Innovation Intensity as a Driver of Firm's Internationalization Intensity: Evidence for Poland

Tomasz Brodzicki[*]

Abstract

The aim of the article is an empirical identification of the relationship between the extent of innovation and the extent of internationalization in the cross-sectional sample of firms from Poland. Firstly, both extents of innovation and of internationalization are defined, calculated and analyzed separately and then jointly. The mean changing characteristics of companies along two dimensions are depicted. Secondly, the nexus between internationalization and innovation is econometrically analyzed with the use of OLS, MNL, OL, and IV models. Thirdly, the role of both in the likelihood of firm-exports is assessed in a logit model.

The obtained results are in line with the postulates of the firm heterogeneity theory. Productivity seems to be a principal driver of firm exports and firm internationalization. Positive correlation between innovation and internationalization extents is robust with the majority of firm's inferior performance in both dimensions and, in particular, in comparison to the Western European counterparts. The joint distribution along the two analyzed dimensions shows a pyramidal structure with a peak at low levels of internationalization and innovation. There is some support for the causality going from innovation to internationalization. However, more research is necessary for a panel setting to verify this statement thoroughly.

[*] Institute for Development, Sopot, Poland; Economics of European Integration Division, Faculty of Economics, University of Gdansk, Sopot, Poland, e-mail: t.brodzicki@ug.edu.pl.

Acknowledgments

1. Introduction

The critical review of many theoretical economic and business management models leads to a conclusion that innovation should have a positive impact on firm's performance and overall competitive potential. The empirical results are rather mixed. Some studies find private returns to innovation to be significant and positive (Adams and Jaffe 1996), some, on the contrary, find them to be insignificant or even negative (e.g., Lichtenberg and Siegel 1991; Link 1981) if publicly-funded. Some recent studies indicate that the return could depend on the age of the firm (e.g., Coad, Seggara and Teurel 2016) or the sector of its operation or existing market structure (e.g. Greenhalgh and Rogers 2006). Although, there is a clear evidence of a positive interaction between innovation, internationalization including export status and productivity, the direction of causality between them is still being discussed (Cieślik *et al.* 2012).

For instance, Kirayama (2012) in his policy paper discusses three separate channels through which internationalization could affect innovation. Trade leads to knowledge diffusion, and knowledge can be embodied in goods (importing) or disembodied (FDI, licensing and technology transfer). At the same time, trade can have an impact on the incentives of firms towards innovative activities and thus affect competition and export opportunities. The channels previously analyzed at the macro or meso level are nowadays being investigated at the micro or firm-level with growing body of evidence being accumulated (Bernard and Jensen 1999; 2004).

The evidence for learning by exporting is however limited (Wagner 2007; 2012) with some support for Slovenia (de Loecker 2007; Damijan *et al.* 2010) or sub-Saharan Africa (Van Biesebroeck 2005). Most studies on export and productivity find evidence of a self-selection mechanism, with a gain in productivity preceding entry into foreign markets (Bernard and Jensen 1999; Bernard, Jensen and Schott 2006).

Hirsch and Bijaoui (1985), Entorf, Krader and Pohlmeier (1988), Kumar and Siddhrthan (1994), Wakelin (1998), Sterlacchini (1999), Basile (2001), Roper and Love (2002) or Caldera (2010), among others, showed that innovation is a major determinant of probability of exports and export intensity at the firm level. Only a limited number of studies identifies a positive causation from exports and innovation (Salomon and Shaver 2005; Lileeva and Trefler 2010; Bratti and Felice 2012). More studies point to the causation going from innovation to exports (e.g., Cassiman and Golovko 2011; Becker and Egger 2013). Aristei, Castellani and Franco (2013) indicate that prior imports increase exports through its positive impact both on firm's productivity and the extent of product innovation. There is also substantial evidence that firms make a joint decision on innovation and export market participation (e.g., Aw, Roberts and Winston 2007; Trefler 2004).

In their seminal study Altomonte *et al.* (2013) showed a positive, strong and robust correlation between the extent of internationalization, productivity and in-

novation activities at firm-level in a panel of the European manufacturing firms including Hungary (the EFIGE dataset, European companies in a global economy was a research project coordinated by Breugel within the 7th Framework Programme of the EU). We do not know of the other studies conducted for companies from other Central and Eastern Europe countries. Therefore, the study on a representative sample of enterprises from Poland should be of particular importance, illustrative for states at the lower level of overall development and less sophisticated national innovation systems. The methodology of the study is not standard and hence could be criticized. The major methodological problem is related to the cross-sectional and not panel nature of the dataset which forced the authors to utilize an array of empirical methods (OLS, MNL, and IV) to discuss the issue of causality. They were unable, however, to control for potential lags in key variables. We, unfortunately, face the same problem as part of the utilized database is qualitative in nature and was obtained by a one-time survey on a representative group of companies.

The main objective of this paper is an empirical investigation of the relationship between innovation and internationalization extents in a panel of firms from Poland with the use of formal econometric modeling. We follow the approach by Altomonte *et al.* (2013) to obtain comparable results, however, we extend it in several dimensions. We contribute in particular by broadening the definition of variables and considering other possible methods of estimation such as order logit or generalized logit. We also analyze the role of both internationalization and innovation extents in determining the likelihood of firm-exports in a logit model.

In the analysis, we utilize a unique firm-level financial dataset collected by InfoCredit and augmented with the results of an extensive qualitative survey.

The remainder of the paper is structured as follows. Section 2 shortly reviews theoretical and empirical literature. Section 3 describes the survey and financial data utilized in our study and provides our definitions of innovation and internationalization extents. Section 4 presents an initial descriptive analysis of innovation and internationalization extents separately and then jointly pinpointing the differences between companies. Section 5 provides initial econometric analysis with OLS, MNL, OL, and IV estimates. Section 6 using the logit framework identifies the impact of innovation and internationalization extents on the likelihood of exporting of Polish companies. The last section concludes.

2. Review of theoretical and empirical literature

The relationship between innovation and internationalization has been investigated extensively in recent years. Several theoretical approaches predict the existence of a positive relationship between innovation and export/internationalization intensity. Technology-based models of international trade, such as a technology gap model of

Posner (1961) or the product life-cycle model of Vernon (1966), to start with, denote that at the firm-level technology and thus innovation is a key driver of exporting. The concepts were further developed by Krugman (1979) and Dollar (1986) in their models of North-South trade. Jensen and Thurby (1987) incorporated R&D investments into a dynamic North-South trade model with the pattern of trade similar to Vernon's product life cycle (Vernon 1966). Segerstrom *et al.* (1990) constructed a dynamic general equilibrium model of North-South trade that combined the product life cycle hypothesis with Schumpeter's (1942) concept of creative destruction in product development. The seminal work of Melitz (2003) extended the Krugman's analysis by incorporating heterogeneity of the firm-level productivity.

The international business literature suggests that export behavior depends on structural characteristics of a firm, managerial and organizational factors, as well as incentives and disincentives to the internationalization process (Leonidou 1998). The resource-based view of a firm explains some of the principal causes of the observed firm heterogeneity (Barney, 1991; Hitt *et al.* 2001). Last but nor least, the innovation management literature postulates that innovative firms enter foreign markets to increase their total sales and thus decrease the average cost of innovation (Tidd and Bessant 2009).

