Rev Agric Food Environ Stud (2016) 97:159–172
DOI 10.1007/s41130-016-0024-3

RESEARCH ARTICLE

Intra-industry trade in the wine sector in the enlarged European Union

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Received: 12 June 2014 / Accepted: 26 April 2016 / Published online: 19 July 2016

Abstract International trade theory suggests that advanced trade integration may lead to a higher level of intra-industry trade. The enlargement of the European Union (EU) during the last decade is a good example to analyse the intra-industry trade in wine products. The aim of the paper is to analyse the pattern and drivers of horizontal intra-industry trade in the wine sector within the EU between 2000 and 2011. We employ an empirical strategy developed by Cieślik (2005) to test Helpman and Krugman (1985) model. We find a growing trend in intra-industry trade with dominance of vertical intra-industry trade. Estimations suggest that Belgium, France, the Netherlands and Germany report the highest level of intra-industry trade within the EU. The level of intra-industry trade is highest among old member states. Empirical evidence indicates that the standard intra-industry theory finds some support in our data when we control for the sum of capital to labour ratios in the estimated equations instead of relative country-size variables. We find that the EU enlargement positively influences total and vertical intra-industry trade while it has negative impacts on horizontal intra-industry trade. Distance has negative effects on all types of intra-industry trade.

Keywords Horizontal and vertical intra-industry trade · EU wine industry · Helpman and Krugman model · Trade integration

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JEL classification Q170 · F140

Introduction

In the last decade, intra-industry trade (IIT) became a widespread phenomenon with a growing role in international trade providing strong incentives for theoretical and empirical research. New trade theory offers several models to explain IIT based on different assumptions on product differentiation. In the case of horizontal product differentiation, the usual conclusions are about the role of factor endowments and scale economies that stem from the framework of monopolistic competition. This framework, summarised in Helpman and Krugman (1985), and often referred to as the Chamberlin–Heckscher–Ohlin (C–H–O) model, allows for inter-industry specialisation in homogeneous goods and intra-industry trade in horizontally differentiated goods. This model suggests a negative relationship between differences in relative factor endowment, proxied usually by gross domestic product (GDP) per capita, and the share of IIT. Alternatively, the vertical IIT models developed by Falvey (1981), Falvey and Kierzkowski (1987) and Flam and Helpman (1987) predict a positive relationship between IIT and differences in relative factor endowment. The available empirical evidence provides rather contradictory evidence on the impact of relative factor endowments on IIT. One possible explanation for diverging results is that the majority of empirical studies fail to provide the exact link between theory and data. Empirical studies on IIT usually employ a rather eclectic approach using simply the most common explanatory variables to test hypotheses based on different theoretical frameworks.

The formation of stronger economic ties between European countries due to the creation and expansion of the EU contributed to an increase in IIT among European countries. There is a wealth of literature on IIT between a particular EU country and its partner (see for recent examples Jensen and Lüthje 2009; Milgram-Baleix and Moro-Egido 2010). However, a significant part of the studies focuses on industrial products. Interestingly, the industry level studies are still scarce especially in the food industry (see the exceptions of Christodolou 1992; Pieri et al. 1997). We choose wine products for two reasons. First, IIT in the wine sector is a fact of everyday life. A wide selection of wines including domestic and foreign is available to consumers in almost all European countries. Second, wine is a differentiated product, thus, a natural example for IIT analysis.

The aim of the paper is to analyse the pattern and drivers of IIT in the wine industry within the European Union between 2000 and 2011. Although the various aspects of international wine trade are relatively well documented in the literature (e.g. Crozet et al. 2012; Anderson and Wittwer 2013; Agostino and Trivieri 2014, Meloni and Swinnen 2014), this paper is the first attempt to analyse wine IIT within the EU. More specifically, following Helpman (1987) and Hummels and Levinsohn (1995), we focus on the theoretical relationships between factor proportions and intra-industry trade within the original Helpman–Krugman framework. Moreover, we control for the impact of the sums of capital to labour ratios as proposed by Cieślik (2005). Our additional contributions are the following. We employ a multilateral dataset instead of a bilateral framework still predominating recent empirical research. In addition, although the Helpman–Krugman model is based on horizontal product differentiation, empirical tests of their model usually neglect the distinction between horizontal and vertical IIT, when they measure IIT. However, because the main focus in empirical IIT literature is on the analysis of the effect of relative factor endowments on IIT, we can test both horizontal and vertical IIT models using the same modelling framework. Furthermore, we investigate the possible impact of the EU enlargement on the European wine trade. Finally, we check the robustness of our results using total, horizontal and vertical IIT indices.

Theoretical framework

The traditional C–H–O model assumes that goods are horizontally differentiated. In these models (Krugman 1979; Lancaster 1980; Helpman 1981), IIT opens up monopolistically competitive markets, with increasing returns to scale on the supply side and diverse consumer preferences on the demand side. Helpman and Krugman (1985) add factor endowment differences to a model that explains the co-existence of intra- and inter-industry trade. Let us consider two countries (A and B), two factors (labour and capital) and two goods: a homogeneous commodity which is relatively labour intensive and a differentiated product which is relatively capital intensive. If country A is relatively labour-abundant and country B is relatively capital-abundant, Helpman and Krugman (1985) show how country A tends to export the homogeneous product and both countries import the differentiated good. This model predicts that IIT will decrease as the factor endowments of the countries diverge. Moreover, Bergstrand (1990) expanded earlier theoretical works by proposing a new framework that uses a gravity-like equation to explain the relationship between the share of IIT in total trade and factor endowments as well as income. Important determinants of the share of IIT in total bilateral trade in the Bergstrand model are differences in income, average income and average capital to labour ratios as well as differences therein.

However, Cieślik (2005) points out that previous empirical studies fail to provide an exact link between the theory and the data. He shows that the Helpman and Krugman (1985) model does not predict any unique theoretical relationship between IIT and relative country size if we keep differences in capital to labour ratios unchanged. Thus, Cieślik (2005) develops a formal model to eliminate this shortcoming by providing two complementary propositions. First, "the share of IIT between two countries is larger the larger sum of their capital-labour ratios, given the fixed difference in their capital-labour proportions" (Cieślik 2005, p. 912). Second, "the share of IIT between two countries is larger the smaller the difference in their capital-labour ratios given the constant sum of their capital-labour ratios" (Cieślik 2005, p. 913). His results imply that the theory finds support in the data when we control for the sum of capital to labour ratios in the estimating equations instead of relative country-size variables.

