

## Technological Innovations and Firm Internationalisation

*Gamze OZTURK-DANISMAN* (<https://orcid.org/0000-0003-3684-6692>), *Kadir Has University, Turkey;*  
*gamze.danisman@khas.edu.tr*

### Teknolojik İnovasyonlar ve Firmaların Uluslararasılaşma Faaliyetleri

#### Abstract

This paper explores the relevance of technological innovations for the internationalisation of manufacturing firms. It differentiates between two technological innovations: eco-innovations and generic-technological innovations (i.e., intelligent manufacturing). By pooling the Flash Eurobarometer-415 and -433 surveys, we use a broad firm-level sample of 4954 European and non-European (the US and Switzerland) manufacturing firms. Applying the Heckman selection model, the findings indicate that eco-innovations positively affect the decision of the firms to internationalise whilst showing no significant impact on the level of international operations. On the other hand, generic-technological innovations positively affect both the decision and the level of global operations.

**Keywords** : Internationalisation, Eco-Innovation, Intelligent Manufacturing, Generic-Technological Innovations.

**JEL Classification Codes** : Q50, Q55, D22, F18.

#### Öz

Bu makale, teknolojik inovasyonların imalat firmalarının uluslararası operasyonlarına etkisini incelemektedir ve iki tür teknolojik yeniliğe odaklanmaktadır: eko-inovasyonlar ve jenerik-teknolojik yenilikler (akıllı üretim). Flash Eurobarometer-415 ve Flash Eurobarometer-433 anketlerini bir araya getirerek, 4954 adet Avrupa ve Avrupa dışı (ABD ve İsviçre) imalat firmasından oluşan firma düzeyinde geniş bir örneklem kullanılmaktadır. Ekonometrik analizlerde Heckman seçim modeli uygulanmaktadır. Bulgulara göre eko-inovasyon, firmaların uluslararasılaşma kararlarını olumlu etkilemektedir, ancak uluslararası operasyonların düzeyi üzerinde önemli bir etki göstermemektedir. Jenerik-teknolojik yenilikler ise uluslararası operasyonların hem kararını hem de seviyesini olumlu yönde etkilemektedir.

**Anahtar Sözcükler** : Uluslararasılaşma, Eko-İnovasyon, Akıllı Üretim, Jenerik-Teknolojik İnovasyon.

## 1. Introduction

The importance of internationalisation is well acknowledged by scholars, practitioners, and policymakers. As firms develop their exporting skills and enter international markets, they can tap into non-utilized operating capacity, improve their production efficiency, experience an improvement in competitiveness, and ensure survival and growth (Westhead et al., 2001; Matanda & Freeman, 2009; Azar & Ciabuschi, 2017). Since export operations are vital for both firms and economic prosperity, understanding what drives export performance stands as an essential area of research for both academics and policymakers (Sousa et al., 2014).

It is well established in the literature that there is a strong relationship between innovation and firm growth (Walker, 2004; Damanpour et al., 2009), and innovations bring a competitive advantage. Firms innovate as a response to changing market environments, gain early mover advantages, and operate efficiently. Innovations are accepted as the main growth strategy tools for firms willing to enter new markets (Gunday et al., 2011; Wang et al., 2008) and are claimed to improve firms' exports by increasing their productivity and new product developments (Alvarez, 2004). There are different typologies offered in the literature for the distinction between different types of innovations. The technological vs non-technological distinction is the most common one (Damanpour et al., 2009; Camisón & Villar-López, 2014). While technological innovations refer to improvements in the operating systems (i.e., product and process innovations), non-technological innovations include marketing and organisational innovations.

This paper focuses on technological innovations and their components, generic technological innovations vs eco-innovations. Technological innovations help firms rapidly adjust to technological changes in highly competitive global markets, bring more efficient production, offer new products and processes, and enhance their competitive advantage (Kafouros et al., 2008; Zahra & Covin, 1995; Gunday et al., 2011). The strong form of the Porter Hypothesis documents that firms can grow and simultaneously address environmental and growth objectives through their development of eco-innovations (Porter, 1991; Porter & Van Der Linde, 1995). Despite the volume of studies on the innovation-performance relationship, there is scarce evidence on the relationship between technological innovations (both generic ones and eco-innovations) on firm performance (Demirel & Danisman, 2019). The impact of such innovations on firm exports has received relatively less attention than other economic performance indicators such as profitability and market prices. To improve our understanding of how firms accomplish a superior export performance, we argue that it is crucial to consider technological innovations in this paper.

This study contributes to the scant literature by linking the international business and innovation literature and revealing the positive effects of generic technological innovations and eco-innovations on export performance. We pool the Flash Eurobarometer-415 and the Flash Eurobarometer-433 surveys and use a broad firm-level sample of 4954 European and non-European (the US and Switzerland) manufacturing firms. We apply the Heckman

selection model, and our findings indicate that eco-innovations positively influence the decision to internationalise. Still, we document no significant impact on the level of international operations. On the other hand, generic-technological innovations positively affect both the decision and the level of global operations. Overall, our findings reveal that technological innovations are an important first step for manufacturing firms to start international operations, both in sustainable and generic form. Generic-technological innovations are further helping to boost their level of exports.

The rest of the paper is organised as follows. Section 2 presents related literature; Section 3 provides data and methodology. Section 4 discusses the findings, and Section 5 concludes.

