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Revisiting Ricardo: Can productivity differences explain the pattern of trade between EU countries?¹

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Abstract

In this paper we revise the empirical tests of the Ricardian model by testing properly the Ricardian hypotheses on bilateral trade flows. Our tests are based on NACE 2-digit industry aggregation of productivity and of bilateral trade flows between 21 EU member states for the period 1994-2004. We compare the matchings between relative bilateral sectoral productivity rankings and bilateral sectoral exports-to-imports ratio rankings for each of 21 x 20 country pairs. We find that the Ricardian hypothesis is surprisingly good at predicting the static pattern of bilateral trade between individual EU member states even after controlling for the Heckscher-Ohlin type of capital-to-labor ratios. Long-term changes in the bilateral trade patterns, however, do not seem to be explained consistently neither by the variation in changes of relative productivity nor by the variation in changes of capital-to-labor ratios. Furthermore, we find quite a strong autoregressive impact of initial trade patterns on the long-term comparative advantages in the bilateral trade among countries. This implies that comparative advantages are structural by nature and that Ricardian differences in relative productivity can account for a good part of their static representation. Explaining their dynamic evolution over time, however, requires further research.

JEL Classifications: D24, F14

Key Words: International trade, Productivity, Ricardian hypothesis, Empirical tests.

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1 Introduction

Almost two centuries ago Ricardo proposed the famous hypothesis that it is comparative production cost due to the differential labor productivity between countries that determines the pattern of international trade. Though common sense, it is surprising how little empirical evidence has this proposition gained over the centuries. There have been several attempts since 1950s to empirically verify the validity of the comparative advantage hypothesis. MacDougall (1951), MacDougall et al (1962), Stern (1962) and Balassa (1963) using the data on US/UK relative labor productivity and data on US/UK relative exports to third countries have claimed to have found confirmation for Ricardo's hypothesis. Latter researchers, however, have criticized this approach for serious fallacies. Bhagwati (1964) stated that these studies have only a remote overlap with true Ricardian hypothesis - looking at relative export shares with third countries is not in line with the Ricardo hypothesis. Kreinin (1969) by using the Can/Aus, Can/UK and US/Can cases has shown that the selection of US/UK case is biased. In none of these cases he could find confirmation for the Ricardo hypothesis. Similarly, Sailors and Branson (1970) using data on sample of 19 countries with 13 sectors for 1958 overwhelmingly rejected the Ricardo theory. The most comprehensive study on Ricardo theory so far has been conducted by McGilvray and Simpson (1973), which used data for bilateral trade between UK and Ireland for 34 sectors for 1963-64. They have carefully ranked sectors in UK and Ireland according to their relative sectoral productivity and according to their relative export and import propensity. By computing Spearman rank correlations coefficients they found no confirmation for the Ricardian hypothesis as none of the rank correlations has been proven significant and all but two were opposite in sign with respect to the expected.

On the other side, the Bowen et al. (1987) decisive test of the Heckscher-Ohlin model finds no consistent support for the factor proportion theory in the data for international trade flows for 27 countries. This means that the Heckscher-Ohlin model of comparative advantage assuming same technology and same productivity across countries is not consistent with the data on international trade flows. Trefler (1993), instead, modifies the Heckscher-Ohlin-Vanek model by allowing for factor-augmenting international productivity differences. He finds that this simple modification of the Heckscher-Ohlin-Vanek theorem with the Ricardian productivity differences explains much of the factor content of trade and the cross-country variation in factor prices. Similarly, Harrigan (1999) finds large and persistent productivity differences across a group of industrialized countries in the 1980s. He finds support for the constant returns/different technology hypothesis in the data, which is consistent with the Ricardian model.

Some other recent empirical studies have concentrated on the dynamic aspects of comparative advantage. Proudman and Redding (1998) study the extent of persistence or mobility in trade specialization in Germany and United Kingdom. They find evidence of substantial mobility, with the degree of mobility in the United Kingdom exceeding that in Germany. In their later paper, Proudman and Redding (2000) find evidence for significant differences in international trade dynamics among the G-5 economies. Tingvall (2004) studies whether the European integration process has lead to increased specialization and what drives changes in countries' specialization. He finds that there is

no general tendency towards increased specialization with the exception of capital-intensive industries. He demonstrates that scale economies in R&D at the firm level drives productivity and competitiveness.

