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The complementarity effect of exporting, importing and R&D on the productivity of Ukrainian MNEs

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ABSTRACT

After two decades of research on Emerging Market Multinational Enterprises (EMNE), the debate still concerns the antecedents and strategies of their foreign expansion. However, much less has been said on the effects of international participation on their productivity. Building on insights from the Resource-Based View of the firm and agency theory, we develop hypotheses on the presence of complementarities among export, import and R&D and their impact on productivity. Our empirical analyses on a panel of 23,000 time-year observations of Ukrainian MNEs over the period 2000–2006, confirm that: (i) EMNEs benefit from complementarities stemming from the assimilation and integration of knowledge from international external sources (import and export) with internal knowledge (own R&D investment); (ii) the effect is more pronounced for private-owned enterprises (POEs) rather than state-owned enterprises (SOEs), and (iii) especially when they trade with partners in/from advanced markets.

1. Introduction

Recent decades have witnessed the increasing participation of EMNEs in the global arena; more than 25 % of the Fortune Global 500 listed companies are from emerging and transition economies (e.g., https://www.weforum.org/agenda/2018/09/role-companies-emerging-markets/). This evidence raises the question of what has driven the success of these emerging-market companies. Competition in international markets may have played an important role (Anand, McDermott, Mudambi & Narula, 2021), however, less is known about the underlying mechanisms that explain the performance of MNEs from emerging economies involved in international trade.

Studies have investigated the role of learning through FDI strategies (Li, Chen & Shapiro, 2010; Piperopoulos, Wu & Wang, 2018; Thakur-Wernz, Cantwell & Samant, 2019; Amendolagine, Piscitello & Rabellotti, 2022) and learning by trading (e.g., learning by exporting, Bleaney, Filatotchev & Wakelin, 2000; Filatotchev, Isachenkova & Mickiewicz, 2005; Salomon & Jin, 2010) and learning by importing, MacGarvie, 2006; Elliott, Jabbour & Zhang, 2016). Specifically, exporting allows firms to learn by accessing a variety of knowledge – technological and market (Salomon & Shaver, 2005), customers (Utterback & Afuah, 1998), and destination-specific labor and technical expertize, as well as by being exposed to more intense competition (Salomon, 2006). Firms can also learn when they import intermediate products that embody technological knowledge (Halpern, Koren, & Szeidl, 2015). In fact, productivity advantages of globally integrated firms tend to be higher, as they have access to a larger stock of knowledge and ideas through varied sources including their upstream and downstream contacts with suppliers and customers (Criscuolo, Haskel, & Slaughter, 2005). To fully benefit from such learning processes from external sources, e.g., trade activities, firms need internal R&D investments to develop absorptive capacity and be able to absorb and integrate external knowledge (Cohen & Levinthal, 1989, 1990; Li et al., 2010).

Several studies have explored the performance effect of various *pairwise* combinations of these three interdependent learning channels, i.e., learning by exporting, learning by importing and internal R&D (e.g., Smeets & Warzynski, 2013; Golovko & Valentini, 2011) with mixed results. However, to the best of our knowledge, the *joint effect of these three processes* on a firm's productivity has not been investigated and with our study we aim to fill this gap. These mechanisms for learning and enhancing firms' productivity are particularly important for

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companies from emerging economies that are increasingly engaged in international trade, because they are known to be poorer at developing absorptive capacity (Anand et al., 2021; see also the Special Issue on "Innovation in and from emerging economies" in JIBS 2021).

In this paper we refer to the literature that considers the simultaneous engagement in export and import as well as internal knowledge creation activities, and study the impact of three-way complementarities among these activities on firm's performance (Milgrom & Roberts, 1990). We anchor our study on the Resource Based View of the firm (RBV) (Barney, 1991) and we incorporate agency theory (e.g., Jensen & Meckling, 1976) to address different market forces, ownership and incentives structures, i.e., state and private ownership, and in doing so we contribute to the literature on EMNEs.

We adopt the notion of complementarities as defined by Milgrom and Roberts (1995) that "doing (more of) one thing increases the returns to doing (more of) another" (Milgrom & Roberts, 1995: 181). This definition suggests that adopting only some elements of a system does not allow to fully benefit from the returns in terms of performance, and that there is a performance premium in adopting bundles of elements compared to adopting them individually (e.g., Brynjolfsson & Milgrom, 2013). Here we analyse the existence of such complementarities among learning by exporting, learning by importing and internal R&D in the context of EMNEs.

The empirical analysis is based on a large firm-level database from the Ukrainian Office of National Statistics (Derzhkomstat) that combines consolidated annual accounts data on the census of manufacturing firms operating in Ukraine between 2000 and 2006. During this period Ukrainian national legislation was brought into compliance with the WTO rules and regulations in preparation for the WTO accession. These changes have subsequently led to the reorientation of trade flows towards the more advanced Western markets and overall significant dynamism in export markets (Nielsen, 2011).[1] Thus, an increasing number of Ukrainian firms engaged in international trade increased their international presence and the scope of their international trade. In particular, during the period 2000–2006 the number of Ukrainian firms entering export markets has more than doubled and international trade rose by about 100 % following the recovery from the 1998 Russian financial crisis. Overall, this period is characterized by stable macroeconomic policies.

According to the IMF Country Classification, Ukraine falls into the category of emerging and developing countries (Nielsen, 2011).[2] The transition from a planned to a free market economy in Ukraine also offers the opportunity to investigate firms' heterogeneity due to ownership by distinguishing between Private-owned Enterprises (POEs) and State-owned Enterprises (SOEs). Finally, the richness of the database allows studying the productivity effect of learning mechanisms associated with different locations for exporting and importing, namely advanced versus developing countries. Thus, overall, Ukraine represents a suitable setting for our empirical analysis, which differs from the more commonly studied Chinese and Indian EMNEs (e.g., Jiang, Jiao, Lin & Xia, 2021), adding to the heterogeneity of research on EMNEs (Wright, Filatochev, Hoskisson & Peng, 2005) and strengthening international business (IB) research.

Our results provide evidence of positive effect on productivity of combinations of firm's export, import, and internal R&D investment in Ukrainian manufacturing firms, thus confirming the existence of significant complementarities in absorptive capacity and their positive effect on firms' productivity. Further analyses confirm that this effect is particularly strong for POEs trading with advanced markets. At the same time, SOEs, despite enjoying some productivity gains when trading with advanced markets, do not seem to benefit from complementarities in the three-way system.

This study makes three contributions to the IB literature. First, we offer conceptual and empirical novelty in testing the notion of absorptive capacity as complementarities between internal (R&D) and external (export and import) learning processes, which have not often been analysed formally in the literature. These internal and external activities are complementary because the full benefits of each activity are reached only when all the other elements are present (Lewin, Massini & Peeters , 2011), otherwise absorptive capacity will not be realized, but it will only remain potential (Zahra & George, 2002). We build on the Resource Based View of the firm (Barney, 1991) which recognizes that knowledge is a key resource underlying firms' competitiveness; in our study learning processes are fundamental mechanisms that augment the stock of knowledge of firms. We suggest that exporting firms tend to be more competitive and innovative; importing firms often develop internal capabilities and knowledge in order to support the integration of intermediate products; firms engaged in both export and import activities experience higher productivity gains (Golovko & Valentini, 2011); R&D investments intensify the learning processes from exporting and importing. These dynamics are important to fully benefit from internal and external knowledge.

Second, our study considers an important moderating factor in the relationship between exporting, importing and R&D, and productivity, that is the development level of trading destinations and country of origin. We advance a possible explanation that the specific characteristics of the institutional context as well as the development stage of the countries in which firms operate, might contribute to explaining the performance effect differential of these learning mechanisms in MNEs in emerging economies. We posit that the effect of absorptive capacity resulting from the complementarities among exporting, importing and internal R&D investments on a firm's productivity is affected by the development stage of the trading partner-countries where the learning takes place. Exporting to and importing from advanced destinations improves learning rates because EMNEs are supplying to or utilizing products from firms at the technological frontier.

Third, we consider governance and ownership of EMNEs distinguishing between privately owned enterprises (henceforth POEs) and state-owned enterprises (henceforth SOEs) of a transition economy (Cuervo-Cazurra, Inkpen, Musacchio, & Ramaswamy, 2014; Banalieva et al., 2018; Lazzarini, Mesquita, Monteiro & Musacchio, 2021). In doing so, we incorporate agency theory (Jensen & Meckling, 1976) to explain performance. Studies have shown that POEs tend to enjoy better performance, due to stronger incentives and higher efficiency resulting from their governance (Filatotchev, Dyomina, Wright, & Buck, 2001; Goldeng, Grünfeld & Benito, 2008). We propose that the complementarities among external and internal learning processes result in higher performance in POEs compared to SOEs due to benefiting from stronger efficiencies in governance and market forces (Zhu, Ghao, & Zhao, 2017).

This paper offers a novel approach to analyse the effect of three-way complementarities among learning by exporting, learning by importing and internal R&D on firm performance, distinguishing between state-owned and private firms. We argue that both export and import activities operate as learning channels for firms, and that complementarities among them and firms' internal R&D efforts further enhance their performance.

The remainder of this paper is structured as follows. The next section elaborates on learning processes, distinguishing between learning by exporting, importing, and internal R&D. Then we present the data and methods, elaborating on the methodology to test for three-way complementarities. We present and explain our results, and provide further tests on complementarities. We then discuss the implications of our research and conclude with final considerations and further research suggestions.

[1] In our analysis we distinguish between advanced and developing countries using the IMF classification (Nielsen, 2011).

[2] The UNDP country classification system also classifies Ukraine as a developing country (Nielsen, 2011).

2. Theoretical background and development of hypotheses

In this paper we build on the Resource Based View of the firm (Barney, 1991) which recognizes that knowledge is a key resource underlying firms' competitiveness. Learning processes are fundamental mechanisms that augment the stock of knowledge of firms. Theoretical and empirical research on trade has well documented the spillovers of intangible ideas through the exchange of tangible commodities, concluding that export and import activities facilitate and support learning processes and often result in further productivity improvements (e.g., Grossman & Helpman, 1991). Firms engaged in trade can learn from external sources via demand–supply linkages (Alcacer & Oxley, 2014; Aw, Chung, & Roberts, 2000). Exporting firms may access knowledge sources not available or accessible in their domestic market, can interact and compete in foreign markets (Salomon & Jin, 2010), and can exploit this knowledge to produce more and higher-quality innovations (Salomon & Shaver, 2005; Love & Ganotakis, 2013; D'Angelo, Ganotakis & Love, 2020). For recent and comprehensive reviews on learning in exporting, see İpek (2018, 2019).

The impact of import on learning processes remains less researched, however some empirical studies have shown that firms importing intermediate inputs enjoy increases in productivity (Kasahara & Rodrigue, 2008; Halpern, Koren & Szeidl, 2015). Amiti and Konings (2007) and Shepotylo and Vakhitov (2015) explore the impact of trade liberalization on productivity of Indonesian and Ukrainian manufacturing firms respectively through: (i) tougher competition; (ii) access to higher-quality intermediate inputs. Their results reveal that most productivity gains from trade liberalization result from accessing cheaper intermediate inputs. Finally Halpern et al. (2015), using Hungarian firm-level data, find that most of the exporters' productivity premium occurs only when these firms are also importers, indicating complementarity between the two trading activities.

