panel data.

Firstly, a simple OLS regression was compared with FE regression. The Wald test is used to determine which of the two models is more appropriate for the presented data. STATA run this test automatically while generating the results for FE model (see Table 4). The following line shows the results:

```
F test that all u_i=0: F (17, 79) = 6.74 Prob > F = 0.0000
```

As Prob > F is less than the 0,05, FE model is considered to better describe the obtained data.

Breusch-Pagan Lagrange multiplier (LM) is used to decide between simple OLS regression and RE regression. The null hypothesis in the LM test is that variances across entities are zero. This means no significant difference across units (i.e. no panel effect). Table 7 represents the results of the test in STATA.

Table 7. Breusch-Pagan Lagrange multiplier (LM) test.

```
lynetsales[company,t] = Xb + u[company] + e[company,t]

Estimated results:
                        Var     sd = sqrt(Var)
```

	Var	sd = sqrt(Var)
lynetsa~s	2.996616	1.731074
e	.0333638	.1826576
u	.0251273	.1585161

```
Test:   Var(u) = 0
                        chibar2(01) =    13.85
                     Prob > chibar2 =   0.0001
```

As Prob > chibar2 is less than 0,05, we reject the null and conclude that random effects are appropriate. It means that there is evidence of significant differences across entities, therefore we can run RE regression.

From theoretical point of view, to determine whether we should use a FE model or a RE model we have to question ourselves about a potential problem of endogeneity and more precisely about a correlation between unobserved individual heterogeneity α_i and observed regressors. If we suspect such a relation we have to use a FE model since it is the only one to be consistent. There are a lot of variables that could explain the productivity of the enterprise and be included in the term of unobserved individual heterogeneity α_i. We could think that some of these characteristics are correlated with observed regressors. For example the management quality of a firm, which is unobservable, can influence productivity and affect training. We could also think of the intellectual capacity of an employee which is linked to the performance of a firm and which can explain the number of training hours affected to him. These findings lead to think that there may be correlation between the individual specific effects and the regressors and so we can be tempted to use a fixed effects model. To be absolutely sure we can perform some tests.

From econometrical point of view, to choose between a FE and a RE model we can perform a Hausman test which tests the null hypothesis of an absence of correlation between the individual specific effects and the regressors. $E(\alpha_i + \varepsilon_{it} \mid X_{it}) = 0$, where α_i is the time invariant unobservable effect and ε_{it} the error term. Under this hypothesis the RE model is valid but if it is not fully respected, the estimators of the RE model are inconsistent and we have to use the FE model.

The standard Hausman test implemented on Stata verifies that there are no systematic differences between the estimators of the RE model and the FE one. A test statistic can be built on these differences, looking at the variance-covariance matrix of the vector of difference $[b-\hat{\beta}]$, where b is the within estimator and $\hat{\beta}$ is the RE GLS estimator.

$$Var\left[b-\hat{\beta}\right]=Var\left[b\right]+Var\left[\hat{\beta}\right]-Cov\left[b,\hat{\beta}\right]-Cov[b,\hat{\beta}], \tag{11}$$

The covariance between an efficient estimator and its difference with an inefficient estimator equals to zero: $Cov\left[b,\hat{\beta}\right]-Var\left[\hat{\beta}\right]=0.$

By inserting this result in the previous equation, we obtain:

$$Var\left[b-\hat{\beta}\right]=Var\left[b\right]-Var\left[\hat{\beta}\right]=\Psi \tag{12}$$

This results in a test, following a χ^2 (K-1), based on the Wald criterion:

$$W=[b-\hat{\beta}]'\hat{\Psi}^{-1}[b-\hat{\beta}] \tag{13}$$

The results of this test are presented below:

Table 8. Hausman test.