The empirical literature on the nexus between innovation and internationalization of activities at firm or plant-level is quite extensive. The results of early empirical studies (e.g., Hirsch and Bijaoui 1985; Schlegelmilch and Crook 1988) were mixed. A growing number of studies used survey data with precise information on the innovation activities at the level of individual firms (e.g., Wakelin 1998; Bernard and Jensen 1999; Roper and Love 2002; Lachenmaier and Wößmann 2006; Cassiman, Golovko and Martinez-Ros 2010).

Cassiman and Golovko (2011) show in a panel of Spanish firms that product and, to a lesser extent process innovation, drive firms' exports. The successful introduction of product innovation can lead to a decision by an SME to enter the foreign market through exporting. The direct effect is boosted by an indirect impact of innovation on firm's productivity. The positive relation between firm productivity and exports relates mainly to the company's earlier decisions on innovation.

Garcia-Quevedo, Pellegrinoa and Vivarellic (2014) show that innovation depends, to a large extent, on the firm's age. Younger firms' innovation behavior is more erratic and less persistent and driven mostly by demand-pull variables. Incumbents' innovation is much more persistent and driven primarily by technological and market (supply-side) determinants. Innovation activities of firms thus vary with age and could directly or indirectly affect firm's internationalization. Many studies find exporters to be usually older than non-exporters (e.g., Fariñas and Martín-Marcos 2005). At the same time, some studies find that firm productivity iscorrelated with the firm age (e.g., Arnold and Hussinger 2005 in a panel of German enterprises). However, we have not identified it in our sample.

Wakelin (1998) in a sample of the UK firms shows that the determinants of internationalization behavior vary between innovators and non-innovators. What's more, the mare capacity to innovate changes the behavior of the the firms in comparison to non-innovators. Basile (2001) in turn finds that innovation capabilities, to a large extent, explain observed heterogeneity in export behavior among Italian manufacturing companies. The export intensity of innovating firms is systematically higher than that of non-innovators. In addition, Aw, Roberts and Xu (2011) indicate that the marginal benefit of concomitant exporting and innovating increases with productivity. Self-selection mechanism mostly drives the observed complementarity and is found to be driven by self-selection. In contrast to firm's age, Pla-Barber and Alegre (2007) in a sample of 121 French biotechnology firms found the firm size not to have an impact on innovation or export intensity. The results pointed, however, to a positive and significant relationship between innovation and export intensity.

In a Nassimbeni (2001) study of small Italian manufacturing companies, the propensity to export is linked to the firm capacity to introduce product innovations and to develop strong inter-organisational relations. Factors such as age and size play a role as well. Product innovations are of greater importance for small exporters. Nassimbeni (2001) discusses the issue of the reverse causality as exporters, facing more diverse market demands and overall fiercer competition, are stimulated to improve their product innovation or customization capability.

Castellani and Zanfei (2007) reveal that intra-industry heterogeneity in Italy is associated with different internationalization strategies of companies. Firms engaged more in international activities exhibit simultaneously superior economic and innovative performance. Companies with the highest international involvement, active FDI players, are characterized by both the highest productivity premia and the highest R&D efforts and innovation performance. More productive firms self-select into international markets, but at the same time, their commitment to the foreign markets boosts firms' productivity and propensity to innovate.

Lachenmaier and Wößmann (2006) estimate the impact of innovation on exports in German manufacturing firms treating innovation as an endogenous phenomenon. Taking account of potential reverse causality, they isolate variation in innovative activity due to specific impulses and obstacles to innovative activity. The obstacles are treated as instruments which are exogenous to the firms' export performance. The results showed that a share of exports in enterprises' total turnover for innovators was, on average, roughly seven percentage points above the mean export share of one-quarter in support of innovation being a driving force for industrialized countries' exports. The effect of innovation on export varied from sector to sector.

Van Beveren and Vandenbussche (2010) analyze the relationship between firm-level innovation and firms' propensity to commence exporting for a sample

of Belgian enterprises.The results prove that self-selection mechanisms occur. Moreover, what is even more attractive, firms innovate in anticipation of entry into the export markets. The study of Spanish manufacturing firms by Monreal-Perez, Aragon-Sanchez and Sanchez-Marin (2012) leads to similar conclusions. Tackling the problem of endogeneity and even after controlling for firm productivity, authors prove that innovation induces firms to increase their exports. At the same time, there is no evidence of learning-by-exporting effects on product or process innovations.

Cassiman, Golovko and Martinez-Ros (2010) argue that the positive relation between firm productivity and exports is due to the company's decisions on innovation. In a panel of Spanish manufacturing companies, they find strong evidence supporting the impact of product innovation on productivity. The rise in productivity induces small domestic firms to enter the export market. However, they identify no impact of that kind exerted by process innovations.

Damijan, Kostevc and Polanec (2010) explore the causal links between innovation, productivity and export activities of companies in Slovenia over the period 1996–2002 using microdata and innovation and industrial survey data. The authors argue that two causal links are possible. First, from product innovation to productivity and to the decision to export. Second, in the opposite direction, from exporting to process innovation to productivity growth. Applying matching techniques to establish the direction of causality between innovation activity and exporting by testing whether lagged innovations affect the decision to start exporting and whether past exporting has an impact on a firm's decision to start innovating, they estimate average treatment effects on probabilities of exporting and innovating. Damjan *et al.* (2010) find no evidence that either product or process innovations increase the likelihood that a Slovenian firm becomes a first-time exporter. However, past exporting status increases the probability that medium and large enterprises would become process innovators with no similar impact on product innovations.

Hagemajer and Kolasa (2011) study the effects of internationalization on the economic performance of companies in Poland, distinguishing between three modes of outward orientation: foreign direct investment, exporting and importing of capital goods. Internationalized Polish firms are found to be superior regarding their size, productivity and productivity growth, capital intensity and wages. The results of Cieślik *et al.* (2014) confirm the significance of firm characteristics for export performance for Central and Eastern European companies. Financial support to R&D and innovation activities in transition economies is likely to boost the export performance of enterprises.

Cieślik, Michałek and Szczygielski (2016) analyze the relationship between various types of innovations and export performance of Polish firms over the period of 2008–2010. They control for human and physical capital endowment, firm size (employment size groups), the level of technological sophistication of a sec-

tor as well as the presence of foreign capital. They do not control for the level of productivity, however. The likelihood of exporting by a Polish firm is found to be positively related to both product and process innovations, firm's size, its human capital endowment as measured by the share of university graduates in employment and last but not least with foreign capital participation in the company. Similar results are reported by Brodzicki and Ciołek (2016) in a panel of Polish manufacturing industry firms. However, only process and organizational innovations are found to boost the probability of exporting. More general results of the study are reported in Gawlikowska-Hueckel and Umiński (2016).

Kafouros *et al.* (2008) argued that not all firms can reap the rewards from innovation. Only companies with a sufficient degree of internationalization can reap benefits from innovation and can do it in many markets simultaneously. The firm-level evidence confirms that internationalization enhances a company's capacity to improve performance through innovation.