One often overlooked element in understanding the relationship between learning-by-exporting or importing and productivity growth, is the internal investments incurred by firms to support the absorption of knowledge and technology from external sources (Aw, Roberts, & Winston, 2005) and innovate.

Innovative firms tend to enter new geographical markets with novel and improved products (Hitt, Hoskisson, & Kim, 1997; Eckel, Iacovone, Javorcik, & Neary, 2015). Likewise, R&D and innovation can support learning by importing and lead to productivity gains (Damijan & Kostevc, 2015). Altogether, these studies suggest that exports, imports and innovation can give rise to a virtuous circle and improve the AC of the firm.

We go back to the original definition of AC, which is the "ability of a firm to recognize the value of external information, assimilate it, and apply it to commercial ends" (Cohen & Levinthal, 1990) and the importance of balancing internal knowledge-creating processes with the identification, acquisition and assimilation of new knowledge originating in the external environment (Lewin & Massini, 2003). These internal and external activities are complementary in the sense that the full benefits of each activity are obtained when they are all present (Lewin et al., 2011); if this is not the case, absorptive capacity will not be fully realized and will remain potential (Zahra & George, 2002).

As it has been widely acknowledged, learning processes which occur outside the boundaries of the firm require absorptive capacity. Learning and absorptive capacity are coevolving and mutually reinforcing (Barkema & Vermeulen, 1998; Autio, Sapienza, & Almeida, 2000). Absorptive capacity enables firms to learn and innovate, as the new knowledge adds to the existing absorptive capacity (Helfat, 1997; Van den Bosch, Volberda, & de Boer, 1999). Van den Bosch et al. (1999) further argue that the "absorptive capacity–learning–new absorptive capacity" feedback loop suggested by Cohen and Levinthal (1990) is mediated by the environment in which the firm operates and how it copes with it, implying that where the firm learns from (e.g., firms from other countries and sectors) matters. Cohen and Levinthal (1989) had operationalized absorptive capacity with R&D expenditures, and empirical studies that make attributions to the absorptive capacity concept have also utilized this indicator (Schweisfurth & Raasch, 2018; Tsai, 2001; Veugelers, 1997). Differently from research that considers AC as a moderator of learning by exporting (D'Angelo et al., 2020), we take a more comprehensive view of AC where internal sources of knowledge are constituted by a firm's R&D investments and external sources of knowledge are the international customers and suppliers.

We argue that there is a significant relationship among exporting, importing and R&D investments, because internal R&D allows firms to fully benefit from learning processes and the knowledge acquired through exporting and importing. The learning effect of performing these activities jointly has a stronger impact on firms' productivity than the sum of their learning effects if conducted in isolation. The additional benefit would indicate that complementarities exist.

Absorptive capacity is made of both internal and external sources of knowledge (Lewin & Massini, 2003). The internal element is represented by a firm's own R&D investments, whereas the external sources of knowledge are, among others, their customers and suppliers; in the context of MNEs, these are represented respectively by export and import activities. These internal and external activities are complementary and the full benefits of each activity are reached when all the other elements are present (Lewin et al., 2011). If a firm only focuses on the internal R&D efforts, it will miss the opportunity to identify and acquire external knowledge. On the other hand, if a firm only uses external sources of knowledge, via customers and suppliers, it will only be able to make limited use of this knowledge if it has not developed internal knowledge which allows it to assimilate and apply the externally acquired knowledge to commercial ends (Cohen & Levinthal, 1990). Complementarities among internal and external sources of knowledge will result in improved performance.

Empirical studies that followed the seminal works of Milgrom and Roberts (1990, 1995) have provided supportive evidence on the complementarities–performance nexus for technological adoption (such as robotics, and other improved capital equipment or information technology and systems) and organizational practices (such as relationships with suppliers, or interaction between manufacturing and marketing divisions) (Aral & Weill, 2007; Bocquet et al., 2007; Massini & Pettigrew, 2003), with the introduction of a range of human resource practices or adjustments to existing ones (Cappelli & Neumark, 2001; Delaney & Huselid, 1996), and to study complementarities among product, process and organizational innovations (Ballot, Fakhfakh, Galia, & Salter, 2015).[3]

We claim that exporting firms tend to be more competitive and innovative; importing firms often invest in internal capabilities and knowledge in order to integrate intermediate products; firms engaged in both export and import enjoy higher productivity gains (Golovko & Valentini, 2011); and R&D investments support the learning processes of export and import activities. For example, investments in innovation enable a firm to achieve greater ability to meet the demands of its changing domestic and international markets, thus making exporting more profitable (Cassiman & Golovko, 2011). All these dynamics are important to fully benefit from internal and external knowledge, and the benefits are higher when all three activities are present. Therefore, we propose the following hypothesis:

Hypothesis 1. Complementarities among firms' exporting, importing and own innovation efforts improve their productivity.

We argue that the inconsistent evidence on the complementarity effect among binary combinations of learning by exporting, learning by importing and the firm's own innovation on firm performance may be due to not considering the full system of three-way complementarities.

[3] For a comprehensive review on empirical literature on complementarities see Ennen and Richter (2010).

However, these complementarities may be affected also by firms' governance (POEs vs. SOEs) and the development stage of trading countries, which are particularly important to MNEs from emerging economies.

Firm ownership and governance structure are important characteristics of firms that affect their strategies, decision-making processes and performance (Hill & Snell, 1989). POEs and SOEs typically follow different decision-making processes, possess resources in different quantity and of different quality, respond to different incentives' structures, and are exposed to different market forces. As argued by agency theory (e.g., Jensen & Meckling, 1976), SOEs are affected by dual agency and principal-agent problems, which derive from the company's state ownership, i.e., the citizens, who, as principals, appoint politicians (i.e., the agents) to achieve the social and economic objectives of the SOE. The politicians (i.e., the principals) appoint the managers of the SOE, i.e., the agents, to achieve their own objectives. The misalignment between the objectives of politicians who seek to remain in power and those of the citizens who aim at better performance by SOEs result in the dual principal–agent problem (Goldeng, Grünfeld, & Benito, 2008; Cuervo-Cazurra et al., 2014). As a result, SOEs' performance is normally worse than that of private companies (Shleifer, 1998; Goldeng et al., 2008). They also differ in their innovation capabilities and motives to innovate (Kroll & Kou, 2019; Meissner, Sarpong, & Vonortas, 2019; Lazzarini et al., 2021). SOEs are often found to be less efficient or, at least, less profitable, as they are thought to forgo maximum profit opportunities in pursuit of political and social goals (Dewenter & Malatesta, 2001). Furthermore, SOEs might be pressured to hire excess labor inputs for political reasons or employ politically connected people rather than the candidates best suited for the job (Boycko, Shleifer, & Vishny, 1996).

On the other hand, studies have remarked that SOEs normally face softer budget constraints, which enables them to cope better with strong competition, whereby POEs might exit the market if underperforming. SOEs can afford to spend more time adapting to external market conditions (Goldeng et al., 2008), and, while governments might force social and political objectives on SOEs that lead to inefficiencies, they also provide them rents and protection, which could lead them to perform as well as or even better than similar private firms (Colli, Mariotti, & Piscitello, 2014; Lazzarini & Musacchio, 2018). Other studies acknowledge that being located in contexts with more munificent resources, state ownership enables SOEs to obtain crucial R&D resources (Li & Xia, 2017), and that the patient (public) capital in SOEs allows long-term investment activities and operations, and may favor innovation activities (Munari, Oriani, & Sobrero, 2010). However, SOEs might use those resources less efficiently because of market forces and incentive structures (Zhu, Ghao, & Zhao, 2017). Empirical evidence suggests that, on average, private firms are more innovative, more productive and more active in international markets with respect to the SOEs, who are normally focused on internal markets, thus missing an innovative mindset and dedicating fewer resources to R&D (Álvarez & Argothy, 2019). Hence, one should expect stronger performance effects from the export, import and innovation complementarities in private-owned firms. Thus, we propose the following hypothesis:

Hypothesis 2. The effect of complementarities among firms' exporting, importing and own innovation efforts on their productivity is higher in POEs than in SOEs.

Research on MNEs from emerging economies argues that there are benefits in selecting destination countries with similar institutional contexts because this allows EMNEs to leverage from the familiarity with formal and informal institutions, which, in turn, could result in positive performance (Cuervo-Cazurra, 2012), consistently with the so-called institutions-based view (Peng, Wang, & Jiang, 2008). As earlier studies (e.g., Lee & Beamish, 1995) had argued and shown, firms from emerging economies may have a competitive disadvantage in entering advanced economies, but have a competitive advantage, and face a lower knowledge gap, when entering countries with economic and institutional contexts similar to their home country.

EMNEs seeking to upgrade their technological and knowledge base prefer to select advanced economies that offer better learning opportunities (e.g., Cuervo-Cazurra, 2012) to develop new capabilities (Hoskisson, Kim, White, & Tihanyi, 2004). We argue that the effect of absorptive capacity resulting from the complementarities among exporting, importing and internal R&D investments on a firm's productivity is likely to depend on the development stage of the trading partner-countries where the learning takes place. Trofimenko (2008) finds that exporting to more advanced destinations improves export-learning rates. Indeed, exporting to these markets exposes firms to competing with or supplying to firms at the technological frontier that use the most advanced capital goods, best practices, and produce innovative products (De Loecker, 2007; Wagner, 2012). At the same time, learning by importing from advanced economies improves the productivity of firms because importers can access high quality capital goods embodying high knowledge and technology (Lööf & Andersson, 2010; Fernández & Gavilanes, 2017). Existing empirical evidence confirms superior performance outcomes for firms that engage in both import and export with relatively more advanced markets, which can provide access to the latest technological innovations, product design and management practices (Martins & Yang, 2009; Wagner, 2012). Hence, we posit that the economic development of the markets in which firms trade has a beneficial effect on learning processes and knowledge spillovers because the intensity and quality of competition in such markets offer more opportunities to tap into more advanced knowledge pools; a higher number of competitors affects the speed and diffusion of knowledge and innovation (Schumpeter, 1943), thus EMNEs benefit more by trading in these countries, and this can enhance the complementarity effect on firm performance, compared to when they trade with other emerging economies.[4] Therefore, we propose the following hypothesis:

Hypothesis 3. Complementarities among firms' exporting, importing and own innovation efforts are more beneficial for their productivity when firms from emerging economies trade with advanced markets (compared to less advanced countries).

In summary, we investigate the effect of complementarities of learning processes on firms' productivity and anchor our study on RBV for the technological and knowledge upgrade resulting from the learning processes of exporting, importing and in-house R&D activities in advanced economies. RBV is the conceptual framework underlying the three hypotheses. For Hypothesis 2, in addition to RBV, agency theory explains the heterogeneity between POEs and SOEs in benefiting from the complementarities because of different market forces and incentive structures. Fig. 1 illustrates our conceptual model on complementarities among the three learning activities, export, import and R&D, which are fully interconnected, with each element interacting with the other two. The three-way complementarities make it possible to enjoy a premium in performance, while ownership typology and trade locations are moderating factors in this relationship.