	Coefficients (b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
lllabour	-.0654411	-.1169475	.0515064	.1441709
lkcapital	.1492522	.3232325	-.1739804	.0898252
lmmaterials	.3996918	.408037	-.0083452	.0640857
lfmfirmmar~p	.778163	.6573192	.1208438	.
limimports~e	.5103775	.2679408	.2424367	.1053085
lfifdishare	.7677402	.490643	.2770972	.0864951
linvestment	.0109556	.0162339	-.0052783	.

```
                b = consistent under Ho and Ha; obtained from xtreg
    B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho:  difference in coefficients not systematic

            chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                    =       22.28
          Prob>chi2 =      0.0023
          (V_b-V_B is not positive definite)
```

As Prob>chi2 is less than 0,05, the null hypothesis is rejected and we need to use FE model. This is consistent with our panel data, because the entities are the same across the sampled 6-year period.

Based on the results of the test, it may be concluded that the FE regression model is the most adequate for estimating the panel data obtained to assess the influence of FDI and international trade spillovers on Russian chemical market.

4.2. TESTING THE QUALITY OF FIXED EFFECTS MODEL AND INTERPRETING RESULTS

Before making any conclusions based on FE regression model, it is important to conduct several tests to check whether the model shows adequate results.

In order to test for cross-sectional dependence/contemporaneous correlation, Pesaran CD test will be introduced. Cross-sectional dependence is a problem in macro panels with long time series (over 20–30 years). This is not much of a problem in micro panels (few years and large number of cases), like in our case. Therefore, we assume that our model will pass this test without any difficulties.

Table 9. Perasan CD test.

```
Pesaran's test of cross sectional independence = 0.170, Pr = 0.8652
Average absolute value of the off-diagonal elements = 0.580
```

As Pr = 0,8652 is more than 0,05, there is no cross-sectional dependence in the model.

To detect whether a phenomenon of heteroscedasticity is present in our data we can perform a test of Wald which tests the presence of heteroscedasticity between individuals. It tests the null hypothesis that the variance of the error is the same for all individuals.

Table 10. Test for heteroscedasticity.

```
Modified Wald test for groupwise heteroscedasticity
in fixed effect regression model
H0: sigma (i) ^2 = sigma^2 for all i
chi2 (18) = 110.44
Prob>chi2 = 0.0000
```

The P value is inferior to 5%, which leads us to reject the null hypothesis of homoscedasticity between individuals. A phenomenon of heteroscedasticity is present.

Serial correlation causes the standard errors of the coefficients to be smaller than they actually are. A Lagram-Multiplier test for serial correlation is employed. It tests the null hypothesis of the absence of first order autocorrelation in the errors.

Table 11. Test for autocorrelation.

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      17) =     54.794
           Prob > F =      0.0000
```

The null value of the P value leads us to reject the null hypothesis and to validate the presence of autocorrelation of first order. At that point of the study we have seen that a phenomenon of autocorrelation and heteroscedasticity are present in our data. To take this phenomenon into account, we use the method of bootstrap to obtain panel robust standard errors. For more efficiency we have performed 500 replications from the original sample. The final model is presented in Table 12.

Table 12. FE model with robust standard errors.

```
Fixed-effects (within) regression             Number of obs      =       104
Group variable: company                       Number of groups   =        18

R-sq:  within  = 0.7698                       Obs per group: min =         5
       between = 0.9620                                      avg =       5.8
       overall = 0.9543                                      max =         6

                                              Wald chi2(7)       =         .
corr(u_i, Xb)  = -0.6427                      Prob > chi2        =         .