As has already been stressed in the introduction, Altomonte *et al.* (2013) show the extent of internationalization, and the extent of innovation and productivity at firm-level to be positively, strongly and robustly correlated. They do it in the panel of manufacturing entities from seven European states (Austria, France, Germany, Hungary, Italy, Spain, the United Kingdom). In contrast to Cassiman and Golovko (2011), the positive association between internationalization and innovation exists even if controls for productivity are introduced, with some evidence of causality running from the latter to the former. The study by Altomonte *et al.* (2013) will be treated as a benchmark for our analysis, and their empirical approach will be followed and extended in several dimensions to obtain comparable results.

3. The dataset and the definitions of innovation and externalization extents

As the access to micro-level data for Polish enterprises is restricted, we conducted a survey on a sample of exporting and non-exporting enterprises merging it with the financial data provided by InfoCredit.
The following selection criteria were applied:
- an enterprise has a complete five year period of data availability,
- total sales per enterprise exceed 2 million PLN (roughly 500 000 EUR) each year,
- exports exceeds 1 million PLN each year (or approx. 250 000 EUR).

The use of the criteria outlined above provided us with a database of around 7000 relatively large and mature enterprises, from which randomly selected ones were surveyed. Our population of enterprises consists of predominantly larger firms (upper tail of distribution by firm size), predominantly from manufacturing industry, that have at least 5-year continuity of financial reports (and thus have

been active for at least five years). Out of 709 effectively questioned enterprises with a direct contact by a pollster, 498 were exporters and the remaining 211 were non-exporters. They all come from Polish voivodeships. Most of them are from manufacturing industry (80 percent) and the rest (20 percent) from service sectors. Regarding employment size, they are mostly small (38.5 percent) or medium-sized (40.5). Large enterprises constitute only 14.8 percent of the sample. The mean age of a firm is 20 years and eight months. The descriptive statistics on selected, key variables that will be utilized in the formal econometric modeling are provided in Table A in the Appendix.

We follow Altomone *et al.* (2013) in nesting various internationalization and innovation modes rather than considering them disjointly. It allows us to build measures of internationalization and innovation extents, defined as the number of internationalization/innovation modes in which a firm is simultaneously involved. The definitions applied are explained in the forthcoming section.

In their paper Altomonte *et al.* (2013) define internationalization intensity as a number of internationalization modes in which a firm is active simultaneously including the following: exporter, importer, outsourced or outsourcer status and FDI maker. The modes are non-exclusive, and thus internationalization intensity ranges between 0 and 5.

Taking into account the nature of the survey and available data in relation to the benchmark, we adopt to following elements broadening the concept of internationalization extent:

- exports,
- imports,
- the presence of foreign capital,
- being a part of a multinational enterprise (corporation),
- close cooperation in sales in foreign markets,
- own sales abroad through own offices,
- exports constituting a significant share of company's sales,
- exporting on a permanent basis (not sporadically or ad hoc),
- FDI maker.

The modes considered are non-exclusive, and internationalization extent ranges between 0 and 9 (INTERN).

Innovation extent is defined in this article as the number of different innovation modes, in which the particular company is simultaneously involved. We take into account the following innovation inputs and output measures:

- the introduction of new products (radical innovations),
- the introduction of improvements in existing products (incremental innovations),
- the introduction of new or improved production process (process innovations),

- the introduction of new or enhanced organization (organizational innovations),
- functioning of R&D unit (in-house R&D),
- acquisition of R&D from outside of the company (external R&D),
- patents and patent applications,
- acquisition of licenses,
- trademark applications.

Thus our innovation extent, similarly to the internationalization extent, ranges from 0 and 9 (INNOV).

One weakness of our approach, similarly to Altomonte *et al.* (2013), is that we give the same weight to every mode and thus do not apply any weighting schemes, based on the significance of the mode for internationalization or innovation extent. It could bias our results to a certain degree, and thus further work on the issue will be carried out in the future.

4. Internationalization and innovation extents – initial description

In this section of the article, we present the facts related to innovation and internationalization extents of firms that emerge from our sample. First, we examine the internationalization and innovation dimensions separately. Secondly, we discuss the interactions between them.

We use our data to acknowledge the fundamental issues discussed in the contemporary literature on heterogeneous firms' foreign trade activity: internationalized firms differ from non-internationalized. They are identified to be foremost larger and more productive. At the same time, their size and productivity (as measured by total productivity or labor productivity) follow a stable ranking across different internationalization modes.

To control for productivity differences, as postulated by the new trade theory, we calculated a number of productivity measures including: labor productivity, capital productivity, total productivity (TPROD) and, last but not least, the TFP. Kernel distribution estimates of productivity in 2012 are clearly skewed to the right, in accordance with the general results established in the heterogeneous firms' literature. Very productive firms are rare, while companies with low productivity clearly dominate. After a careful quantitative analysis, we choose total productivity, as a proxy for firms' productivity, for the further analysis.

4.1. Extent of internationalization and firm's performance

Only 4.65 percent of companies in our sample are "purely domestic", not involved in any form of internationalization. Most of the companies (95.35 percent) are internationally active in at least one dimension or mode.

Internationally active firms differ significantly from domestic companies (please refer to Table 1). Domestic companies are significantly smaller and less productive. Internationally active firms are on average older than purely domestic firms (by three years, not reported in the Table).

If we focus on internationally active companies with at least one active mode, 73.7 percent export but only 46.7 percent import. Out of the active firms, 63.9 percent export a significant share of their production (most of the companies sell simultaneously domestically and abroad, only 5.25 percent of exporters sell abroad only). 45.3 percent of active firms exports on a permanent basis (61 percent of exporters). One-third of exporters, does so on a regular basis. At the same time, only 6 percent of companies export sporadically at various export spells. 11.7 percent of internationalized firms are part of multinational corporations, while foreign capital is present in 26.9 percent of enterprises. 17.8 percent of companies cooperates in their sales abroad with foreign organizations. Only one in ten businesses is an FDI maker and only one in twenty sales is completed internationally through own sales offices established abroad.

Table 1. Dimension of internationalization (descriptive statistics)

Internationaliza-tion dimension	# of firms	Frequency (per cent)	Avg.Sales (million PLN)	Avg. Employment	Avg.Sales per employee (k PLN)
Non-active	33	4.65	9.5	41.1	231.8
Active	676	95.35	140.7	113.9	1235.0
of which:					
Exporters	498	73.7	188.8	136.3	1384.6
Importers	316	46.7	235.2	151.7	1550.9
Own sales offices	32	4.7	70.3	66.8	1052.6
Int. cooper. sales	120	17.8	262.8	117.8	2230.8
Foreign capital	182	26.9	247.6	149.5	1655.9
MNE	79	11.7	271.9	169.5	1604.1
FDI maker	72	10.7	66.6	116.2	573.4
Permanent ex-porter	306	45.3	179.9	110.7	1624.8
Large export share	432	63.9	124.6	124.9	997.7
Total	**709**	**100.0**	**134.6**	**110.5**	**1217.6**

Notes: Modes of internationalization are non-mutually exclusive.

Source: author's own calculations from survey and InfoCredit databases.

