Complementarities between trade and innovation efforts in their impact on performance of emerging economy firms

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Abstract

Empirical evidence has widely demonstrated the positive effect of exports on firm performance, especially for emerging economies' firms. This paper extends this analysis by exploring three-way complementarities among exports, imports and R&D investments, and their implications for firm performance. We advance and test the idea that learning effects of exports are enhanced by the learning effects that emerge from imports and reinforced by internal R&D expenditure of the firm. Indeed, imports of intermediate and capital goods can improve firm performance via several channels: learning, variety and quality. At the same time, an increase in internal R&D expenditure should raise firm's absorptive capacity and lead to better integration of the knowledge acquired through various external sources, such as export and import linkages. We test our theory using an unbalanced panel of Ukrainian manufacturing firms over the period 2000-06. We find robust empirical support for our hypothesis and show that positive effect of exports on firm performance is higher for firms that simultaneously engage in imports and R&D. The effect is more pronounced for private manufacturing firms that engage in trade with advanced markets.

Keywords: exports, imports, R&D expenditure; complementarity, firm performance

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Introduction

Recent empirical studies of firm dynamics struggle to provide conclusive evidence on the impact of trade participation on firm performance.

This paper investigates the effect of learning by trading – exporting and importing - on the performance of firms from an emerging country. While learning by exporting has been recently recognized in the IB literature, learning by importing has not been investigated to same extent as a vehicle to productivity growth.

We argue that both export and import activities operate as learning channels form manufacturing firms and that complementarities among them and internal R&D efforts of firms further enhancing their absorptive capacity and performance. In this paper we develop and test hypotheses about complementarities among these three learning channels and the joint impact of learning-by-trading and internal R&D on productivity.

The notion of complementarities among activities was defined by Milgrom and Roberts (1995) as when "doing (more of) one thing increases the returns to doing (more of) another" (emphasis in original) (Milgrom and Roberts, 1995: 181). It implies that it is relatively unprofitable to adopt only some of elements of a system, but not the whole system, as partial adoption does not allow to fully benefit from the returns in terms of performance.

At the same time, providing direct empirical evidence on complementarities among import, export and R&D might be challenging due to the endogeneity of firm trade and investment decisions (Gibbons and Roberts, 2012; Tambe et al., 2012). Hence, we follow mainstream empirical literature on organizational complements and provide evidence on the economic implications of complementarities between trade and R&D investments (Arora and Gambardella, 1990; Bresnahan et al., 2002). In particular, complementarities would imply that one should observe that simultaneous use of the complements should have higher impact on firm performance than the sum of the individual effects (Tambe et al., 2012).

This paper explores the effect of complementarities by: (i) measuring correlations among import, export and R&D activities and their changes over time; (ii) measuring the effect of complements on firm performance by regression models with interactions and by using the

latest tests developed by Brynjolfsson and Milgrom (2012) that compare performance outcomes for different combinations of complementary practices.

The empirical analysis is grounded on a large database from the Ukrainian Office of National Statistics (Derzhkomstat) that groups consolidated annual accounts data on the census of manufacturing and service firms operating in Ukraine between 2000 and 2006.

The paper contributes to the IB literature in several. First, we consider both learning by exporting and learning by importing. Second, our empirical setting is a transition economy, relatively understudied but relevant to IB debate due to the increasing participation of firms from transition economies in international trade. Third, we present conceptual and empirical novelty in testing the notion of complementarities among internal and external firm learning processes. Furthermore, current analysis takes into account such important moderating factors of the learning-by-trading - R&D productivity nexus as: types of firm ownership and geography of trade.

Our preliminary results indicate the existence of significant complementarities among export, import and internal R&D investment in Ukrainian manufacturing firms. In particular, engaging in all three activities seems to have the strongest positive effect on firms' performance. Further analysis reveals that this effect is driven by private manufacturing firms trading with advanced markets. At the same time, state-owned firms show no significant productivity gains when trading with advance countries, while some productivity gains arise while trading with the countries-members of the Commonwealth of Independent States and other emerging and developing markets.

Theoretical background and hypotheses development

Recent literature on linkages between trade and firm performance has so far failed to provide conclusive evidence on learning-by-trading effects. While theoretical side of the argument is well-understood; the extant empirical evidence tends to be inconclusive. One possible explanation for the lack of consensus might be related to the fact that most of the empirical trade-productivity literature is focused on exports and its impact on firm performance. At the same the literature on import-productivity nexus remains relatively scarce. Several studies, including Amiti and Konings (2007) and Shepotylo and Vakhitov (2015), explore the impact of trade liberalisation on productivity of Indonesian and Ukrainian manufacturing firms respectively through i) tougher competition; ii) access to cheaper intermediate inputs. The

results reveal that majority of productivity gains from trade liberalisation occur due to access to cheaper intermediate inputs. Furthermore, Altomonte and Bekes (2010) and Halpern, Koren and Szeidl (2011), using Hungarian firm-level data, find that most of the exporters productivity premium occurs only when these firms are importers at the same time. Finally, Bass and Strauss-Kahn (2010) and Goldberg (2011), using French and Indian firm-level data respectively, find a significant productivity effect of higher diversification of imported input varieties.

Another reason for missing evidence on learning-by-trading might be related to measurement errors (Damijan and Kostevc, 2015). In particular, Aw, Roberts and Winston (2005) maintain that failure to find evidence of learning-by-exporting arises due to the fact that many export-productivity studies omit a factor that might be crucial for productivity change: internal investments made by firms to better absorb knowledge and technology from external sources.