## **2. Related Literature**

Innovation includes the generation and adoption of a new idea or behaviour transformed into new products or services, new process technologies, new organisational forms, or new managerial approaches (Damanpour & Aravind, 2011; Azar & Ciabuschi, 2017). It is acknowledged in the literature that innovation improves firm performance (Walker, 2004; Damanpour et al., 2009; Fazlıođlu et al., 2019; Dalgıç & Fazlıođlu, 2021) and brings a competitive advantage in international markets (Pla-Barber & Alegre, 2007; Singh, 2009). Firms innovate to respond to changing market environments, gain early mover advantages, eliminate performance gaps, operate efficiently, and respond to environmental demands. Such efforts lead to superior firm performance (Damanpour & Evan, 1984; Damanpour et al., 2009) and enhance a firm's export status (Alvarez, 2004).

The resource-based view (RBV) constitutes a theoretical background to analyse innovations and their effect on firm performance (Damanpour et al., 2009; Yang et al., 2009). According to the RBV, firms with specific capabilities gain a competitive advantage and perform better. The success of these capabilities depends on their uniqueness, value, durability, and inimitability (Amit & Schoemaker, 1993; Barney, 1986, 1991; Peteraf, 1993). A capability denotes the deployment and reconfiguration of resources to achieve better performance, and it can be either technological or non-technological innovation capability (Demirel & Kesidou, 2019). Technological innovations are achieved through capabilities that improve a firm's operating systems, production processes, and service operations, including product and process innovations. Non-technological innovations mainly impact the management systems and comprise marketing and organisational innovations.

Our interest in this paper is on technological innovations and how they impact the export performance of firms. Technological innovation capability is an important source of competitive advantage (Coombs & Bierly, 2001, 2006). Technology-based models posit that firms' quality of products and services do drive their competitive advantage. These models are based on a firm's capabilities, such as investments in new technology implementations new product and process developments (Nelson, 1993; Metcalfe, 1994). Bustos (2011), in a model of heterogeneous firms allowing for firms investing in innovations, find that they can

reduce their marginal costs and improve their technology, thereby experiencing product upgrading, lower production costs, lower prices on sales, and an increase in their exports. Technological innovation capabilities help conduct any relevant technical function within the firm, such as developing new products or services and more effective operations. It is a vital determinant of firm performance (Ortega, 2010; Tsai, 2004). However, a growing literature documents that it is not always possible for firms to reap benefits from innovations. The impact of innovation on firm growth is observed to be conditional on certain firm-level factors (Coad et al., 2016), specific innovation strategies (Coad & Rao, 2008), and the industry structure (Mazzucato & Parris, 2015). Nevertheless, in this paper, we expect to observe a positive impact of generic technological innovations on export performance (both the decision to export and the level of exports) in line with the view above that they spur competitiveness of firms and impact firm exports positively.

Regarding the influence of eco-innovations on firm performance, there has been a debate on the impact of environmental regulations on competitiveness. Two hypotheses stand out in the environmental economics literature: the pollution haven hypothesis (PHH) and the Porter hypothesis (PH). PHH takes environmental policies as a constraint to factor endowment in the Heckscher-Ohlin theoretical framework. It argues that firms face higher production costs under more stringent environmental policies, which deteriorates the international competitiveness and leads dirty industries to delocalised towards countries with less stringent environmental regulations, causing pollution havens (Copeland & Taylor, 2004; Levinson, 2010; Levinson & Taylor, 2008). On the other hand, PH takes a dynamic approach and argues that environmental regulations cost-cutting productivity gains. They reduce or offset the regulatory costs, stimulate innovations and enable firms to obtain international leadership in technology (Porter and van der Linde 1995; van den Bergh et al., 2000; Wagner, 2007). Regulations adjust the behaviour of firms at the frontier of efficiency. They create a favourable environment for green product demand, scarce resources are priced, and thereby unexploited technologies are generated (Wagner, 2007). Environmental focus brings more investment in developing cleaner technologies and generates input savings that offset compliance costs and improve export performance.

Empirical evidence regarding the influence of eco-innovations on firm growth is ambiguous. In line with the abovementioned economics of innovation literature, eco-innovation literature documents that it is not always likely to capture economic gains from eco-innovations (Stucki et al., 2018). These studies find that the positive impact is contingent on specific firm or innovation characteristics, and some of the studies show insignificant or negative results (Filbeck & Gorman, 2004; Rexhäuser & Rammer, 2014; Popp, 2005). Other studies support the positive effects of environmental and innovation strategies on firm performance. Costantini and Mazzanti (2012) find support for PH for the EU15 countries over the 1996-2007 period and see that green exports are flourished under environmental policies and environmental innovation efforts. They state that when complemented by relevant public policies and firm-level innovation efforts, the environmental protection activities of firms turn into a net benefit instead of "cost" through the efficiency gains in the

production stage. Since the findings are mixed in the literature, we do not have a priori expectation of eco-innovations impact on firm exports.