Overview of recent empirical studies on comparative advantage hints that productivity differences may play an important role in determining international trade patterns. The aim of this paper is to account for the role of productivity differences in the patterns of international trade specialization among a set of comparable countries building a common trade bloc. We are interested in testing the impact of productivity differences on both the static patterns of international trade as well as on mobility of comparative advantage over time. We revise the empirical tests of the Ricardian hypothesis by testing properly the so-called “*Type-I*” and “*Type-II*” Ricardian hypothesis on bilateral trade flows between EU-member states while controlling for the Heckscher-Ohlin factor proportion differences. We base our tests on NACE 2-digit industry aggregation of productivity and bilateral trade flows between 21 EU member states for the period 1994-2004. Two alternative measures of productivity are used – unit labor cost (*Type-I* hypothesis) and labor productivity (*Type-II* hypothesis). We rank relative sectoral productivities and bilateral sectoral exports-to-imports ratios for each country pair and then compare the matchings between the two sets of rankings for each of 21 x 20 country pairs for the period of 11 years. We employ several empirical test of the Ricardian model, including the static and the dynamic version. We find that the Ricardian hypothesis is surprisingly good at predicting the pattern of bilateral trade between individual EU member states even after controlling for the Heckscher-Ohlin type of capital-to-labor ratios. Mobility of comparative advantages over time defined as long-term changes in the bilateral trade patterns, however, does not seem to be explained in a sufficient way neither by the variation in changes of productivities nor by the variation in changes of capital-to-labor ratios.

The structure of the paper is as follows. Section 2 provides a detailed description of our empirical approach. Section 3 describes the data and methodology. Section 4 presents the results and the last Section concludes.

2 Empirical approach

In order to study the Ricardian pattern of trade properly, there are several assumptions to be made, which mean a departure from the original Ricardian model, such as a multiproduct framework, degree of specialization and the wage structure. Below we discuss these issues in more detail.

2.1 Many goods and specialization

Empirical studies of the Ricardian model as overviewed above are based on the implicit assumption of the 2-country, multiproduct framework. To allow for this, we have to extend the 2-goods Ricardian model to the case of many goods. The simplest way to do this is to apply the continuum assumption developed by Dornbusch et al. (1977), which both simplifies the analysis and allows for structuring very clear hypotheses.

The many goods Ricardian model assumes that each good is produced with a constant unit labor requirement. Let us denote $a(z)$ and $a^*(z)$ the unit labor requirements in the home and foreign country, respectively. The ratio $A(z) = a^*(z)/a(z)$ represents the ratio of domestic to foreign labor productivity. The continuum assumption of n goods produced in each country then allows us to rank the goods in order of diminishing home country comparative advantage:

$$(1) \quad A(1) > A(2) > \dots > A(m) > \dots > A(n), \quad \text{where } A(z) = \frac{a^*(z)}{a(z)} \text{ and } A'(z) < 0$$

Hence, good 1 is assigned the highest comparative advantage over all goods in the home country as it is characterized by the highest relative domestic productivity. Similarly, good n presents the highest comparative advantage in the foreign country. The ranking of above relative productivities can be reproduced as a downward sloping schedule of z in the interval $[0, 1]$.

To arrive at the set of goods produced and exported by each country, we have to multiply the relative productivity ratios by the relative foreign wage w^*/w , which gives us an ordered set of relative foreign prices:

$$(2) \quad P(1) > P(2) > \dots > P(m) > \dots > P(n), \quad \text{where} \quad P = \frac{p_z^*}{p_z} = \frac{a_z^* w_z^*}{a_z w_z}$$

Based on (2), home country will export the subset of goods $z = 1, \dots, m$, which enjoy a competitive margin over the foreign goods, i.e. goods with price ratios p^*/p exceeding one:

$$\frac{p^*(z)}{p(z)} > 1, \quad z = 1, \dots, m$$

and foreign country will export a subset of $j = m+1, \dots, n$ goods, where it holds:

$$\frac{p^*(j)}{p(j)} < 1 \quad j = m+1, \dots, n$$

In practice, there are two problems with the above exposition that concern the extent of specialization. First, the Ricardian model predicts complete specialization, so that in trade equilibrium the imported goods are not produced in the home country, and vice versa. This makes it logically impossible to observe the unit labor requirements of the imported goods in the home country except in the autarkic state, which prevents from addressing this issue empirically. The way to overcome this is to assume that complete specialisation is prevented by the existence of trade cost and/or trade barriers (Borkakoti, 1998). Second, the statistics of trade flows reveals that it is almost impossible for a single country to identify its traded goods unambiguously as either exporting or importing. Even at extremely detailed levels of classification, such as HS⁴ or CN⁵ 8-digit, there is a certain extent of intra-industry trade. This means that the Ricardian outcome of complete

⁴ HS – Tariff classification of traded goods according to the Harmonized System.