Indeed, learning processes which occur outside the boundaries of the firm require that firms possess absorptive capacity (henceforth AC), that is internal knowledge which allows them to "recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal 1990:128). Indeed, learning and absorptive capacity have been described as coevolving and mutually reinforcing (Barkema and Vermeulen 1998, Simonin, 1999, Autio *et al.* 2000). AC enables firms to learn and innovate, as the new knowledge adds to the existing AC (Kim and Kogut 1996, Helfat 1997, and Van den Bosch *et al.* 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 learn from (other 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 utilised this indicator (e.g., Veugelers 1997, Rocha 1999, Stock *et al.* 2001, Wenpin 2001)

We argue that not only there is a significant relationship among learning by exporting, learning by importing, and internal R&D activities, as suggested by the notion of absorptive capacity, because internal R&D activities are a necessary condition to fully benefit from the leaning generated through exporting and importing. We claim that the joint effect of trading – both exporting and importing - and carrying out R&D activities has a stronger impact on firms' productivity than the sum of these activities had they been carried out in isolation. The

additional benefit of carrying out these activities jointly indicates that complementarities exist. The notion of complementarities has been developed by Paul Milgrom and John Roberts (1990, 1995) to understand the revolutionary changes in modern manufacturing which involved changes in both technological production and organizational strategy and the multiple interactions and interdependencies between them.

Milgrom and Roberts (1990, 1995) use the notion of complementarities to refer to the relation among groups of activities with the characteristic that if the level of any subset of activities is increased, then the marginal return to increases in any or all remaining activities rises. Therefore, if the marginal cost of some activities in the group falls, it may be optimal to increase the level of all the activities in the group (Milgrom and Roberts, 1990, p.514). The existence of complementarities implies that it is relatively unprofitable to adopt a partial system or reduced combination of complementors. Empirical studies which have followed Milgrom and Roberts (1990, 1995) seminal works and provided additional supportive evidence on the complementarities-performance, referring to the interaction of technological adoption (like robotics, and other improved capital equipment or information technology and systems) and organizational practices (like relationship with suppliers, or interaction between manufacturing and marketing divisions) (e.g., Aral and Weill, 2007; Bharadwaj et al., 2007; Black and Lynch, 2001; Bocquet et al., 2007), with the introduction of a range of human resource practices or adjustments to existing ones (e.g., Capelli and Neumark, 2001; Delaney and Huselid, 1996; Laursen and Foss,2003). Whittington et al. (1999) have researched the complementarities - performance relationship in Western organizations, referring to a number of organizational dimensions which captures three main aspects of the firm: structure, processes and boundaries. Their findings suggest positive returns to system wide rather than piecemeal changes. In particular, they found that the most comprehensive system of organizational innovation gives the highest premium in terms of performance. Consistently with the notion of complementarities they found the adoption of partial systems might be associated with negative performance. However rich quantitative evidence in such studies is still rare, as testing complementarities thinking requires information on a high number of organizational and technological dimensions, for a large number of firms, over time (for comprehensive review on empirical literature on complementarities see Ennen and Richter, 2010). More recently the notion of complementarities has been applied in the context of innovation processes and R&D (e.g., Colombo et al., 2006; Cozzarin and Percival, J. C. 2006; Hashai and Almor, 2008; Schmiedeberg, 2008; Lenox et al., 2010), often building on Teece's 1986 seminal work on

complementary assets (Helfat, 1997; Song et al., 2005), in relation to acquisitions and alliances (King et al., 2008; Rothaermel, 2001) and more in general to "resources" and "capabilities" (e.g., Aral and Weill, 2007; Hitt et al. 2006; Ravichandran and Lertwongsatien, 2005), and is gaining some traction in organizational economics (e.g., Caroli and Van Reenen, 2001; Bloom et al., 2010).

These empirical studies provide valuable and interesting contributions of the effect of organizational change on business performance, but most of them present *static* analyses. A rare exception is the work by Ichnioswski et al. (1997). As Milgrom and Roberts (1990) acknowledge, they also present a static model which, however, is suggestive about the nature of the path of the modern manufacturing strategy, but captures the notion of *change* underlying the definition of complementarities only partially.

Hypothesis 1. Complementarities among learning by exporting, learning by importing and the firm own innovation efforts improve firm performance.

A crucial factor to be taken into account for the impact of learning by trading on productivity is the geography of firm trade. Existing empirical evidence confirms superior performance outcomes for firms that engage in trade (both import and export) with relatively more advanced markets that can provide access to the latest technological innovations, product design and management practices (Wagner, 2012; Martins and Yang, 2009).

Hypothesis 2. Complementarities among learning by exporting, learning by importing and the firm own innovation efforts when trading in advanced markets is more beneficial for firm performance compared to trading in countries of lower or similar development levels.

Another factor that can moderate the effect of complementarities among learning by exporting, learning by importing and the firm own innovation efforts on firm performance is the type of firm ownership and governance structure. The extant empirical evidence suggests that, on average, private firms are more innovative, more productive and more active in international markets with respect to the state-owned firms. Hence, one should expect stronger performance effects from the international trade – innovation complementarity for the private-owned firms.

Hypothesis 3. The ownership structure moderates the complementarities among learning by exporting, learning by importing and the firm innovation efforts for firm performance.

