The impact of innovation on imports

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Abstract

This research investigates the impact of innovation on import flows for Italy and Germany by considering countries' competitive advantages and sector characteristics. Following the new trade theory, an import demand model is elaborated to analyze the impact of both price and non-price factors that could influence bilateral trade flows between two countries. Furthermore, the innovation effect is analyzed for different sectors. The empirical results suggest that 1) there is no significant impact of innovation on imports at the aggregated country level; 2) while importing countries' innovation does not have an effect on imports in low-technology sectors, the effect of innovation in high-technology sectors depends on the characteristics of the trading countries. Innovation by the importing country has no effect or a positive effect on imports from quality-disadvantaged countries, depending on the trading partner's cost advantage. A negative impact can be found for imports from countries that have a quality advantage; 3) if the impact of innovation on imports is distinguished for concentrated versus fragmented sectors, it shows that importing countries' innovation stimulates their imports in fragmented sectors and reduces imports for concentrated sectors. These findings result from different specializations between countries based on their competitive advantage in terms of low-cost versus high-quality production.

Forewords

This paper is written for my master thesis. It is conducted in AEP chair group, Wageningen University.

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Table of Contents

1. Introduction

Many international trade theories manifest innovation as a key factor in explaining trade performance of a country (e.g. Vernon, 1966; Dollar, 1986; Grossman and Helpman, 1990). Innovation is seen as a crucial determinant of non-price competitiveness[1] (e.g. Fagerberg, 1988; Buxton et al., 1991; Magnier and Toujas-Bernate, 1994). Investment in innovation often yields increased productivity, upgraded product quality and an expanded range of product variety. Consequently it can increase consumers' satisfaction and reduce both production and transaction costs (Ghazalian and Furtan, 2007).

The existing literature mainly investigates the trade versus innovation relationship either at industry level or at firm level. At firm level, the focus is mostly on the correlation between innovation, productivity and participation or intensity of exporting. At industry level, sector studies for bilateral trade are often applied to enable discrimination of the role played by innovation across different sectors. In addition, a number of researchers also discuss the effect of technology diffusion and knowledge spillovers on international trade (e.g. León-Ledesma, 2000; Falvey, et al., 2004). All in all, most studies find a positive impact of innovation on trade, whereas evidence of the impact of trade on innovation activities is mixed.

While a vast literature exists that explains the impact of innovation on trade based on sector-level, firm-level and country-level studies[2], few studies focus on explaining bilateral trade flows based on countries' competitive advantage in terms of cost advantage or high quality production. Moreover, further insights can be gained from categorizing different sectors based on relevant indicators and analyzing trade flows between categories. Relevant categorizations include high-technology sectors versus low-technology sectors, and sectors with fragmented market structure versus sectors with concentrated market structure[3]. This paper concentrates on bilateral import flows of Italy and Germany, two large trading countries, in different manufacturing sectors. The research objective is: to investigate the impact of innovation on countries' bilateral import flows by taking into account countries' competitive advantages and sector characteristics.

Research question: what are the innovation impacts on countries' bilateral import flows taking into account the characteristics of trading partners and sectors?

Sub-question 1: what does the existing theoretical and empirical trade literature contribute regarding the role of innovation for trade flows?

Sub-question 2: what is the impact of innovation on Italy and Germany's bilateral import flows given differences in countries' competitive advantages?

Sub-question 3: what is the impact of innovation on both countries' import flows for different types of sectors?

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[1] Non-price competitiveness is interpreted as the ability to compete in all non-price determinants of a product, such as quality, technology, reputation.

[2] Country-level studies assess countries' macro trade performance by aggregating data from different countries or different sectors. For example, Fagerberg (1988) focused on countries' competitiveness by pooling macro trade data of different countries but ignored sector level variations.

[3] Fragmented markets include many firms, with fragmented market shares for each firm. Competition is mainly dominated by price; concentrated markets have few firms, with concentrated market shares. Non-price factors (e.g. quality) dominate competition. See also the detailed definition in 3.2.

The conceptual model for the analysis of the innovation–import relationship is based upon the new trade theory. The empirical model is based on Anderton (1999) to analyze the relative impact of price and non-price factors on countries' bilateral import demand.

Bilateral trade data are collected for 21 manufacturing sectors for Germany and Italy and two other EU trading partners: the Czech Republic and Spain for the period 1991-2010. These countries were in a free trade agreement during the measurement period and are geographically near to each other. Hence, the impact of transportation costs and possible distortions due to trade barriers are ignored in the empirical model.

Chapter 2 presents a systematic review of the existing theories and empirical studies in this field. Chapter 3 explains the methodology and data used in this research. It also provides a description of countries' export performance and competitive advantages in terms of costs and quality of production. Chapter 4 shows the empirical results and interpretation of research findings. Chapter 5 concludes the thesis.

2. The relationship between trade and innovation

The first section in this chapter summarizes the main theories that explain the relationship between innovation and trade. It also describes how the relevant trade theories have evolved over time. The second section describes the most influential empirical studies that have aided to further develop these theories.