The earlier empirical literature on IIT typically assumes, sometimes implicitly, that product differentiation is horizontal. But, recent empirical studies show that vertical IIT is markedly more important than horizontal IIT (e.g. Fontagné et al. 2006; Jensen and Lüthje 2009), highlighting the importance of respective theoretical models for empirical analysis. To explain vertical IIT, the theoretical models emphasise three factors which are important for both the demand and supply sides: the role of differences in factor endowments, the effect of income distribution and production size. The first strand of models focuses on the comparative advantage of vertical IIT, like in the C–H–O model. Falvey (1981) assumes a perfectly competitive market with two countries, two goods (a homogeneous product and a differentiated one) and two factors (labour and capital). The author introduces technological differences between countries but only in the homogeneous product sector. In the differentiated sector, it is assumed that more capital is used in producing higher-quality varieties than in lower-quality ones. Therefore, the higher-income, relatively capital-abundant country specialises in exporting relatively high-quality varieties, while the lower-income, relatively labour-abundant country specialises in exporting low-quality varieties. Falvey's model does not have an explicit demand side, but Falvey and Kierzkowski (1987) also elaborate on this.

On the demand side, goods are distinguished by perceived quality. Although all consumers have the same preferences, each individual demands only one variety of the differentiated product, determined by their income. Given that aggregate income is not equally distributed, consumers with lower incomes will demand low-quality varieties and high-income consumers will demand high qualities, regardless of their country of origin. Thus, it is possible to establish a marginal level of income in such a way that consumers with higher earnings will purchase the varieties produced in the relatively capital-abundant country, while low-income consumers will purchase the varieties produced in the relatively labour-abundant country. In this framework, IIT exists because each variety of a differentiated good is produced in only one country but is consumed in both countries. In this two-country world, the country which is relatively labour-abundant will tend to export the lower-quality/labour-intensive varieties of a differentiated good demanded abroad by low-income consumers and will tend to import the higher-quality/capital-intensive varieties demanded by high-income consumers in that country. Thus, the greater the IIT is, the greater the differences in the relative factor endowments (which correspond to per capita income differences in the context of the model) between the two countries are. The model also suggests that vertical IIT positively correlates with differences in the pattern of income distribution between partner countries.

The second group of models turns to a more heterodox explanation in line with the neo-Ricardian and neo-factorial models (Gabszewicz et al. 1981; Shaked and Sutton 1984). A similar model of IIT according to Flam and Helpman (1987) is created in which north–south trade is determined by differences in technology, income and income distribution. The results of this model are very similar to those of Falvey and Kierzkowski (1987). In the model of Flam and Helpman, there are two countries: a home country (north) and a foreign country (south), one factor (labour) and two goods. One of the goods is homogeneous and perfectly divisible while the other is quality differentiated and indivisible. Both countries have the same unit labour requirements for producing the homogeneous good. The labour input per unit of output of the quality-differentiated products differs between countries, where quality is a positive function of the labour input. The home country has an absolute advantage in production of all qualities, while the foreign country may have a comparative advantage in low-quality variety. Note that the source of quality differentiation is not the amount of capital used in producing the good, like in the Falvey and Kierzkowski (1987) model, but the technology used.

The demand for varieties stems from variation in income across consumers who buy a specific quality, reflecting their preferences and income constraint. Consumers with higher incomes demand the higher-quality differentiated good. Therefore, the home country specialises completely in the differentiated good of high quality, while the foreign country exports the homogeneous good. Assuming an overlap in income distribution, IIT appears. The model predicts that higher bilateral differences in factor endowment lead to a higher share of IIT.

Measuring intra-industry trade

The basis for the various measures of IIT used in the present study is the Grubel–Lloyd (GL) index (Grubel and Lloyd, 1975), which is expressed formally as follows:

$$\mathrm{GL}_i = 1 - \frac{|X_i - M_i|}{(X_i + M_i)} \quad (1)$$

where X_i and M_i are the values of exports and imports of product category i in a particular country. The GL index varies between 0 (complete inter-industry trade) and 1 (complete intra-industry trade) and can be aggregated at the level of countries and industries as follows:

$$\mathrm{GL} = \sum\nolimits_{i=1}^{n} \mathrm{GL}_i w_i \ \text{ where } \ w_i = \frac{(X_i + M_i)}{\sum\nolimits_{i=1}^{n} (X_i + M_i)} \quad (2)$$

where w_i denotes the share of industry i in total trade.

The literature suggests several options to disentangle the horizontal and vertical IIT. Greenaway et al. (1995) developed the following approach: a product is horizontally differentiated if the unit value of export compared to the unit value of import lies within a 15 % range, and otherwise, they define vertically differentiated products. Formally, the bilateral trade of horizontally differentiated products is expressed as follows:

$$1 - \alpha \leq \frac{UV_i^X}{UV_i^M} \leq 1 + \alpha \quad (3)$$

where UV^X means export unit values and UV^M describes import unit values, for goods i and α = 0.15. The choice of 15 % range is rather arbitrary, thus already Greenaway et al. (1994) proposed to widen the spread to 25 %. Interestingly, the papers checking the possible impact of various thresholds on results confirm that results coming from the selection of the 15 % range do not change significantly when the spread is widened to 25 % (Jensen and Lüthje 2009). Based on the logic above, the IIT index comes formally as follows:

$$IIT_k^p = \frac{\sum_j \left[\left(X_{j,k}^p + M_{j,k}^p\right) - \left|X_{j,k}^p - M_{j,k}^p\right|\right]}{\sum_j \left(X_{j,k} + M_{j,k}\right)} \tag{4}$$

where X and M denote export and import, respectively, while p distinguishes horizontal or vertical intra-industry trade, j is for the number of product groups and k is for the number of trading partners (j, k = 1,… n). Blanes and Martín (2000) emphasise the distinction between high and low vertical IIT. They define low vertical IIT when the relative unit value of a good is below the limit of 0.85, while unit value above 1.15 indicates high vertical IIT. Following the literature, we employ the 15 % threshold to distinguish the horizontal and vertical IIT.

We employ trade data from the UN Comtrade database with the World Integrated Trade Solution (WITS) software developed by the World Bank using the ISIC Revision 2 system (four-digit level). Wine trade is defined as trade in product groups coded in ISIC-3132 including three products in harmonised systems (sparkling wine, wine in containers holding 2 l or less, other wine). In the WITS, export values are reported on a free on board (f.o.b.) basis, while import values are presented on a cost insurance and freight (c.i.f.) basis. To reconcile the differences between f.o.b. and c.i.f. values following Ando (2006), we multiplied the export values by 1.05 in order to adjust the discrepancy between export and import values. Our analysis focuses on the period 2000–2011. In this context, the EU is defined as the member states of the EU-27. Thus, our sample includes 27 countries for 12 years resulting in 8424 observations.