Data and Methods

The Sample

This paper uses the data submitted to the Ukrainian Office of National Statistics (Derzhkomstat) that groups consolidated annual accounts data on the census of manufacturing and service firms operating in Ukraine between 2000 and 2006.[i] All firms are uniquely defined by their VAT (EDRPOU) number and divided into sectors according to the Ukrainian Office of National Statistics nomenclature, comparable to the NACE Rev.1 classification. The data contain information on firm-specific characteristics, such as 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. The dataset is merged with the Ukrainian Customs office data that contains information on the monetary value of firm-level exports/imports by destination/origin country, year and type of goods. All variables were deflated using two-digit subsector price deflators, available from the Ukrainian Office of National Statistics.[ii] We limit the study to firms in the manufacturing sectors (NACE Rev.1 15-36) with at least one employee. The final dataset, used for the statistical analysis, comprises a panel with an average of 35,816 firms per year and 237,577 firm/year observations covering the period 2000-06. Table 1 shows that the average annual percentage of exporting firms in the sample is around 12%.

Table 1. Number of firms and shares of exporters, importers and two-way traders (%), selected years

Year	2000	2002	2003	2006	Average
Number of firms	31,268	35,259	36,157	36,524	34,802
Number of exporters	3,102	3,723	4,112	3,634	3,643
Share of exporters	9.92%	10.56%	11.37%	9.95%	10.5%
Number of importers	3,119	3,382	3,522	3,394	3,354
Share of importers	10.0%	9.6%	9.7%	9.3%	9.7%
Number of two way traders	1,616	1,832	1,961	1,726	1,784

Share of two-way traders	5.2%	5.2%	5.4%	4.7%	5.1%

Table 2 contains summary statistics for the basic variables - output, capital, employment, and material costs - for selected years. The figures show increasing output and material expenditures alongside a declining average size and capital, caused primarily by the productivity growth and by the increasing number of small and medium market entrants during 2000-06.

Table 1. Means (standard deviation) of production function variables (2000, 2003, 2005)

	2000	2003	2005
Output (Value added)	1692.25	2061.05	5303.714
	(43923.67)	(51019.31)	(124614.1)
Employment	54.52	37.78	34.63
	(762.04)	(646.03)	(429.79)
Materials	3648.21	6348.61	5974.77
	(49598.52)	(79180.38)	(107172.1)
Capital	3097.75	2467.32	1858.93
	(60613.25)	(53056.17)	(33621.67)

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

The data cover all Ukrainian manufacturing sectors (Please see Appendix A for the number of firms, the average size (number of registered employees) and the share of exporters, importers, two-way traders by industry). The average number of firms per sector is 5,086. However, as a result of industry specifics and Soviet Union heritage, some sectors, such as Coke & Chemistry; Rubber & Plastic and Motor vehicles and trailers are characterised by a smaller number of large firms. Finally, we excluded the Tobacco industry from the analysis as in Ukraine it is traditionally characterised by an oligopolistic structure and, as a result, a very limited number of observations are available.

The time period 2000-06 is well-suited for the empirical analysis as it is characterised by stable macroeconomic policies, a high dynamism in Ukrainian export markets and a significant reorientation of trade flow towards more advanced Western countries. It is also worth noting that during the period of study Ukrainian national legislation was brought into compliance with the WTO rules and regulations in preparation for the WTO accession in 2008. Due to these

legislative changes as well as the recovery from the 1998 Russian financial crisis the number of Ukrainian firms entering export markets between 2000 and 2006 has increased more than twofold and international trade rose by about 100$%.

Key Variables

This study aims to identify the effect of complementarities among learning by exporting, learning by importing and the firm own innovation efforts on firm performance. Following the extant literature, we employ one of the most commonly used measures of firm performance, total factor productivity (henceforth, TFP), as a dependent variable. The firm-level TFP estimates for this study were computed using a modified version of the Olley Pakes (1996) methodology, controlling for demand shocks and different market structures for exporting and non-exporting firms (De Loecker, 2011). For each firm and year we know whether a firm invested in R&D, whether it exported and/or imported, as well as the destinations of its exports and origins of its imports (Please see Appendix B for the full definition of variables). Hence, following Cassiman and Veugelers (2006) and Golovko and Valentiti (2011), we use this information to create an exclusive set of dummy variables capturing all possible combinations of firms' participation in international markets and innovation strategies, which are presented in Table 3 below.

Overall Ukrainian manufacturing firms reveal frequent changes in terms of export and import status over the period. Hence the concern that potential performance effect might be driven by the unobserved firm specific characteristics is relatively low in our case. Furthermore, the matrix of transitional probabilities, presented in Table 4, confirms that Ukrainian manufacturing firms exhibit high degree of dynamism in international markets, which provides us with an appropriate setting to test the effect of the firm innovation and international trade strategies on firm performance.

Table 3. Firm innovation and international markets participation strategies

Strategy	Export	Import	Innovation Efforts
NoExpNoImpNoInn	No	No	No
OnlyInn	No	No	Yes
OnlyImp	No	Yes	No
OnlyExp	Yes	No	No
Imp&Exp	Yes	Yes	No

Imp&Inn	No	Yes	Yes
Exp&Inn	Yes	No	Yes
Exp&Imp&Inn	Yes	Yes	Yes

Statistical approach

Performance regressions

We start the analysis by identify positive relationship between firm trade activities, innovation efforts and performance, therefore replicating the results of the extant literature (REF). In particular, we estimate the following regression:

$$lnTFP_{it} = f\left(Export_{it-1}, Import_{it-1} Innovate_{it-1,}, X_{1it-1}, \dots, X_{nit-1}, \gamma, \beta\right) \quad (1)$$

where:

- lnTFP_{it} is a logarithm of firm's *i* TFP at time *t*.
- *Export, Import, Innovate* are dummy variables that are equal to 1 if the firm exported/ imported/engaged in R&D and zero otherwise;
- $X_{1it-1}, \dots, X_{nit-1}$ is a set of firm control variables that might be associated with its productivity growth;
- *ɣ*, *ß* represent the parameters to be estimated.