### 3. Data and Methodology

#### 3.1. Data and Variables

This paper uses a unique data source by pooling the two recent Eurobarometer surveys: Flash Eurobarometer-415 on 'The Innovation Trends at EU Enterprises' and Flash Eurobarometer-433 on 'EU business innovation trends'. These two surveys cover the same questions but are conducted on anonymous and unmergeable firms. These surveys have been requested by the European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship, and SMEs. Flash Eurobarometer-415 was conducted in 2015 and Flash Eurobarometer-433 in 2016. The two surveys cover more than 25,000 enterprises, employing one or more persons (excluding the owner) from various sectors and are conducted in 28 European Union and two non-European (the US and Switzerland) countries. The firms that participated in the surveys include small and medium enterprises (SMEs) (with the number of employees fewer than 250) and larger firms. The selected respondents are general managers, financial directors, or significant owners. Our focus is on manufacturing firms, consisting of 4954 firms from 30 countries, when generating our sample. The manufacturing sector was selected because the survey questions for our variables of interest were directed only to manufacturing firms. All interviews were carried out through phones using the TNS e-call centre. Table 1 presents the country breakdown of the sample. The highest number of firms is in Switzerland (248), and the lowest is in Malta (82).

**Table: 1**  
**Country Breakdown**

Country	Number of firms	% of total	Country	Number of firms	% of total
Austria	180	3.63	Latvia	153	3.09
Belgium	145	2.93	Lithuania	161	3.25
Bulgaria	171	3.45	Luxembourg	31	0.63
Croatia	191	3.86	Malta	82	1.66
Cyprus	92	1.86	The Netherlands	129	2.6
Czech Republic	205	4.14	Poland	207	4.18
Denmark	171	3.45	Portugal	173	3.49
Estonia	189	3.82	Romania	213	4.3
Finland	150	3.03	Slovakia	210	4.24
France	158	3.19	Slovenia	243	4.91
Germany	165	3.33	Spain	150	3.03
Greece	177	3.57	Sweden	159	3.21
Hungary	211	4.26	Switzerland	248	5.01
Ireland	127	2.56	The UK	167	3.37
Italy	176	3.55	The USA	120	2.42
			<b>Total</b>	<b>4954</b>	<b>100</b>

*Note: This table presents the country breakdown of the sample.*

Table 2 presents a brief description of the variables used in our analysis. The dependent variable is firm internationalisation (INT LEVEL), a continuous variable calculated as the share of turnover from sales outside their own country. Table 3 presents the descriptive statistics, and we observe that, on average, the share of sales revenue from

international markets is 31% in our sample. We use an alternative internationalisation variable, INT DUMMY, generated as an indicator variable that equals 1 for firms with sales abroad; 0 otherwise. On average, 58% of the firms in our sample have sales abroad.

The first independent variable of interest is eco-innovation (EI) which takes a value of 1 if the company has implemented sustainable manufacturing technologies or planning to adopt them in the next year; 0 otherwise. Sustainable manufacturing technologies cover the technologies that use energy and materials more efficiently and help diminish emissions. Table 3 shows that, on average, 38% of the firms in our sample either implement or plan to implement eco-innovations. For robustness, we generate an alternative eco-innovation variable by excluding the firms with plans for implementation and including only those who have already adopted one. We call this variable EI V2 equals one if they have already adopted sustainable manufacturing technologies, 0 otherwise. On average, 31% of the firms in our sample have already implemented eco-innovations.

**Table: 2**  
**Variables**

<b>Dependent variable</b>	<b>Description</b>
Internationalisation level (INT LEVEL)	The share of turnover from sales outside their own country.
Internationalisation Dummy (INT DUMMY)	Equals one if the company sells products or services outside their home country; 0 otherwise.
<b>Independent variables</b>	
Eco-innovation (EI)	Takes a value of 1 if the company has adopted or planning to adopt sustainable manufacturing technologies in the next year; 0 otherwise. Sustainable manufacturing technologies cover the technologies which use energy and materials more efficiently and reduce emissions.
Eco-innovation (EI V2)	Takes a value of 1 if the company has already adopted sustainable manufacturing technologies; 0 otherwise.
Technological innovation (TECH INV)	Equals one if the firm has implemented or planning to implement the following technologies in the next 12 months; 0 otherwise: ICT-enabled intelligent manufacturing or high-performance manufacturing.
Technological innovation (TECH INV V2)	Equals one if the firm has already implemented the following technologies, 0 otherwise: ICT-enabled intelligent manufacturing or high-performance manufacturing.
Technological innovation (TECH INV IM)	Equals one if the firm has implemented or planning to implement ICT-enabled intelligent manufacturing (IM) in the next 12 months; 0 otherwise.
Technological innovation (TECH INV HP)	Equals one if the firm has implemented or planning to implement high-performance manufacturing (such as high precision machine tools, advanced sensors, and 3D printers) in the next 12 months; 0 otherwise.
Size (SIZE)	The natural logarithm of the number of employees
Firm age (YOUNG)	Equals one if the company is young, i.e., less than five years old; 0 otherwise.
Part of a group (GROUP)	Takes a value of 1 if the firm belongs to a group; 0 otherwise.
M&A activity (M&A)	Equals one if the firm has participated in a merger and acquisition (M&A) in the last three years and 0 otherwise.
R&D intensity (RD)	Equals 1 if the firm has invested more than 5% of their turnover in R&D in the last three years, 0 otherwise.
Firm growth (GROWTH)	Takes a value of 1 for firms with turnover growth of more than 5%; 0 otherwise.
Design importance (DESIGN IMP)	Takes a value of 1 for firms with design as a central element in their company strategy; 0 otherwise.
Market testing (MARKET TEST)	It is a proxy for public support for market testing. It equals 1 when firms think that market testing of a product or service before launch would have the most positive impact on their company as public support for commercialisation of their innovative goods or services; 0 otherwise.