3. Methods

3.1. Data and sample

This study focuses on Ukrainian manufacturing firms over the period 2000–2006. Because of the transition from a planned to a free-market economy Ukraine represents a suitable setting for our empirical analysis. It offers important firms' heterogeneity in ownership, distinguishing between Private-owned Enterprises (POEs) and State-owned

[4] We are grateful to one anonymous reviewer for the suggestion of elaborating further on this point.

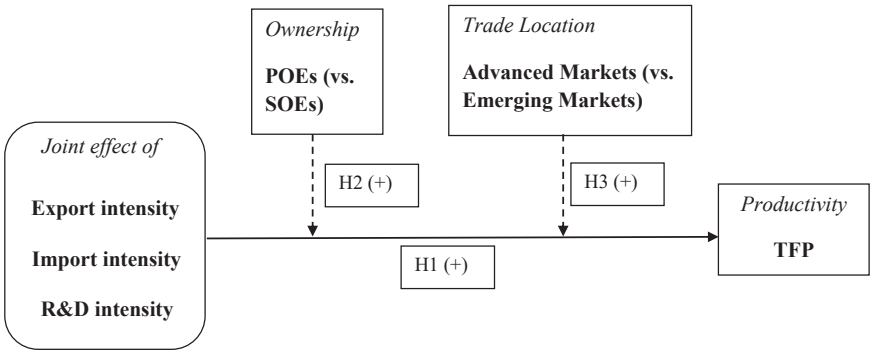

Fig. 1. Complementarity effect of Export, Import and R&D on firm's productivity, and the moderating role of ownership and trade location.

Enterprises (SOEs) as well as the different exporting and importing locations, namely advanced versus developing countries. We test the three hypotheses using the data submitted to the Ukrainian Office of National Statistics (Derzhkomstat) that contains consolidated annual accounts data on the census of manufacturing and service firms operating in Ukraine in 2000–2006.[5] All firms are identified by their unique VAT numbers and allocated into sectors according to the Ukrainian Office of National Statistics nomenclature, comparable to the NACE Rev.1. The data include information on several firm-specific characteristics, including: employment (measured as the annual average number of registered employees), output, sales, tangible and intangible assets, material costs and other types of intermediate expenditure (including R&D and innovation expenditures), and gross capital investment. We merged this dataset with the Ukrainian Customs office data that contain information on the monetary value of firm-level exports/imports by destination/origin country, year, and type of goods. The merger of the Ukrainian Office of National Statistics data and the Ukrainian Customs Office data was based on the unique firm VAT numbers present in both datasets. All variables were deflated using two-digit subsector price deflators, available at the Ukrainian Office of National Statistics website (http://www.ukrstat.gov.ua). We focus on firms operating in the manufacturing sectors (NACE Rev.1 15–36). The final dataset, used for the statistical analysis, comprises a panel with an average of 33,237 firms per year and 232,657 firm/year observations covering the period 2000–2006. Table 1 shows the average annual percentages of exporters, importers, two-way traders (i.e., firms that both export and import) and R&D investors in the sample separately for the POEs and SOEs.

The data cover all Ukrainian manufacturing sectors. However, due to the unbalanced nature of the panel, the numbers can vary from year to year. Moreover, due to specific industry characteristics and Soviet Union heritage, some sectors, such as *Coke & Chemistry* and *Motor vehicles and trailers*, are characterized by a smaller number of large firms. Finally, we excluded the Tobacco industry from the analysis, as in Ukraine this is traditionally characterized by an oligopolistic structure and, as a result, a very limited number of observations are available. [6]

The key production function variables exhibit increasing patterns of output and material expenditures alongside a declining average size (employment) and capital, indicating productivity growth during 2000–2006.[7]

To verify the variability of trade-innovation strategies in our sample we construct the matrix of aggregate annual combinations of international trade and R&D investment strategies. As shown in Table 2, the aggregate strategy-mix shares exhibit relatively stable patterns over time. Of course, the composition of these shares in our sample varies across firms, as firms tend to experiment with various practices and change their strategy mix from year to year. This feature of the data should ensure that performance tests provide a reliable way to assess the impact of various trade and innovation strategies on firm performance.

3.2. Empirical strategy

Providing robust empirical evidence on complementarities may be problematic, as complementary practices often tend to be endogenous in observational data. Hence, empirical studies usually seek for evidence on various economic implications of complementarities. In a similar vein, we test for complementarities among exports, imports, and R&D investment in three different (complementary) ways.

First, if there are complementarities, we should observe the clustering of practices across firms and over time (Arora & Gambardella, 1990), hence we carry out correlations among complementary trade and innovation practices in the base year of our data, followed by the analysis of changes in their mutual correlations over time. It is worth noting that this approach might fail to capture the full effects of complementarities because it relies on the linear (additive) combinations of practices, ignoring any non-linear (synergetic) interaction effect.

Second, we test for complementarities in the performance of exports, imports, and R&D by using regression-based tests. This approach allows us to catch both linear and non-linear effects of complementary practices on firm performance. However, the results may be affected by the endogeneity issues that arise because of firms' self-selection into various combinations of complementary practices (i.e., selection bias). The selection bias occurs because firms that actively participate in international trade may possess some unobservable characteristics that could result in their better performance relative to non-participants. These characteristics, in turn, might be correlated with firms' decisions regarding global markets, leading to biased results. For instance, engaging in export activities requires a significant amount of initial investment and efforts to overcome entry barriers, known as sunk exporting costs (Roberts & Tybout, 1997; Love & Roper, 2015). These costs might include becoming acquainted with foreign demand conditions, establishing new distribution channels, investing in product rebranding, and marketing activities for exported goods. The substantial empirical evidence suggests that more productive, more capital intensive and larger firms are more likely to make a decision to self-select into exporting (Clerides, Lach, & Tybout, 1998; Melitz, 2003; Bernard & Jensen, 2004). Moreover, whilst the selection bias in exporting has been extensively explored, the selection bias in importing has received less attention in the empirical literature (Vogel & Wagner, 2010). Indeed, barriers to importing are usually less pronounced. Still, significant efforts might be required to identify and develop connections with reliable foreign suppliers of intermediate inputs. Hence, both activities might be

[5] The data is restricted and not available for public use. The data have been previously used in Shepotylo and Vakhitov (2015), Huynh et al. (2016), and Reggiani and Shevtsova (2018).

[6] Please see Appendix B for the number of firms, the average size and the share of exporters, importers, two-way traders, and innovating firms by industry.

[7] Please see Appendix A for the summary statistics of the main production function variables.

Table 1
Number of firms and shares of exporters, importers, two-way traders and R&D investors (%), 2000–06.

Year	Firms	Exporters	Importers	Two-way traders	R&D Investors	Exporters share, %	Importers Share, %	Two-way traders share, %	R&D Investors share, %
					Private firms (POEs)				
2000	29,085	1387	1242	1416	3542	4.8%	4.3%	4.9%	12.2%
2001	31,184	1553	1281	1504	5015	5.0%	4.1%	4.8%	16.1%
2002	33,059	1776	1299	1611	5883	5.4%	3.9%	4.9%	17.8%
2003	33,975	2002	1331	1724	6156	5.9%	3.9%	5.1%	18.1%
2004	34,663	2327	1386	1968	6823	6.7%	4.0%	5.7%	19.7%
2005	23,543	1391	1201	1335	4843	5.9%	5.1%	5.7%	20.6%
2006	34,567	1789	1379	1536	7364	5.2%	4.0%	4.4%	21.3%
Average	31,439	1746	1303	1585	5661	5.5%	4.2%	5.1%	18.0%
					State-owned firms (SOEs)				
2000	1927	99	71	134	339	5.1%	3.7%	7.0%	17.6%
2001	1930	106	65	139	482	5.5%	3.4%	7.2%	25.0%
2002	1916	115	44	144	600	6.0%	2.3%	7.5%	31.3%
2003	1904	149	37	152	533	7.8%	1.9%	8.0%	28.0%
2004	1914	145	47	155	558	7.6%	2.5%	8.1%	29.2%
2005	1391	49	42	95	364	3.5%	3.0%	6.8%	26.2%
2006	1599	119	29	92	484	7.4%	1.8%	5.8%	30.3%
Average	1797	112	48	130	480	6.1%	2.7%	7.2%	26.8%

Note: Own calculations.

Table 2
Share of firms (%) engaged in Export, Import and R&D by year.

	R&D= 0, Exp= 0, Imp= 0	R&D= 0, Exp= 0, Imp= 1	R&D= 0, Exp= 1, Imp= 0	R&D= 1, Exp= 0, Imp= 0	R&D= 0, Exp= 1, Imp= 1	R&D= 1, Exp= 0, Imp= 1	R&D= 1, Exp= 1, Imp= 0	R&D= 1, Exp= 1, Imp= 1
2000	79 %	3 %	3 %	7 %	2 %	1 %	1 %	3 %
2001	76 %	2 %	3 %	10 %	2 %	2 %	2 %	3 %
2002	74 %	2 %	3 %	11 %	2 %	2 %	2 %	3 %
2003	74 %	2 %	4 %	11 %	2 %	2 %	2 %	4 %
2004	72 %	2 %	4 %	12 %	2 %	2 %	3 %	4 %
2005	71 %	3 %	3 %	12 %	2 %	2 %	2 %	4 %
2006	72 %	2 %	3 %	14 %	1 %	2 %	3 %	3 %

Note: Own calculations

potentially subject to selection bias.

The econometric literature suggests a number of approaches to tackle the issues of endogeneity and selection bias, including instrumental variables (IVs), matching methods, and Heckman control function methods (Blundell & Dias, 2009). This paper uses a modified version of *Heckman control function* approach that is widely used in the empirical literature and is closely related to the IV approach. Moreover, due to the multicotomous nature of the selection variable (i.e., firms can self-select into all possible combinations of export and import activities), the first stage of the analysis uses a multinomial logit estimator that includes lagged labor productivity, firm size (as number of full-time registered employees), and dummies indicating the possession of intangible assets and foreign ownership as explanatory variables. We also include lagged export and import status of the firm to take into account possible persistence in trade participation (Blanes-Cristóbal, Dovis, Milgram-Baleix, & Moro-Egido, 2008), and lagged annual 2-digit industry sales, export and import intensity to take into account domestic demand conditions and knowledge spillovers that might affect firms' decisions regarding international trade participation. We use lagged export and import intensity of a given industry/year as exclusion restrictions, required to identify the sample-selection model. Finally, we use the predicted probabilities of various export–import strategies to compute the sample selection correction terms (i.e., Inverse Mills Ratios) for each potential strategic outcome; and subsequently include these terms in the second-stage regression to correct for the potential selection bias (Schmertmann, 1994; Cassiman & Veugelers, 2006; Jäckle & Himmler, 2010). Finally, to control for remaining potential endogeneity among export, import, R&D activities and factor inputs, the second stage model is estimated using the Generalized Method of Moments (GMM) system approach (Arellano & Bond, 1998). The system GMM estimator allows for endogenous regressors (via the use of instruments involving lagged values of potentially endogenous regressors in the model) and a first-order auto-regressive error term (Golovko & Valentini, 2011; Harris & Cher, 2012).