To take into account of potential differences in the complementarities among learning by exporting, learning by importing and the firm own innovation efforts and innovation efforts between domestic and foreign-owned firms we use *the percentage of foreign capital*. Finally, to account for exogenous macroeconomic shocks, such as trade-policy changes, exchange-rate movements, changes in demand for Ukrainian exports and other time-varying factors, we include a set of time and industry-time-specific fixed effects.[iii]

In the main part of our empirical analysis we use a set of strategy variables presented in Table 3 to assess the complementarity effects of complementarities among learning by exporting, learning by importing and the firm own innovation efforts on firm performance. To this end we estimate the following model:

$$lnTFP_{it} = f(D_{1it-1}, \dots, D_{nit-1}, X_{1it-1}, \dots, X_{nit-1}, \gamma, \beta) \quad (2)$$

This model goes beyond the analysis of independent linkages between TFP, trade and innovation efforts and uses a vector of dummy variables that constitute an exhaustive set of firm trade-innovation strategies. In particular:

- $D_{1t-1, \ldots,} D_{nt-1}$ = {(*OnlyInn*), (*OnlyExp*), (*OnlyImp*), (*Imp&Exp*), (*Imp&Inn*), (*Exp&Inn*), (*Exp&Imp&Inn*)}[iv];
- $X_{1it-1}, \ldots, X_{nit-1}$ is a set of firm control variables associated with firms' productivity growth;
- γ, $ß$ represent the parameters to be estimated.

If firms' learning by trading and innovation efforts are complementary we would expect that parameter estimate of the strategy that combines higher trading activities with positive innovation efforts (*Exp&Imp&Inn*) to be positive and significant. Furthermore, we would expect this coefficient to be statistically significantly higher than the coefficients of other strategies that include lower degrees of trading activities and innovation efforts.

To account for possible endogeneity of trade-innovation decisions, and performance measure we take several steps (Golovko and Valentini, 2011; Hamilton and Nickerson, 2003; Cassiman and Veugelers, 2006).

First, to control for unobserved firm-heterogeneity that might drive our results we employ fixed effects (henceforth, FE) estimator. The FE estimator assumes that unobserved firm-specific characteristics are fixed over time. Furthermore, the method allows unobserved firm characteristics to be correlated with the independent variables in the model. In the current setting, firm-specific characteristics might refer to the firm organization and management structures or industrial classification. Hence, it is reasonable to assume that such characteristics might be correlated with a firm trade and innovation decisions and with its innovation efforts. Finally, to formally justify our choice of estimator we implement a Hausman test that rejects the hypothesis that the individual-firm effects are adequately modelled by the random-effects model at less than 1% level (chi2(16) = 4507.27; Prob>chi2 = 0.0000).

Next, we address the problem of serial correlation that might be of some concern in our case, as firm export and import decisions tend to exhibit some persistence over time. In order to account for potential serial correlation we modify a standard FE estimator to include an AR(1) process for errors (Golovko and Valentini, 2011).

Finally, we control for the endogeneity of firm strategic choices driven by a selection bias. A selection bias may occur as the most productive firms tend to self-select into exporting,

importing and innovation activities. Indeed, all these activities would require significant amount of initial investment and efforts to overcome entry barriers (Love and Roper, 2015). Entry barriers have been extensively studied in case of entering export markets and are known as *sunk exporting costs* (REF?). These costs might include becoming acquainted with foreign demand conditions, investing in product rebranding and marketing activities for exported goods.

While barriers into importing and innovation are less pronounced, still, significant efforts might be required to identify and develop connections and relationships with reliable foreign suppliers of intermediate inputs; also investing in R&D activities might require non-negligible amounts of financial investments and efforts to attract high-skilled workers. Whilst the existence of selection bias in exporting has been extensively explored, the selection bias in innovation and importing has received relatively less attention in the empirical literature (Wagner, 2007). Nevertheless, as all these activities might be potentially subject to selection bias, we adopt a two stage estimation procedure in line with Cassiman and Veugelers (2006). To this end, we estimate a multinomial logit regression model that estimates the drivers of the eight strategic choices regarding trade-innovation strategies and use the predicted values from the first stage regression as instruments in the productivity regression given by Eq.(2). We do not employ predicted values of firm strategic choices in the second-stage productivity regressions directly as this might lead to biased and inconsistent results (Angrist, 2001). The dependent variable in the first stage regression is a categorical non-ordered variable captured at time *t*, assuming values j=(0(*NoExpNoImpNoInn*); 1(*OnlyInn*); 2(*OnlyExp*); 3(*OnlyImp*); 4(*Imp&Exp*); 5(*Imp&Inn*); *6*(*Exp&Inn*); 7(*Exp&Imp&Inn*)) ; the explanatory variables are measured at *t-1*.

The regressors of the multinomial logit model include lagged R&D investment, as well as lagged export and import status of the firm to take into account possible persistence in trade and innovation activities.

To control for relevant firm characteristics we include a measure of firm size as a number of registered employees (e.g., Golovko and Valentini, 2011; Lu & Beamish, 2006; De Loecker, 2007). Furthermore, to take into account of non-linearity in the relationship between firm size and its productivity growth we include firm size squared. Numerous empirical studies have shown that larger firms are more likely to become exporters/importers and engage in various types of innovation and R&D activities (Bernard and Jensen, 1995; Isgut, 2001; De Loecker,

2007). Indeed, larger firms tend to have more resources that can be used to overcome the entry barriers into exportin, importing and innovation. Hence, size in as important control for both international trade and innovation strategy of a firm. Finally, we control for the firm capital intensity and possession of intangible assets to control for the complementary assets of a firm (Teece, 1986). The management 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, including tangible, such as capital, and intangible assets, such as IP, brand, reputation, marketing and distribution channels). In our analysis we include capital intensity measured as a share of capital investment in total sales, while the possession of intangible assets is represented by a dummy variable that take value one when a firm owns some intangible assets (e.g. brand name, trademarks, distribution channels) and zero otherwise. Finally, we include the vectors of year and NACE2 2-digit industry dummies to controls for industry fixed effects and common macroeconomic conditions.