⁵ CN – Tariff classification of traded goods according to the Combined Nomenclature.

specialization is empirically rejected in any data set and that looser versions of the Ricardian model have to be empirically studied.

2.2 Wage structure and Ricardian hypotheses

Another empirical complexity arises from the assumed wage structure. The Ricardian model assumes perfect labor mobility between sectors and hence complete wage equalization within the economy is to be established. Again, the casual observation of wage structure within each single economy reveals huge differences in wages across sectors. Therefore, empirical literature as summarized in Bowen et al. (1998) makes three types of assumptions about the wage structure in home and foreign countries leading to three distinctive Ricardian hypotheses.

Type-I hypothesis assumes that wages are different both between sectors in each country as well as between countries. This means that the ordered set of relative foreign prices in (2) will be based upon the ranking of relative unit labor cost $a_z^* w_z^* / a_z w_z$ and not upon the ranking of relative labor productivities a_z^* / a_z . Therefore, home country will export a subset of goods z with a pre-trade relative unit labor cost greater than one:

$$(3) \quad \frac{p_z^*}{p_z} = \frac{a_z^* w_z^*}{a_z w_z} > 1, \quad z = 1, 2, \dots, m$$

Analogously, foreign country will export a subset of goods j with a pre-trade relative unit labor cost smaller than one:

$$(4) \quad \frac{p_j^*}{p_j} = \frac{a_j^* w_j^*}{a_j w_j} < 1, \quad j = m+1, \dots, n$$

Combining (3) and (4) reproduces this condition:

$$(5) \quad \frac{p_z^*}{p_z} > \frac{p_j^*}{p_j} \Leftrightarrow \frac{a_z^* w_z^*}{a_z w_z} > 1 > \frac{a_j^* w_j^*}{a_j w_j},$$

Type-II Ricardian hypothesis instead assumes that the inter-sectoral relative wages are identical between home and foreign country. This means that $w_z^* / w_z = w_j^* / w_j$ equals a constant, and the trade condition (5) can now be written as:

$$(6) \quad \frac{a_z^*}{a_z} > 1 > \frac{a_j^*}{a_j} \quad z = 1, 2, \dots, m ; j = m+1, \dots, n$$

In (6) the Ricardian hypothesis is restated in its original form, i.e. in terms of relative labor productivities.

Finally, *Type-III* Ricardian hypothesis assumes that wages are unique in each country but different across countries, i.e. $w = w_z = w_j$ and $w^* = w_z^* = w_j^*$, where w^* / w is a constant.

In comparison to *Type-II* hypothesis, the ranking of labor productivities is maintained but the relative wage now serves as a dividing line between the exported and imported goods:

$$(7) \quad \frac{a_z^*}{a_z} > \frac{w^*}{w} > \frac{a_j^*}{a_j}, \quad z = 1, 2, \dots, m ; j = m+1, \dots, n$$

According to (7), home country will export the goods where relative labor productivity exceeds the relative wages and import the goods with relative labor productivity below the ratio of wages between the home and foreign country.

Although *Type-III* hypothesis resembles the Ricardian hypothesis most closely, its underlying assumption about the wage structure is in stark contrast with the empirical regularities. In our empirical verification we will therefore focus on *Type-I* and *Type-II* hypotheses assuming wages in absolute terms to differ between sectors in each country.

3 Data and methodology

3.1 Data

Previous Section revealed that a proper test of the Ricardian model in order to be close to the real world regularities should follow either the *Type-I* or *Type-II* hypothesis. *Type-I* hypothesis assumes that both absolute and comparative sectoral wages within each country are different. Empirical test of this hypothesis should therefore relate bilateral trade pattern to the pattern of relative sectoral unit labor cost for each country-pair. On the other side, *Type-II* hypothesis assumes equalized relative sectoral wages in each country. This means that empirical test of bilateral trade patterns should be based on the comparison of the relative sectoral labor productivities for each country-pair.

We test the Ricardian hypotheses using the bilateral trade data for EU member states. Exhaustive data sets for a full set of EU countries⁶ are available for the period 1994-2004. For this period, we are able to combine both the bilateral trade data and the data on labor productivity and unit labor cost for 21 member states.⁷ This gives us a dimension of the data set $(21 \times 20 \times 11)/2$, equalling to 2,310 potential annual observations for each commodity traded.