Finally, we implement a set of direct complementarities tests proposed by Brynjolfsson and Milgrom (2013), based on the supermodularity framework (Milgrom & Roberts, 1990). These tests compare firm performance corresponding to the different combinations of complementary activities (i.e., various combinations of export–import–R&D choices).

3.3. Dependent variables

To test complementarities in performance of exports, imports and firms' own innovation efforts we construct the firm-level total factor productivity (TFP), a widely used performance indicator (Januszewski, Köke, & Winter, 2002; Alcalá & Ciccone, 2004; Tambe, Hitt, & Brynjolfsson, 2012). We estimate the firm-level TFP using a modified version of the Olley and Pakes (1996) methodology to control for the industry-specific price and demand shocks, as well as different market structures and factor prices for exporting and non-exporting firms (see also De Loecker, 2011; Shepotylo & Vakhitov, 2015). The latter distinction is incorporated into the model by adding export status information to the investment function in the Olley and Pakes (1996) algorithm. As emphasized by De Loecker (2011), controlling for export status should solve the problem of the upward bias in the labor coefficient and a problem of the downward bias in the capital coefficient that

may arise as a result of the higher capital-intensity of exporters.[8]

3.4. Independent variables: Exports, imports, R&D

For each firm/year, we know the export and import values broken down by destination/origin country and monetary value of R&D investments (see Appendix C for the definition of variables). Using this information, we compute annual firm-level values of export, import and R&D intensity as a share of total annual firm sales. We emphasize the use of continuous variables, instead of dichotomous variables in our analysis, as the former is better suited to capture the effect of complementarities on firm performance. For example, using a dummy for exports might not provide us with the complete information about a firm's involvement in international trade. Indeed, as discussed in Eaton et al. (2008), many firms enter exporting with relatively small quantities, and almost half of them cease exporting in less than a year. Such strategy allows firms to reduce sunk exporting costs while uncovering information about foreign market conditions. However, it is unlikely that such export activity will have any significant impact on firm performance. At the same time, using intensity measure should serve as a more precise indicator of a firm's engagement in international trade.

3.5. Micro-level control variables

It is widely accepted that firm performance and trade decisions are correlated with some firm characteristics, therefore our analysis controls for a number of firm-specific variables that may affect a firm's performance as well as its international trade choices, in line with the mainstream international business and trade literature.

Numerous studies have shown that foreign ownership increases the likelihood of R&D investments and trade expansion (Filatotchev et al., 2001; Guadalupe, Kuzmina, & Thomas, 2012; Girma, Gong, Görg, & Lancheros, 2015). Hence, in our analysis we include a dummy variable that is equal to one if a firm is wholly or partially foreign-owned. In particular, we define a firm as foreign-owned if 10 or more percent of a local firm is owned by foreign equity. Our definition follows the definition of foreign ownership adopted by the US government, that identifies a firm as foreign-owned if a foreign facility holds an equity stake of at least 10 % (Graham & Krugman, 1995). On average, *foreign parents* hold around 60 % of the purchased firms, with equity stakes varying between 1 % and 100 %. The results remain qualitatively similar when, in line with Salomon and Shaver (2005), we define a firm with any percent of foreign ownership as foreign-owned. This is probably because only about 1% of companies in our sample have a foreign ownership share of less than 10 %.

Furthermore, substantial empirical evidence reveals that larger firms are more likely to engage in international trade, as they tend to have more resources that can be used to overcome the entry barriers into exporting and/or importing (Bernard & Jensen, 1999; Isgut, 2001; De Loecker, 2007). Hence, we include a firm-size variable, measured by the number of full-time registered employees, into the regression analysis. We also add a firm size squared term to account for any potential non-linearity in the relationship between firm performance and its size (De Loecker, 2011; Golovko & Valentini, 2011).

Finally, the management and innovation literature has long highlighted the importance of complementary assets for firm capabilities that may stimulate the adoption of innovation and R&D activities by the firm. These assets might include tangible assets, such as capital, and intangible assets, such as intellectual property, brand, reputation, marketing and distribution channels. Hence, our analysis includes capital intensity, measured as share of capital investment in total sales, to proxy for tangible assets; and a dummy variable that takes value one when a firm owns a brand name, a trademark or distribution channels and zero otherwise to control for intangible assets.

3.6. Macro-level control variables

In line with Bernini, Du & Love (2016), we augment our empirical analysis with variables that control for domestic and foreign demand conditions and other macroeconomic shocks that may affect firm performance. In particular, we control for domestic demand conditions by augmenting the first stage selection equation with the annual 2-digit industry sales that capture the changes in demand in a specific domestic industry with higher (lower) sales indicating a growing (declining) demand and more (less) favorable market conditions. Furthermore, we augment the first stage regression with the annual industry export and import intensity. These variables, in line with international trade literature, should capture the impact of knowledge spillovers on firm internationalization strategies (Fernandes & Tang, 2014).

Finally, we include the vectors of time and industry-time-specific fixed effects to account for exogenous macroeconomic conditions, industry heterogeneity and industry-specific shocks, such as trade-policy changes, exchange rate movements, and changes in demand for Ukrainian exports.

3.7. Empirical methodology

To analyse the *complementarities-in-performance* of various combinations of trade and R&D-investment strategies we estimate the following regression model using system GMM estimator:

$$Growth_{it} = Growth_{it-1} + d'_{1it-1}\gamma_1 + d'_{2it-1}\gamma_2 + \gamma_3 d_{3it-1} + x'_{it-1}\beta_1 + t'_t\beta_2 + t'_{tk}\beta_3 + \alpha_i + \varepsilon_{it}, \quad (1)$$

where $Growth_{it}$ stands for the growth rate of firm's i total factor productivity at time t; d'_{1it} is a vector of pure firm trade and investment strategies that includes a firm's export, import and R&D intensities, each measured as a share of total annual sales; d'_{2it} is a vector of two-way interactions between export and import intensity, export and R&D investment intensity, and import and R&D investment intensity; and finally d_{3it} is the triple interaction of export, import and R&D intensity. x'_{it} is a vector of firm characteristics that includes lagged logarithms of firm size, size squared (measured as number of full-time registered employees) and capital intensity (measured as a share of annual sales), foreign ownership dummy and a dummy that indicates the possession of intangible assets. t'_t is a vector of time fixed effects and $t'_{tk}\beta_3$ is a vector of industry-time-specific fixed effects.[9] Finally, α_i is a firm specific component of the error term that reflects unobserved firm heterogeneity that may be correlated with firms' trade and investment choices; and ε_{it} is white noise.

3.8. Moderating factors

In addition to testing direct complementarities in performance among export, import and R&D investment, this study also investigates

[8] The TFP estimates might still be biased due to measurement errors and imperfect competition in factor markets. However, Van Biesebroeck (2007) shows that semiparametric estimates of the production function are among the least sensitive to measurement errors. The other drawback of the Olley and Pakes (1996) estimation procedure is the requirement for positive investment in every period. However, Pavcnik (2002) and De Loecker (2007) relax this requirement by using an unrestricted sample of firms (including firms with both zero and positive investment in each period) with no significant changes in the results. Following these developments, the TFP estimates in this study were obtained using the unrestricted sample of firms.

[9] Industry dummies are absorbed by the firm fixed effects.

the moderating effect of firm-ownership structure and the geography of trade.

To test Hypothesis 2 on the role of ownership in the complementarities-in-performance effect, we define a dummy variable that distinguishes between POEs and SOEs. In particular, we define firms owned by the local, regional or national government as SOEs, and firms in private or cooperative ownership as POEs.

To test Hypothesis 3 on the role of geography of trade in complementarities-in-performance, we distinguish between EU and OECD trade partners (henceforth *advanced markets*) and countries of similar or lower development levels (henceforth *emerging markets*), such as CIS countries, countries of Central and Eastern Europe (ex-Soviet Block members), and other emerging markets.

Hence, we test Hypothesis 2 by estimating Eq.(1) separately for POEs and SOEs, and Hypothesis 3 by estimating Eq.(1) separately for the firms that trade with *advanced markets* and for the firms that trade with *emerging markets*.

Finally, to test for the moderating effect of the location of trading activities and firm ownership simultaneously we repeat the analysis separately for the private and state-owned firms trading with advanced and emerging markets.

4. Results

Table 3 presents summary statistics and product moment correlation for the sample. Overall, the correlations follow expected patterns. The dependent and main independent variables (i.e., import, export, and R&D intensities) show positive and significant correlations consistent with prior research ($r = 0.181$, $p < 0.001$; $r = 0.136$, $p < 0.001$; $r = 0.116$, $p < 0.001$, respectively). Furthermore, these activities exhibit high positive mutual correlation supporting our premise on the positive synergies between trading activities and innovation for firm performance ($r = 0.378$, $p < 0.001$; $r = 0.304$; $p < 0.001$; $r = 0.305$; $p < 0.001$). Table 4.

4.1. Correlation tests

We proceed by examining pairwise correlations between export and R&D intensity, by running pooled OLS regressions controlling for the firm size, industry, year, industry-year fixed effects. The correlation between the two practices is positive and significant ($\beta = 0.058$; $\rho < 0.003$) when the full sample of firms is used. Moreover, when the sample is split into the firms characterized by high and low import intensity, the abovementioned practices remained positively correlated for both types of firms, suggesting that they might be complementary independently of the firms' importing activities. Moreover, the magnitude of the correlation between export and R&D intensity is larger for high-intensity importers ($\beta = 0.233$; $\rho = 0.00$), which provides some initial evidence of the presence of three-way complementarities among these three activities.

Next, we examine how firms adjust their R&D practices to match their international trade activities.

Fig. 2 compares the changes in R&D intensity over time for firms with: (i) high export and import intensity; (ii) low export and import intensity; (iii) mismatched export and import intensities, when only one activity is highly intensive, while the other one is of low intensity. The trends in Fig. 2 suggests that internal R&D investments increase faster in firms intensively involved in both trading activities.

Overall, the correlation pattern observed in the data is consistent with three-way complementarities among international trade activities and R&D. Nevertheless, we cannot rule out the impact of some unobservable factors that could potentially mimic the correlation patterns of true complementary activities. Hence, we proceed by testing for complementarities in performance of exports, imports, and R&D by using regression-based tests.