*Note: This table shows the list of variables used in the analysis and their brief descriptions.*

**Table: 3**  
**Descriptive Statistics**

Variable	Obs.	Mean	Min	Max	Stand. Dev.	Median
INT LEVEL	4954	0.31	0	1	0.37	0.1
INT DUMMY	4954	0.58	0	1	0.49	1
EI	4954	0.38	0	1	0.49	0
EI V2	4954	0.31	0	1	0.46	0
TECH INV	4954	0.45	0	1	0.50	0
TECH INV V2	4954	0.37	0	1	0.48	0
TECH INV IM	4954	0.26	0	1	0.44	0
TECH INV HP	4954	0.35	0	1	0.48	0
RD	4954	0.13	0	1	0.33	0
DESIGN IMP	4954	0.17	0	1	0.38	0
SIZE	4954	3.62	0	11.51	1.74	3.58
YOUNG	4954	0.08	0	1	0.27	0
GROUP	4954	0.31	0	1	0.46	0
M&A	4954	0.13	0	1	0.33	0
GROWTH	4954	0.41	0	1	0.49	0
MARKET TEST	4954	0.10	0	1	0.30	0

*Note: The table shows summary statistics for the variables.*

The second independent variable of interest is generic technological innovations (TECH INV), which takes a value of 1 if the firm has implemented or planning to implement ICT-enabled intelligent manufacturing or high-performance manufacturing in the next 12 months, 0 otherwise. ICT-enabled intelligent manufacturing involves technologies that digitalise the production process. High-performance manufacturing includes technologies that combine precision, flexibility, and zero-defect, such as high precision machine tools, advanced sensors, and 3D printers. For robustness checks, we generate an alternative variable TECH INV V2, which equals one if the firms have already adopted these technological innovations; and we do not consider the ones that are planning to adopt. Besides, we decompose the variable TECH INV into its two components, TECH INV IM and TECH INV HP. TECH INV IM equals one if the firm has implemented or planning to implement only ICT-enabled intelligent manufacturing, 0 otherwise. TECH INV HP takes a value of 1 if the firm has implemented or planning to implement only high-performance manufacturing. Table 3 shows that, on average, 45% of the firms in our sample either implement or intend to implement generic technological innovations (TECH INV). 37% have already adopted generic technological innovations (TECH INV V2), 26% either implement or plan to implement intelligent manufacturing (TECH INV IM). Finally, 35% either implement or intend to implement high-performance manufacturing (TECH INV HP).

We control for some firm characteristics, which are well-accepted determinants of internationalisation and firm performance in the literature (Cassiman & Golovko, 2011; Ganotakis & Love, 2011; Azar & Ciabuschi, 2017; Demirel & Danisman, 2019). These include firm size (SIZE), which is the natural logarithm of the number of employees; firm age (YOUNG), coded as equals one if the company is young, i.e., less than five years old; group firms (GROUP), which takes a value of one if the firm belongs to a group. Besides, we use control variables for M&A activity which equals one if the firm has participated in a merger and acquisition (M&A) in the last three years and 0; otherwise, firm growth (GROWTH) equals one for firms with turnover growth more than 5%. Finally, we control for R&D investment (RD), which equals one if the firm has invested more than 5% of their

turnover in R&D in the last three years, and Design importance (DESIGN\_IMP), which is equal to 1 for firms, which state that design is a central element in their company strategy (Danisman, 2022). The survey questions indicate that design covers "a range of applications within companies, providing means to integrate functionality, appearance and user experience, for goods and services. Design can also provide a means to build corporate identity and brand recognition". Table 3 shows that, on average, 8% of the firms are young (YOUNG), 31% belong to a group, 13% have participated in M&As, 41% have turnover growth of more than 5%, 13% of them invest more than 5% of their turnover in R&D activities; and 17% think that design is a core component of their overall strategy.

Finally, we use the variable market testing (MARKET\_TEST) to identify the selection equation. MARKET\_TEST is a proxy for public support. It equals 1 when firms perceive that market testing of a product or service before launch would have the most positive impact as public support for commercialisation of their innovative goods or services; 0 otherwise. Market testing opportunities from the public are not directly expected to affect internationalisation. Still, it would affect the initial decision to enter international markets and, therefore, be excluded from the outcome equation. On average, 10% of the firms in the sample believe that market testing would positively impact the commercialisation of innovative goods and services (see Table 3).

Table 4 displays the correlation coefficients among the variables and shows no major collinearity problems.

### 3.2. Methodology

As Table 3 shows, our dependent variable INT LEVEL is left-censored, with a median of 0.1 and a lower zero threshold. Therefore, the analysis cannot be estimated with an OLS regression, which would bring inconsistent estimations of the coefficients due to selection bias and truncation (Amemiya, 1985). We resolve this problem by utilising a two-step Maximum Likelihood Heckman model (Heckman, 1979). First, a selection equation is estimated, and then the outcome equation adjusts for selection bias (Greene, 2003). Therefore, we can distinguish between the factors that affect the decision of the firm to internationalise; and those that affect the level of internationalisation. Country fixed effects with robust standard errors are used.