2.1 Theoretical background

The new trade theory predicts that economies of scale and network effects are the dominant factors in determining international trade patterns. Countries will produce and export either horizontally differentiated product varieties (which differ by characteristics) or vertically differentiated varieties of goods (which differ by quality). In order to gain higher margins from differentiated goods, countries will specialize in certain varieties to achieve economies of scale and hence, higher production at lower cost. Since specialization will reduce the number of supplied varieties, the trade incentive appears.

Although there is a consensus that innovation can positively affect countries' trade performance, different schools of theory put a different emphasis in their explanations. According to a review by Chen (2013), the first school of theories emphasizes the function of innovation in developing new products or expanding product varieties, namely the gain from the extensive margin (e.g. Vernon, 1966; Krugman, 1979; Jenson and Thursby, 1986; Dollar, 1986). The second school focuses on the role of innovation (mainly process innovation) to raise productivity and reduce production costs (e.g. Posner, 1961; Diewert, 1987). The third school emphasizes that innovation improves product quality and hence shifts a country's export demand curve outwards (e.g. Flam and Helpman, 1987; Grossman and Helpman, 1991). In other words, the second and third schools of theories focus on the intensive margin of exports.

Exogenous technology-trade relationship

Early technology-based trade theories highlighted the role of technology and its level of advancement in determining countries' trade patterns. One of the first attempts was made by Posner (1961) which was later extended by Hufbauer (1966). They illustrated that countries leading at the technological frontier could temporarily own and benefit from the technological advantage. Due to the fact that knowledge is a public good, the less advanced countries would gradually catch up through imitating efforts. Similar theoretical models followed and introduced the concept of dynamic comparative advantage or the product cycle feature. Vernon (1966), Krugman (1979) and Dollar (1986) emphasized that countries' trade behavior is driven by its relative technological position compared to its competitors, and their models predicted product differentiation and innovation as the main ways to gain competitive advantage in international markets. They argued that technology can improve the terms of trade of developed countries whereas the transfer of technology can also upgrade the production in developing countries. Later work by Grossman and Helpman (1991) tried to add the quality effect into the theory. A main feature of these models is that innovation and technological development factors were regarded as exogenous.

Endogenous technology-trade relationship

The endogenous growth model was built on the basis of several empirical studies, including Arrow (1962) and Uzawa (1965). In the 1980s, scholars such as Nelson and Winter (1982) and Romer (1986) introduced technological progress and accumulation of knowledge as the primary reason for economic growth. Since then, works by e.g. Grossman and Helpman

(1989); Romer (1990); and Aghion et al. (1998) endogenized technological factors into the trade models and illustrated that international trade could also affect domestic innovation activities. These theories argued that fierce competition on international markets would stimulate firms to improve their products and services, and this may trigger new innovation activities. Furthermore, participation in international markets also forces exporters to adjust their products to meet the needs of foreign buyers. Consequently, this raises the probability of engaging in innovation activities. This is referred to the learning by exporting hypothesis, which describes the mechanism whereby producers try to improve their performance after they start exporting (De Loecker, 2010).

Deriving from aforementioned theories, Coe and Helpman (1995) associated domestic productivity growth with foreign R&D activities via international trade flows. These studies provided evidence that technology spillovers from advanced countries can significantly impact total factor productivity (TFP) of less developed countries. Consequently, countries' trade competitiveness is directly linked with foreign innovation activities. These results challenged the views that foreign innovations weaken countries' trade competiveness as found in earlier studies.

2.2 Empirical evidence

2.2.1 Empirical evidence at industry or country level

Sector studies are often applied to investigate the technology-trade relationship in both exogenous and endogenous models. Using disaggregated industry data, sector studies allow variation across countries and sectors. This can generate more precise conclusions and discrimination of the relationship in a specific country/sector context. In order to identify the 'specifics', Buxton et al. (1991) compare the effect of innovation for different sectors within a country while Dosi et al. (1990) studied this relation for the same sectors across countries. Later studies tried to incorporate both into their empirical models (Magnier and Toujas-Bernate, 1994; Verspagen and Wakelin, 1997; Wakelin, 1998; Anderton, 1999a). Wakelin (1998) analyzed the bilateral trade flows for nine OECD countries, adding dummy variables for countries and sectors in the model. The results indicate that only sector dummy variables are significant. Magnier and Toujas-Bernate (1994) used data from twenty manufacturing industries for five major industrialized countries. The results show that supply-side variables play a crucial role in explaining export market shares and that there are significant differences across individual countries as well as across sectors. Chen (2013) used data for manufacturing exports of 105 countries in the period 1975-2001. He found that innovation is positively correlated with both extensive and intensive margins of exports. Furthermore, he concluded that the innovation effect is stronger in low-income countries and technology intensive sectors. Moreover, Sanyal and Chhabra (2004) analyzed the innovation impact at both sector and aggregated country levels and found a positive impact of innovation and technological opportunity on trade at country level, but this effect is only significant for high-technology sectors at sector level. Contradicting to many other findings, Cotsomitis et al. (1991) only found weak connection between innovation and trade for few sectors in number of innovating countries.