Source of trade data is the Eurostat COMEXT data⁸ covering virtually all CN 8-digit commodities traded bilaterally between EU member states. Source of data on labor productivity and unit labor cost is the EU KLEMS data set provided by the University of Groningen,⁹ which contains comparable data for EU member states on productivity, employment, capital formation and technological change, disaggregated to 20 Nace 2-digit sectors. While the trade data would allow for a much more disaggregated level of analysis, unfortunately, the aggregation level of the productivity data limits our empirical

⁶ For “old” EU-15 and for “new” EU-12 member states.

⁷ Note that in the trade data Luxembourg is treated together with Belgium, while detailed trade and productivity data for Greece, Malta, Cyprus, Bulgaria and Romania were not available for the most part of the period analyzed.

⁸ <http://epp.eurostat.ec.europa.eu/newxtweb/executequery.do>

⁹ <http://www.euklems.net/>

endeavour to the level of 20 Nace 2-digit sectors only. Nevertheless, the combination of *country-pair* x *sector* x *year* data gives us a data set of some 46,200 potential observations over 11 years.

3.2 Methodology

To study the Ricardian hypotheses we construct ordered sets of bilateral trade patterns and relative sectoral productivities.¹⁰ This means that for each country-pair k consisting of country i and country h ordered sets of trade ratios are calculated:

$$(8) \quad T_{kzt} = \frac{x_{ihzt}}{m_{ihzt}} \quad k \in \begin{cases} i=1, \dots, p; & z=1, 2, \dots, n \\ h=1, \dots, p \end{cases}$$

where T_{kzt} is a ratio of exports (x_{ihzt}) of country i to country h and of imports (m_{ihzt}) of country i from country h for each good z in period t . Ratio $T_{kzt} [0, \infty]$ will take the value greater than 1 if country i is a net exporter of good z to country h , and a value smaller than 1 in case of net imports.

Similarly, labor productivity ratio A_{kzt} and unit labor cost ratio U_{kzt} are calculated for each country-pair k and good z in period t :

$$(9) \quad A_{kzt} = \frac{a_{izt}}{a_{hzt}} \quad k \in \begin{cases} i=1, \dots, p; & z=1, 2, \dots, n \\ h=1, \dots, p \end{cases}$$

$$(10) \quad U_{kzt} = \left(\frac{a_{izt} * w_{izt}}{a_{hzt} * w_{hzt}} \right)^{-1} \quad k \in \begin{cases} i=1, \dots, p; & z=1, 2, \dots, n \\ h=1, \dots, p \end{cases}$$

Here, $A_{kzt} [0, \infty]$ is a ratio of labor productivities in producing good z between country i and country h . Note that $U_{kzt} [0, \infty]$ is defined as an inverse of relative unit labor cost, i.e. as a unit labor cost of country h relative to country i .¹¹ This is to ensure similar ranking order of U_{kzt} as with the labor productivity and hence to make the econometric results achieved with both measures of productivity comparable in terms of signs of the coefficients.

It is important to note that the values of ratios of both measures of productivity exceeding 1 indicate the comparative cost advantage of country i over country h in terms of producing each particular good z . Values below 1 indicate country's i cost disadvantage relative to country h in producing the good z . For each country-pair k and period t we can now rank all goods z according to the diminishing relative labor productivity A_{kzt} and relative unit labor cost U_{kzt} . Similarly, bilateral exports-to-imports ratios T_{kzt} can be ranked in the same diminishing order.

Hence, in order to satisfy the *Type-I* hypothesis the ranking order of bilateral trade pattern T_{kzt} should correspond to the ranking order of relative unit labor cost U_{kzt} :

¹⁰ Here, productivity is used as a general term for both the labor productivity and unit labor cost.

¹¹ This is a difference to the ratio of labor productivities A_{kzt} where this ratio is defined as a relative labor productivity in producing good z between country i and country h .

$$(11) \quad U_{kt}(1) > U_{kt}(2) > \dots > U_{kt}(m) > \dots > U_{kt}(n), \quad z = 1, 2, \dots, m; j = m+1, \dots, n$$

$$T_{kt}(1) > T_{kt}(2) > \dots > T_{kt}(m) > \dots > T_{kt}(n)$$

In accordance with the ranking order in (11), country i will enjoy a comparative cost advantage in terms of unit labor cost over country h for the subset of goods $z=1, \dots, m$ and will therefore be a net exporter of the same subset of goods $z=1, \dots, m$ to country h . For the subset of goods $j = m+1, \dots, n$, country i will have a comparative cost disadvantage and will hence be a net importer of these goods from country h . An empirical test of the *Type-I* hypothesis would therefore require checking whether the rankings of bilateral trade patterns T_{kzt} correspond to the rankings of relative sectoral unit labor cost U_{kzt} .