Table 2 demonstrates the altering firms' characteristics with increasing internationalization intensity. None of the companies in our sample attained a score of 7

or above, out of a possible maximum of nine. It is evident that internationalization intensity increases with firm size, as measured by employment. Companies with moderate levels of internationalization, however, have the highest mean sales and average sales per employee.

Average labor productivity and total productivity show a similar pattern, which to some extent is in contrast to our benchmark study by Altomonte *et al.* (2013)and could be due to the nature of our internationalization measure (a broader concept not taking into account only basic internationalization modes).

Table 2. Internationalization intensity and firm characteristics

Int. intensity	# of firms	Frequency (percent)	Avg. Sales (M PLN)	Avg. Employ	Avg.Sales per employee (k PLN)	Avg.log (labor prod.)	Avg. log (TPROD)
0	33	4.65	9.5	41.1	231.8	5.03	2.77
1	109	15.37	28.8	51.8	556.2	5.56	2.79
2	169	23.84	59.1	73.0	810.2	5.71	3.29
3	199	28.07	248.2	125.5	1977.1	5.89	3.16
4	131	18.48	293.3	168.8	1737.1	5.96	3.10
5	59	8.32	97.2	159.9	607.6	5.64	2.80
6	9	1.27	76.8	236.6	324.6	5.61	2.68
7	0	0.0	:	:	:	:	:
8	0	0.0	:	:	:	:	:
9	0	0.0	:	:	:	:	:
Total	**709**	**100.0**	**134.6**	**110.5**	**1217.6**	**5.75**	**3.07**

Notes: Modes of internationalization are non-mutually exclusive.

Source: author's own calculations from survey and InfoCredit databases.

Figures 1 allows us for a closer look into the relation between internationalization intensity and firm's productivity by plotting kernel density estimates of total productivity for companies with different internationalization intensity (none or low, medium, high). They clearly differ, however, all are skewed to the right. We have to stress that the right tails of distributions are clearly longer and thicker for more internationalized firms.
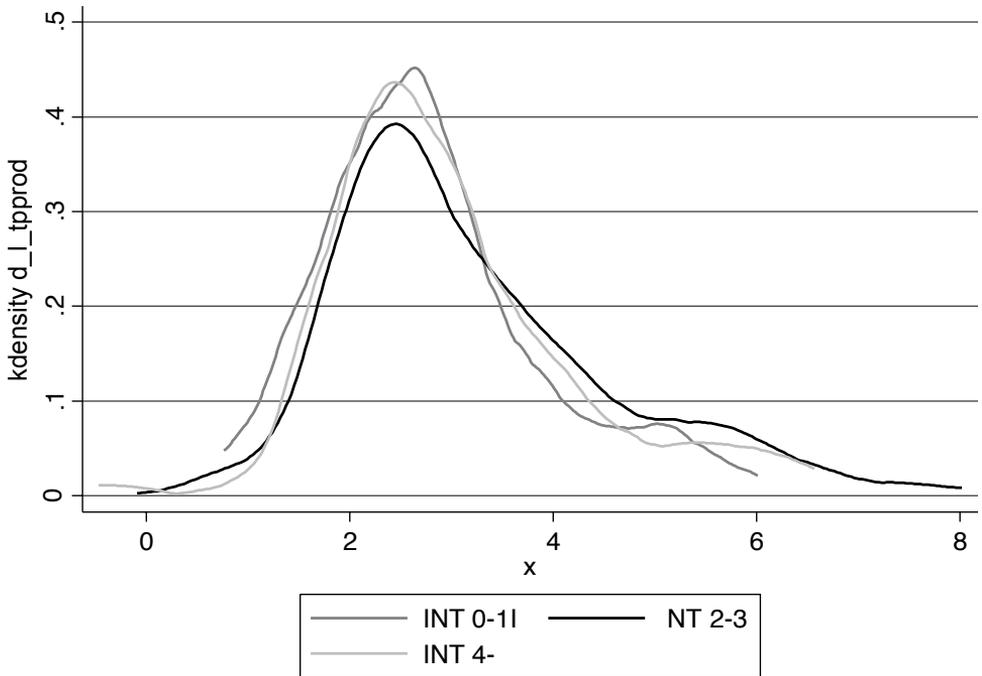
**Figure 1. Kernel estimates of total productivity of enterprises
by internationalization intensity (INT)**
Source: author's own calculations from survey and InfoCredit databases. Estimates in STATA.

4.2. Extent of innovation and firms' performance

We now replicate the analysis performed for internationalization intensity for firms' innovation intensity linking it to the firms' performance.

Having adopted a very broad measure of innovation, we see that 93.4 percent of companies in our sample are active innovators. The share is higher than it was reported in the EU Community Innovation Survey reports or in our benchmark study of Altomonte *et al.* (2013) – but not very far off (87 percent respectively). It is also quite clear that innovatively active firms are larger with respect to sales and employment (please refer to Table 3) and have higher sales per employee. They are also, on average, older than passive firms (by two years, not reported in the Table).

Incremental product innovations are the most frequent, followed by the introduction of new products. Around one-third of firms introduces process innovations and one-fourth organizational innovations. Around one-fourth of enterprises have obtained trademarks and only approximately one-sixth patents. One in six firms has own R&D unit (these firms have on average twice higher sales per employee) and one in seven commissions R&D externally.

Table 3. Dimensions of innovation activities of firms (descriptive statistics)

Innovation dimensions	# of firms	Frequency (percent)	Avg.Sales (million PLN)	Avg. Employ-ment	Avg. Sales per employee (k PLN)
Non active	47	6.6	101.1	94.4	1070.7
Active	662	93.4	136.9	111.7	1226.4
of which:					
New product	390	58.9	154.7	110.1	1405.7
Product (incremental)	468	70.7	90.7	122.7	738.9
Process	230	34.7	190.1	132.4	1435.6
Organizational	171	25.8	103.3	143.0	722.6
Own R&D unit	107	16.2	241.2	96.9	2488.5
External R&D	104	15.7	113.1	110.2	1027.0
Patents	123	18.6	114.4	123.8	924.2
Licences	129	19.5	104.0	127.4	816.4
Trade marks	172	26.0	173.2	105.5	1642.7
Total	709	100.0	134.6	110.5	1217.6

Notes: Modes of innovation activity are non-mutually exclusive.

Source: author's own calculations from survey and InfoCredit databases.

Table 4 illustrates the changing firm's characteristics with increasing innovation intensity. It is evident that none of the companies in our sample attains the score of 8 or above. Nearly half of companies in our sample have the innovation intensity of two or less, and 70 percent of three or less. Only 10 percent has high innovation intensity of 5 or more.

Simultaneously, Table 4 clearly demonstrates that innovation intensity increases with the increasing mean employment of firms. Companies with larger average sales per worker surprisingly are more likely to have lower innovation intensity. The relation with mean labor productivity and total productivity are not that obvious. The interpretation could be due to utilization of means and not take into account standard deviations which in reality are quite high. It is worth to note that the most innovation-intensive (creative) firms have, on average, the highest total productivity and labor productivity.