In addition to sector studies, a number of empirical studies make use of country-level data to analyze the technology-trade relationship. These studies can provide a more straightforward view of countries' macro competitiveness, so that the policy implications can be directly generated. Fagerberg (1988), pooling trade flows for 15 OECD countries, found that technological advantages and ability of efficient delivery (indicated by transportation equipment and distribution infrastructures) are the most important determinants of countries' trade competitiveness and growth rate. Amendola et al. (1993) investigated the impact of both technology and labor cost on macro competitiveness of 16 OECD countries.

In the framework of endogenous growth theory, Amable and Verspagen (1995) used an error correction model to explain the relationship. They distinguished the impact of technology on 'Supplier dominated', 'Production intensive' and 'Science based' sectors and concluded the impact of technology differs across countries and sectors. Salim and Bloch (2009) have recently analyzed this bidirectional causality for Australia. They used monthly macro data and showed R&D Granger-causes exports in the long run[4]. Along with Coe and Helpman (1995), a large number of studies have discussed the effects of importing on domestic total factor productivity (TFP), the so-called technology spillover effect. Besides trade, FDI inflows (e.g. Hymer, 1976; Barrell and Pain, 1997) and geographical distance (Jaffe and Trajtenberg, 1993) are also decisive factors in explaining the extent of technology spillovers. MacGarvie (2005) finds that physical and technological proximity, closer geographical distance and a shared common language bring a country greater benefit from technology diffusion, while technology diffusion through trade is conditional on countries having similarly distributed inventions across technology classes.

2.2.2 Empirical evidence at the firm level

In addition to sector or country studies, there is a large number of empirical studies carried out at the firm level. Firm level data allow to investigate the trade-technology relation more precisely and to associate it with firms' heterogeneity and productivity. This section first reviews basic evidence on the innovation-trade link. Then, the innovation impact will be discussed for different types of firms. The next section demonstrates the mutual effect between trade and innovation in endogenous trade models. Finally, the importance of productivity in explaining the innovation-trade relationship is illustrated.

Innovation and trade performance

A number of studies have explored the effect of firms' innovation efforts on trade performance. Hirsch and Bijaoui (1985) considered the relationship between export behavior and R&D expenditures for 111 Israeli firms, and concluded that innovation is an important explanatory factor. Wakelin (1998a) used a sample of UK manufacturing firms and found differences in export behavior between innovating firms and non-innovating firms. A large amount of studies (e.g. Roper and Love, 2002; Bernard and Jensen, 1995; Sterlacchini 1999; Lachenmaier and Wößmann 2006; Cassiman and Martinez-Ros, 2007; Van Beveren and Vandenbussche, 2009) have found significant differences between exporting- and non-exporting firms in their innovation activities. Lachenmaier and Woßmanny (2006) used a unique instrumental variables approach and found that innovation significantly enlarges firms' export share.

Gourlay et al. (2005) and Love and Mansury (2009) investigated the innovation-trade relationship for service firms and found positive links between innovation activities and the probability of exporting. Moreover, Zahler et al. (2013) find that service firms that the exports are more innovative than their non-exporting competitors in comparison with the situation in

[4] It is also country-level studies

the manufacturing sector. Becchetti and Rossi (2000) investigated Italian firms and found that innovation is neither significantly correlated with the probability to export, nor with export intensity.

Innovation-trade relations and heterogeneity

Many empirical studies at firm level also pay special attention to firms' heterogeneity when studying the innovation-trade relationship. Factors such as firm size and innovation capacity seem to play a crucial role in explaining firms' export behavior. For example, Lachenmaier and Woßmanny (2006) also paid attention to the different innovation effects across industries and the effects were found to be larger for technology intensive industries. Higón and Driffield (2011) find positive impacts of both product and process innovation for SMEs' decision to export. Lefebvre et al. (1998) and Sterlacchini (2001) pointed out that R&D expenditures might not significantly affect trade performance when considering the type and size of firms and other innovation indicators may have more explanatory power.

Endogenous innovation

Based on the learning by exporting effect, some researchers investigated the opposite causality that exporting makes firms more innovative. Hall et al. (2009) find a direct and positive link between international market participation and R&D intensity. They explain this result based on the fact that more competition on international markets could stimulate innovation, and this is especially true for high-technology firms. The literature in favor of this causality includes Alvarez (2001), Girma et al. (2004), Salomon and Shaver (2005), Crespi et al. (2008). Baldwin and Gu (2004), on the other hand, do not find direct evidence in favor this causality.

Another strand of the literature focuses on bi-directional causality considerations. Aw et al. (2007) model the decisions to export and to invest in R&D simultaneously by applying Bivariate Probit methods, and they find a correlation between export participation and innovation. Damijan et al. (2010) start from similar methods and distinguish product innovation and process innovation by using a sample of Slovenian firms. Their results show that both product and process innovations increase the likelihood of exporting and moreover, that participating in the international market positively affects process innovation. Harris and Moffat (2011) use an instrumental variables approach to investigate the link between export and innovation for UK manufacturing and non-manufacturing sectors. The results suggest that engaging in exporting would increase the probability of innovation for both sectors, but only in the manufacturing sector innovation would also increase the probability to export. Other similar studies include Zhao and Li (1997); Girma et al. (2008); Aw et al. (2009); Bratti and Felice (2012).