The outcome equation is as follows:

$$INT\ LEVEL_i = Z_i' \beta_i + \varepsilon_i \quad (1)$$

where INT LEVEL is the level of internationalisation, explained by the vector Z and a random error term  $\varepsilon$ . The vector Z includes the control variables described above. However, the dependent variable, INT LEVEL, is not always observed. It is observed if the below selection equation is greater than zero:

$$INT\ DUMMY_i^* = Z_i' \alpha + MARKET\_TEST_i + \varepsilon_i > 0 \quad (2)$$

where the selection equation shows whether or not the firm internationalizes.

INT DUMMY indicates the internationalisation propensity, explained by the vector Z and a random error term  $\varepsilon$ . As stated; we have an additional variable for identification, MARKET\_TEST.

**Table: 4**  
**Correlation Table**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) INT LEVEL	1							
(2) INT DUMMY	0.6982*	1						
(3) EI	0.0989*	0.1043*	1					
(4) EI V2	0.1019*	0.0979*	0.8497*	1				
(5) TECH INV	0.1782*	0.1948*	0.2544*	0.1987*	1			
(6) TECH INV V2	0.1786*	0.1761*	0.1987*	0.1440*	0.8415*	1		
(7) TECH INV IM	0.0983*	0.1246*	0.2633*	0.2217*	0.6517*	0.6182*	1	
(8) TECH INV HP	0.1839*	0.1919*	0.2399*	0.1945*	0.8050*	0.7032*	0.3135*	1
(9) RD	0.0982*	0.1193*	0.0761*	0.0620*	0.1146*	0.1026*	0.0701*	0.1177*
(10) DESIGN IMP	-0.016	-0.0188	0.0384*	0.0335*	0.0540*	0.0620*	0.0768*	0.0444*
(11) SIZE	0.3261*	0.2781*	0.1917*	0.1937*	0.1982*	0.1856*	0.1455*	0.1683*
(12) YOUNG	-0.0628*	-0.0740*	-0.0303*	-0.0263	-0.0076	-0.0101	0.0007	-0.0177
(13) GROUP	0.2750*	0.2104*	0.1092*	0.1237*	0.1210*	0.1184*	0.0998*	0.1067*
(14) M&A	0.0876*	0.0746*	0.0746*	0.0766*	0.0652*	0.0822*	0.0683*	0.0483*
(15) GROWTH	0.1312*	0.1456*	0.0702*	0.0775*	0.1073*	0.1003*	0.0552*	0.1151*
(16) MARKET TEST	0.0322*	0.0473*	0.0729*	0.0623*	0.0795*	0.0807*	0.0441*	0.0719*
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(9) RD	1							
(10) DESIGN IMP	0.0982*	1						
(11) SIZE	0.0672*	0.0332*	1					
(12) YOUNG	-0.0138	-0.0211	-0.1275*	1				
(13) GROUP	0.0666*	0.0477*	0.4123*	-0.0535*	1			
(14) M&A	0.0562*	0.0338*	0.2009*	0.0012	0.2074*	1		
(15) GROWTH	0.0801*	0.0373*	0.0742*	0.0433*	0.0818*	0.0493*	1	
(16) MARKET TEST	0.0813*	0.0577*	0.0964*	-0.0173	0.0597*	0.0165	0.0222	1

\* Denotes significance at the 5% level.

#### 4. Results

Table 5 presents the findings of the Heckman selection model on the impact of eco-innovations and generic-technological innovations on firm internationalisation. We use a two-step Maximum Likelihood Heckman model where a selection and an outcome equation are estimated, the former adjusting for selection bias (Greene, 2003). This way, we can distinguish between the factors that affect the decision of the firm to internationalise and those that affect the level of internationalisation. Country fixed effects with robust standard errors are implemented. Panel A presents the regression findings using the outcome equation where the dependent variable is INT LEVEL, and Equation (1) is used. Panel B displays the findings using the selection equation, and our dependent variable is the indicator variable, decision to internationalise (INT DUMMY). We use the variable public support for market testing (MARKET TEST) to identify the selection equation. This variable is expected not to affect the level of internationalisation, but such market testing would affect the initial decision to internationalise. Thus, it can be omitted from the outcome equation. Rho and Sigma are tabulated at the bottom of the table, which are the estimated coefficients of the decomposed lambda estimation on the Inverse Mill's Ratio. We see that the estimated Rho

coefficients are not statistically significant, implying no selection bias. The reported model  $\chi^2$  test is a Wald test with a null hypothesis stating that all coefficients in the regression model are zero. The coefficients of the Wald test are all significant, showing the validity of the Heckman models.

Columns 1&2 use EI and EI V2 as proxies for the adoption to explore the influence of eco-innovations on firm growth. It is observed that eco-innovations positively and significantly improve the decision to internationalise (Panel B) but not the level of international operations (Panel A). This is in line with the PH hypothesis stating that firms can grow out of their eco-innovation efforts, and at the same time, they can address environmental and economic goals (Porter & Van Der Linde, 1995). Eco-innovations generate win-win outcomes and help the firms to take the initial decision to internationalise. Once the initial decision is taken, however, they do not significantly determine the level of international operations.