Table 4. Innovation intensity and firm characteristics

Innov. intensity	# of firms	Frequency (percent)	Avg. Sales (M PLN)	Avg. Employ	Avg.Sales per employee (k PLN)	Avg.log (labor prod.)	Avg. log (TPROD)
0	47	6.63	101.1	94.4	1070.7	5.9	3.1
1	124	17.49	84.0	68.2	1231.7	5.7	3.2
2	168	23.70	91.4	115.1	794.3	5.8	3.1
3	161	22.71	270.9	118.3	2289.8	5.8	3.1
4	126	17.77	107.5	129.0	833.2	5.7	3.0
5	57	8.04	64.7	124.2	521.0	5.4	2.9
6	20	2.82	78.7	126.0	625.0	6.0	3.0
7	6	0.85	123.1	185.0	665.7	6.0	3.6
8	0	0.00	:	:	:	:	:
9	0	0.00	:	:	:	:	:
Total	**709**	**100**	**134.6**	**110.5**	**1217.6**	**5.7**	**3.1**

Notes: Modes of innovation activity are non-mutually exclusive.

Source: author's own calculations from survey and InfoCredit databases.

Figures 2 depicts the relation between innovation intensity and firm's productivity, by plotting kernel density estimates of total productivity for companies with different innovation intensities (none or low, medium, high). In contrast to internationalization intensity, the density plots do not differ greatly from each other. Being more innovative is not linked automatically to a greater productivity at least in our sample of Polish companies.
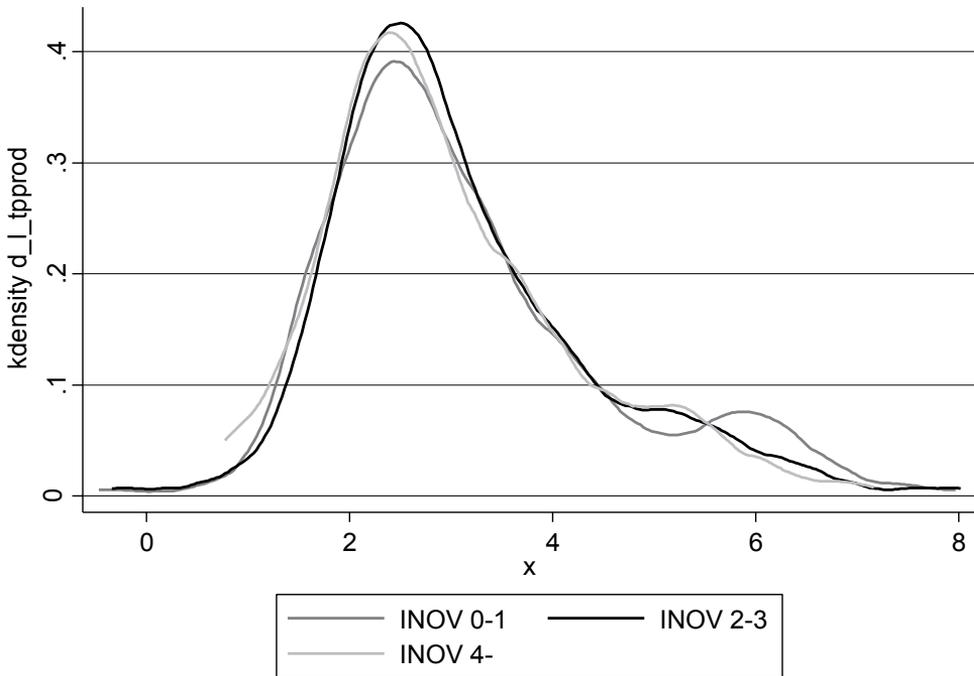
Figure 2. Kernel estimates of total productivity of enterprises by innovation intensity (INOV)

Source: author's own calculations from survey and InfoCredit databases. Estimates in STATA.

4.3. Internationalization and innovation of firms

Having investigated the relationship between internationalization and innovation and firm performance separately, we now turn to a simultaneous analysis of both dimensions.

The result is given in Figures 3 and 4 in which internationalization intensity and innovation intensity are correlated and presented jointly. Similarly to Altomonte *et al.* (2013), we clearly observe pyramidal structures. Moving along the diagonal in Figure 3, which depicts the distribution of firms along the two dimensions and their shares in a total number of companies in our sample (i.e. simultaneous increase in internationalization and innovation), leads to a clear drop in the number of firms. It is evident that most companies in our sample belong to the group of low innovation and internationalization extents. There are no companies present at the other extreme – with high values on both dimensions. On the positive note, only two companies have zero innovation and internationalization intensity scores.
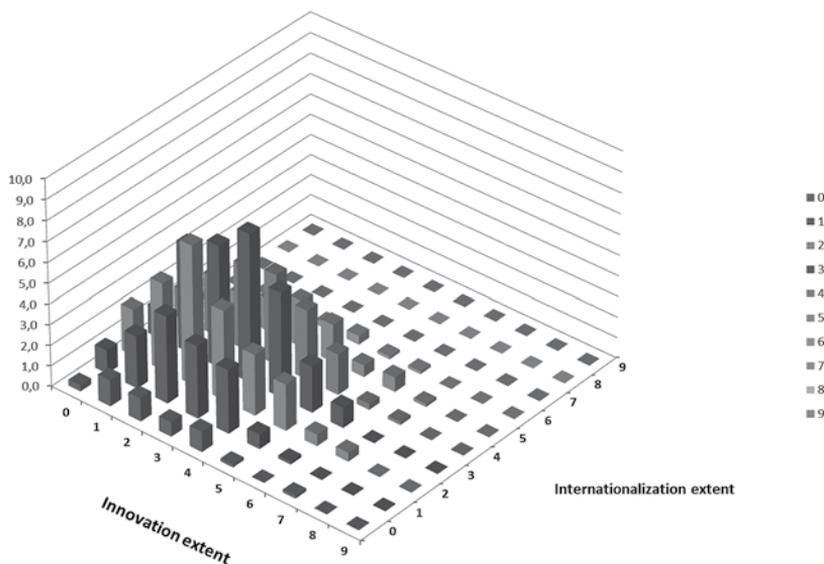
Figure 3. Internationalization vs. innovation intensity (frequencies)
Source: author's own calculations from survey and InfoCredit databases.