Causality between trade and productivity

Different from industry or country studies, many firm-level studies focus on the role of productivity as an intermediate link between firms' trade performance and innovation activities. A debate is still ongoing on whether productive firms self-select into international market or whether international market participation makes firms more productive. Except for Damijan and Kostevc (2006) and De Loecker (2007) who found a significant effect of exporting on productivity growth, most scholars tend to stand by the view that productive firms self-select into export markets (e.g. Clerides et al., 1998; Roberts and Tybout, 1997; Bernard and Jensen, 1999 and 1999a; Kaiser and Kongsted, 2004; Aw et al., 2000; Bernard and Jensen, 2004; Greenaway and Kneller, 2007; Wagner, 2007). Self-selection into export markets is explained by the presence of sunk cost, which makes that firms' export behavior determined by prior experience. For instance, Roberts and Tybout (1997) develop a discrete-choice model that quantifies the prior-export experience of Colombian manufacturing plants and confirm the self-selection hypothesis due to these sunk entry costs. Specifically, prior export experience increases the probability of engaging in export markets by sixty percent. Falvey et al. (2004) finds that self-selection is stronger for those industries for which the degree of substitution among goods is higher.

3. Methodology

This chapter explains the theoretical framework, assumptions and models at the basis of the empirical analysis. All involved variables and data are described in detail. A descriptive section of countries' export performance and competitive advantages in terms of costs and quality of production is included at the end of the chapter.

3.1 model and variables

Our econometrical constructs are derived from the import demand model of Anderton (1999). Following the new trade theory, product innovation will lead to either vertical product differentiation (higher quality) or horizontal product differentiation (expanded range of varieties). The model assumes buyers will choose among available varieties on the basis of price and non-price characteristics. The non-price characteristics are basically a result of product innovation activities, namely quality and new varieties[5]. On the other hand, assume that process innovation only affects the selling price since it improves productivity and ultimately reduces the selling price. Hence, import demand is determined by the relative domestic price, the total domestic demand and relative domestic innovation intensity. Since time series data are used, a determinant of time-related variation is also included.

$$IM_t^{kij} = \int (RP_t^{kji}, DE_t^{kj}, RI_t^{kji}, TIME) \tag{1}$$

Where: IM_t^{kij} is import volume of sector k from country i to country j; RP_t^{kji} is the domestic price of k sector goods in country j relative to import price of k from country i. DE_t^{kj} is the real demand for the goods of sector k in country j. RI_t^{kji} represents the relative real R&D intensity between countries of j and i for sector k. $TIME$ represents the trend of world specializations.

Equation (1) will be estimated in log-linear form:

$$\ln IM_t^{kij} = \beta_1 \ln RP_t^{kji} + \beta_2 \ln DE_t^{kj} + \beta_3 TIME + \beta_4 \ln RI_t^{kji} + u_t \tag{2}$$

In addition, dummy variables are added to discern the impact of innovation for different types of sectors.

$$\ln IM_t^{kij} = \beta_1\, ln\, RP_t^{kji} + \beta_2\, ln\, DE_t^{kj} + \beta_3 TIME + \beta_4\, ln\, RI_t^{kji} + \beta_T (Dummy\; T) + u_t \tag{3}$$

$$\ln IM_t^{kij} = \beta_1\, ln\, RP_t^{kji} + \beta_2\, ln\, DE_t^{kj} + \beta_3 TIME + \beta_4\, ln\, RI_t^{kji} + \beta_S (Dummy\; C) + u_t \tag{4}$$

Dummy T is the interaction term that multiplying relative innovation with dummy variable of high-technology (value: 1) versus low-technology sectors (value: 0). It measures the difference of innovation impact in high-technology sectors and low-technology sectors; similarly Dummy C is the multiplication of relative innovation and the dummy variable that indicates the difference between concentrated (value: 1) and fragmented sectors (value: 0).

[5] Quality is defined as the number of desired attributes of the goods. Hence, almost all non-price characteristics will ultimately be reflected in product quality. For example, environmentally-friendly production or guarantees are desired attributes and hence a variety with these attributes has better quality than other varieties.

The sign of parameters are expected to be positive for $\beta_1, \ \beta_2$, because both a higher domestic price and higher domestic demand will stimulate consumption of imported goods. Furthermore, β_3 is expected to be positive. As a result of the increasing trend of world specialization, the number of domestically supplied varieties will reduce and imports will increase. I expect β_4 to be negative since more local innovation will make local products more competitive and therefore domestic demand will be less dependent on imports. The sign of β_T and β_S are expected to be negative because innovation is generally higher in both high-technology sectors and concentrated sectors and hence the negative effect of domestic innovation on import flows will be reinforced.

3.2 Variable specifications and data sources

Bilateral import volume (IM_t^{kij}) is calculated as the bilateral import value divided by producer price indices of the exporting country. Bilateral import value data are derived from the World Bank Integrated Solutions database. Producer price indices come from the Eurostat data base.