4.2. Regression-based productivity analysis

4.2.1. Whole sample

We begin by testing H1 using full-sample dynamic system GMM regressions based on Eq. (1). Model 1 of Table 5 includes a full set of core independent variables, interactions, a lagged dependent variable and selection correction terms (Inverse Mills Ratios). The results suggest that a 10 % increase in export intensity increases TFP growth by 5.8 % ($\beta = 0.058$; $\rho = 0.001$); a 10 % increase in R&D intensity raises TFP growth by 0.9 % ($\beta = 0.009$; $\rho < 0.000$), while a 10 % increase in import intensity increases TFP growth by 7.3 % ($\beta = 0.073$; $\rho = 0.001$). Furthermore, all the two-way interactions of the three complementary activities positively and significantly affect TFP growth. Finally, the coefficient on a three-way interaction term is positive and significant ($\beta = 0.001$; $\rho = 0.001$). These findings provide additional support of complementarity among exports, imports, and internal R&D investment.

The coefficients on the rest of the control variables in Model 1 of Table 5 including the indicators of firm size ($\beta = 0.277$; $p < 0.000$) and size squared ($\beta = 0.031$; $p < 0.000$) reveal an inverse U-shape relationship between firm size and performance. The capital intensity coefficient is insignificant but bears an expected positive sign ($\beta = 0.005$, $p < 0.728$). The coefficients on the intangible assets ($\beta = -0.007$; $\rho = 0.624$) dummy and foreign ownership dummy ($\beta = -0.038$; $\rho = 0.096$) do not seem to have a significant effect on firm performance. The parameter on the lagged value of TFP growth is insignificant. This fact is in line with previous studies (Golovko & Valentini, 2011) and might be related to the fact that organizational and performance growth processes can sometimes be associated with random walks (Geroski, 1999). Finally, most of the Inverse Mills ratios are negative and significant providing evidence of self-selection in trading activities and supporting the modeling approach adopted in this paper.

4.3. Moderating factors

4.3.1. Type of ownership

To test H2 we replicate the regression-based productivity tests separately for POEs and SOEs. Column 2 of Table 5 presents the results of the regression-based productivity tests separately for the sub-sample of POEs. The results are aligned with the results of the benchmark model with a three-way interaction term ($\beta = 0.001$) being positive at $p = 0.001$. Similarly, column 3 presents the results of the productivity regressions for the SOEs only. In this case the results point to a lack of complementarities-in-performance among export, import, and R&D activities: the coefficients on most of the core independent variables, as well as their two and three-way interactions are insignificant. Taken as a whole, these results support H2 of larger complementarities in performance effects for POEs compared to SOEs.

4.3.2. Geography of trade

To test H3 we use the two main global trade regions. The first one encompasses the EU and OECD countries that, according to the IMF country classification, are identified as advanced economies (Nielsen, 2011). The second one includes the CIS countries, non-EU countries of Central and Eastern Europe and other trading partners of Ukraine from the rest of the world. Overall, the second region includes countries of similar or lower development levels and is referred to as emerging markets. We then re-estimate Eq. (1) separately for the subsample of firms that trade with advanced markets and those firms that trade with emerging markets.

The results presented in columns 4 and 5 of Table 5 offer some new insights. In particular, the results in column 4 suggest the presence of complementarities in performance for the firms that locate their trading activities in advanced markets. The coefficients on two-way interactions among export and import intensity ($\beta = 0.019$; $p = 0.001$), export and R&D intensity ($\beta = 0.003$; $p = 0.003$) and import and R&D intensity ($\beta = 0.003$; $p = 0.001$) are positive and of similar magnitude to the

Table 3
Descriptive statistics and product moment correlations.

	VARIABLES	1	2	3	4	5	6	7	8	9
1	ln(TFP)	1								
2	Import	0.181	1							
3	Export	0.136	0.378	1						
4	R&D	0.116	0.304	0.305	1					
5	ln(Emp)	0.06	0.362	0.423	0.436	1				
6	ln(Emp)^2	0.054	0.409	0.476	0.462	0.941	1			
7	FDI share	0.054	0.184	0.149	0.098	0.121	0.128	1		
8	ln(Capital Intensity)	-0.205	-0.045	-0.009	-0.023	0.052	0.087	-0.005	1	
9	Intangible assets	0.063	0.186	0.171	0.337	0.216	0.237	0.052	0.059	1
	Mean	-1.26	0.11	0.12	0.19	2.52	8.82	0.01	-0.63	0.04
	S.D.	2.34	0.31	0.33	0.39	1.57	10.01	0.07	1.67	0.2
	Min	-16.13	0	0	0	-0.69	0	0	-13.93	0
	Max	11.29	1	1	1	8.51	72.44	1	12.86	1

Note: Own calculations

Table 4
Three-way correlations: Export intensity, Import intensity and R&D intensity.

	All obs.	High Import intensity	Low Import intensity
Dependent variable	R&D intensity	R&D intensity	R&D intensity
Export intensity	0.058	0.233	0.121
	[0.003]	[0.000]	[0.000]
Control variables	Industry	Industry	Industry
	Year	Year	Year
	Industry * Year	Industry * Year	Industry * Year
	Firm size	Firm size	Firm size
Observations	33,630	10,492	10,494
R^2	0.233	0.249	0.197

Note: Pooled OLS regression analysis. *p*-values are reported in brackets.

benchmark model. The coefficient on a three-way interaction term is positive ($\beta = 0.001$) and significant at $\rho = 0.009$.

Similarly, the estimates of Eq. (1) for the subset of Ukrainian manufacturing firms that locate their trading activities in emerging markets (column 5, Table 5) do not reveal significant differences with respect to the benchmark case. In particular, the coefficient on export intensity ($\beta = 0.079$; $\rho = 0.000$) and all the two-way interaction terms are positive and significant. Moreover, the coefficient on a three-way interaction term is positive and significant pointing to the existence of complementarities among export, import and R&D intensity for the firms that engage in trading activities with emerging markets.

Overall, the results in columns 4 and 5 of Table 5 do not support Hypothesis 3 and suggest that complementarities among internal R&D investment and trade are similar for the firms that locate their trading activities in advanced markets and emerging markets alike. These results seem to contravene some of the prior international trade literature that shows that the performance benefits emerge mainly from trading with *advanced markets*, as they can offer more and/or better learning opportunities via knowledge spillovers, which can lead to better performance due to tougher market competition (Andersson, Lööf, & Johansson, 2008; Castellani, Serti, & Tomasi, 2010; Silva, Afonso, & Africano, 2012). To further explore the impact of the type of ownership and geography of trade on complementarities among export, import and R&D activities we test for the simultaneous moderating effect of the type of ownership and geography of trade in the next section.

4.4. Further analyses on moderating factors: Type of ownership and geography of trade

Having found supporting evidence for H2, we test whether POEs/SOEs that trade in advanced markets enjoy a higher productivity premium than POEs/SOEs that trade in emerging markets. In other words,

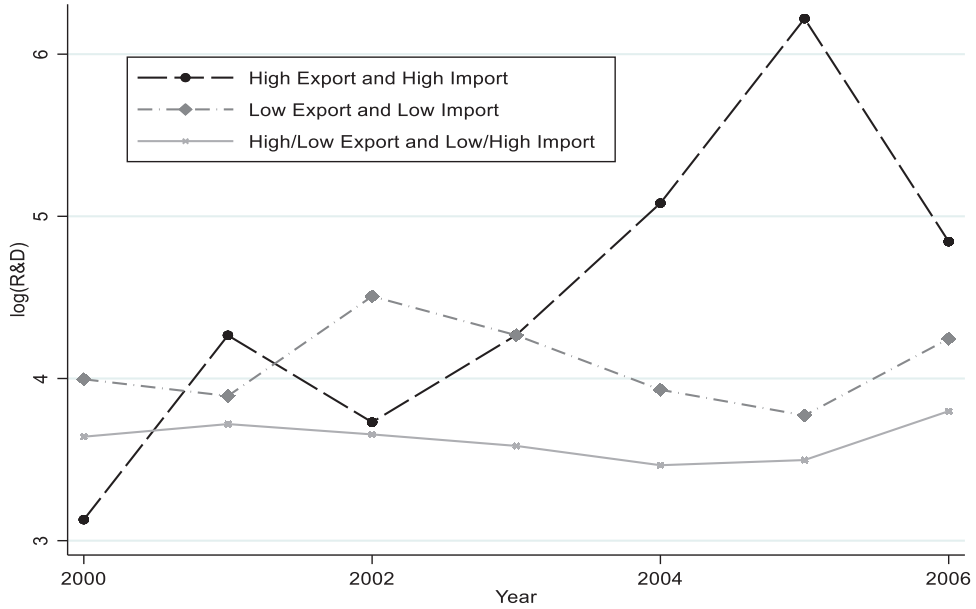

Fig. 2. Dynamics of R&D intensity by groups of firms for different combinations of Export and Import intensities, Note: Own calculations.

Table 5
Performance effect of complementarities between trade and innovation efforts.

Dependent variable: TFP growth	(1) Total	(2) POEs	(3) SOEs	(4) Advanced markets	(5) Emerging markets
TFP growth (t-1)	-0.025	-0.020	-0.191	-0.029	-0.044
	(0.015)	(0.016)	(0.071)	(0.017)	(0.030)
	[0.105]	[0.202]	[0.008]	[0.095]	[0.144]
Export intensity	0.058	0.060	0.031	0.052	0.079
	(0.009)	(0.009)	(0.031)	(0.011)	(0.015)
	[0.000]	[0.000]	[0.317]	[0.000]	[0.000]
Import intensity	0.073	0.075	0.014	0.071	0.074
	(0.009)	(0.009)	(0.032)	(0.010)	(0.018)
	[0.000]	[0.000]	[0.662]	[0.000]	[0.000]
Export#Import intensity	0.021	0.023	-0.022	0.019	0.030
	(0.004)	(0.004)	(0.021)	(0.005)	(0.009)
	[0.000]	[0.000]	[0.297]	[0.000]	[0.001]
R&D intensity	0.009	0.009	0.005	0.008	0.008
	(0.002)	(0.002)	(0.008)	(0.003)	(0.004)
	[0.000]	[0.000]	[0.536]	[0.001]	[0.049]
Export#R&D intensity	0.004	0.004	0.001	0.003	0.005
	(0.001)	(0.001)	(0.003)	(0.001)	(0.002)
	[0.000]	[0.000]	[0.729]	[0.003]	[0.004]
Import#R&D intensity	0.003	0.003	-0.001	0.003	0.005
	(0.001)	(0.001)	(0.003)	(0.001)	(0.002)
	[0.000]	[0.000]	[0.771]	[0.001]	[0.012]
Export#Import#R&D intensity	0.001	0.001	-0.002	0.001	0.003
	(0.000)	(0.000)	(0.002)	(0.000)	(0.001)
	[0.000]	[0.000]	[0.288]	[0.009]	[0.002]
Intangibles	-0.007	-0.005	-0.072	-0.010	-0.006
	(0.014)	(0.015)	(0.061)	(0.015)	(0.042)
	[0.624]	[0.756]	[0.240]	[0.508]	[0.891]
FDI	-0.038	-0.045	0.091	-0.048	0.017
	(0.021)	(0.022)	(0.081)	(0.021)	(0.087)
	[0.069]	[0.037]	[0.263]	[0.025]	[0.845]
Employment	-0.277	-0.260	-0.517	-0.250	-0.129
	(0.062)	(0.063)	(0.211)	(0.070)	(0.156)
	[0.000]	[0.000]	[0.015]	[0.000]	[0.406]
Employment ^2	0.031	0.029	0.038	0.027	0.012
	(0.006)	(0.007)	(0.020)	(0.007)	(0.020)
	[0.000]	[0.000]	[0.060]	[0.000]	[0.542]
Capital intensity	0.005	0.004	0.080	0.010	0.028
	(0.014)	(0.014)	(0.044)	(0.016)	(0.022)
	[0.728]	[0.769]	[0.068]	[0.535]	[0.205]
Inverse Mills ratios	Yes	Yes	Yes	Yes	Yes
Observations	16,541	15,550	991	12,980	3561
Number of firms	6769	6396	373	5024	1745
AR(1) z - statistics	-16.06 * **	-15.40 * **	-5.16 * **	-14.31 * **	-7.53 * **
AR(2) z - statistics	-1.84	-1.08 *	-0.85	-1.87 *	-0.39

Note: Robust standard errors are reported in parentheses; *p*-values in brackets. Robust standard errors. All regressors, except FDI and Intangibles dummies are in logarithms and lagged one year. Year and Year x Industry dummies included.

we test the simultaneous moderating effect of the type of ownership and development stage of the trade-partner countries, and repeat our analysis separately for: (i) POEs that locate their trading activities in *advanced markets*; (ii) POEs that locate their trading activities in the *emerging markets*; (iii) SOEs that trade with *advanced markets*; (iv) SOEs that trade with *emerging markets*.