Econometric specifications

We start by testing two main theoretical propositions of the Helpman–Krugman model. First, the share of IIT should be larger for countries with similar incomes per capita. Second, "the more similar countries are in size the larger the share of intra-industry trade" (Helpman 1987, p. 76.). Early tests of the Helpman–Krugman model are based on the following specifications.

$$\begin{aligned}\mathrm{IIT}_{ijt} = \alpha_0 + \alpha_1 \mathrm{lnDGDPC}_{ijt} \\ + \alpha_2 \min\left(\mathrm{lnGDP}_{it},\ \mathrm{lnGDP}_{jt}\right) \\ + \alpha_3 \max\left(\mathrm{lnGDP}_{it},\ \mathrm{lnGDP}_{jt}\right) +_{ijt}\end{aligned} \tag{5}$$

where IIT, the dependent variable, is the bilateral GL for total IIT. It is calculated with Eq. 2. Horizontal and vertical IIT are computed applying Eq. 4. Subscripts i and j denote the exporter and importer countries, respectively, and t describes time. The main independent variables are expressed by the relative factor endowments in terms of log of absolute difference in per capita GDP. The relative market size variables include the minimum and maximum of GDP levels. Precise definitions of the variables are given in Table 1.

To separate the effect of absolute country size from the impact of relative country size Helpman (1987) suggests the following modification:

$$\begin{aligned}\mathrm{IIT}_{ijt} = \alpha_0 + \alpha_1 \mathrm{lnDGDPC}_{ijt} + \alpha_2 \mathrm{lnGDPsum}_{ijt} \\ + \alpha_3 \mathrm{lndispersion}_{\mathrm{ijt}} + \varepsilon_{ijt}\end{aligned} \tag{6}$$

where dispersion is expressed as

Table 1 Description of independent variables

Variable	Variable description	Data source	Expected sign
lnDGDPC	The logarithm of the absolute difference between trading partners' per capita GDP measured in Purchasing Power Parity (PPP) in current international US dollar (USD)	WDI	−/+
lnGDPsum	The logarithm of the sum of GDP of trading partners measured in PPP in current international USD	WDI	+
lndispersion	Logarithm of dispersion as defined by Eq. 7	WDI	+
lnDCAPLAB	The logarithm of absolute difference between trading partners' capital labour ratios	Penn World Table 7.0., WDI	−/+
lnsumCAPLAB	The logarithm of the sum of capital labour ratios between trading partners	Penn World Table 7.0., WDI	+
lnDIST	The logarithm of absolute difference between trading partners' capital city measured in kilometres	CEPII	−
EU accession	Dummy variable taking the value 1 if a country is member of the EU and zero otherwise		+
OMS	Dummy variable taking the value 1 if a country is an old member state of the EU, and zero otherwise		

Source: own composition

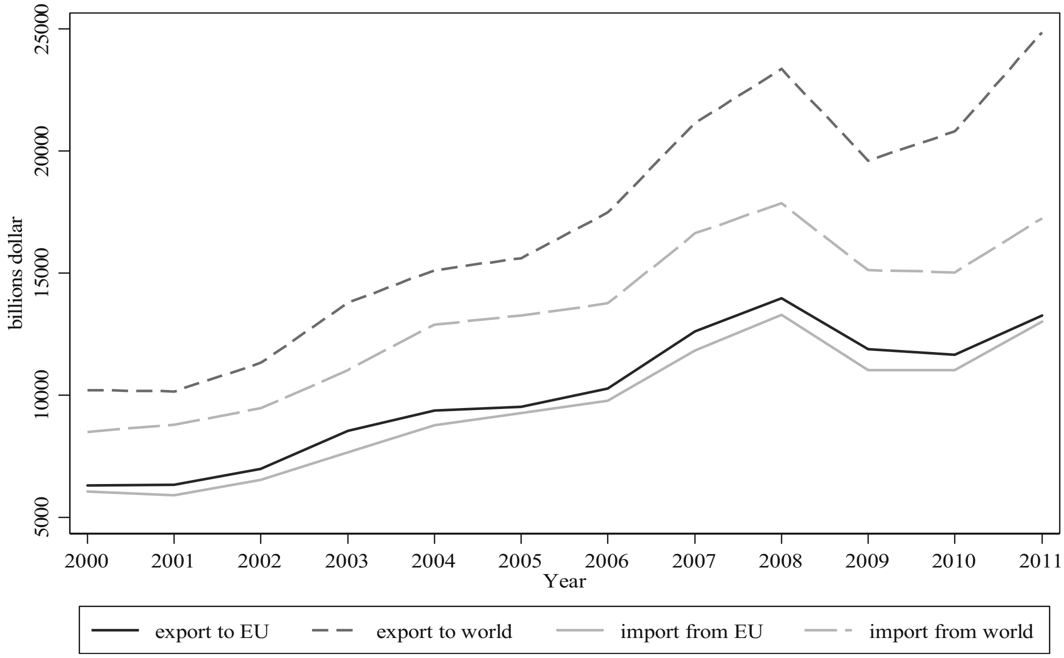

Fig. 1 EU-27 wine trade at the EU and world market. Source: own calculations based on the WITS database

$$\text{dispersion} = ln\left[1-\left(\frac{GDP_i}{GDP_i+GDP_j}\right)^2-\left(\frac{GDP_j}{GDP_i+GDP_j}\right)^2\right] \quad (7)$$

To test two propositions by Cieślik (2005) indicated above, we estimate the following model:

$$\text{IIT}_{ijt} = \alpha_0 + \alpha_1 \text{lnDCAPLAB}_{ijt} + \alpha_2 \text{lnsumCAPLAB}_{ijt} + \varepsilon_{ijt} \quad (8)$$

The GDP, GDP per capita and labour data come from the World Bank's World Development Indicators (WDI) database. For capital to labour ratios, the physical capital was estimated by the perpetual inventory method using investment and GDP variables from Penn World Table 7.0. (Heston et al. 2011). It is generally accepted that economic integration increases IIT (e.g. Jámbor 2014; Fertő and Jámbor 2015). After almost a decade, the question arises whether EU accession has had any impact on agri-food trade patterns and especially on