Learning, Ownership and Size

The main focus of the current study is to analyse the relationship between firm's learning by exporting, learning by importing, and firms' internal innovation efforts and performance outcomes. In addressing these questions it is crucial to take into account of important factors that could moderate this relationship.

The first factor is heterogeneity of firms' absorptive capacity. The exporters of low-tech products and raw materials rely mainly on low-cost advantage rather than on new technologies developed through internal R&D or reverse engineering of imported intermediate inputs. Exposure to these trade opportunities such firms is often limited to producing labour-intensive parts of final products and is unlikely to lead to significant improvements in firm performance. Hence, we should not expect to see significant complementarities between internal R&D and learning from trading for this type of firms.

At the same time, firms in high-technology sectors usually possess superior assets, such as intangibles and human capital, and more effective managerial practices, which in turn imply improved ability of such firms to absorb new knowledge and adopt new technologies available in the export markets: this mechanism would result in a significant relationship among learning by exporting, learning by importing, internal R&D activities and performance outcomes for such firms (Kogut and Zander, 1996).

Another crucial factor to be taken into account is the geography of firm trade. Given the fact that Ukraine is classified as an emerging market economy in the IMF World Economic Outlook, we expect a more pronounced complementarity effect for Ukrainian firms that participate in international trade located in relatively more advanced markets of the European Union and other OECD countries. At the same time, participating in international trade located in the countries of the Commonwealth of Independent States and other countries of the Soviet Block is more related to the geo-political history of the region and, thus, might not result in any significant effect on firm performance.

In order to take into account all the factors that may result in heterogeneity of firm performance outcomes we estimate the benchmark model presented in Eq. (2) by splitting the sample in two subsamples, as a way to test for moderation of different industries, location of trading activities and ownership of the firms. This method is appropriate when the regression is non-linear (REF).

First, we consider only firms that engage in trade of high technology products, as according to the theoretical predictions imports and exports of high-technology products is associated with higher productivity benefits due to better access to frontier technologies and potential for reverse engineering. Following previous international business literature we rely on the OECD industry technology intensity classification to identify technological intensity of the industries in our sample. The classification, developed by Hatzichronoglu (1997), is based on the direct R&D expenditure as a percentage of industrial production (gross sector output) and R&D embodied in investment and intermediate goods.[v] For simplicity, our empirical analysis combines two high-tech industry classifications of the original OECD (2011) classification (medium-high technology and high technology) into one class which we label high technology.

Next, to address potential differences in performance outcomes that may arise due to the trading markets characteristics we estimate Eq.(2) separately for firms that engage in trade with EU and OECD countries (advanced markets) and for firms that engage in trade with countries of similar development levels including CIS countries, countries of Central and Eastern Europe (ex-Soviet Block) and other emerging markets.

Finally, to take into account the role of ownership structure we estimate Eq. (2) separately for the state-owned and private firms.

Results

Table 4 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, R&D) show positive and significant correlations consistent with prior research ($r=0.181$, $p<0.001$; $p=0.136$, $p<0.001$; $p=0.116$, $p<0.001$, respectively). Furthermore, export, import and innovation activities exhibit high positive correlation supporting our premises on the positive synergies between trading activities and innovation for firm performance ($r=0.38$, $p<0.001$; $r=0.304$; $p<0.001$; $r=0.305$; $p<0.001$).

Table 4. Descriptive statistics and product moment correlations

	VARIABLES	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
1	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	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

Benchmark case

We start with estimating Eq. (1) to replicate results of prior research and verify the relationship between export, import and innovation efforts and firm performance. The results of the estimation, presented in Table 4 (Model 1) suggest that all three main independent variables have a positive and significant effect on firm performance: the coefficients of Export, Import and Innovation variables are positive and significant at 1% level. The coefficients on the indicators of firm size (Size and Size^2) reveal a non-linear inverted-U relationship between firm size and performance, suggesting higher productivity growth for smaller firms: coefficient on the Size variable is positive and significant at 1% level, while the coefficient on the (Size)^2 variable is negative, of a smaller magnitude and significant at 1% level. Finally, the coefficient

of the FDI share variable does not seem to have a significant effect on firm performance in our sample.

Next, we estimate the model to test potential complementarities between firm international trade and innovation strategies (Hypothesis 1). To this end, we regress firm performance on a set of exclusive combination trade-innovation strategies accompanied by the set of control variables. As discussed, the model setup distinguishes between eight different strategies: firms that do not import, export or innovate (*NoExpNoImpNoInn* – base category), firms that only import (*OnlyImp*), firms that only export (*OnlyExp*), firms that only innovate (*OnlyInn*); firms that import and innovate (*Imp&Inn*), firms that export and innovate (*Exp&Inn*) and, finally, firms that export, import and innovate at the same time (*Exp&Imp&Inn*). Table 5 reports the results of the AR(1) FE estimator (Model 2) and an IV-FE estimator that uses predicted values of the eight strategic choices obtained from the first stage multinomial logit regression (Model 3). The results of both models are similar and suggest that innovation activities combined with deeper integration in international markets via imports and exports have a significant positive effect on firm performance. And this effect increases in magnitude as more activities are added.

