EXTENDED ABSTRACT

Title: The impact of innovation on trade at subnational level: Preliminary evidence for European Union

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Extended abstract

Understanding how to increase trade flows is fundamental to explain the dynamics of the ongoing globalization. Among the multiple elements that can result in greater trade flows, we pay special attention to technological spillovers and, more importantly, innovation (e.g., Grossman and Helpman, 1990; Keller, 2004; Akcigit et al., 2018). This is a dynamic process governed by firms that constitutes a competitive advantage, which allows them to rise trade flows and compete internationally (Schumpeter, 1944). For this reason, it would be convenient to disentangle how innovation affects trade.

The impact of innovation on trade is not, however, a recent topic in academic literature. In fact, we find a first attempt to analyze such relationship in Ricardo (1821) when

describing the theory of comparative advantage. Although this is the seminal contribution that analyzes the impact of technology on trade, it suffers from certain caveats. First, technology is exogenous, which means that countries cannot improve their trade performance over time by improving their technology. Second, technology is considered from a general point of view, without disentangling specific components such as innovation. However, conclusions point how better technologies lead to trade improvements by raising wages and this seminal work can be considered as an opportunity window to undertake future research.

Grossman and Helpman (1995) constitute a remarkable approach to create a theoretical framework to analyze the impact of innovation on trade. In particular, they study how technology impacts on trade by developing a deep review on different theoretical settings. Rather than considering technology from a general point of view, they build on different theoretical frameworks, where technological progress can be exogenous, as in Ricardo (1821) or can be controlled by firms in a context of learning by doing. Innovation is addressed specifically by considering that trade can be affected by investments in knowledge under intellectual property rights. When an innovation has been diffused at the firm, productivity can register substantial increases and hence, rise trade flows.

There have been growing attempts to uncover how innovation affects trade. Most of the studies cover either country aggregate level or a specific firm level. The country level has brought substantial attention from academic research, given the higher degrees of data availability. Soeté (1987) is one of the first empirical studies to address this topic by focusing on whether innovation has fostered trade from OECD countries in 1977. By considering both R&D and patents as indicators of innovational performance, he obtains a positive association between both variables and trade performance. Márquez-Ramos and Martínez-Zarzoso (2010) analyze the impact of Technological Achievement Index and its four components on trade between 13 exporters and 77 importers in the year 2000 to find a positive impact on trade.

However, such country aggregate level overlooks a fundamental ingredient, since most of innovations take place by collaboration between firms and research centres (Hervás-Oliver et al., 2021). When analyzing firms´ performance, it is fundamental to pay

attention to the existence of large superstar exporters dominating country performance (Freund and Pierola, 2015). For this reason, most of the studies on how innovation affects trade have been developed at the firm level.

At the firm level, Basile (2001) finds a positive relationship between innovation and export performance for Italian manufacturing firms during the 90s. He specifically distinguishes whether firms have invested in an innovative activity through R&D. Other authors obtain similar findings when analyzing Spanish (Cassiman and Golovko, 2011; Damijan and Kostevc; 2015) or Dutch (Dierckx and Stroeken, 1999) firms. Becker and Egger (2013) focus on German firms to find that process innovation spurs trade.

The study of innovation impacts, however, can be considered as challenging. The national innovation systems approach (Freeman, 1995) has become the most widely accepted framework. In this context, innovation systems can be fueled by the flows of information and technology between agents involved in the process (i.e.: people, enterprises and institutions). Since we can find sharp cross-country differences in technology diffusion causing income divergences (e.g., Comin and Mestieri, 2018), it is expected that the intensity of information and technology flows strongly differs across countries.

The attention has, however, been progressively shifting to the subnational level, originating the paradigm of Regional Systems of Innovation (Doloreux, 2002; Iammarino, 2005; Asheim et al., 2016). This is in line with the expected outcomes, as economic activity is unequally distributed across space and this fact leads to substantial spatial differences (Krugman, 1991). When explaining innovation, this fact is crucial because firms agglomerate to share information and knowledge flows, and this relationship is more intense at the subnational level (e.g., Caragliu and Nijkamp, 2016). As a consequence, certain regions are expected to emerge as core centers of innovation by concentrating a larger number of firms than other regions.

To the best of our knowledge, no studies have been conducted at subnational level to analyze how innovation impacts on trade. The most remarkable approach can be found in Barbero and Rodríguez-Crespo (2018), who address how information technology impacts on regional trade at European Union. They find a positive relationship between

both variables, and it holds when controlling by the effect of neighbouring proximity in terms of trade. Innovation and information technology presents certain complementarities and similarities at subnational level (e.g., Billon et al., 2017). In addition, it has been alleged in trade and industry that information technology leads to innovation in different fields (Diercks and Stroeken, 1999), innovation has been left aside from their analysis. In a context dominated by RSI, it would be desirable to study whether innovation stimulates trade performance, since this issue can be considered of further interest for our analysis. More importantly, we can find more salient differences between regions at subnational level, and they need to be taken into account when studying trade patterns. This is precisely the objective to be undertaken in this study.

We consider the European Union as the reference to study how innovation has impacted on trade because of certain reasons. First, a strong interest to mitigate regional disparities via initiatives such as the Cohesion Policy and, more importantly, authorities are reluctant to implement place-based policies. Second, further measures of innovation efforts have been developed at subnational level, although a debate on how to improve such indicators by adding others at subnational level is gaining attention from academic scholars (Barbero et al., 2021a).