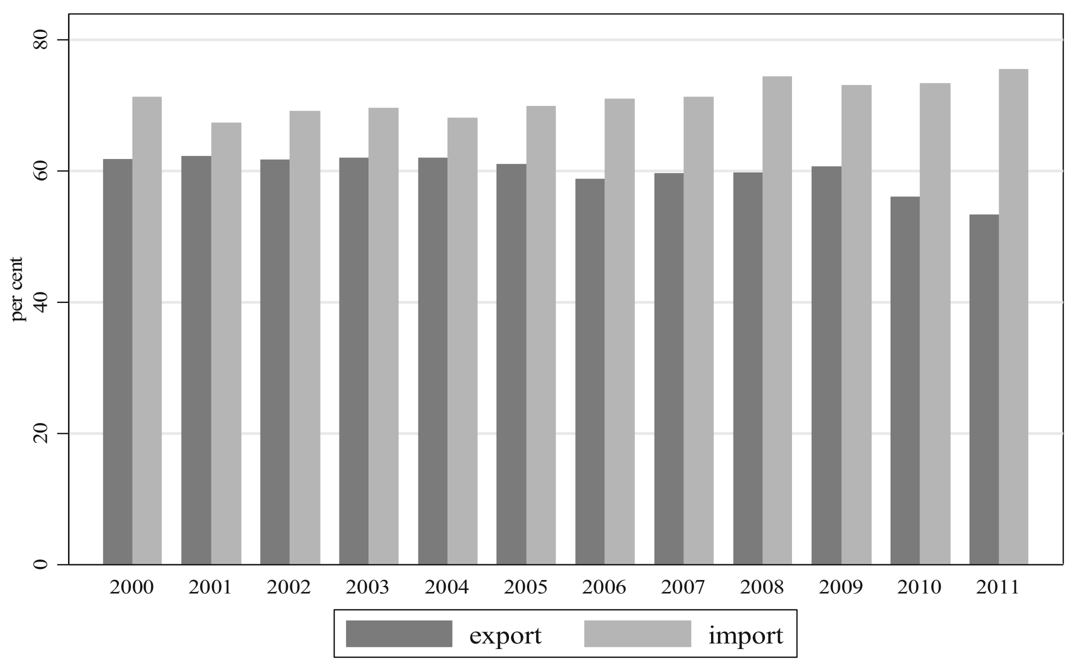

Fig. 2 The share of EU market in the EU-27 wine trade. Source: own calculations based on the WITS database

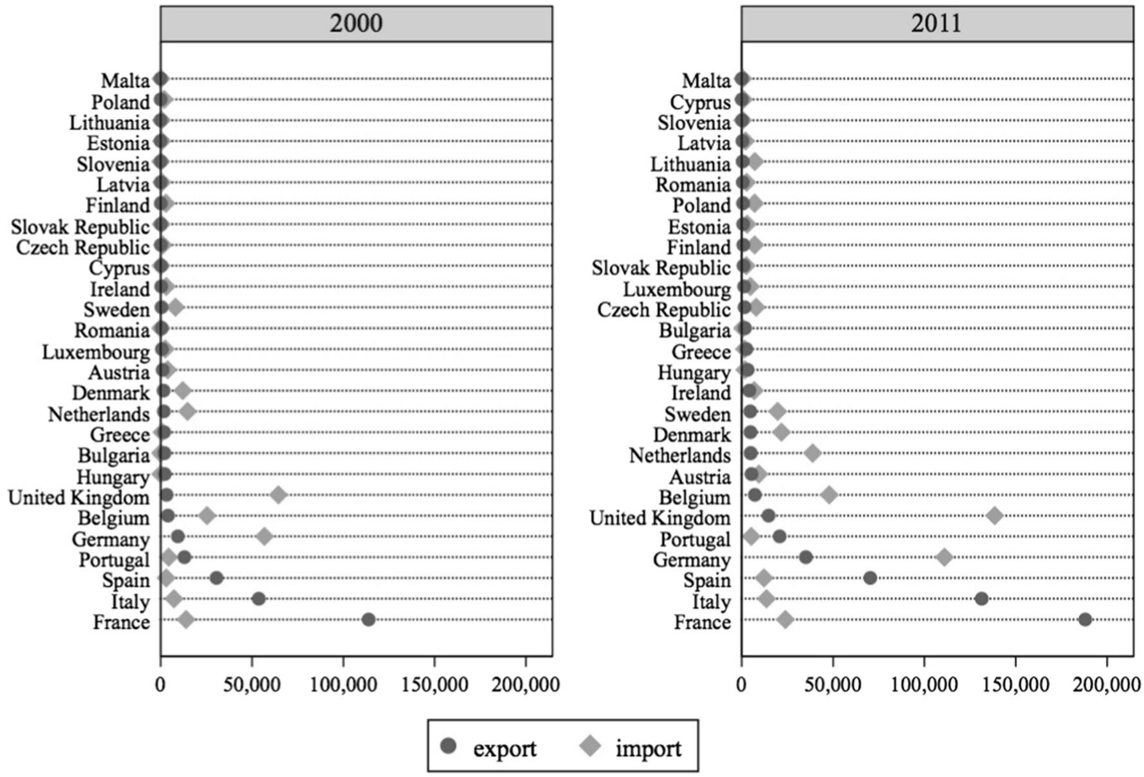

Fig. 3 Wine trade at the EU market by country (in thousand USD). Source: own calculations based on the WITS database

IIT. Thus, we include a variable capturing EU accession. Finally, for sensitivity analysis, we add a distance variable (lnDIST) to extend our model in Eq. 8. The source of distance data is the database of the French research centre in international economics (CEPII). Table 1 provides an overview of the description of variables and related hypotheses.

The nature of trade in the European wine sector

The characteristics of wine trade in the EU

The EU-27 wine trade has increased significantly at both EU internal market and the world markets (Fig. 1) during the analysed period. The values of exports and imports have more than doubled at both markets. We can also observe two important features of the wine trade pattern. First, a rapid growth has occurred in wine trade after EU enlargement in 2004. Second, there was a considerable drop in 2009 due to global economic crises, and the full recovery of wine trade has not yet finished in 2011 except wine exports to the world market.

The internal EU market plays a significant role in the European wine trade. The share of internal EU import has been above 70 %, while the proportion of exports has varied around 60 % except the last 2 years (Fig. 2).