Figure 4 shows the distribution of firms along the two dimensions and their shares in total employment in our sample. In contrast, we now control for firm's size, as measured by employment. It is evident in comparison to Figure 3, that the shares are shifted towards larger firms. Compared to Altomonte *et al.* (2013) – we clearly observe, the lack of shift in the distribution towards the companies with greater internationalization and innovation extents. In their study the peak of the distribution existed for the high levels of innovation and internationalization – the bulk of employment was thus accounted for by the firms engaged with several internationalization and innovation modes. In our study, the clear shift does not occur – the pyramidal structure is only steeper with the peak corresponding to companies with low innovation and internationalization intensities. The lack of a clear shift in the distribution could be considered one of the prime reasons for the weaker competitive position of Poland in the international markets: Poland in comparison to its Western European counterparts, clearly lacks larger firms.
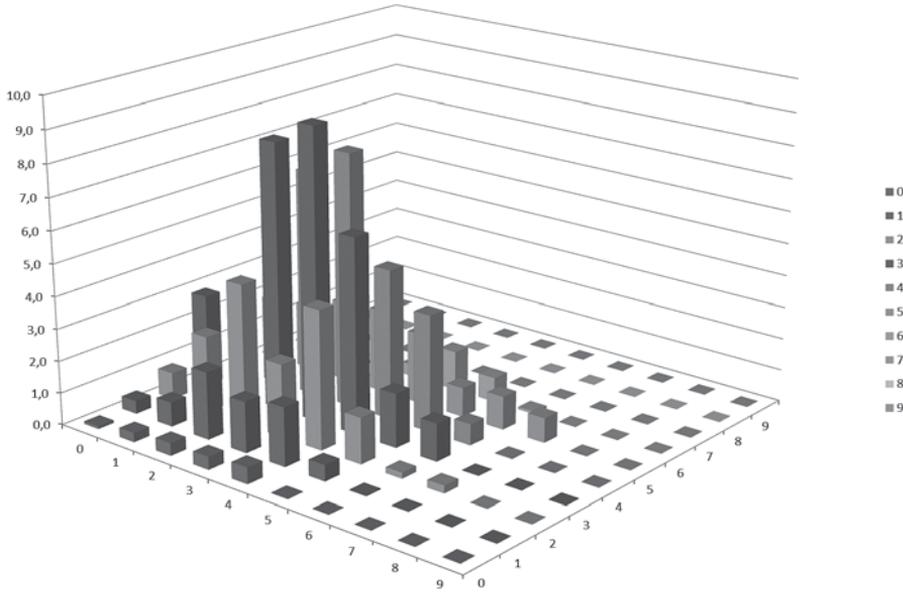
Figure 4. Internationalization vs. innovation intensity (share in total employment)

Source: author's own calculations from survey and InfoCredit databases.

5. Initial econometric analysis

Similarly to Altomonte *et al.* (2013), we start the econometric analysis by estimating a set of simple regression models. Models M1−M4 in Table 5 are estimations of the following equations using OLS, respectively:

$$INTER_i = \alpha_0 + \beta_1 INNOV_i + \varepsilon_i \tag{1}$$

$$INTER_i = \alpha_0 + \beta_1 INNOV_i + \vartheta_r + \gamma_e + \delta_s + \varepsilon_i \tag{2}$$

$$INTER_i = \alpha_0 + \beta_1 INNOV_i + \beta_2 \ln (TPROD)_i + \vartheta_r + \gamma_e + \delta_s + \varepsilon_i \tag{3}$$

$$INTER_i = \alpha_0 + \beta_1 INNOV_i + \beta_2 \ln (TPROD)_i + \beta_3 X_i + \vartheta_r + \gamma_e + \delta_s + \varepsilon_i \ (4). \tag{4}$$

Where $INTER_i$ represents the internationalization intensity of firm i; $INNOV_i$ is the innovation intensity of firm i; α_0 is the intercept, β_1 is the coefficient of interest; ln (TPROD) is the natural logarithm of total productivity for firm i, X_i is a vector of other explanatory variables, controlling for other firm-specific features discussed in the mainstream literature of the subject and ϑ_r, δ_s and γ_e are region, sector, and size effects; ε_i is the error term. The regional effects reflect variation in regional innovation systems (at NUTS-2 level), in which companies are nested and

variation in regional innovation, export promotion and structural policies which could both benefit or hinder firm internationalization and innovation activities (Cooke 2002). Size effects are introduced by dummies for micro, small, medium and large enterprises based on their employment with thresholds at 10, 50, 250 employees. Taking into account significant heterogeneity across sectors, we control sectoral effects at the NACE 2-digits or by a simple dummy variable, discriminating between manufacturing and service firms (the preferred method).

Table 5. Internationalization and innovation intensity – OLS estimates

	M1	M2	M3	M4
INNOV	0.105	0.089	0.102	0.081
	(0.033)***	(0.033)***	(0.033)***	(0.034)**
L_TPROD			0.115	0.132
			(0.041)***	(0.043)***
L_CAPITAL				0.061
				(0.026)**
L_AGE				0.152
				(0.088)*
Const	2.423	2.483	1.454	-0.434
	(0.997)***	(0.394)***	(0.526)***	(0.584)
Region		yes	yes	yes
Sector		yes	yes	yes
Size		yes	yes	yes
R2	0.02	0.12	0.18	0.20
N	709	709	709	577
F	9.95	4.39	7.17	7.09

Source: author's own calculations from survey and InfoCredit databases. Estimated in STATA. Robust standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

The results of estimation in Table 5 show that higher innovation intensity is strongly correlated with higher internationalization intensity (M1). It even holds after we control for region, size and sector fixed effects (M2), to account for constant characteristics of firms that might induce both innovation and internationalization. The positive relationship also holds after controlling for a firm-level total productivity (M3) as well as other features (M4) such as capital endowment (lnK) or firm age (lnAGE). Firm age is computed as the difference between the calendar year at t and the company's birth-year. The control for human capital endowment proved to be statistically insignificant – the share of employees with higher education and thus has not been shown here. The regional effects were statistically significant at least at 5 percent level and positive for wielkopolskie, mazowieckie,

dolnoslaskie and lodzkie (given in order of decreasing magnitude). The effects of employment size are the strongest for medium and large firms in accordance with our expectations.

However, the OLS estimates do not acknowledge the discrete character of the dependent variable. If the dependent variable has three or more categories (as in our case) and is nominal or ordinal one, then we can utilize either the multinomial logit (MNL) and ordered logit (OL) models that are most commonly used in the empirical literature (Greene 2012). In MNL we deal with nominal outcomes with no intrinsic order (for instance qualitative in nature). In OL, in turn, we deal with ordinal or inherently ordered variables. The key question is whether taking into account our definitions of internationalization and innovation extents, we can assume that natural order of internationalization exists.

In MNL a series of binary logit (probit) models is estimated. One group is chosen to be the base, or in other words, reference category for the other groups – in our case the zero internationalization intensity.

In ordered logit, we estimate the cumulative probability of being in one category versus all lower or higher categories. The ordered logit is based on the proportionality assumption – the distance between each category is assumed to be equivalent. The assumption is tested using the Brant test. If it fails, one can utilize the generalized ordered logit/partial proportional odds models (Williams 2006) or utilize MNL.

Thus Table 6 gives first the results of a Multinomial Logit (MLN) postulated by Altomonte *et al.* (2013), where no particular order is given to the non-zero outcomes of the dependent variable. The downside of MNL is that the information contained in the ordering of variable is lost. Furthermore, several issues in specification tests have to be taken into consideration (Hausman and McFadden 1985; Small and Cheng 1985). The zero outcome (zero internationalization intensity or being a purely domestic firm) is treated as the base category. The analyzed model relies on specification M3. Similarly to the OLS results reported above, we estimate two versions of the MNL without and with fixed effects. The values correspond to the possible outcome variable levels in line with our definition. It should be noted that in the table, for clarity, we do not report the coefficients for other explanatory variables, apart from innovation intensity. The odds ratios can be calculated as the base *e* and raised to the power of the coefficient.