The relative domestic price (RP_t^{kji}) is the ratio of domestic producer price index over import price index. Since the import price is not available, the producer price index in the exporting country is used as a proxy of import price. This is reasonable because the sampled countries had free trade agreements with one another during the measurement period and they are geographically near to each other. Hence, transportation costs and possible distortions due to trade barriers can be ignored and producers will equalize their selling price in these markets. The data source is the Eurostat database.

Real domestic demand (DE_t^{kj}) is calculated as the sum of the total import value divided by producer price indices of the exporting country and the production value minus total export value divided by domestic producer price indices. The value of import, export and production is retrieved from the OECD STAN database, and the producer price indices are the same as aforementioned.

Relative innovation intensity (RI_t^{kji}) is the ratio of domestic R&D and exporting country's R&D in constant US dollar measurement. Data is retrieved from the OECD STAN database.

The categorization of sectors for **Dummy T and Dummy C** is based on OECD (2011) and Oliveira-Martins (1993). OECD (2011) classifies high-technology and low-technology sectors based on R&D intensities divided by value added of the sector. Sectors with a ratio above 5.0 are categorized as high-technology, others are considered to be low-technology sectors. According to Oliveira-Martins (1993), concentrated sectors observe a limited number of firms – despite growth in market size – due to the large sunk costs of starting a business. Competition in this kind of market is intense and generally based on non-price characteristics. In fragmented sectors the number of firms increases along with the market size, normally the sunk costs for these sectors is low and price is the dominant factor to compete. Table 1 presents the sectors in different type:

Table 1 Sector type

	Concentrated (dummy value:1)	Fragmented (dummy value: 0)
Low Tech sectors (dummy value: 0)	D17: Paper and paper products D18: Printing and reproduction of recorded media D22: Rubber and plastic products D24 Basic metals D25: Fabricated metal products, except machinery and equipment	D10T12: Food products, Beverage and Tobacco D13: Textiles D14: Wearing apparel D15: Leather and related products, footwear D16: Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials D23: Other non-metallic mineral products D31T33 Furniture; other manufacturing; repair and installation of machinery and equipment
High Tech sectors (dummy value: 1)	D19: Coke and refined petroleum products D21: Pharmaceuticals, medicinal chemical and botanical products D30: Other transport equipment D29: Motor vehicles, trailers and semi-trailers	D28: Machinery and equipment n.e.c. D27: Electrical equipment D20: Chemicals and chemical products[6] D26: Computer, electronic and optical products

Based sources: ANBERD and STAN databases, and Oliveira-Martins (1993)

With panel data from approximately 20 manufacturing sectors during 1991-2010, 6 bilateral trade flows will be analyzed at aggregated country level. The six flows are Italy’s and Germany’s respective imports from Spain, the Czech Republic and each other. All required data were downloaded under International Standard Industrial Classification of All Economic Activities, ISIC Rev.4. Import volume data were only available in ISIC Rev.3 and were converted into ISIC Rev.4 using the ‘STAN approximate 2-digit mapping Table ’ in the OECD database.

Intuitively, there should have 400 observations (20 sectors multiplied by 20 years) available for each bilateral trade flow. However, the sample is smaller because there are small deviations in data span across countries and sectors. For Italy, the database provides demand data for the period 1991 to 2010, while the bilateral import data is only available from 1994 to 2011, consequently the number of observations for Italian import flows is only around 340 (20 sectors multiplied by 17 years). For Germany, 18 years of data are available for 21 sectors, but the values are missing for some sectors in the first 4 years. Nevertheless, the sample size is larger than 300 observations for every bilateral trade flow, and this is considered to be sufficient.

3.3 Countries’ export performance and competitive advantages

This section provides descriptive statistics on the trade position and characteristics of the countries in the sample. This information will help to interpret the results of the empirical estimations in the next chapter. Table 2 reveals the export market share in manufacturing sectors and table 3 indicates the level of unit labor costs in manufacturing sectors for the countries in the sample. The trade competitiveness is determined by cost advantages on the one hand and non-price characteristics of trade flows, such as the quality of traded goods on the other. It can be assumed that countries that have a cost disadvantage but are leaders in terms of world market share, derive a strong competitive position based on non-price factors such as the quality of traded goods.

I use unit labor costs in manufacturing sector to indicate cost advantages. In terms of table 3,

[6] Chemicals and Chemical products can be categorized into both concentrated sectors and fragmented sectors. Here we decide to put it into fragmented category.

Germany and Italy have a competitive disadvantage in terms of the cost of production compared to Spain and the Czech Republic. On the other hand, Germany ranks significantly higher than Spain and the Czech Republic in terms of export performance. This means that Germany's competitive advantage is likely to be more in terms of the production of high-quality varieties. In most sectors, Italy is also substantially leading Spain and the Czech Republic in terms of world market shares. In other words, both Germany and Italy can be seen as competing on quality compared to Spain and the Czech Republic, who are competing more on price. With labor costs at a similar level, it is hard to determine which is the more quality-advantaged country between Germany and Italy. Generally, Germany seems to have more advantages in high-technology sectors since its world market shares are substantially larger than Italy in these sectors.