The largest wine exporter countries are France, Italy, Spain, Portugal and Germany (Fig. 3), their share in average is around 90 %, but the proportion of France and Italy is around two third at the intra-EU markets. This indicates that wine export is highly concentrated within the EU. The relative position of some countries has changed over time: especially the new member states with traditionally strong wine sector (Bulgaria, Hungary, Romania) could not keep their relative share in the enlarged EU markets. Although Hungary and Romania increased their wine exports, these countries were not able to efficiently exploit the opportunities of increasing EU demand, while the Czech Republic and Slovakia increased their market share. Moreover, some non-traditional wine producer countries, including Denmark, Finland, the Netherlands, and Sweden, improved their export performance at the EU markets. More specifically, these countries increased the exports to their neighbours considerably. On the import side, the UK, Germany, Belgium, the Netherlands and France are the most important partners with around 75 % share at the

Table 2 Markov transition probability matrix for classification of trade types using 15 % threshold (shares in per cent)

	Low vertical IIT	Horizontal IIT	High vertical IIT
Low vertical IIT	64.2	6.0	29.8
Horizontal IIT	33.3	26.2	40.5
High vertical IIT	11.9	3.5	84.7

Source: own calculations based on the WITS database

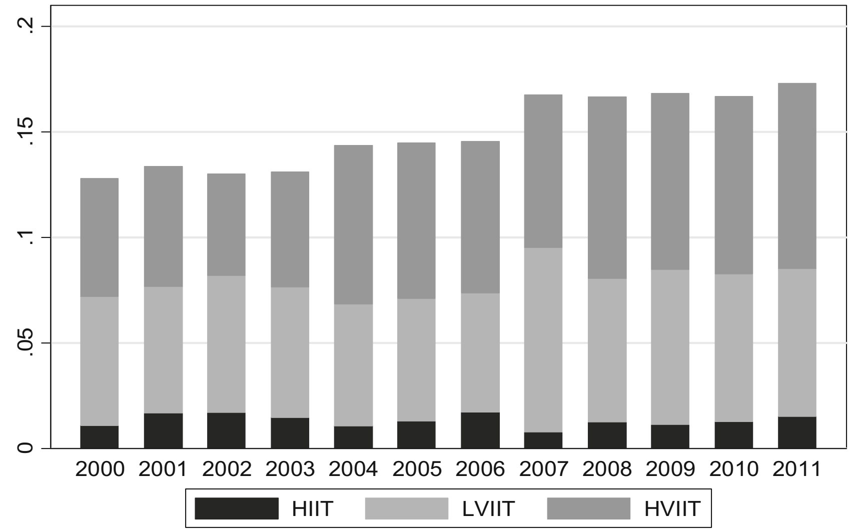

Fig. 4 Development of wine IIT in the EU-27. *HIIT* horizontal IIT, *LVIIT* low vertical ITT, *HVIIT* high vertical IIT. Source: own calculations based on Comtrade database with WITS

intra-EU markets. Moreover, the ratio of the UK and Germany is around 50 %. It implies also a geographically concentrated import structure within the EU. These countries import wine mainly from France, Italy and Spain. These countries strongly dominate the British and German markets. Figure 3 also shows that the overlap between exports and imports is relatively low for the largest exporters and importers implying relatively low level of IIT.

The nature of IIT in wine sector

One well-known problem in empirical IIT analysis is the stability of classification of IIT types (Nielsen and Lüthje 2002). The literature on the use of export/import unit values for assessing trade types, product qualities is mixed (Bojnec and Fertő 2010). International export/import unit values may differ and be volatile due to product mix and short-run consumers' preferences, as a reason for criticism of their use in competitiveness and other economic analyses (e.g. Silver 2007). On the other hand, there are no other available data to address the analysed questions; thus, the use of export/import unit values is widespread in the empirical trade literature (e.g. Greenaway et al. 1994) under the assumption that even with imperfect information, prices tend to reflect quality (Stiglitz 1987) and determine the direction of trade. To check the stability of classification in IIT types, we employ the Markov transition probability matrix. We distinguish three different trade types: low vertical IIT, horizontal IIT and high vertical IIT.

Table 2 presents the Markov transition probability matrix for the trade types for the probability of staying in a state or moving from one state to another between the starting year (2000) and the ending year (2011). The diagonal elements of the Markov transition probability matrix indicate that the probability of staying with high vertical industry trade is high (84.7 %) while it is low for horizontal IIT (26.2 %); the figure for low vertical IIT is 64 %. Moreover, there is a high chance for horizontal IIT to move to high vertical IIT *status* (40.5 %). The low persistence of horizontal IIT can be explained by the relatively narrow threshold value. There is a high chance to leave the 15 % price ratio interval in both negative and positive directions. In short, our estimations reinforce the findings by Nielsen and Lüthje (2002), namely that the IIT classification is rather unstable.

Figure 4 shows that total IIT is rather low (below 0.2) with an upward trend. There is also evidence of IIT, mainly of a vertical nature, suggesting the exchange of products of a different quality. Within vertical IIT, low-quality IIT and high-quality IIT are roughly equally shared. The dominance of

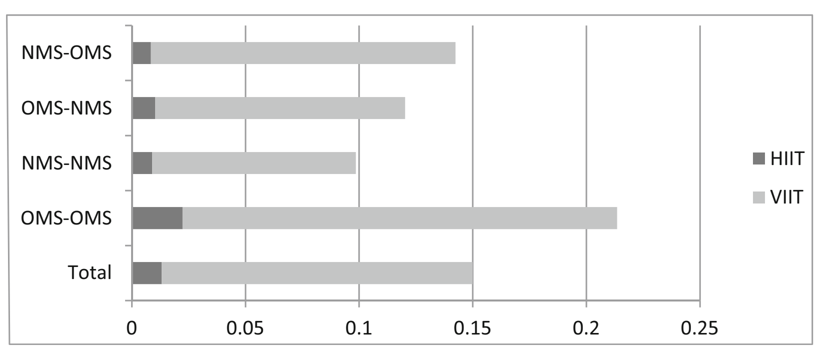

Fig. 5 Types of wine IIT in the EU-27. *LVIIT* low vertical ITT, *HVIIT* high vertical IIT, *NMS* new member states, *OMS* old member states. Source: own calculations based on Comtrade database with WITS

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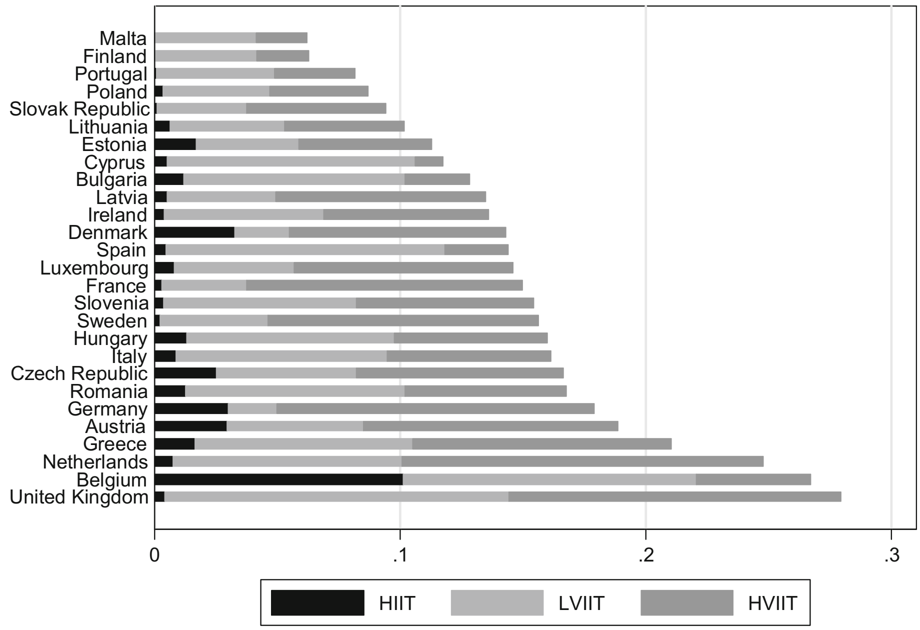