To accomplish our research objective, we acknowledge the evolution of empirical trade methodologies especially during the second half of the Twentieth Century. In this context, several contributions have highlighted how gravity models of bilateral trade are a useful methodology to explain factors driving bilateral trade flows (e.g., Mátyás, 1998; Anderson and Van Wincoop, 2003; Head and Mayer, 2014; Redding and Weinstein, 2019). However, most of the contributions refer to country level and do not capture that most of trade volumes concentrate on borders, which are particularly sensitive to subnational dimension (e.g., McCallum, 1995; Capello et al., 2018). In this context, it is fundamental to distinguish between intra-national trade, when regions from the same country trade with each other, and interregional trade, when regions from different countries trade with each other. As a consequence, trade costs and barriers at the subnational level strongly differ in comparison to the country level. For this reason, we build our gravity equation at subnational level following prior specific contributions (Gallego and Llano, 2014). More specifically, we follow the specification pointed by

Barbero et al. (2021b) when studying the impact of quality of government on trade. Our baseline trade openness equation (1) is defined as follows:

$$TRADE_{ij} = \beta_0 + \beta_1 INNOV_i * INTERNATIONAL\_BRDR_{ij} + \beta_2 \ln DIST_{ij} + \beta_3 CONTIG_{ij} + \beta_4 INTERNAL\_BRDR_{ij} + \beta_5 INTERNATIONAL\_BRDR_{ij} + \mu_i + \mu_j + \varepsilon_{ij} \quad (1)$$

Where *i* and *j* refer to the origin and destination, and *ln* to the natural logarithm, respectively. $TRADE_{ij}$ is the bilateral trade flow from *i* to *j*. $INNOV_i$ is the regional innovation measure for i, while $INTERNATIONAL\_BRDR_{ij}$ is a control variable that takes value 1 for interregional trade and 0 otherwise. $DIST_{ij}$ is the bilateral distance that separates *i* and *j*. $CONTIG_{ij}$ is a control variable that takes value 1 when *i* and *j* are adjacent and 0 otherwise. $INTERNAL\_BRDR_{ij}$ is also a control variable that takes value 1 for intra-national trade between *i* and *j* and 0 otherwise. μ_i and μ_j are regional fixed effects at origin and destination and, finally, ε_{ij} is the error term.

To estimate our equation, we resort to pseudo-poisson maximum likelihood (PPML) estimator, developed by Santos-Silva and Tenreyro (2006). Among the traditional Ordinary Least Squares estimation, PPML reduces the heteroskedasticity at the dependent variable derived from taking logarithm. In addition, it allows to include zero values at the dependent variable, avoiding efficiency loss. Finally, it has been argued that PPML could be capturing MRT, the impact of third locations on bilateral trade between origin and destination locations. For these reasons, PPML can be considered as a baseline empirical strategy when estimating gravity equations.

Data have been gathered from different territorial sources of information, including Eurostat, and the Regional Innovation Scoreboard. In relation to innovation, there is a growing debate on the academic literature about the best variable to measure innovation efforts. At subnational level, the debate is more prominent, given that we find recent institutional efforts to elaborate variables measuring innovation at the European Union. To this end, we resort to four main variables measuring innovation: (i) Regional Innovation Scoreboard (RIS), (ii) innovation performance, measured as the ratio of innovation outputs to innovation inputs, (iii) SMEs product innovation and (iv) SMEs process innovation. The consideration of these four variables confers us an eclectic approach that captures the dimensions of innovation.

A first glimpse of our results is shown in Table 1, where we include the four regional innovation variables separately in equation (1). The aim is to prevent collinearity issues between innovation variables that lead to overriding information.

Table 1. Estimation results.

	(I)	(II)	(III)	(IV)
Log RIS x International	0.285***			
	(0.039)			
Log Innovation Performance X International		0.519***		
		(0.077)		
Log SMEs Product Innovation X International			0.285***	
			(0.039)	
Log SMEs Process Innovation X International				0.130***
				(0.016)
Log of Distance	-0.453***	-0.451***	-0.453***	-0.453***
	(0.029)	(0.029)	(0.029)	(0.029)
Contiguity	-0.060	-0.058	-0.060	-0.061
	(0.045)	(0.045)	(0.045)	(0.046)
Internal Trade	3.272***	3.269***	3.272***	3.275***
	(0.053)	(0.053)	(0.053)	(0.053)
International Trade	-5.083***	-4.021***	-5.083***	-3.666***
	(0.180)	(0.055)	(0.180)	(0.041)
Constant	11.383***	11.374***	11.383***	11.389***
	(0.169)	(0.169)	(0.169)	(0.169)
Observations	53,815	53,815	53,815	52,875

*Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1*

Results show how the four variables measuring innovation are positive and significant. The highest coefficient is found for innovation performance, 0.519 in Column (2), while the lowest one is from SMEs process innovation, 0.130 in Column (4). These results show the importance of considering different dimensions of innovation to explain trade patterns, since their impact of trade costs and hence on trade flows depends on the variable used.

In relation to the rest of the variables, distance is negative and significant, as expected from the theoretical outcomes of gravity equation. Contiguity is negative but significant, which is not surprising because its impact may be overridden by national borders, since this variable is positive and significant. International borders are negative but significant, denoting that most of trade flows concentrate within borders and trade barriers are still significant even in a context of liberalized trade.

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