Table 2 Countries' ranking on world market share in manufacturing sector 2009

Industry\Country	**Italy**	**Germany**	**Spain**	**the Czech Republic**
Processed food	5	1	11	32
Wood product	9	1	16	20
Textiles	3	2	14	18
Chemicals	11	1	13	29
Leather product	2	4	7	26
Basic manufactures	5	2	10	24
Non-electronic machinery	5	1	16	18
IT& Consumer electronics	24	6	28	14
Electronic components	11	3	21	17
Transportation equipment	9	1	7	14
Clothing	2	3	10	36
Miscellaneous manufacturing	5	3	24	23

Source: UNCTAD/WTO.

Table 3 Indices of countries' unit labor cost in manufacturing sector

Country	Unit Labor Cost Indices
Germany	0.855
Italy	0.884
Spain	0.753
Czech	0.553

Source: OECD

4. Results and interpretation

This chapter shows econometric estimations and corresponding results. The results are interpreted for different model specifications.

4.1 Econometric estimations

Econometric estimation models are based on the equations derived in section 3.1 and the dataset described in section 3.2. Due to the cross-section and time-series features of the data, existence of cross-panel heteroskedasticity and serial correlation were suspected. Therefore, the Modified Wald test (Baum, 2001) and the Wooldridge test (Wooldridge, 2002) have been applied for diagnostic reasons. Modified Wald test statistics suggest the presence of groupwise heteroskedasticity in all six bilateral import flows and at least four of them are suspected to also have first-order autocorrelation.

Based on this, the Feasible Generalized Least Squares (FGLS) and the Prais–Winsten regression with panel-corrected standard errors seem appropriate because both allow for estimation in the presence of heteroskedastisty and first-order autocorrelation. However, Beck and Katz (1995) demonstrate that FGLS provides severely underestimated standard errors (underestimations of 50% or even more are reported) if the number of periods (T) is not far larger than the number of panels (N)[7]. Instead of FGLS standard errors, they advocate to use panel-corrected standard errors and find good results even with complicated error structures. Moreover, Reed and Webb (2010) explore the characteristics of FGLS standard errors and panel-corrected standard errors in depth and declare that the latter performs better than FGLS standard errors when T is close to N. However, panel-corrected standard errors would have efficiency losses if T and N diverge substantially or when serial correlation is present. In our case, T is smaller but quite close to N. Therefore, panel-corrected standard errors are more suitable and they will be applied using the Prais-Winsten regression model[8].

4.2 Results and interpretation

The estimation results are presented in table 4 for Italy and table 5 for Germany. Model (1) predicts the basic model specification that excludes relative R&D and sector-specific interaction terms to obtain basic specifications for relative price and demand effects. The innovation variable is included in model (2). Model (3) and (4) include interactions terms to assess the impact of innovation in different types of sectors. I will discuss the results of each model separately. The results of model (1) show that, in line with expectations, real domestic demand (DE) has a positive and significant effect on import flows. Furthermore, real domestic demand coefficients are larger for Italy's import flows than for Germany. A potential reason is that Germany has a high self-sufficiency level in manufacturing sectors. As shown in table 2, Germany has the top world market share in almost every manufacturing sector. Because of this, Germany is capable to produce various goods that make it less dependent of imports. The relative price coefficient (RP) is significant in only 3 out of the 6 import flows. The increasing trend of specialization may explain the limited effect of relative prices. With specialisation, varieties are exclusively supplied and since consumer preferences are relatively stable in the

[7] Based on rule of thumb, T should be at least three times larger than N.

[8] The command xtpcse in Stata is used to estimate the model. The command estimates parameters by either OLS or Prais–Winsten regression. The OLS estimates apply when the data is free from serial correlation; but in our case, Prais–Winsten regression is appropriate.

short run, import flows are relatively independent of price fluctuations within a certain range. Finally, both countries show a slightly increasing trend with time except for Germany's imports from Italy, this also reflects the trend in world specialization as countries become increasingly depend on imports to fulfil diverse consumer needs.

Model (2) presents the estimation results including the variable of relative innovation (RI). The results show that none of the import flows have significant RI coefficients, which suggests that there is no innovation impact for aggregated country flows.

Comparing the results of the base coefficients in model (1) with model (2) provides additional insights in the relative price effect. In general, the relative price coefficients in model (1) vary within a range of 0.8 – 3.0. This is consistent with other empirical findings (e.g. Anderton, 1999; Greenhalf et al., 1994; Whaklin, 1998). However, the price elasticity may be underestimated in this base model (1). As Grozet and Erkel-Rousse (2004) argue, ignoring quality attributes that are captured by price differences in trade models would suppress the price elasticity. In model (2), variations in quality are captured by the variable RI because innovation efforts are assumed to lead to new product varieties and upgraded product quality. Therefore, the coefficients of RP are expected to increase when the RI variable is added to the base model. This expectation is only confirmed for import flows from the Czech Republic and Italy into Germany. The relative price effect remains insignificant for the other import flows. In the case of import flows from Germany to Italy, the relative price effect even becomes significantly negative. The latter result is counterintuitive and suggests that imports of German manufactured goods decrease as the price of domestic goods increases. An increase in relative price may reflect improved quality of Italian products. This improved domestic production of high quality products may substitute for imports of similar products produced in Germany.