The results, presented in Table 6, reveal several interesting trends. First, we observe the complementary productivity effect of intensifying R&D and trading activities for the POEs that locate their trading activities in advanced markets (column 1, Table 6): the coefficients on the two-way interactions among exports and imports ($\beta = 0.021$; $p = 0.000$), exports and R&D ($\beta = 0.003$; $p = 0.003$) and imports and R&D intensity ($\beta = 0.003$; $p = 0.001$) are positive and statistically significant. The coefficient on the three-way interaction term is positive ($\beta = 0.001$) and significant at $p = 0.007$. At the same time, no significant returns to firm performance measured as productivity growth arise when POEs match their R&D investments by trading more intensively with countries of similar or lower development levels.

The results for the SOEs are presented in columns (3) and (4) of Table 6 and reveal a similar picture. The estimated coefficients clearly reveal lack of complementary effects when SOEs engage in trading activities with other emerging markets, but the said effects are present when the trading activities are located in advanced countries. In particular, the three-way interaction term is statistically significant for the SOEs trading with advanced markets ($\beta = 0.001$; $p = 0.006$) and insignificant for the SOEs trading with emerging markets ($\beta = 0.001$; $p = 0.859$). However, as suggested by Tambe et al. (2012), a positive and significant coefficient on a three-way interaction term is not sufficient to prove the existence of complementarities, as the high value of this variable can correspond to various combinations of potentially complementary practices (i.e., high-high-high, high-low-high, or any other of the nine possible combinations). Hence, to provide further support to the findings presented in this section we turn to formal complementarities tests proposed by Brynjolfsson and Milgrom (2013).

4.5. Formal complementarities tests

This section implements a set of complementarities tests proposed by Brynjolfsson and Milgrom (2013). These tests were designed to compare the productivity of firms that have adopted different combinations of export, import and R&D activities.

Most previous empirical studies that explore performance effects of complementary activities employ dichotomous variables to indicate such practices (Cassiman & Veugelers, 2006; Golovko & Valentini,

Table 6
Performance Regression with market characteristics and firm characteristics.

	POEs		SOEs	
Dependent variable: TFP growth	(1) Advanced markets	(2) Emerging markets	(3) Advanced markets	(4) Emerging markets
TFP growth (t-1)	-0.024	-0.195	-0.054	-0.057
	(0.018)	(0.080)	(0.047)	(0.109)
	[0.172]	[0.016]	[0.254]	[0.599]
Export intensity	0.053	0.021	0.107	0.031
	(0.011)	(0.032)	(0.026)	(0.049)
	[0.000]	[0.505]	[0.000]	[0.525]
Import intensity	0.072	0.010	0.074	0.044
	(0.010)	(0.032)	(0.029)	(0.115)
	[0.000]	[0.758]	[0.011]	[0.699]
Export#Import intensity	0.021	-0.026	0.030	0.004
	(0.005)	(0.021)	(0.011)	(0.080)
	[0.000]	[0.215]	[0.007]	[0.965]
R&D intensity	0.008	0.008	0.014	0.000
	(0.003)	(0.008)	(0.008)	(0.012)
	[0.002]	[0.335]	[0.068]	[0.997]
Export#R&D intensity	0.003	0.000	0.007	0.003
	(0.001)	(0.003)	(0.003)	(0.005)
	[0.003]	[0.968]	[0.010]	[0.558]
Import#R&D intensity	0.003	-0.001	0.006	0.005
	(0.001)	(0.003)	(0.003)	(0.010)
	[0.001]	[0.651]	[0.066]	[0.647]
Export#Import#R&D intensity	0.001	-0.003	0.001	0.001
	(0.000)	(0.002)	(0.001)	(0.007)
	[0.007]	[0.182]	[0.006]	[0.859]
Intangibles	-0.010	-0.085	0.051	0.026
	(0.016)	(0.068)	(0.065)	(0.133)
	[0.517]	[0.218]	[0.430]	[0.847]
FDI	-0.055	0.105	-0.067	0.929
	(0.022)	(0.092)	(0.106)	(0.169)
	[0.013]	[0.255]	[0.527]	[0.000]
Employment	-0.234	-0.406	0.154	-0.458
	(0.072)	(0.207)	(0.152)	(0.161)
	[0.001]	[0.051]	[0.313]	[0.005]
Employment ^2	0.026	0.030	-0.018	0.031
	(0.007)	(0.020)	(0.019)	(0.014)
	[0.000]	[0.138]	[0.330]	[0.023]
Capital intensity	0.008	0.085	0.011	0.075
	(0.016)	(0.040)	(0.031)	(0.049)
	[0.625]	[0.036]	[0.720]	[0.130]
Inverse Mills ratios	Yes	Yes	Yes	Yes
Observations	12,101	1209	879	330
Number of firms	4703	453	321	172
AR(1) z - statistics	-13.66***	-6.17***	-4.78***	-3.94***
AR(2) z - statistics	-1.73*	-1.08	-1.19	1.10

Note: Robust standard errors are reported in parentheses; *p*-values in brackets. All regressors, except FDI and Intangibles dummies are in logarithms and lagged one year. Year and Year x Industry dummies included.

2011; Aral, Brynjolfsson, & Wu, 2012; Tambe et al., 2012). However, as discussed earlier, in the case of international trade, dichotomous variables might not reflect the true extent of firm's trade engagement. Hence, we proceed using continuous measures of our complementary activities and identify values located in the bottom quartiles (i.e., bottom 25 %) of the corresponding distributions as low levels; and values located in the top quartiles (i.e., top 25 %) of the corresponding distributions as high levels. The identification of the low and high levels of complementary activities results in eight possible combinations of such activities ($2 \times 2 \times 2$). Next, we compute average productivity differences between firms that adopt each of the seven possible combinations of complementary activities and firms that adopt all three complementary practices at low levels, i.e., (L,L,L) cell. According to the Brynjolfsson and Milgrom (2013)'s complementarities argument, the marginal benefit of adopting a practice should be increasing in the presence of other complementary practices. Hence, in our setting, the marginal effect of, for example, intensifying internal R&D should be higher when accompanied by high intensity exports and imports.

The summary of the results, presented in Tables 7 and 8, indicates that the performance complementarities on the whole sample are driven by the firms that engage in all three complementary practices at high levels, (H,H,H). Furthermore, the moderating effects of ownership and geography of trade indicate that complementarities in performance are mostly observed for the POEs locating their trading activities in advanced markets (Table 8).

Finally, the complementarities argument implies that the marginal benefit of intensifying the use of one practice should be increasing in the presence of an intensive use of other complementary practices. This can be visualized as a comparison along the edges of a cube (Fig. 3), where each side is increasing in the intensity of the use of one of the complementary practice measures (Aral et al., 2012; Tambe et al., 2012).

To test the increasing returns from the adoption of complementary practices we implement three specific complementarities tests along three pairs of edges of the cube and a fourth full system test that simultaneously considers three pairs of edges. First, we test if an increase in R&D intensity results in greater productivity benefits at high levels of export and import intensities. In particular, we compute the performance effect of an increase in R&D intensity from a low (L) to high (H) level, while the other two complementary activities are at their corresponding high levels, i.e., an increase from (H,H,L) to (H,H,H). Then we compute the same increase in R&D intensity with the two other complementary activities held at their corresponding low levels, i.e., an increase from (L,L,L) to (L,L,H). Finally, we compare the two performance effects. We then repeat the same algorithm for import and export intensities and for all the sub-samples that disentangle the moderating effects of ownership and the geography of trade.

The results of the tests, presented in columns 1 and 2 of the top panel of Table 9, suggest that for the whole sample the productivity benefits of an increase in export intensity are greater when both R&D and import intensities are high at $p = 0.01$. The tests also suggest that the benefits of raising import intensity are higher when matched by high intensities of exports and R&D ($p = 0.00$). At the same time, the benefits of raising R&D intensity do not seem to increase when matched by high levels of export and import practices ($p = 0.22$). Finally, the system complementarities test that examines all three comparisons simultaneously rejects the null hypothesis of no increasing returns, confirming the complementary effect from concurrently intensifying export, import and R&D activities on firm performance ($p = 0.01$).[10]

To explore the role of moderating factors in the existence of complementarities among exports, imports and R&D we proceed by implementing similar tests on various sub-samples of the original dataset and implement the complementarities tests separately for the firms that locate their trading activities in advanced (columns 3 and 4, top panel of Table 9) and emerging markets (columns 5 and 6, top panel of Table 9). The results indicate that the complementary performance effects are experienced mostly by the firms that engage in trade with advanced markets. Furthermore, the distinction between the POEs (columns 1 and 2, middle panel of Table 9) and SOEs (columns 1 and 2, bottom panel of Table 9) indicates that the productivity effect of complementarities is observed mostly in private firms. Finally, we compare the complementarity gains of the POEs and SOEs that trade with EU and those that trade with other emerging markets. The results indicate that significant complementary productivity gains exist for those POEs that trade with advanced markets (columns 3 and 4, middle panel of Table 9), while the private firms that trade with emerging markets only do not experience any additional productivity gains related to the increased use of complementary practices (columns 5 and 6, middle panel of Table 9). Similar patterns of productivity benefits related to the use of the complementary

[10] The complementarities among import, export and R&D activities were also tested using Dawson and Richter (2006) slopes analysis leading to similar results. The results of the analysis are available upon request from the authors.

Table 7
Productivity differences with matches and mismatches on complementary practices.