In line with the literature on complementarities, the coefficient at *Exp&Imp&Inn* is positive and significant at 1% level. The coefficients on *OnlyExp*, *OnlyImp* and *OnlyInn* also exhibit positive and significant impact on firm performance. However, they are statistically significantly lower in magnitudes with respect to the coefficient at *Exp&Imp&Inn*, which indicates that firms that engage in all three activities should experience some positive synergies with respect to their performance outcomes.

To test this premise we use a one-sided Wald test and compare the coefficient of *Exp&Imp&Inn* to the sum of the coefficients at *OnlyImp*, *OnlyExp* and *OnlyInn*. The results of the test point towards synergies between export, import and innovation activities. The H_0 hypothesis of no difference between the coefficients at *Exp&Imp&Inn* and the sum of the coefficients at *OnlyImp*, *OnlyExp* and *OnlyInn* is rejected at 5% in Model 2 and Model 3. The rest of the control variables exhibit expected signs.

Table 5. Performance Regression: The effect of complementarities between trade and innovation efforts n TFP

VARIABLES	Model 1 FE AR(1)	Model 2 FE AR(1)	Model 3 IVFE Bootstrap
Import	0.157***		
	(0.011)		
Export	0.125***		
	(0.011)		
R&D	0.069***		
	(0.007)		
No Export, No Import, R&D		0.085***	0.088***
		(0.008)	(0.008)
No Export, Import, No R&D		0.210***	0.156***
		(0.017)	(0.026)
No Export, Import, R&D		0.231***	0.170***
		(0.019)	(0.030)
Export, No Import, No R&D		0.155***	0.190***
		(0.015)	(0.020)
Export, No Import, R&D		0.204***	0.197***
		(0.017)	(0.024)
Export, Import, No R&D		0.307***	0.285***
		(0.020)	(0.039)
Export, Import, R&D		0.313***	0.255***
		(0.019)	(0.041)
Log Size	0.191***	0.190***	0.191***
	(0.011)	(0.011)	(0.015)
Log Size squared	-0.040***	-0.040***	-0.043***
	(0.002)	(0.002)	(0.003)
FDI share	0.026	0.028	0.002
	(0.025)	(0.025)	(0.019)
Constant	-1.328***	-1.331***	-1.188***
	(0.017)	(0.017)	(0.022)
Year	Yes	No	Yes
Year x Industry	Yes	No	Yes
Observations	104,279	104,279	104,280
Number of firms	33,811	33,811	33,812

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The role of trading activities characteristics

In this section we estimate the moderating effect of trading activities, whether it is located in advanced or emerging markets, the model for the subsamples of firms that engage in the trade of high technology products with emerging (Table 6: Models 4 and 5) and advanced (Table 6: Models 6 and 7) markets.

The results of both AR(1) and two-stage IV-FE estimators exhibit some differences. IThe results of Models 4 and 5 reveal that most firm strategies that involve trade with countries of similar or lower development levels exhibit no effect on firm performance. Moreover, the coefficient at *Exp&Imp&inn* that had a positive and highly significant effect on firm productivity in the benchmark case (Models 2 and 3) is not statistically significant. This lack of benefits associated with international trade aimed at countries of similar development levels is in line with our hypothesis # and prior research that shows that the performance benefits emerge from trading in advanced markets because they can offer more learning opportunities, for example due to knowledge spillovers, and encourage better performance due to tougher market competition (Andersson et al., 2008; Castellani, 2010; Silva et al., 2012, 2013). Not surprisingly, the results of the one-sided Wald test for the difference in parameters fail to reject the null hypothesis (H_0) of no difference between the coefficient at *Exp&Imp&Inn* and the sum of the coefficients at *OnlyImp*, *OnlyExp* and *OnlyInn* in Model 4 and Model 5.

Next we estimate equation (2) for the subset of firms that trade with the countries of the European Union and other OECD economies. The results confirm that trade activities in advanced markets result in significant productivity benefits: the coefficients of *OnlyImp*, *OnlyExp* and *Exp&Imp* are all positive and statistically significant ($p<0.01$). Furthermore, the magnitude of the coefficients increases when firms' own innovation efforts are added to any combination of trade strategies (Table 6: Model 6&7). This result is especially pronounced in the results of the IV-FE regression (Model 7). The coefficient of the most inclusive strategy – *Exp&Imp&Inn* – is positive and significant and has the highest magnitude among all firm strategic choices. Nevertheless, the results of the one-sided Wald test for the difference of parameters reveal mixed results. In particular, in Model 6 the test holds at 1% significance level ($p<0.01$). However, in Model 7 - a more robust IV-FE estimator - the test fails to reject the null: (Chi2(1) = 0.04; Prob > chi2 = 0.8417).