Model (3) adds an interaction term combining the RI variable with a dummy variable for high-technology sectors to investigate if the innovation impacts diverge between high-technology sectors and low-technology sectors. Including the interaction term means that the RI coefficient represents innovation intensity in low-technology sectors, while the sum of RI and Dum-T coefficients represents innovation intensity in high-technology sectors. Results show that there is no significant innovation impact on import flows in low-technology sectors, while significant innovation impacts are found in four high-technology import flows. This is in line with Chen (2008) who states that a substantial innovation impact is only observed in high-technology sectors.

In high-technology sectors, Italy and Germany's innovation activities show a positive impact on their imports from the Czech Republic and Spain respectively. An explanation for the positive innovation impact is vertical product differentiation. As indicated in 3.4, the Czech Republic and Spain can be considered low-cost producers and hence have a competitive cost advantage compared to Germany and Italy. On the other hand, Germany has a competitive advantage in terms of quality of production, and to a lesser extent Italy. Deriving from the new trade theory, relatively high innovation intensity in the quality-advantaged countries would raise their total cost against the cost-advantaged countries. In order to stay competitive, quality producers have to specialise in production of high-quality varieties and gain economies of scale. The Czech Republic and Spain as the cost-advantaged trading partners are competitive in producing the basic varieties, so their exports complement the product range of both importing countries.

Negative innovation impacts are found in two trade flows. Italy's innovation activities show a strong impact on reducing its imports from Germany. In terms of our arguments in 3.3, Germany is the quality-advantaged country relative to Italy in high-technology sectors. This means that high relative innovation intensity in these sectors helps Italy to catch up and reduce import dependency from quality-advantaged countries, in this case Germany. This is in line with the literature. The negative innovation impact is also noted in Germany's high-technology import from the Czech Republic, but the impact is limited. As Germany is ranking much higher than the Czech Republic in most sectors in table 2, this is a surprising result. Since this study lacks disaggregated data, this issue remains unexplained in our paper.

Finally, Model (4) introduces an interaction effect of innovation (RI) and the dummy variable (Dum-C) to capture the innovation difference between concentrated sectors and fragmented sectors. The Dum-C coefficient is found to be significant and negative in three import flows. Furthermore, for the import flows that have a significant Dum-C coefficient, a significantly positive RI coefficient is also found. In other words, fragmented sectors show positive innovation impacts (RI) on import demand, whereas the impact for concentrated sectors is negative (RI + Dum-C). As aforementioned, higher innovation expenditures will force quality-advantaged countries to focus on producing high-quality varieties. Since price plays a dominant role in fragmented markets, higher expenditures caused by innovation activities will make producers less competitive when producing basic varieties. As a result, the demand for basic varieties will be fulfilled by the cost-advantaged partners.

Concentrated sectors show the opposite tendency. The higher the relative innovation intensity, the lower the imports demand. In concentrated markets, price is not a dominant factor to win competition. Innovation is the main approach to gain non-price advantages and compete with other big players in the market. Hence, higher relative innovation will result in higher market shares and lower import demand.

Table 4 Results of Italy's import flows (Prais-Winsten regression with Panel Corrected Standard Errors PCSE)														
Partner: Czech Republic	***Model (1)***	***Model (2)***	***Model (3)***	***Model (4)***	**Partner: Spain**	***Model (1)***	***Model (2)***	***Model (3)***	***Model (4)***	**Partner: Germany**	***Model (1)***	***Model (2)***	***Model (3)***	***Model (4)***
RP	0.804* (0.492)	0.184 (0.580)	0.036 (0.605)	0.569 (0.497)	***RP***	-1.682 (1.242)	-1.548 (1.206)	-1.028 (1.248)	-1.437 (1.191)	***RP***	-0.634 (0.543)	-1.041* (0.568)	-0.970* (0.582)	-1.001* (0.572)
DE	1.030** (0.161)	0.978** (0.158)	0.952** (0.152)	0.854** (0.165)	***DE***	1.308** (0.114)	1.301** (0.110)	1.309** (0.116)	1.297** (0.108)	***DE***	1.251** (0.102)	1.296** (0.100)	1.286** (0.094)	1.282** (0.095)
TIME	0.083** (0.019)	0.067** (0.021)	0.067** (0.020)	0.079** (0 .019)	***TIME***	0.024** (0.011)	0.024** (0.010)	0.031** (0.010)	0.026** (0.010)	***TIME***	0.030** (0.011)	0.033** (0.012)	0.029** (0.012)	0.033** (0.012)
RI	−	0.009 (0.044)	-0.027 (0 .038)	0.131** (0.040)	***RI***	−	0.077 (0.048)	-0.001 (0.030)	0.028 (0.030)	***RI***	−	-0.037 (0.045)	0.020 (0.030)	-0.047 (0.037)
Dum-T	−	−	0.186* (0 .108)	−	***Dum-T***	−	−	0.252 (0.166)	−	***Dum-T***	−	−	-0.215* (0.116)	−
Dum-C	−	−	−	-0.258** (0.064)	***Dum-C***	−	−	−	0.121 (0.104)	***Dum-C***	−	−	−	0.030 (0.078)