Columns 3-6 explore the impact of generic-technological innovations on firm internationalisation. Column 3 uses TECH INV as a proxy, and Column 4 uses an alternative for robustness, TECH INV V2. TECH INV is an indicator variable and shows whether firms implement or plan to implement ICT-enabled intelligent manufacturing or high-performance manufacturing. TECH INV V2 considers only the case if firms have already implemented these technologies, and those which plan to use such technologies are not considered. Columns 5 and 6 decompose into the two components, TECH INV IM and TECH INV HP. It is observed from Table 5 Columns 3&4 Panels A&B that generic-technological innovations significantly increase both the decision and the level of international operations. Columns 5&6 show that it is mainly the high-performance manufacturing component (TECH INV HP) that increases both the decision to internationalise and its level. This is in line with the view that technological innovation capabilities help to develop new products or services, expand more effective operations, and act as strategic tools for firms willing to enter new markets or boost their international operations (Gunday et al., 2011; Wang et al., 2008; Ortega, 2010; Tsai, 2004).

The influence of control variables on internationalisation is in line with expectations (Cassiman & Golovko, 2011; Ganotakis & Love, 2011; Azar & Ciabuschi, 2017; Demirel & Danisman, 2019). R&D investments are positively and significantly associated with both the decision and the level of internationalisation. Larger firms are more likely to internationalise (both the decision and the level) than smaller firms. Firm age is negatively and significantly associated with internationalising, but not the level. Group firms are more likely to internationalise in terms of the decision to do so and its level. And finally, growing firms tend to internationalise more (both at the decision and the level).

**Table: 5**  
**Effect of Eco-innovations and Technological Innovations on Internationalisation**

	(1) EI	(2) EI V2	(3) TECH INV	(4) TECH INV V2	(5) TECH INV IM	(6) TECH INV HP
<b>Panel A: Outcome Equation - Dependent variable: INT LEVEL</b>						
EI	-0.005 (0.01)	0.001 (0.01)				
TECH INV			0.022* (0.01)	0.040*** (0.01)		
TECH INV IM					-0.004 (0.01)	
TECH INV HP						0.033*** (0.01)
RD	0.046*** (0.02)	0.046*** (0.02)	0.044*** (0.02)	0.044*** (0.02)	0.047*** (0.02)	0.043*** (0.02)
DESIGN IMP	0.001 (0.02)	0.001 (0.02)	0.000 (0.02)	-0.000 (0.02)	0.001 (0.02)	0.001 (0.02)
SIZE	0.052*** (0.00)	0.051*** (0.00)	0.050*** (0.00)	0.050*** (0.00)	0.052*** (0.00)	0.050*** (0.00)
YOUNG	-0.022 (0.03)	-0.021 (0.03)	-0.022 (0.03)	-0.023 (0.03)	-0.022 (0.03)	-0.023 (0.03)
GROUP	0.096*** (0.01)	0.096*** (0.01)	0.096*** (0.01)	0.096*** (0.01)	0.095*** (0.01)	0.095*** (0.01)
M&A	0.003 (0.02)	0.003 (0.02)	0.003 (0.02)	0.002 (0.02)	0.003 (0.02)	0.004 (0.02)
GROWTH	0.029** (0.01)	0.028** (0.01)	0.027** (0.01)	0.026** (0.01)	0.029** (0.01)	0.027** (0.01)
Constant	0.058 (0.04)	0.060 (0.04)	0.050 (0.04)	0.046 (0.04)	0.053 (0.04)	0.049 (0.04)
<b>Panel B: Selection Equation- Dependent variable: INT DUMMY</b>						
EI	0.102** (0.04)	0.084* (0.04)				
TECH INV			0.334*** (0.04)	0.318*** (0.04)		
TECH INV INTELLIGENT					0.235*** (0.05)	
TECH INV HP						0.374*** (0.04)
RD	0.447*** (0.06)	0.451*** (0.06)	0.413*** (0.06)	0.423*** (0.06)	0.441*** (0.06)	0.407*** (0.06)
DESIGN IMP	-0.061 (0.05)	-0.060 (0.05)	-0.078 (0.05)	-0.079 (0.05)	-0.074 (0.05)	-0.074 (0.05)
SIZE	0.177*** (0.01)	0.178*** (0.01)	0.168*** (0.01)	0.171*** (0.01)	0.175*** (0.01)	0.171*** (0.01)
YOUNG	-0.231*** (0.07)	-0.232*** (0.07)	-0.244*** (0.07)	-0.240*** (0.07)	-0.241*** (0.07)	-0.234*** (0.07)
GROUP	0.252*** (0.05)	0.252*** (0.05)	0.247*** (0.05)	0.247*** (0.05)	0.250*** (0.05)	0.249*** (0.05)
M&A	0.018 (0.06)	0.020 (0.06)	0.012 (0.06)	0.006 (0.06)	0.014 (0.06)	0.016 (0.06)
GROWTH	0.292*** (0.04)	0.292*** (0.04)	0.275*** (0.04)	0.280*** (0.04)	0.292*** (0.04)	0.270*** (0.04)
MARKET TEST	0.058 (0.07)	0.061 (0.07)	0.038 (0.07)	0.041 (0.07)	0.059 (0.07)	0.039 (0.07)
Constant	-0.718*** (0.11)	-0.710*** (0.11)	-0.770*** (0.11)	-0.744*** (0.11)	-0.723*** (0.11)	-0.768*** (0.11)
Rho	0.114 (0.06)	0.106 (0.06)	0.117 (0.06)	0.132 (0.05)	0.125 (0.06)	0.119 (0.05)
Sigma	0.319 (0.00)	0.319 (0.00)	0.319 (0.01)	0.319 (0.01)	0.320 (0.01)	0.319 (0.01)
Observations	4954	4954	4954	4954	4954	4954
Wald test Chi-Square	3.78***	3.09***	4.43***	6.13***	4.83***	4.74***
Log-pseudo likelihood	-3739.022	-3740.463	-3705.675	-3708.347	-3728.464	-3699.519