Table 6. Performance Regression with market characteristics

	Model 4	Model 5	Model 6	Model 7
	Emerging markets		Advanced markets	
VARIABLES	FE, AR(1)	IVFE	FE, AR(1)	IVFE
No Export, No Import, R&D	0.064***	0.071***	0.084***	0.091***
	(0.008)	(0.008)	(0.009)	(0.008)
No Export, Import, No R&D	0.316***	0.305**	0.285***	0.236***
	(0.104)	(0.153)	(0.024)	(0.035)
No Export, Import, R&D	0.062	0.199***	0.286***	0.248***
	(0.093)	(0.067)	(0.024)	(0.037)
Export, No Import, No R&D	0.069	0.098	0.213***	0.248***
	(0.064)	(0.065)	(0.029)	(0.038)
Export, No Import, R&D	0.011	0.018	0.291***	0.323***
	(0.059)	(0.047)	(0.026)	(0.039)
Export, Import, No R&D	0.304	0.495*	0.345***	0.337***
	(0.247)	(0.280)	(0.033)	(0.05)
Export, Import, R&D	0.270	0.138	0.347***	0.615***
	(0.170)	(0.203)	(0.065)	(0.197)
Size	0.179***	0.179***	0.183***	0.184***
	(0.012)	(0.015)	(0.012)	(0.016)
Size squared	-0.034***	-0.039***	-0.036***	-0.040***
	(0.002)	(0.003)	(0.002)	(0.003)
FDI share	-0.001	0.009	-0.041	0.03
	(0.064)	(0.039)	(0.056)	(0.036)
Constant	-1.380***	-1.223***	-1.476***	-1.321***
	(0.019)	(0.022)	(0.019)	(0.022)
Year	No	Yes	No	Yes
Year x Industry	No	Yes	No	Yes
Observations	90,573	90,573	86,226	86,226
Number of kd	29,482	29,482	28,600	28,600

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The role of ownership regime

This section tests for the moderating role of public versus private ownership on the complementarities between trade and innovation strategies, and their effect on performance. We estimate the benchmark model separately for private and state-owned firms. A large strand of literature has studied the role of ownership as a source of differences in firm strategies and

performance outcomes (Refs.) and it has shown that, while private firms tend to set profit-maximising goals or are pressured to short term performance targets by external stakeholders, state-owned enterprises might choose to forgo profit maximisation in pursuit of social welfare and wealth redistribution (Shleifer, 1998; Deventer and Malatesta, 2001). As a result, private firms tend to exhibit higher levels of productivity growth and better innovation outcomes (Ehrlich et. al, 1994), while state-owned firms tend to lag behind.

To explore the impact of ownership on synergies between firm trade and innovation strategies for firm performance we repeat the analysis, presented in the previous section, separately for private and state-owned firms.

The results, presented in Table 7, reveal a number of interesting trends. First, the trade-innovation synergies for private firm performance appear to follow the expected pattern. In particular, no complementarities between trade and in-house innovation efforts are observed when private firms trade with emerging markets. However, significant trade-innovation synergies arise when trade is with advanced markets: the coefficients of all seven trade-innovation strategic dummies are positive and statistically significant and the magnitude of the coefficients' increase as more activities are added. Finally, the coefficient at *ExpImpInn* is positive and significant at 1% level and of the highest magnitude.

Table 7. Performance Regression within different markets - Private firms

VARIABLES	Model 8	Model 9	Model 10	Model 11
	Emerging markets		Advance markets	
VARIABLES	FE, AR(1)	IVFE	FE, AR(1)	IVFE
No Export, No Import, R&D	0.068***	0.074***	0.088***	0.094***
	(0.009)	(0.008)	(0.009)	(0.009)
No Export, Import, No R&D	0.315***	0.308**	0.289***	0.235***
	(0.106)	(0.153)	(0.025)	(0.035)
No Export, Import, R&D	0.039	0.209***	0.290***	0.248***
	(0.101)	(0.072)	(0.025)	(0.038)
Export, No Import, No R&D	0.085	0.120*	0.219***	0.249***
	(0.069)	(0.070)	(0.030)	(0.039)
Export, No Import, R&D	0.053	0.040	0.303***	0.332***
	(0.065)	(0.051)	(0.027)	(0.040)
Export, Import, No R&D	0.316	0.508*	0.353***	0.338***
	(0.252)	(0.284)	(0.034)	(0.050)

Export, Import, R&D	0.151	0.014	0.373***	0.703***
	(0.181)	(0.208)	(0.071)	(0.219)
Size	0.188***	0.188***	0.188***	0.191***
	(0.012)	(0.016)	(0.013)	(0.017)
Size squared	-0.037***	-0.041***	-0.038***	-0.042***
	(0.002)	(0.003)	(0.003)	(0.003)
FDI share	-0.007	0.009	-0.046	0.030
	(0.065)	(0.039)	(0.058)	(0.036)
Constant	-1.298***	-1.155***	-1.397***	-1.253***
	(0.019)	(0.022)	(0.019)	(0.022)
Year	No	Yes	No	Yes
Year x Industry	No	Yes	No	Yes
Observations	84,364	119,425	80,435	114,856
Number of firms	27,773	35,061	27,000	34,421

The final set of results, presented in Table 8, analyse the impact of trade-innovation strategies on the performance of the Ukrainian state-owned manufacturing firms. The results is this group clearly reveal the lack of synergies, especially when such firms engage in trade with advanced markets of the European Union and other OECD countries (Models 13, 14). On the other hand, the results suggest the presence of some synergies between trade and innovation for the performance of state-owned firms when their trade is aimed at other emerging markets: the coefficient of *ExpImpInn* in Model 12 is positive and statistically significant at 1% level. One possible explanation for this result lies in the fact that the majority of the business linkages between state-owned firms is conditioned by the unique historic structure of the industrial production in the Soviet Union. In particular, the structure of the centrally planned USSR economy ensured that value-added chains where spread equally among the Soviet republics to tie their economies closely together. Many of these value-chain links still remain active, especially among state-owned enterprises, and might be one of the possible explanations for the results in Model 12. However, it has to be noted that the IV results of Model 12 are not robust, as none of the trade-innovation strategies remains statistically significant when the IV-FE estimator is applied.