Fig. 6 Types of wine IIT by country. *HIIT* horizontal IIT, *LVIIT* low vertical ITT, *HVIIT* high vertical IIT. Source: own calculations based on Comtrade database with WITS

vertical over horizontal type trade is consistent with the general findings of recent empirical literature.

We calculated the mean values of IIT indices by subsamples between old member states and new member states for all combinations. The distributions of IIT types across samples, but the predominant role of vertical IIT is confirmed in all samples (Fig. 5). The share of horizontal IIT is the smallest in the full sample and in all subsamples. Moreover, IIT is the highest between old member states and the lowest between new member states.

The levels of IIT and of horizontal IIT are rather low in wine trade in the EU (Fig. 6). However, one may observe considerable difference across countries. The UK, Belgium, the Netherlands, Greece and Austria show the highest, while Malta, Finland and Portugal present the lowest value of IIT indices. The horizontal IIT is high for Belgium, Denmark and Germany indicating that in average, these countries export and import relatively the same-quality wine. The importance of low vertical IIT within the total vertical IIT is high for Cyprus, Bulgaria and Spain implying lower export prices and higher import prices in bilateral trade. High vertical IIT plays a dominant role in Germany, France and Denmark, where export prices exceed import prices.

Regression results

Before estimating the panel regression models, the main model variables are pre-tested for unit root tests. Given the low

Table 3 Panel unit root tests

	IIT	Horizontal IIT	Vertical IIT	lnDGDPC	lnGDPmin	lnGDPmax	lnDCAPLAB	lnsumCAPLAB
Without trend								
Levin, Lin and Chu t*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
Im, Pesaran and Shin W-stat	0.000	0.000	0.000	0.000	0.000	0.000	0.999	1.000
ADF–Fisher chi-square	0.000	0.000	0.000	0.000	0.000	0.000	0.999	1.000
PP–Fisher chi-square	0.000	0.000	0.000	0.000	0.000	0.000	0.068	1.000
With trend								
Levin, Lin and Chu t*	0.000	0.000	0.000	0.080	0.000	0.000	0.000	0.000
Im, Pesaran and Shin W-stat	0.008	0.000	0.000	0.000	1.000	0.086	1.000	1.000
ADF–Fisher chi-square	0.000	0.000	0.000	0.000	0.989	0.990	1.000	1.000
PP–Fisher chi-square	0.000	0.000	0.000	0.000	0.997	1.000	0.000	0.003

Source: own estimations

P values: t*

Statistics: W-stat

Table 4 Baseline Helpman model 1

	IIT	Horizontal IIT	Vertical IIT	IIT	Horizontal IIT	Vertical IIT
lnDGDPC	−0.018***	−0.001*	−0.016***	−0.019***	−0.001	−0.018***
lnGDPmin	0.011***	0.003***	0.009***	0.010***	0.003***	0.007***
lnGDPmax	0.018***	−0.000	0.018***	0.018***	−0.000	0.018***
EU accession				0.019***	−0.004**	0.023***
constant	−0.453***	−0.036***	−0.417***	−0.422***	−0.043***	−0.379***
R^2	0.367	0.266	0.332	0.378	0.030	0.349
N	8424	8424	8424	8424	8424	8424

Source: own estimations

N number of observations

***Statistically significant at the 1 % level; **statistically significant at the 5 % level; *statistically significant at the 10 % level

power properties of these tests, we use the following unit root tests: the Levin, Lin and Chu (2002) method (common unit root process); the Im, Pesaran and Shin (2003) method (assuming individual unit root processes); the ADF-Chi square; and the PP-Chi square. In all cases, we employ, without trend and with trend, a specification as a deterministic component, and the lag length is chosen according to the modified Akaike information criterion (MAIC) proposed by Ng and Perron (2001).

Table 3 presents the results of four different panel unit root tests (Levin, Lin and Chu; Im, Pesaran and Shin; ADF–Fisher chi-square, PP–Fisher chi-square). Mixed results were obtained. The most important model variables such as the IIT, horizontal IIT and vertical IIT do not have unit roots, i.e. are stationary, with individual effects and individual trend specifications. The majority of tests indicate that explanatory variables are probably non-stationary with trend specifications, except the lnGDPC variable.

To ensure that all IIT variables are stationary I(0) and not integrated of a higher order, we apply unit root tests on first differences of all variables. All tests (not shown here) reject the unit root null hypothesis for the first differences. In sum, we may conclude that the panel is likely to be stationary.

We apply several estimation techniques to equations (5–6, 8) in order to ensure the robustness of the results. Preliminary Hausman tests favour the use of fixed effect panel models for the majority of models. However, there are some additional issues that we have to address when such panel models are estimated. First, heteroscedasticity may occur because trade between two smaller countries or between a smaller and a larger country is probably more volatile than trade between two larger countries. The panel dataset is also subject to the potential existence of autocorrelation. Contemporaneous correlation across panels may occur because exporting to one country can take place as an alternative to exporting to another country. Similarly, adjacent exporter(s)'/importer(s)' time-specific shocks result in larger correlated error terms of their trade with their partners. Preliminary analysis (likelihood ratio tests, Wooldridge test for autocorrelations and Pesaran tests) confirms the presence of heteroscedasticity, autocorrelation and cross-sectional dependence (see Appendix). To deal with issues of contemporaneous correlation, the panel-corrected standard error (PCSE) model is applied which controls heteroscedasticity and the AR(1) type of

Table 5 Baseline Helpman model 2

	IIT	Horizontal IIT	Vertical IIT	IIT	Horizontal IIT	Vertical IIT
lnDGDPC	−0.018***	−0.001*	−0.017***	−0.007***	−0.001	−0.006***
lnGDPsum	0.045***	0.004***	0.042***	0.045***	0.004***	0.040***
lndispersion	0.017***	0.004***	0.013***	0.020***	0.004***	0.016***
EU accession				0.001	−0.005***	0.006
constant	−0.880***	−0.069***	−0.811***	−0.936***	−0.076***	−0.861***
R^2	0.497	0.344	0.450	0.446	0.410	0.402
N	8424	8424	8424	8424	8424	8424