Note: This table presents the findings of the Heckman selection model on the impact of eco-innovations and generic-technological innovations on firm internationalisation. Panel A presents the regression findings using the outcome equation where the dependent variable is INT LEVEL. Panel B displays the findings using the selection equation, and our dependent variable is the indicator variable, decision to internationalise (INT DUMMY). Columns 1&2 use EI and EI V2 as proxies of eco-innovation. Columns 3&4 use TECH INV and TECH INV V2 as proxies of generic technological innovations. Columns 5 and 6 decomposes into the two components, TECH INV IM and TECH INV HP. Standard errors are reported in parentheses. \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01

Overall, our findings indicate that technological innovations, whether in the eco-innovations or generic form, are crucial for firms to implement a decision to internationalise. Generic-technological innovations are further helpful for manufacturing firms to enhance international operations.

## 5. Conclusions

This study contributes to the scant literature by bringing together the international business and innovation literature and generating new evidence regarding the mechanisms of how different types of technological innovations may improve global operations. We classify technological innovations into generic- and eco-innovations. Using the Flash Eurobarometer-415 and the Flash Eurobarometer-433 surveys and a firm-level sample of 4954 European and non-European (the US and Switzerland) manufacturing firms, we apply the Heckman selection model to investigate this relationship. Our findings show that technological innovations, both in the sustainable and generic form, are significantly and positively associated with internationalisation. Generic-technological innovations further boost the level of international operations.

Our findings have important implications for firms that want to enter new markets or expand their international operations. We document that it is beneficial for such firms to focus on technological innovations in the form of generic and sustainable innovations. Our study calls for policy interventions that could ensure that firms with environmental innovations have the necessary resources and capabilities. Especially smaller and younger firms that lack the necessary skills and access to finance need to be supported more for their eco-innovation efforts, which would help them go into international markets.

## References

- Alvarez, R. (2004), "Sources of export success in small and medium-sized enterprises: the impact of public programs", *International Business Review*, 13(3), 383-400.
- Amemiya, Y. (1985), "Instrumental variable estimator for the nonlinear errors-in-variables model", *Journal of Econometrics*, 28(3), 273-289.
- Amit, R. & P.J. Schoemaker (1993), "Strategic assets and organizational rent", *Strategic Management Journal*, 14(1), 33-46.
- Azar, G. & F. Ciabuschi (2017), "Organizational innovation, technological innovation, and export performance: The effects of innovation radicalness and extensiveness", *International Business Review*, 26(2), 324-336.
- Barney, J. (1986), "Strategic factor markets: Expectations, luck and business strategy", *Management Science*, 32(10), 1231-1241.
- Barney, J. (1991), "Firm resources and sustained competitive advantage", *Journal of Management*, 17(1), 99-120.
- Bustos, P. (2011), "Trade liberalization, exports, and technology upgrading: Evidence on the impact of MERCOSUR on Argentinian firms", *American Economic Review*, 101(1), 304-40.

- Camisón, C. & A. Villar-López (2014), "Organizational innovation as an enabler of technological innovation capabilities and firm performance", *Journal of Business Research*, 67(1), 2891-2902.
- Cassiman, B. & E. Golovko (2011), "Innovation and internationalization through exports", *Journal of International Business Studies*, 42(1), 56-75.
- Coad, A. & R. Rao (2008), "Innovation and firm growth in high-tech sectors: A quantile regression approach", *Research Policy*, 37(4), 633-648.
- Coad, A. et al. (2016), "Innovation and firm growth: does firm age play a role?", *Research Policy*, 45(2), 387-400.
- Costantini, V. & M. Mazzanti (2012), "On the green and innovative side of trade competitiveness? The impact of environmental policies and innovation on EU exports", *Research Policy*, 41(1), 132-153.
- Coombs, J.E. & P.E. Bierly (2001), "Looking through the kaleidoscope: Measuring technological capability and performance", *Academy of Management Proceedings*, B1-B7.
- Coombs, J.E. & P.E. Bierly (2006), "Measuring technological capability and performance", *R&D Management*, 36(4), 421-438.
- Copeland, B.R. & M.S. Taylor (2004), "Trade, growth, and the environment", *Journal of Economic Literature*, 42(1), 7-71.
- Dalgıç, B. & B. Fazlıoğlu (2021), "Innovation and firm growth: Turkish manufacturing and services SMEs", *Eurasian Business Review*, 11(3), 395-419.
- Damanpour, F. & W.M. Evan (1984), "Organizational innovation and performance: the problem of organizational lag", *Administrative Science Quarterly*, 392-409.
- Damanpour, F. et al. (2009), "Combinative effects of innovation types and organizational performance: A longitudinal study of service organizations", *Journal of Management Studies*, 46(4), 650-675.
- Damanpour, F. & D. Aravind (2011), "Managerial innovation: Conceptions, processes, and antecedents", *Management and Organization Review*, 8, 423-454.
- Danisman, G.O. (2022), "What Drives Eco-Design Innovations in European SMEs?" [Chapter], in: *Disruptive Technologies and Eco-Innovation for Sustainable Development*, IGI Global.
- Demirel, P. & G.O. Danisman (2019), "Eco-innovation and firm growth in the circular economy: Evidence from European small-and medium-sized enterprises", *Business Strategy and the Environment*, 28(8), 1608-1618.
- Demirel, P. & E. Kesidou (2019), "Sustainability-oriented capabilities for eco-innovation: Meeting the regulatory, technology, and market demands", *Business Strategy and the Environment*, 28(5), 847-857.
- Fazlıoğlu, B. et al. (2019), "The effect of innovation on productivity: Evidence from Turkish manufacturing firms", *Industry and Innovation*, 26(4), 439-460.
- Filbeck, G. & R.F. Gorman (2004), "The relationship between the environmental and financial performance of public utilities", *Environmental and Resource Economics*, 29(2), 137-157.
- Ganotakis, P. & J.H. Love (2011), "R&D, product innovation, and exporting: evidence from UK new technology based firms", *Oxford Economic Papers*, 63(2), 279-306.
- Greene, W.H. (2003), *Econometric Analysis*, Pearson Education India.