High R&D Intensity										
	Total		Advanced markets		Emerging markets		POEs		SOEs	
			Export Intensity							
	High	Low	High	Low	High	Low	High	Low	High	Low
Import Intensity										
High	0.074	0.062	0.063	0.053	0.134	0.093	0.075	0.057	0.074	0.122
	[0.002]	[0.015]	[0.007]	[0.034]	[0.053]	[0.140]	[0.003]	[0.028]	[0.191]	[0.108]
Low	0.028	0.042	0.027	0.039	0.021	0.039	0.027	0.045	0.041	0.036
	[0.107]	[0.036]	[0.120]	[0.057]	[0.326]	[0.184]	[0.127]	[0.038]	[0.250]	[0.288]
Low R&D Intensity										
	Total	Advanced Markets			Emerging markets			POEs	SOEs	
		Export Intensity								
	High	Low	High	Low	High	Low	High	Low	High	Low
Import Intensity										
High	0.064	0.067	0.065	0.070	0.085	-0.038	0.065	0.069	0.056	0.023
	[0.003]	[0.003]	[0.003]	[0.002]	[0.102]	[0.716]	[0.004]	[0.002]	[0.257]	[0.416]
Low	-0.013	0	-0.014	0	-0.019	0	-0.012	0	-0.014	0
	[0.734]	N/A	[0.731]	N/A	[0.667]	N/A	[0.713]	N/A	[0.581]	N/A

Note: Own calculations

Table 8
Productivity differences with matches and mismatches on complementary practices: geography and ownership.

	POEs				SOEs			
	Advanced markets		Emerging markets		Advanced markets		Emerging markets	
		Export Intensity						
	High	Low	High	Low	High	Low	High	Low
Import Intensity		High R&D Intensity						
High	0.063	0.046	0.119	0.097	0.073	0.133	0.252	-0.025
	[0.009]	[0.062]	[0.091]	[0.135]	[0.199]	[0.101]	[0.111]	[0.526]
Low	0.027	0.038	0.004	0.041	0.035	0.058	0.116	0.026
	[0.134]	[0.079]	[0.464]	[0.184]	[0.286]	[0.195]	[0.128]	[0.403]
			Export Intensity					
	High	Low	High	Low	High	Low	High	Low
Import Intensity			Low R&D Intensity					
High	0.067	0.072	0.094	-0.042	0.055	0.022	0.019	0.052
	[0.004]	[0.002]	[0.095]	[0.729]	[0.266]	[0.423]	[0.456]	[0.434]
Low	-0.012	0	-0.018	0	-0.016	0	-0.035	0
	[0.707]	N/A	[0.654]	N/A	[0.588]	N/A	[0.585]	N/A

Note: Own calculations

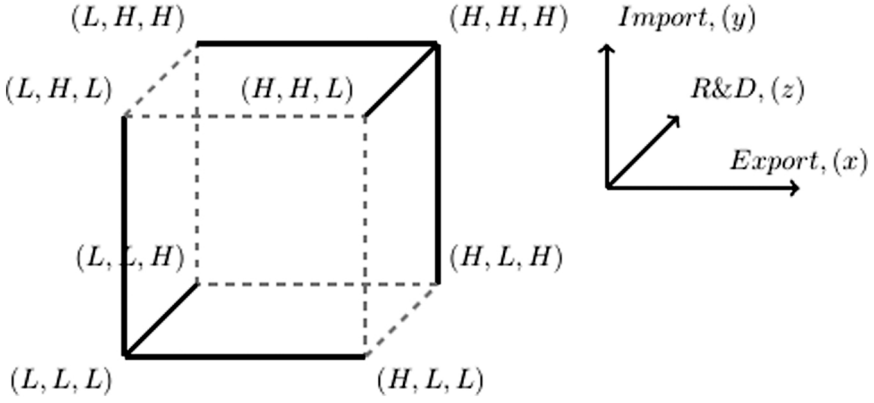

Fig. 3. Cube view of complementarities.

practices are recorded for the SOEs that trade with advanced markets (columns 3 and 4, bottom panel of Table 9) and emerging markets (columns 5 and 6, bottom panel of Table 9).

4.6. Robustness checks

The main results, presented in the last section, confirmed that complementarities among import, export and R&D activities result in additional positive effects on firm TFP growth. These effects are mainly driven by the synergies of international trade and R&D investments of the firms locating their trading activities in advanced markets. In this section we assess the robustness of these conclusions to a number of methodological issues.

We start by providing an out of sample validation of our main analysis. To this end, we randomly split the sample in half and repeated the regression-based productivity tests and formal complementarities

Table 9
Formal complementarities tests.

Whole sample		Total		Advanced markets		Emerging markets	
		(1)	(2)	(3)	(4)	(5)	(6)
		Chi2	Prob	Chi2	Prob	Chi2	Prob
Export intensity	F(1,1,1) - F(0,1,1)>F(1,0,0) - F(0,0,0)	6.21	0.01	5.28	0.02	0.43	0.51
Import intensity	F(1,1,1) - F(1,0,1)>F(0,1,0) - F(0,0,0)	12.24	0.00	11.99	0.00	0.00	0.95
R&D intensity	F(1,1,1) - F(1,1,0)>F(0,0,1) - F(0,0,0)	1.48	0.22	1.57	0.21	1.10	0.29
System test		6.81	0.01	6.58	0.01	0.54	0.46
POEs		Total		Advanced markets		Emerging markets	
		(1)	(2)	(3)	(4)	(5)	(6)
		Chi2	Prob	Chi2	Prob	Chi2	Prob
Export intensity	F(1,1,1) - F(0,1,1)>F(1,0,0) - F(0,0,0)	6.96	0.01	5.32	0.02	0.35	0.55
Import intensity	F(1,1,1) - F(1,0,1)>F(0,1,0) - F(0,0,0)	12.72	0.00	10.89	0.00	0.11	0.74
R&D intensity	F(1,1,1) - F(1,1,0)>F(0,0,1) - F(0,0,0)	1.23	0.27	1.02	0.31	0.72	0.39
System test		7.01	0.01	5.79	0.02	0.55	0.46
SOEs		Total		Advanced markets		Emerging markets	
		(1)	(2)	(3)	(4)	(5)	(6)
		Chi2	Prob	Chi2	Prob	Chi2	Prob
Export intensity	F(1,1,1) - F(0,1,1)>F(1,0,0) - F(0,0,0)	2.28	0.13	2.84	0.09	0.02	0.90
Import intensity	F(1,1,1) - F(1,0,1)>F(0,1,0) - F(0,0,0)	1.33	0.25	2.01	0.16	0.05	0.83
R&D intensity	F(1,1,1) - F(1,1,0)>F(0,0,1) - F(0,0,0)	2.69	0.10	3.31	0.07	0.00	0.96
System test		2.76	0.11	3.49	0.06	0.00	0.99

System test: (F(1,1,1) - F(0,1,1) + F(1,1,1) - F(1,0,1) +F(1,1,1) - F(1,1,0) - (F(1,0,0) - F(0,0,0) + F(0,1,0) - F(0,0,0) + F(0,0,1) - F(0,0,0)) > 0

tests separately for the two random sub-samples of firms. The results of the regression-based productivity tests, presented in columns (1) and (2) of Appendix D, show no significant difference across the two sub-samples.

Some empirical studies on the trade-productivity nexus have shown that trade-related productivity benefits might differ for firms of different sizes (Eliasson, Hansson, & Lindvert, 2012; Silva et al., 2012; Damijan & Kostevc, 2015). To verify this conjecture in our sample we repeat our analysis separately for firms smaller than 40 employees (small firms) and firms larger than 40 employees (large firms). The results, presented in columns (3) and (4) of Appendix D, confirm that effects of complementary practices are stronger for smaller firms.[11]

Finally, we repeat the main analysis using an alternative measure of firm performance: growth of sales (Golovko & Valentini, 2011). The results of the regression-based complementarities tests using growth of sales as a dependent variable, presented in column (5) of Appendix D, show no statistically significant differences with the main results of this study supporting the robustness of our findings. The last set of results, presented in Appendix D, show that complementarities among export, import and R&D activities benefit not only productivity but other measures of firm performance (e.g., sales growth), indicating that the complementarities between internal and external learning processes which constitute absorptive capacity can have positive effect on both productivity and market related performance.

5. Discussion and conclusions

This paper explores the effect of complementarities that occur among firms' international trading activities and internal R&D investment on their performance. Whilst research on the relationship between exporting, importing and firm performance has discussed the theoretical side of the argument, the extant empirical evidence tends to be inconclusive (Wagner, 2012). One possible explanation for the lack of consensus might be related to the fact that most of the empirical literature is focused only on export and its impact on firm performance, with only a few studies including both export and import, or export and internal R&D, or import and R&D. To the best of our knowledge no empirical studies include these three activities in the same analysis, and no empirical tests of the associated three ways complementarities have been carried out. Adding to previous international business and strategy literature, we argue that the beneficial effect of exports on firm performance is further reinforced, i.e., complemented, by the positive effect stemming from imports and by the firm's internal R&D investments. Thus, engaging in all three activities appears to have the strongest positive effect on firms' performance as the benefits of learning-by-trading further increase when firms expand their knowledge-absorptive capacity by investing in R&D activities (Damijan & Kostevc, 2015).

The empirical setting considered here, i.e., a transition economy, constitutes a particularly interesting context because it allows testing for the moderating effect of firm ownership, distinguishing between POEs and SOEs (stemming from privatization processes, and the consequent radical organizational changes), and the stage of development of the trade-partner countries. Our findings reveal that three-way complementarities benefit more POEs than SOEs, especially when trading with advanced countries, thus contributing to the literature on the performance differentials of SOEs vs. POEs. This could be explained by the fact that while POEs tend to set profit-maximizing goals, SOEs might choose to forgo profit maximization in pursuit of social welfare and wealth redistribution (Dewenter & Malatesta, 2001; Shleifer, 1998). These results are also in line with the literature arguing that SOEs are, in general, less efficient because they are affected by dual agency problems (e.g., Goldeng et al., 2008; Li & Xia, 2008; Cuervo-Cazurra et al., 2014). As a result, POEs tend to exhibit higher levels of productivity growth and better innovation outcomes, while SOEs tend to lag behind (Álvarez & Argothy, 2019), although our study shows that there are some significant learning effects for SOEs that are internationally integrated with advanced markets through trade, possibly due to the stronger institutional settings of these markets which create favorable conditions for SOEs to become global players (Lazzarini et al., 2021).

5.1. Theoretical contributions

We have anchored our theoretical framework to the Resource Based View of the firm (Barney, 1991) to explain the role of learning processes of exporting, importing and in-house R&D activities for the technological and knowledge upgrade and the complementarities among learning mechanisms on firms' productivity. We combine RBV and agency theory (e.g., Jensen & Meckling, 1976) because of the specific context of MNEs from emerging economies, and distinguish between different ownership

[11] The results of the formal complementarities tests separately for small and large firms are available upon request.

and incentives structures. This has allowed us to develop a more nuanced framework to explain why POEs tend to enjoy better performance compared to SOEs, that is because of stronger incentives and higher efficiency resulting from their governance (see also, Filatotchev et al., 2001). Thus, we contribute to research on the impact of internationalization of EMNEs and their performance, and the role of specific contingencies, such as firm ownership and trading markets characteristics.