Table 5 Results of Germany's import flows (Prais-Winsten regression with Panel Corrected Standard Errors)														
Partner: Czech Republic	***Model (1)***	***Model (2)***	***Model (3)***	***Model (4)***	**Partner: Spain**	***Model (1)***	***Model (2)***	***Model (3)***	***Model (4)***	**Partner: Italy**	***Model (1)***	***Model (2)***	***Model (3)***	***Model (4)***
RP	0.895** (0.283)	0.989** (0.327)	1.227** (0.345)	0.773** (0.307)	***RP***	0.886 (0.894)	1.077 (0.950)	1.103 (1.030)	1.117 (0.949)	***RP***	2.950** (0.701)	3.435** (0.753)	3.490** (0.748)	3.323** (0.736)
DE	0.520** (0.059)	0.533** (0.047)	0.576** (0.052)	0.532** (0.050)	***DE***	0.609** (0.061)	0.613** (0.073)	0.568** (0.082)	0.616** (0 .073)	***DE***	0.283** (0.054)	0.305** (0.059)	0.293** (0.075)	0.277** (0.058)
TIME	0.083** (0.014)	0.078** (0.015)	0.084** (0.015)	0.073** (0.015)	***TIME***	0.029* (0.016)	0.031** (0.016)	0.032* (0.016)	0.032** (0.015)	***TIME***	0.017 (0.013)	0.019 (0 .014)	0.019 (0.014)	0.023* (0.014)
RI	−	-0.037 (0.026)	-0.031 (0.026)	0.047* (0 .029)	***RI***	−	0.017 (0.067)	-0.056 (0.058)	0.004 (0.070)	***RI***	−	-0.036 (0.052)	-0.046 (0.039)	0.072* (0.041)
Dum-T	−	−	-0.073** (0.036)	−	***Dum-T***	−	−	0.195** (0.079)	−	***Dum-T***	−	−	0.051 (0.137)	−
Dum-C	−	−	−	-0.125** (0.030)	***Dum-C***	−	−	−	0.036 (0.063)	***Dum-C***	−	−	−	-0.230** (0.081)

*Notes: the numbers in brackets are the Panel Corrected Standard Error. * indicates where the parameters are significant at 90% confidence level and ** indicates where the parameters are significant at 95% confidence level.*

5. Conclusion

This paper studies the impact of innovation on Italy and Germany's bilateral import flows. In the framework of the new trade theories, I analyzed both price and non-price factors of import demand. Special attention has been paid to product differentiation and country's competitive advantage in terms of their low-cost and high-quality production. More concretely, the research objectives of this study were to explore the findings in the trade-technology literature, the innovation impact on import flows in terms of competitive advantage between countries as well as differences in innovation impact in different types of sectors. I answered the research questions as follows.

At first, the theories and empirical evidence that relate to the trade-technology (or innovation) relationship have been reviewed. The theory part highlights the dominant role of technology in determining countries' trade patterns and how innovation activities improve producers' trade competiveness. The majority of the empirical studies find a positive link between innovation and trade performance either at country/industry level or at firm level. Evidence shows that the impact of innovation is country- or sector-specific. Furthermore, some scholars claim that innovation exerts a substantial impact only in technology intensive sectors or low-income countries. At firm level, the technology and trade relation is often associated with firms' heterogeneity and productivity. The discussion of the mutual causality is still ongoing.

In the presence of heteroskedasticity and serial correlation, I choose Prais-Winsten regression with panel corrected standard errors to estimate the econometric results. At aggregated level, innovation does not impact bilateral import flows. Relative price is not significant in several bilateral trade flows. Due to the increasing trend of world specialization, many varieties are uniquely supplied and consumer preferences are hardly changed in short term, so the differentiated goods import is relatively independent of certain range of price fluctuation. The empirical results suggest there is no innovation impact on low-technology imports. Innovation in the importing country has no or a positive effect on high-technology imports from countries which have a quality disadvantage in production, whether it is positive or no effect depends on their cost advantage. The effect for imports from quality-advantaged countries is negative. Similarly, innovation activities stimulate imports in fragmented sectors and reduce imports in concentrated sectors. The results are caused by differences in competitive advantage – either in terms of cost advantage or quality advantage between the importing country and its partners.

To conclude, there are still several drawbacks in this study that need to be addressed: 1) aggregated country flows ignore individual sector specifications, for example Germany's negative innovation impact for high-technology imports from the Czech Republic remains unexplained; 2) a relatively small sample size and the existence of heteroskedasticity and autocorrelation may influence the accuracy of the econometric findings; 3) all countries in the sample have neighbouring relations and close economic cooperation. This may limit the value of research finding for generalization to a global context. Therefore, our recommendation is to extend the research by using data from more countries and at a more disaggregated level.

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