- Gunday, G. et al. (2011), "Effects of innovation types on firm performance", *International Journal of Production Economics*, 133, 662-676.
- Heckman, J.J. (1979), "Sample selection bias as a specification error", *Econometrica*, 47(1), 153-161.
- Kafouros, M.I. et al. (2008), "The role of internationalization in explaining innovation performance", *Technovation*, 28(1-2), 63-74.
- Levinson, A. & M. Taylor (2008), "Unmasking the pollution haven effect", *International Economic Review*, 49(1), 223-54.
- Levinson, A. (2010), "Offshoring pollution: is the US increasingly importing polluting goods?", *Review of Environmental Economics and Policy*, 4(1), 63-83.
- Matanda, M.J. & S. Freeman (2009), "Effect of perceived environmental uncertainty on exporter-importer inter-organisational relationships and export performance improvement", *International Business Review*, 18, 89-107.
- Mazzucato, M. & S. Parris (2015), "High-growth firms in changing competitive environments: the US pharmaceutical industry (1963 to 2002)", *Small Business Economics*, 44(1), 145-170.
- Metcalfe, J.S. (1994), "Evolutionary economics and technology policy", *The Economic Journal*, 104(425), 931-944.
- Nelson, R.R. (ed.) (1993), *National innovation systems: a comparative analysis*, Oxford University Press on Demand.
- Ortega, M.J.R. (2010), "Competitive strategies and firm performance: Technological capabilities' moderating roles", *Journal of Business Research*, 63(12), 1273-1281.
- Peteraf, M.A. (1993), "The cornerstones of competitive advantage: a resource-based view", *Strategic Management Journal*, 14(3), 179-191.
- Pla-Barber, J. & J. Alegre (2007), "Analysing the link between export intensity, innovation and firm size in a science-based industry", *International Business Review*, 16(3), 275-293.
- Popp, D. (2005), "Lessons from patents: Using patents to measure technological change in environmental models", *Ecological Economics*, 54(2-3), 209-226.
- Porter, M.E. (1991), "America's Green Strategy", *Reader in Business and the Environment*, 33.
- Porter, M.E. & C. van der Linde (1995), "Toward a new conception of the environment-competitiveness relationship", *Journal of Economic Perspectives*, 9(4), 97-118.
- Rexhäuser, S. & C. Rammer (2014), "Environmental innovations and firm profitability: unmasking the Porter hypothesis", *Environmental and Resource Economics*, 57(1), 145-167.
- Singh, D.A. (2009), "Export performance of emerging market firms", *International Business Review*, 18(4), 321-330.
- Sousa, C.M.P. et al. (2014), "Testing for linear and quadratic effects between price adaptation and export performance: The impact of values and perceptions", *Journal of Small Business Management*, 52, 501-520.
- Stucki, T. et al. (2018), "How different policy instruments affect green product innovation: A differentiated perspective", *Energy Policy*, 114, 245-261.
- Tsai, K.H. (2004), "The impact of technological capability on firm performance in Taiwan's electronics industry", *The Journal of High Technology Management Research*, 15(2), 183-195.

- van den Bergh, J.C.J.M. et al. (2000), "Alternative models of individual behaviour and implications for environmental policy", *Ecological Economics*, 32, 43-61.
- Walker, R.M. (2004), "Innovation and organisational performance: Evidence and a research agenda", *Advanced Institute of Management Research Paper*, (002).
- Wang, C.H. et al. (2008), "Evaluating firm technological innovation capability under uncertainty", *Technovation*, 28(6), 349-363.
- Wagner, M. (2007), "On the relationship between environmental management, environmental innovation and patenting: evidence from German manufacturing firms", *Research Policy*, 36(10), 1587-1602.
- Westhead, P. et al. (2001), "The internationalization of new and small firms: A resource-based view", *Journal of Business Venturing*, 16(4), 333-358.
- Yang, C.C. et al. (2009), "Assessing resources, logistics service capabilities, innovation capabilities and the performance of container shipping services in Taiwan", *International Journal of Production Economics*, 122(1), 4-20.
- Zahra, S.A. & J.G. Covin (1995), "Contextual influences on the corporate entrepreneurship-performance relationship: A longitudinal analysis", *Journal of Business Venturing*, 10, 43-58.

Ozturk-Danisman, G. (2022), "Technological Innovations and Firm Internationalisation", *Sosyoekonomi*, 30(52), 71-85.