Table 6. Internationalization and innovation intensity – multinomial logit (MNL) and order logit (OL) estimates

	MNL (1)	MNL (2)		OL (1)	OL (2)
			0	0.300	0.243
				(0.321)	(0.323)
Pr (1)	0.189	0.199	**1**	0.157	−0.011
	(0.158)	(0.171)		(0.305)	(0.310)
Pr (2)	0.187	0.179	**2**	0.662	0.632
	(0.154)	(0.167)		(0.307)**	(0.311)**
Pr (3)	0.329	0.331	**3**	0.600	0.415
	(0.154)**	(0.168)**		(0.320)*	(0.326)
Pr (4)	0.302	0.279	**4**	0.671	0.563
	(0.156)*	(0.172)		(0.362)*	(0.371)
Pr (5)	0.460	0.423	**5**	1.406	1.357
	(0.171)***	(0.189)**		(0.518)***	(0.527)***
Pr (6)	0.600	0.657	**6**	1.099	0.726
	(0.263)**	(0.297)**		(0.962)	(0.963)
No. of observations	623	623	**No. of observations**	623	623
Pseudo R2	0.0144	0.1142	**Pseudo R2**	0.0077	0.0615
LR chi 2	30.64	246.96	**LR chi 2**	16.44	130.58
AIC	2128.91	2140.58	**AIC**	2135.11	2058.97
Region dummies	no	yes	**Region dummies**	no	yes
Sector dummies	no	yes	**Sector dummies**	no	yes
Size dummies	no	yes	**Size dummies**	no	yes

Source: author's own calculations from survey and InfoCredit databases. Estimated in STATA. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

The likelihood chi-square ratio tells us that our models are statistically significant, as compared to the null model with no predictors. Furthermore, it is clear that the MNL results are in general in line with the OLS model: higher intensity of innovation increases the probability of internationalization, although in a non-monotonic manner. The effect of innovation intensity on the extent of internationalization tends to be statistically significant and increases once the firm is already involved in at least three or more innovation activities.

If in turn, we treat the dependent variable as ordered, we can utilize the ordered logit estimation method, as has been suggested by the peer reviewer of the original paper. Once again, the models (OL1 and OL2 in the right-hand side of Table 6) rely on specification M3 without and with fixed effects for the region, sector, and firm

size. As we do not assume the base category, as was the case in MNL, the values go from 0 to 6. Non-significant test statistic of Brant (not reported here) tells us that proportional odds assumption has not been violated. Most coefficients on the innovation intensity are statistically significant. Moreover, once again higher intensity of innovation increases the probability of internationalization in a non-monotonic manner. Pseudo R2 are low. However, they is no exact analog to R-square in OLS. The results point to the same direction as the estimates of MNL models. Generalized order logit has also been considered (Williams 2006). The results, not shown here for clarity, do not differ significantly from the ones obtained by OL (they are available upon request).

Comparing the results of the four models in Table 6, it should be noted, however, that the likelihood chi-square ratios are the highest along with AIC values for MNL with fixed effects – controlling for size, regional and sectoral effects. We still treat it as the best alternative, non-assuming the ordered nature of the dependent variable alongside innovation intensity.

The previous results support the conclusion that the positive correlation between internationalization and innovation intensities is not spuriously driven by observable firm characteristics, including total productivity. It is consistent with the correlation, being the outcome of specific firm choices to increase both internationalization and innovation dimensions (though not necessarily in that sequence) over time.

Although the positive correlation between internationalization and innovationis robust, we face the problem of potential reverse causality. Due to the cross-sectional character of the available dataset, it is hard to sort out the actual direction of causality. Endogeneity of variables leads OLS to produce biased and inconsistent estimates. It necessitates the use of the instrumental variable method (IV). IV is utilized when the correlation between the explanatory variable and the dependent variable does not reasonably reflect their causal relationship. A valid instrument should induce changes in the explanatory variable, but should not have an independent effect on the explained variable.

After a careful analysis and after taking into account the nature of the available data in the present study, we utilize two innovation-related variables as instruments of the innovation intensity that is membership in an industrial cluster (CLUSTER) and the declared innovation strategy of the firm (IN_STRATEGY). Both variables are only very weakly correlated with the internationalization intensity (pairwise correlations of 0.0838 and 0.0254, respectively) but more firmly and robustly with the innovation extent of a company (0.1960 and 0.2785).

The IV regression results are reported in Table 7. In the first stage, we regress innovation intensity on the two instruments and find that coefficients are both positive and statistically significant (at 1 percent level). The summary statistics of the first stage are at the same time encouraging both for R^2 and adjusted R^2 (0.1814 and 0.1564).

Table 7. Internationalization and innovation intensity – MNL estimates

First stage Regression	
	Innovation Intensity
CLUSTER	1.800
	$(0.301)^{***}$
IN_STRATEGY	0.292
	$(0.043)^{***}$
Region dummies	yes
Sector dummies	yes
Size dummies	yes
R2	0.1814
Adj. R2	0.1564
No of observations	709
F (21, 687) test	8.86
IV Regression	
	Internationalization intensity
Innovation intensity	0.271
	$(0.100)^{***}$
No. of observations	709
R2	0.1495
Region dummies	yes
Sector dummies	yes
Size dummies	yes
Test of over-identifying restrictions	
Hansen's J chi2(1) = 2.02531 (p = 0.1547)	

Source: author's own calculations from survey and InfoCredit databases. Estimated in STATA. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Moving to the second stage of the regression, the coefficient on innovation intensity is positive and significant (at 1 percent) with a unit increase in innovation intensity associated with (on average) an almost 1/3 unit increase in internationalization intensity (0.271).

Furthermore, the output of the instrumental variable model demonstrates that the coefficient on the innovation intensity is approximately three times larger than the one initially returned by the OLS regression (please refer to Table 5).

Testing for the weakness of the instruments, we see that the value of the F statistic for joint significance is lower than the rule of thumb value of 10 but not very far away from it. The test of over-identifying restriction shows that one cannot reject the null hypothesis that both instruments are valid (p = 0.1547 > 0.05).

The IV results confirm the previous OLS estimates (that is a positive effect of innovation intensity on internationalization intensity) and suggest that greater in-

novation activity is very likely to increase the internationalization extent of a firm. Nonetheless, due to a cross-sectional nature of our dataset, we should interpret the results with certain caution.

6. Econometric analysis of the probability of exporting

Taking into consideration the hereto obtained results we would like to jointly estimate the impact of internationalization intensity and innovation intensity on the likelihood of exporting using the standard logit approach.

The estimation results of a logit model are presented in Table 8. The base model, not taking innovation-related aspects into account, is estimated in the specification L1. The dependent variable is binary – exporter versus non-exporter status. Higher productivity (l_TPROD), as expected, has a positive impact on the likelihood of exporting. We also control for other standard features, such as firm size (measured by the log of employment, l_EMPLOY), firm age (FIRM AGE) and other aspects of greater internationalization, such as importer status (IMPORTER), the presence of foreign capital (FOR.CAPITAL) or foreign capital investments carried out by the company itself (FDI). We control for firm age, as it was shown to play a significant role in some studies (e.g., Garcia-Quevedo, Pellegrinoa and Vivarellic 2014; Nassimbeni 2001). The coefficients on the base variables are statistically significant. Of these, the odds ratios are highest for FDI and imports.