                                        (Replications based on 18 clusters in company)
```

Table 12. FE model with robust standard errors. *(Continued from previous page)*

lynetsales	Observed Coef.	Bootstrap Std. Err.	z	P>|z|	Normal-based [95% Conf.	Interval]
lllabour	-.0654411	.2324586	-0.28	0.778	-.5210515	.3901694
lkcapital	.1492522	.1509844	0.99	0.323	-.1466719	.4451762
lmmaterials	.3996918	.1139047	3.51	0.000	.1764426	.622941
lfmfirmmar~p	.778163	.2733327	2.85	0.004	.2424407	1.313885
limimports~e	.5103775	.2011871	2.54	0.011	.1160581	.904697
lfifdishare	.7677402	.1759583	4.36	0.000	.4228683	1.112612
linvestment	.0109556	.0102039	1.07	0.283	-.0090437	.030955
_cons	.2298174	2.944158	0.08	0.938	-5.540626	6.000261
sigma_u	.43975151					
sigma_e	.18265759					
rho	.85285775	(fraction of variance due to u_i)				

We see, with the R^2 between, that the part of the variability across individuals which is explained by the explicative variables is about 96%. The R^2 within gives an idea of the contribution of the random effects to the model, which is of 77% in this case. Finally we can note that more than 85% of the variance is due to differences across panel.

Concerning the variables, they are all significant except for labour, capital and investment. However, the constant is not significant. From the estimated econometric model we can interpret the coefficients:

- If materials increase by 10%, the sales will decrease by 4,00%;
- If firm mark-up increases by 10%, the sales will decrease by 7,78%;
- If import share increases by 10%, the sales will decrease by 5,10%;
- If FDI share increases by 10%, the sales will decrease by 7,67%;

The results of the above FE regression model confirms our theoretical hypothesis that foreign activity of the entities on Russian chemical market in the form of FDI and international trade leads to increase of productivity within the whole industry.

These results have important implications for policymakers in Russia. As chemical industry represents a significant part of the economy, productivity growth in this particular sector may lead to a high increase in GDP. In the light of the above-mentioned results, we could conclude that accession to the WTO will benefit Russia.

However, the study findings may be limited by two constraints. Firstly, it will be severely bounded in the time period of data to be collected, as the firm product-level trade data of each transaction from Russian customs agency is available only from 2005. Secondly, quantitative research always has its limits, although methodology itself implies minimum noise from input data, probably it's not able to capture the dynamics of certain parameters.

CONCLUSION

Governments all over the world spend large amounts of resources in order to attract multinational companies to their region or country, often based on the assumption that such companies generate various types of positive externalities, or spillovers, to domestic firms. This stands in sharp contrast to the influential recent literature that has used microlevel data to provide econometric evidence for such FDI spillovers — without finding much. In this paper, we estimate international technology spillovers to Russian-owned manufacturing firms via imports and FDI between the years of 2007 and 2012. Our results suggest that FDI leads to significant productivity gains for domestic firms. The size of FDI spillovers is economically important. There is also some evidence for imports-related spillovers, but it is weaker than for FDI.

The results emphasize the importance of internationalization for productivity and welfare growth, both through the internationalization of domestic firms and through foreign direct investments by multinational firms. The results imply that export promotion policies and FDI promoting policies should be designed in a balanced manner, as they may potentially be substitutes in reaching productivity growth. Policies aiming to facilitate internationalization of domestic firms should furthermore not focus solely on developing export markets but also on the facilitation of import activities for high quality inputs.

However, despite the presence of positive spillovers from FDI, the policy implications of these findings are not straightforward. These results may support the continuing fiscal and investment incentives provided by the Russian government for FDI. However, more general policies should be pursued, which not only attract FDI but also benefit domestic firms, for example, building modern infrastructure, increasing and strengthening the institutions for accelerating and sustaining economic growth.

Based on the empirical results, we may predict that Russian accession to the WTO in 2012 should result in productivity growth. However, further research on this topic will be possible when the statistical data is available for several years after accession.

Our research suggests a number of future research directions. For one, the heterogeneity of FDI spillover strength across industries partly reflects the heterogeneity in the motivation for FDI. Not all FDI is equally likely to transfer technology internationally, which suggests a promising avenue of future research focusing on specific industries and mechanisms. Another issue is whether the literature so far has taken a sufficiently broad view of the effects that MNEs' entry might have, including inter-industry effects, the longer-run effects (e.g. of worker training programs), and signaling effects to other potential foreign investors.

For the time being, the results in this paper provide the strongest evidence supporting the provision of subsidies to attract FDI from a viewpoint of social welfare. Another important question, of course, is whether a socially optimal policy is indeed implemented, given the political-economic realities of local electoral competition.

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