Table 8. Performance Regression within different markets - State-owned firms

VARIABLES	Model 12	Model 13	Model 14	Model 15
	Emerging markets		Advanced markets	
VARIABLES	FE, AR(1)	IVFE	FE, AR(1)	IVFE
No Export, No Import, R&D	0.028	0.028	0.043**	0.052***
	(0.019)	(0.018)	(0.019)	(0.019)
No Export, Import, No R&D			0.001	0.215
			(0.161)	(0.134)
No Export, Import, R&D	0.188	-0.020	0.194**	0.078
	(0.188)	(0.067)	(0.093)	(0.091)
Export, No Import, No R&D	-0.070	-0.085	0.059	0.233
	(0.139)	(0.149)	(0.101)	(0.203)
Export, No Import, R&D	-0.251**	-0.168	0.100	0.153
	(0.109)	(0.121)	(0.078)	(0.143)
Export, Import, No R&D			0.222	0.287
			(0.154)	(0.287)
Export, Import, R&D	1.554***	0.658	0.040	-0.049
	(0.416)	(0.484)	(0.150)	(0.173)
Size	0.168***	0.131	0.118**	0.106
	(0.048)	(0.094)	(0.054)	(0.099)
Size squared	-0.007	-0.019	0.002	-0.014
	(0.007)	(0.012)	(0.009)	(0.013)
FDI share	2.373***	1.019	2.467***	1.946***
	(0.902)	(1.159)	(0.900)	(0.198)
Constant	-2.946***	-2.430***	-2.982***	-2.605***
	(0.125)	(0.227)	(0.126)	(0.194)
Year	No	Yes	No	Yes
Year x Industry	No	Yes	No	Yes
Observations	6,209	8,117	5,791	7,586
Number of kd	1,709	1,908	1,600	1,795

Discussion and Conclusion

This paper explores the effect of complementarities that occur among firms' international trading activities and internal R&D investment on their performance. Adding to previous IB literature, we argue that beneficial effect of exports on firm performance is complemented by the positive effect stemming from imports and further reinforced by firm internal R&D investment. In particular, in line with Aw et al. (2008, 2009) and Damijan et al. (2010) we pose that, by engaging in trade, firms learn from external sources via demand-supply linkages. And the benefits of learning-by-trading further increase when firm expand their knowledge-absorptive capacity by investing in R&D activities (Damijan and Kostevc, 2015).

We use micro-level data on Ukrainian manufacturing firms that combines firm-level accounting data with information on trade volumes and geographic trade structure. Using several alternative estimators we find that significant positive complementarities exist among export, import and internal R&D investment in Ukrainian manufacturing firms. In particular, engaging in all three activities seems to have the strongest positive effect on firms' performance. Further analysis reveals that this effect is driven mainly by private manufacturing firms trading with advanced markets. At the same time, state-owned firms show no significant productivity gains when trading with advance countries, while some productivity gains arise while trading with the countries-members of the Commonwealth of Independent States and other emerging and developing markets.

Bibliography

Arora, A., Gambardella, A., 1990. Complementarity and External Linkages: The Strategies of the Large Firms in Biotechnology. The Journal of Industrial Economics 38, 361–379. https://doi.org/10.2307/2098345

Autio, E., Sapienza, H.J., Almeida, J.G., 2000. Effects of Age at Entry, Knowledge Intensity, and Imitability on International Growth. AMJ 43, 909–924. https://doi.org/10.5465/1556419

Barkema, H.G., Vermeulen, F., 1998. International Expansion Through Start-Up or Acquisition: A Learning Perspective. AMJ 41, 7–26. https://doi.org/10.5465/256894

Bresnahan, T.F., Brynjolfsson, E., Hitt, L.M., 2002. Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence. Q J Econ 117, 339–376. https://doi.org/10.1162/003355302753399526

Cohen, W.M., Levinthal, D.A., 1990. Absorptive Capacity: A New Perspective on Learning and Innovation. Administrative Science Quarterly 35, 128. https://doi.org/10.2307/2393553

Gibbons, R., Roberts, J., 2012. The Handbook of Organizational Economics. Princeton University Press.

Simonin, B.L., 1999. Ambiguity and the process of knowledge transfer in strategic alliances. Strategic Management Journal 20, 595–623. https://doi.org/10.1002/(SICI)1097-0266(199907)20:7<595::AID-SMJ47>3.0.CO;2-5

Tambe, P., Hitt, L.M., Brynjolfsson, E., 2012. The Extroverted Firm: How External Information Practices Affect Innovation and Productivity. Management Science 58, 843–859. https://doi.org/10.1287/mnsc.1110.1446

Arora, A., Gambardella, A., 1990. Complementarity and External Linkages: The Strategies of the Large Firms in Biotechnology. The Journal of Industrial Economics 38, 361–379. https://doi.org/10.2307/2098345

Bresnahan, T.F., Brynjolfsson, E., Hitt, L.M., 2002. Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence. Q J Econ 117, 339–376. https://doi.org/10.1162/003355302753399526

Gibbons, R., Roberts, J., 2012. The Handbook of Organizational Economics. Princeton University Press.

Tambe, P., Hitt, L.M., Brynjolfsson, E., 2012. The Extroverted Firm: How External Information Practices Affect Innovation and Productivity. Management Science 58, 843–859. https://doi.org/10.1287/mnsc.1110.1446

ENDNOTES

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

[ii] Ukrainian State Statistic Committee website: http://www.ukrstat.gov.ua

[iii] Industry dummies are absorbed by the fixed effects

[iv] No Import., No Export, No innovation is a base category

[v] The full list of NACE Rev.1 industries corresponding to the OECD technology classification can be found here: https://www.oecd.org/sti/ind/48350231.pdf