Despite the lack of consensus about the causal effects of international trade on productivity by export/import destinations/origins, significant trade-related productivity benefits are more commonly found in the studies based on developing markets' firms. Moreover, these gains seem to be more pronounced when export is directed to more advanced economies (Wagner, 2012). Given the fact that Ukraine is classified as an emerging market economy in the IMF World Economic Outlook, our findings support the conjecture of more pronounced complementarities in performance for Ukrainian firms that participate in international trade with partners located in relatively more advanced markets of the European Union and other OECD countries. At the same time, participating in international trade with firms located in countries of similar or lower development levels does not seem to result in complementarities-in-performance. Thus, we offer new evidence which challenges past studies on firms from emerging economies having a competitive disadvantage in entering advanced markets (e.g., Lee & Beamish, 1995). Our results are consistent with the predictions from RBV because learning processes occur when trading with partners who offer better sources of knowledge for the development of absorptive capacity. Our results also contribute to the literature on the effects of global value chain (GVC) participation for emerging countries (e.g., Taglioni & Winkler, 2016; Gereffi, 2019), with recent studies showing that both backward and forward GVC participation contributes to an increase in the productivity of the countries involved in GVCs (Winkler & Farole, 2015).

5.2. Managerial and policy implications

Our study offers several implications for managers and policy makers. From a managerial perspective, our study suggests that participating into GVCs which comprise firms from advanced economies may yield higher benefits in terms of learning effects on productivity compared to trading with less advanced economies, as long as firms continue investing in internal R&D, thus enjoying the full effect of complementarities in learning. This suggests that companies from emerging economies should be proactive in entering GVCs which allow them to trade and engage directly with businesses from more advanced economies to fully benefit from the complementarities in learning by trading. In parallel, they should not neglect investing in developing internal knowledge and capabilities which not only would allow them to absorb external knowledge and support learning processes, but by enhancing the quality and innovativeness of their own products, it would also make them more attractive and promote their selection for international trade agreements. Our research also offers implications for policy makers because it shows the positive performance effect of certain governance and incentive structures typically found in POEs, compared to SOEs. Moreover, creating environments that boost productivity, e.g., supporting international linkages and trade with firms in advanced markets, can be beneficial to both POEs and SOEs.

5.3. Limitations and future research

As is often the case with most empirical studies, the present paper is not immune from limitations, related to the measurement of some key variables and the empirical context; addressing them, however, could pave the way for future research. First of all, the choice of a performance measure is a complex subject (Goldeng et al., 2008). In particular, as we aim to measure the performance stemming from learning processes, TFP might be measured using alternative measures that relate more directly to learning processes, such as the productivity of innovation activities (Salomon & Jin, 2010). Additionally, the comparison between SOEs and POEs may require some further nuances, for example distinguishing further the nature of private ownership, whether national or international, or by institutional category (e.g., businesses or financial institutions).

While research on strategy in emerging economies has grown in the last two decades, coverage of countries and regions has been uneven. Understanding the factors underlying heterogeneity of emerging countries remains a fertile area for research. Our study contributes to this growing literature. The Ukrainian setting represents a well-suited empirical context due to the transition status and the role of firms' trading activities, to the contextual presence of SOEs and POEs in many industries, as well as to the high quality and comprehensiveness of available data. Similar studies in other settings are obviously needed to establish the generalizability of the findings as challenges faced by enterprises vary considerably due to different macroeconomic and institutional contexts. It is not clear whether the experience of centrally planned economies in transition applies to those emerging economies that have not followed this trajectory (Wright et al., 2005) and this might be the object of future research. A question for future research is whether and how much exogenous disruptive events, such as international conflicts, might alter the longer-term effect of complementarities in external and internal learning processes on productivity in emerging economies, such as Ukraine and maybe others.

Data availability

The authors do not have permission to share data.

Appendix A. Means (standard deviation) of production function variables (2000, 2003, 2005)

	2000	2003	2005
Value added	3264.27	5232.53	7272.77
	(57,389.25)	(89,817.32)	(126,006.37)
Materials	2126.08	2975.31	3616.137
	(40,093.11)	(52,151.01)	(66,177.66)
Employment	93.80	73.48	54.33
	(646.64)	(629.64)	(348.37)
Capital	3673.81	2478.50	2151.38
	(33,874.62)	(26,284.99)	(21,200.68)

Note: Capital, materials and output are expressed in constant 2000 prices, thousands of UAH.

Appendix B. Number of firms, average size and share of exporters, importers and two-way traders by industry

Industry	N. firms	Average size	Exporters	Importers	Two-way traders	R&D investors	% exporters	% importers	% two-way traders	% R&D investors
Food and beverages	10826	60	636	684	712	3127	5.87	6.32	6.58	28.88
Textile, leather, apparel	5369	48	145	228	324	922	2.70	4.25	6.03	17.17
Wood and paper	5292	24	700	204	355	874	13.23	3.85	6.71	16.52
Printing and publishing	7152	12	55	390	117	2459	0.77	5.45	1.64	34.38
Coke, chemistry	2312	89	130	240	377	879	5.62	10.38	16.31	38.02
Rubber, plastic	2211	26	109	256	242	768	4.93	11.58	10.95	34.74
Non-metallic minerals	3940	66	300	211	260	1112	7.61	5.36	6.60	28.22
Metallurgy & basic metals	4402	51	337	242	381	1449	7.66	5.50	8.66	32.92
Machinery and equipment	6360	75	591	351	615	2183	9.29	5.52	9.67	34.32
High-tech machinery	5657	52	326	380	504	1895	5.76	6.72	8.91	33.50
Motor vehicles, trailers	1481	139	160	97	226	575	10.80	6.55	15.26	38.83
Furniture/ manufacturing	4610	28	269	219	278	1250	5.84	4.75	6.03	27.11
Total	59612		3758	3502	4391	17493				
Mean	4968	56	313	292	366	1458	6.67	6.35	8.61	30.38

Appendix C. Definitions of variables

Variable	*Description*
TFP growth rate	Measure of firm performance defined as $\ln(TFP_t / TFP_{t-1})$, used in a production function empirical framework.
Sales growth rate	Measure of firm performance defined as $\ln(sales_t / sales_{t-1})$, used in a production function empirical framework. Sales are deflated using 2-digit industry-specific PPI.
Employment	Number of full-time registered employees, in logarithms
Capital intensity	Share of tangible assets in total sales.
FDI	Dummy variable that equals 1 if over 10% of the company is foreign-owned.
Intangibles	Dummy variable that equals 1 if a firm possesses some intangible assets (e.g., brand name, trademarks, distribution channels).
Export intensity	Export sales, deflated using 2-digit industry-specific PPI, expressed as a share of firm annual sales.
Import Intensity	Imports, deflated using 2-digit industry-specific CPI, expressed as a share of firm annual sales.
R&D intensity	R&D investments, deflated using 2-digit industry-specific PPI, expressed as a share of firm annual sales.
Export intensity of the industry	Aggregate 2-digit industry annual export sales, as a share of 2-digit industry annual sales deflated using 2-digit industry-specific PPI.
Import Intensity of the industry	Aggregate 2-digit industry annual imports, as a share of 2-digit industry annual sales deflated using 2-digit industry-specific CPI.
2-digit annual industry sales	Aggregate sales of all firms in a specific 2-digit industry deflated using 2-digit industry-specific PPI.

Appendix D. Robustness checks: External validity, size, alternative performance measure

	External validity		Size		Growth of
VARIABLES	Group 1	Group2	< 50 empl	> 50 empl	Sales
Export intensity	0.067	0.048	0.085	0.016	0.056
	(0.013)	(0.013)	(0.013)	(0.011)	(0.009)
	[0.000]	[0.000]	[0.000]	[0.139]	[0.000]
Import intensity	0.078	0.064	0.104	0.025	0.051
	(0.012)	(0.013)	(0.013)	(0.009)	(0.009)
	[0.000]	[0.000]	[0.000]	[0.008]	[0.000]
Export#Import intensity	0.024	0.017	0.034	0.003	0.021
	(0.006)	(0.005)	(0.007)	(0.005)	(0.004)
	[0.000]	[0.002]	[0.000]	[0.526]	[0.000]
R&D intensity	0.009	0.008	0.009	0.004	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)
	[0.003]	[0.006]	[0.007]	[0.154]	[0.392]
Export#R&D intensity	0.004	0.003	0.003	0.001	0.003
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
	[0.001]	[0.009]	[0.034]	[0.289]	[0.000]
Import#R&D intensity	0.004	0.003	0.003	0.001	0.002
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
	[0.000]	[0.015]	[0.030]	[0.198]	[0.007]
Export#Import#R&D intensity	0.001	0.001	0.001	0.000	0.001
	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)
	[0.007]	[0.021]	[0.089]	[0.574]	[0.001]
Employment	-0.217	-0.306	-0.037	-0.855	-0.261

(*continued on next page*)

(*continued*)

VARIABLES	External validity		Size		Growth of
	Group 1	Group2	< 50 empl	> 50 empl	Sales
	(0.083)	(0.086)	(0.120)	(0.230)	(0.060)
	[0.009]	[0.000]	[0.760]	[0.000]	[0.000]
Employment ^2	0.026	0.032	0.009	0.060	0.035
	(0.009)	(0.008)	(0.018)	(0.019)	(0.006)
	[0.004]	[0.000]	[0.626]	[0.002]	[0.000]
Capital intensity	-0.007	0.020	-0.046	0.098	-0.095
	(0.020)	(0.019)	(0.019)	(0.014)	(0.015)
	[0.705]	[0.294]	[0.014]	[0.000]	[0.000]
Intangibles	-0.007	-0.008	0.019	-0.011	0.055
	(0.020)	(0.020)	(0.031)	(0.014)	(0.014)
	[0.747]	[0.707]	[0.541]	[0.428]	[0.000]
FDI	-0.055	-0.016	0.016	-0.099	0.034
	(0.032)	(0.028)	(0.046)	(0.023)	(0.026)
	[0.087]	[0.563]	[0.726]	[0.000]	[0.190]
Lagged TFP growth	-0.022	-0.039	-0.026	-0.039	0.035
	(0.222)	(0.321)	(0.019)	(0.021)	(0.014)
	[0.325]	[0.161]	[0.172]	[0.164]	[0.215]
Inverse Mills ratios	Yes	Yes	Yes	Yes	Yes
Observations	8203	8338	8000	8541	16,541
Number of firms	3373	3396	3741	3028	6769
AR(1) z-statistics	-11.66***	-11.28***	-12.02***	-13.60***	-19.21***
AR(2) z-statistics	1.07	-1.50	-1.02	0.30	0.86

Note: Robust standard errors are reported in parentheses; *p*-values in brackets. All regressors, except FDI and Intangibles dummies are in logarithms and lagged one year. Year, Year x Industry dummies and constant term included.

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