Source: own estimations

N number of observations

***Statistically significant at the 1 % level; **statistically significant at the 5 % level; *statistically significant at the 10 % level

Table 6 Cieślik model

	IIT	Horizontal IIT	Vertical IIT	IIT	Horizontal IIT	Vertical IIT
lnDCAPLAB	−0.013***	−0.002**	−0.011***	−0.013***	−0.002**	−0.011***
lnsumCAPLAB	0.083***	0.009**	0.073***	0.079***	0.013***	0.066***
EU accession				0.006	−0.006***	0.012**
Constant	−0.761***	−0.085*	−0.676***	−0.718***	−0.126***	−0.592***
R^2	0.149	0.193	0.123	0.150	0.280	0.127
N	8424	8424	8424	8424	8424	8424

Source: own estimations

N number of observations

***Statistically significant at the 1 % level; **statistically significant at the 5 % level; *statistically significant at the 10 % level

autocorrelation and contemporaneous correlation across panels (Beck and Katz 1995, 1996).

Baseline models

Table 4 shows results on the benchmark of the Helpman model (Eq. 5). Estimations highlight that relative factor endowments proxied by a difference in GDP per capita have a significant impact on all models. The lnDGDPC negatively influences both the total IIT and the horizontal IIT, confirming the prediction by the Helpman model. However, we also find a negative impact of the relative factor endowments on vertical IIT model which contradicts to the theoretical vertical IIT models. The lnGDPmin variables have expected signs with significance for all specifications. The lnGDPmax variables are significant with unexpected signs for IIT and vertical IIT specifications. The EU accession variable has significant positive impacts on IIT and vertical IIT, while it influences horizontal IIT negatively.

As the next step, we consider the alternative specification of the benchmark model to separate the effect of absolute country size from the impact of relative country size. Our results are rather mixed (Table 5). Similar to the previous model, the difference in GDP per capita is significant with the expected sign also for IIT and horizontal IIT but unexpected for vertical IIT. However, our estimations support positive and significant effects of the absolute and relative country sizes, confirming theoretical expectations. The EU accession variable presents the same results as in estimations of Table 4.

New evidence

It is well known that the use of per capita GDP as a proxy for relative factor endowments is problematic. Linder (1961) already noted that inequality per capita income may serve as a proxy for differences in preferences. In addition, Hummels and Levinsohn (1995) argued that this proxy is appropriate only when the number of factors is limited to two and all goods are traded; thus, they proposed income per worker as a measure of differences in factor composition and also using actual factor data on capital to labour and land to labour ratios. Interestingly, despite these limitations of the use of GDP per capita, it became a popular and dominating proxy for factor endowments in the empirical literature.

Table 7 Sensitivity analysis 1

	IIT	Horizontal IIT	Vertical IIT	IIT	Horizontal IIT	Vertical IIT
lnDCAPLAB	−0.010***	−0.002**	−0.008***	−0.010***	−0.001	−0.009***
lnsumCAPLAB	0.044***	0.007*	0.037***	0.043***	0.011***	0.033***
lnGDPmin	0.012***	0.002***	0.010***	0.012***	0.003***	0.010***
lnGDPmax	0.013***	−0.001	0.014***	0.013***	−0.001	0.014***
EU accession				0.000	−0.007***	0.007
Constant	−0.951***	−0.100**	−0.851***	−0.949***	−0.148***	−0.801***
R^2	0.352	0.341	0.310	0.035	0.005	0.031
N	8424	8424	8424	8424	8424	8424

Source: own estimations

N number of observations

***Statistically significant at the 1 % level; **statistically significant at the 5 % level; *statistically significant at the 10 % level

Table 8 Sensitivity analysis 2

	IIT	Horizontal IIT	Vertical IIT	IIT	Horizontal IIT	Vertical IIT
lnDCAPLAB	−0.008***	−0.002*	−0.006***	−0.008***	−0.001	−0.007***
lnsumCAPLAB	0.020***	0.005*	0.014***	0.022***	0.009**	0.013**
lnGDPsum	0.042***	0.003***	0.039***	0.042***	0.003***	0.039***
lndispersion	0.019***	0.004***	0.015***	0.019***	0.004***	0.015***
EU accession				−0.004	−0.007***	0.003
constant	−1.114***	−0.110**	−1.004***	−1.145***	−0.163***	−0.983***
R^2	0.451	0.380	0.404	0.045	0.005	0.040
N	8424	8424	8424	8424	8424	8424

Source: own estimations

N number of observations

***Statistically significant at the 1 % level; **statistically significant at the 5 % level; *statistically significant at the 10 % level

First, we present results focusing on the relationships between IIT and differences in capital to labour ratios and control for the variation in the sum of capital–labour proportions predicted by Cieślik (2005). The estimated coefficients for the sum of capital to labour ratios (lnsumCAPLAB) are highly significant and consistent with the theoretical predictions irrespective of alternative specifications (Table 6). The absolute value of differences in capital to labour ratios (lnDCAPLAB) has a negative sign with high significance in all models. Note that we expect a positive impact for the vertical IIT model. The EU accession variable has a positive impact on vertical IIT, while its coefficient is negative for horizontal IIT.

Sensitivity analysis

To check the robustness of our results, we perform several alternative models including common control variables offered by the empirical literature. Bergstrand (1990) suggests distinguishing the demand and supply sides for explanation of IIT. The author argues that since the inequality in per capita incomes between countries seems to influence the share of IIT via two channels, both of which should be taken into account in econometric analysis. Thus, we add two Helpman (1987) control variables including lnGDPmin and lnGDPmax. LnGDPmin variables have significantly positive impacts as in Table 4 across all alternative specifications, while lnGDPmax variables also have positive and significant impacts except in the horizontal IIT model (Table 7). More importantly, capital–labour variables keep their significance with expected signs for IIT and horizontal IIT models. The EU accession variable negatively influences the horizontal IIT, while one cannot observe any significant effect on vertical IIT and IIT.