In the next step, we augment the logit analysis by introducing the concepts of innovation and internationalization extents. The scope of internationalization is modified, in contrast to the initial part of the paper, by excluding export-related aspects for obvious reasons. We thus introduce a new measure for internationalization (INTERN.MOD), taking all export related elements from our initial variable INTERN. The modes considered are once again non-exclusive and internationalization extent now ranges between 0 and 6.

It is clearly evident, looking at the results, that innovation intensity has a clearly positive impact on the likelihood of exporting whether we control (L2) or we do not control (L3) other dimensions of internationalization included in the base regression. It is in line with the studies like Monreal-Perez, Aragon-Sanchez and Sanchez-Marin (2012) or Van Beveren and Vandenbussche (2010) and in contrast to the result of Damijan *et al.* (2010) which found no impact of innovation on the likelihood of exporting in a sample of Slovenian firms.

If we take into account only the extent of internationalization (L4), the impact is statistically significant and positive, in accordance with our expectations. If, as in (L5), we control simultaneously for the impact of both innovation and internationalization extents – it is positive. However, the magnitude of the second one is much stronger. The odds ratios are respectively 1.25 and 1.76. A unit increase in the innovation extent raises the likelihood of exporting by 25 percent.

In the last specification, we control for potential regional variation in innovation systems (Cooke 2002) by adding the regional dummies for NUTS 2 voivodeships. It does not change the results greatly. However, it increases the magnitude of the impact of both key variables. The odds ratio increases to 1.328 and 1.846, respectively. The regional effects are positive, strong and robust in particular for dolnoslaskie, kujawsko-pomorskie, and wielkopolskie (not reported in the Table).

Table 8. The impact of innovation and internationalization extents on likelihood of firm's exports

	(L1)	(L2)	(L3)	(L4)	(L5)	(L6)
L_TPROD	0.508***	0.505***	0.580***	0.547***	0.545***	0.564***
	(0.103)	(0.102)	(0.100)	(0.0988)	(0.0986)	(0.100)
L_EMPLOY	0.912***	0.864***	0.983***	0.910***	0.863***	0.870***
	(0.124)	(0.124)	(0.116)	(0.116)	(0.114)	(0.121)
IMPORTS	1.174***	1.166***				
	(0.227)	(0.228)				
FOR. CAPITAL	0.0196***	0.0194***				
	(0.00460)	(0.00453)				
FDI	3.784***	3.709***				
	(0.910)	(0.942)				
FIRM AGE	0.0366***	0.0333***	0.0377**	0.0392***	0.0367**	0.0383**
	(0.0129)	(0.0127)	(0.0149)	(0.0152)	(0.0146)	(0.0152)
INNOV		0.196***	0.218***		0.228***	0.284***
		(0.0744)	(0.0684)		(0.0739)	(0.0785)
INTERN. MOD				0.569***	0.578***	0.613***
				(0.101)	(0.102)	(0.110)
Constant	−5.705***	−5.949***	−5.917***	−6.041***	−6.406***	−7.549***
	(0.715)	(0.726)	(0.747)	(0.708)	(0.729)	(0.923)
Region dummies	no	no	no	no	no	yes
Observations	621	621	621	621	621	621
Pseudo R2	0.306	0.3152	0.1973	0.2296	0.2429	0.2802
AIC	542.50	537.53	621.85	596.68	588.54	590.16
AUC	0.8546	0.8595	0.7989	0.8129	0.8209	0.8438

Source: author's own calculations. Estimated in Stata 12. Logit model. Dependent variable – exporting, binary. Robust standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The odds ratio is equal to e raised to the power of a coefficient on the variable.

7. Concluding remarks

Innovation is said to play a central role in the export, and more generally, in internationalization behavior of firms. To verify this hypothesis, we have exploited the unique quantitative and qualitative dataset to investigate the relationship between internationalization and innovation extents in a sample of firms operating in Poland. Our results firmly support the postulates of the new trade theory of Melitz (2003). Firms self-select to export, with productivity being a key determinant. Firms, that are inferior – regarding productivity – are not able to enter or compete and remain in the more demanding foreign markets.

We have found that the firms in our data set are quite active in both innovation and internationalization. Descriptive statistics showed that companies differ a lot along both innovation and internationalization dimensions. Internationalization intensity, as well as innovation intensity, increases with firm's size (as measured by employment). It is clearly in contrast to Pla-Barber and Alegre (2007). Average labour productivity and total productivity show a similar pattern. The distribution of productivity among internationalization intensities clearly differs, however, all are skewed to the right. The right tails of distributions are clearly longer and thicker for more internationalized firms. In contrast, the density plots for various innovation intensity classes do not differ greatly from each other. Companies with higher innovative intensity, at least in our sample of enterprises from Poland, do not noticeably enjoy a distinct advantage automatically, in terms of superior productivity.

Overall, we have identified a substantial heterogeneity in the extent of simultaneous involvement in internationalization and innovation. Firms with relatively low intensities along the two dimensions clearly dominate – the pyramidal structure of simultaneous distribution along the two analyzed dimensions has its peak at low levels. Enterprises with higher innovation intensity also tend to show higher internationalization intensity; they are rare, however. If we take employment size into account, the distribution of total employment is steeper, however, does not shift along the diagonal as was the case in Altomonte *et al.* (2013).

Econometric analysis (OLS, MNL, OL, and IV) has proven, to a large extent, the role of innovation in the internationalization of firms. By instrumenting innovation intensity, we found evidence that this positive association is causal – from innovation to internationalization. However, some caution is still necessary, bearing in mind the cross-sectional nature of our dataset. More elaborated analysis on a panel of firms observed over an extended period is required to confirm our results fully. In the future more effort is needed to eliminate a potential bias due to our definition of internationalization and innovation extents – assuming equal weight and thus significance to each mode.

Our results support the postulates by Altomonte *et al.* (2013), on the close connection between innovation and internationalization extents. The nexus is evident. The results obtained for Poland are generally speaking in line with the results

obtained in the benchmark study for seven European states. Furthermore, innovation intensity has a clearly positive impact on the likelihood of exporting. A unit increase in innovation extent raises the probability of exporting by roughly 25 percent.

It seems that the nexus between innovation and internationalization extents as well as firm productivity should be closely addressed by a new type of economic policy to boost the overall level of competitiveness.

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Appendix

Table A. Summary statistics of variables utilized in econometric modeling

Variable	Obs.	Mean	Std. Dev.	Min	Max
CLUSTER	709	0.020	0.139	0.000	1.000
FDI	709	0.102	0.302	0.000	1.000
FIRM AGE	709	20.670	18.694	1.000	172.000
FOR.CAPITAL	709	0.257	0.437	0.000	1.000
IMPORTS	709	0.446	0.497	0.000	1.000
IN_STRATEGY	709	2.568	1.291	1.000	4.000
INNOV	709	2.671	1.522	0.000	7.000
INTERN	709	2.704	1.349	0.000	6.000
INTERN.MOD	709	2.001	1.133	0.000	4.000
L_CAPITAL	661	7.504	2.204	−1.011	12.501
L_EMPLOY	672	3.976	1.201	0.000	7.601
L_TPROD	623	3.068	1.292	−0.470	8.018

Source: author's own calculation. Estimated in Stata 12.