Second, we extend our models with relative and absolute country size variables (Table 8). Capital–labour variables remain significant with expected signs for IIT and horizontal IIT models, while relative and absolute country size variables

Table 9 Sensitivity analysis 3

	IIT	Horizontal IIT	Vertical IIT	IIT	Horizontal IIT	Vertical IIT
lnDCAPLAB	−0.012***	−0.002**	−0.010***	−0.013***	−0.002**	−0.011***
lnsumCAPLAB	0.077***	0.008**	0.069***	0.072***	0.012***	0.061***
lndistance	−0.097***	−0.017***	−0.081***	−0.097***	−0.017***	−0.081***
EU				0.008*	−0.006**	0.014***
constant	−0.006	0.046	−0.052	0.051	0.007	0.044
R^2	0.763	0.178	0.570	0.0765	0.0185	0.0576
N	8424	8424	8424	8424	8424	8424

Source: own estimations

N number of observations

***Statistically significant at the 1 % level; **statistically significant at the 5 % level; *statistically significant at the 10 % level

have strong positive impacts on the IIT at 1 % level of significance. The EU accession variable has the same impact as in Table 7.

Finally, we investigate the role of distance in explaining IIT. Bergstrand (1990) provides a formal justification for the relationship between horizontal IIT and transportation costs. Our results support the widespread view, namely distance is significantly and negatively related to IIT in all specifications (Table 9). At the same time, the estimates of the coefficients on sums of capital to labour ratios have predicted signs and remain statistically significant at the 1 % level. Similar to previous estimations, differences of capital to labour ratios have predicted signs with significance for IIT and horizontal IIT models. Finally, the EU accession variable has a positive effect on IIT and vertical IIT, while it negatively influences horizontal IIT. Theoretically, we can expect positive impacts of EU enlargement on IIT. However, we show that various types of IIT evolve differently during the analysed period (Fig. 4). Horizontal IIT shows a rather constant and very small share in total IIT. Figure 5 reveals that horizontal IIT is concentrated mainly on wine trade among old member states. On the other hand, vertical IIT is predominant with increasing trend after 2004. Moreover, vertical IIT is relatively important in all market segments of the EU.

Summary and conclusions

The paper analyses the pattern and driving forces of IIT in wine industry in the EU between 2000 and 2011 using the integrated Helpman and Krugman model. Our results confirm the increasing role of IIT within the enlarged EU for wine products during the analysed period. Estimations support the dominance of vertical over horizontal type of IIT and are in line with the general findings of recent empirical literature. At the country level, the UK, Belgium, the Netherlands, Greece and Austria report the highest level of IIT within the EU.

We identify various market segments within the EU. The level of total and vertical IIT is the highest among the old member states and the lowest among the new member states. It indicates that wine trade is more intensive within old member states compared to new member states. We find that low vertical IIT is dominant within vertical IIT for new member states especially in trade with old member states, implying a special division of labour between two regions of the EU. The majority of new member states export low-price wine to old member states and they import high-price wine from these states. Results also suggest that EU enlargement has a positive impact on total IIT and vertical IIT, and a negative effect on horizontal IIT. This finding reflects the deepening vertical product differentiation in intra-EU wine market after EU enlargement.

Our empirical evidence suggests that the standard IIT theory finds some support in our data when we control for the sum of capital to labour ratios in the estimated equations instead of relative country-size variables. Moreover, the absolute and relative market sizes positively influence IIT, while distance has negative impacts on IIT irrespective of the type of IIT. This latter finding highlights the importance of trade costs in wine trade within the borderless EU. Although empirical research based on the C–H–O framework usually neglects the distinction between horizontal and vertical IIT, our results are relatively robust to indices for total, horizontal and vertical IIT. Contrary to previous research, coefficients of factor endowment variables do not differ between horizontal IIT and vertical IIT models as we would expect from theoretical predictions. This can be explained partly by the lack of the unified theory incorporating both horizontal and vertical IIT. Furthermore, we probably need to have better proxies for factor endowment at both aggregate- and sector-specific levels. Our estimations show that the unit value approach provides considerable uncertainties in the identification of horizontal IIT. In sum, there is room for further research on IIT in both theoretical and empirical directions.

Acknowledgments The authors gratefully acknowledge two anonymous referees for their helpful comments and suggestions on earlier drafts of this manuscript. This research was supported by the project NKFI-115788 "Economic crises and international agricultural trade".

Appendix

Specification tests for Table 4 (*p* values)

	IIT	Horizontal IIT	Vertical IIT	IIT	Horizontal IIT	VerticalIIT
Hausman test	0.0213	0.3562	0.0165	0.0315	0.8364	0.0415
Wooldridge test for autocorrelation in panel data	0.0000	0.9092	0.0000	0.0000	0.9075	0.0000
Modified Wald test for groupwise heteroscedasticity	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pesaran's test of cross-sectional independence	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Specification tests for Table 5 (*p* values)

	IIT	Horizontal IIT	Vertical IIT	IIT	Horizontal IIT	VerticalIIT
Hausman test	0.5527	0.2026	0.2158	0.4989	0.9235	0.3338
Wooldridge test for autocorrelation in panel data	0.0000	0.9083	0.0000	0.0000	0.9072	0.0000
Modified Wald test for groupwise heteroscedasticity	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pesaran's test of cross-sectional independence	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Specification tests for Table 6 (*p* values)

	IIT	Horizontal IIT	Vertical IIT	IIT	Horizontal IIT	Vertical IIT
Hausman test	0.1749	0.0011	0.5691	0.0226	0.0176	0.0715
Wooldridge test for autocorrelation in panel data	0.0000	0.9101	0.0000	0.0000	0.9086	0.0000
Modified Wald test for groupwise heteroscedasticity	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pesaran's test of cross-sectional independence	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Specification tests for Table 7 (*p* values)

	IIT	Horizontal IIT	Vertical IIT	IIT	Horizontal IIT	Vertical IIT
Hausman test	0.2345	0.0069	0.5169	0.0650	0.1012	0.1400
Wooldridge test for autocorrelation in panel data	0.0000	0.9102	0.0000	0.0000	0.9088	0.0000
Modified Wald test for groupwise heteroscedasticity	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pesaran's test of cross-sectional independence	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Specification tests for Table 8 (*p* values)

	IIT	Horizontal IIT	Vertical IIT	IIT	Horizontal IIT	Vertical IIT
Hausman test	0.9234	0.0076	0.9900	0.6873	0.1550	0.6660
Wooldridge test for autocorrelation in panel data	0.0000	0.9094	0.0000	0.0000	0.9085	0.0000
Modified Wald test for groupwise heteroscedasticity	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pesaran's test of cross-sectional independence	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Specification tests for Table 9 (*p* values)

	IIT	Horizontal IIT	Vertical IIT	IIT	Horizontal IIT	Vertical IIT
Hausman test	0.3355	0.0006	0.4783	0.0335	0.0071	0.0548
Wooldridge test for autocorrelation in panel data	0.0000	0.9109	0.0000	0.0000	0.9094	0.0000
Modified Wald test for groupwise heteroscedasticity	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pesaran's test of cross-sectional independence	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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