Similarly, for the *Type-II* hypothesis to be satisfied the ranking order of bilateral trade pattern T_{kzt} should reproduce the ranking order of relative labor productivity A_{kzt} :

$$(12) \quad A_{kt}(1) > A_{kt}(2) > \dots > A_{kt}(m) > \dots > A_{kt}(n), \quad z = 1, 2, \dots, m; j = m+1, \dots, n$$

$$T_{kt}(1) > T_{kt}(2) > \dots > T_{kt}(m) > \dots > T_{kt}(n)$$

Again, country i will enjoy a comparative cost advantage in terms of labor productivity over country h for the subset of goods $z=1, \dots, m$ and will be a net exporter of the same subset of goods $z=1, \dots, m$ to country h . The roles are reversed for the subset of goods $j = m+1, \dots, n$.

3.3 Empirical model

Based on the previous Section, empirical tests of the *Type-I* and *Type-II* hypotheses have to verify in what extent the rankings of relative sectoral unit labor cost U_{kzt} in (11) and the rankings of relative sectoral labor productivities A_{kzt} in (12) do resemble the rankings of bilateral sectoral trade patterns T_{kzt} . Possible empirical methods to perform these tests would include simple correlation analysis between the rankings of productivity and the rankings of trade data. Previous empirical tests including the McGilvray and Simpson (1973) – using, however, differently specified variables – have typically performed the Spearman rank correlation analysis. This empirical approach, however, is not appropriate. Obviously, simple correlation analysis will inevitably lead to biased coefficients, since it does not take into account the country-pair specific fixed effects and the sector specific fixed effects. Instead, we run fully specified Ricardian models taking into account this type of variation in the data as well as controlling for the initial productivity structure and for time specific effects.

To test the *Type-I* and *Type-II* hypotheses we estimate following models:

Type-I hypothesis

$$(13) \quad T_{kzt} = \alpha + \beta_1 U_{kzt_0} + \beta_2 U_{kzt} + \beta_3 G_{kt} + \beta_4 P_i * S + \beta_5 R_h * S + \delta T + \varepsilon_{kzt}$$

Type-II hypothesis

$$(14) \quad T_{kzt} = \alpha + \beta_1 A_{kzt_0} + \beta_2 A_{kzt} + \beta_3 G_{kt} + \beta_4 P_i * S + \beta_5 R_h * S + \delta T + \varepsilon_{kzt}$$

where U_{kzt_0} and A_{kzt_0} are the initial values of relative sectoral productivities. This serves to check whether either divergence or convergence of the current bilateral trade patterns from the initial pattern of comparative cost (dis)advantage is in place. U_{kzt} and A_{kzt} are our main variables of interest, showing whether bilateral trade pattern is determined by either type of comparative cost. We expect to find positive coefficients on both variables indicating that a good with higher relative productivity in country i (relative to country h) will more likely result in country's i higher export-to-import ratio in bilateral trade with country h . G_{kt} denotes the relative GDP per capita of the country-pair k . Here, GDP per capita is taken as a proxy for the overall capital-to-labor ratio, which in accordance with Hummels and Levinsohn (1995) serves to control for the Heckscher-Ohlin type of determinants of trade patterns. We also include two types of fixed effects into our models. First, fixed effects for each partner country (P_i and R_h) control for country specific fixed effects, which take into account that individual countries can have specific prices and productivities. Second, we control also for sector specific fixed effects (S) in order to pick up any sector specific prices and productivities. In addition, the interaction terms country*sector (P_i*S and R_h*S) enable us to control for the fact that sectoral productivities and prices can be country specific. Finally, year dummies are included to control for time specific productivity shocks and common external shocks. The remaining disturbances are captured in the error term ε_{kzt} .

Both models (13) and (14) have a cross-section and a time dimension and have to be estimated by using one of the panel data econometric techniques. However, as we explicitly control for all sorts of fixed effects, one can show that by doing this the models (13) and (14) can be effectively estimated by OLS.

4 Results

This Section provides a set of results on testing both Ricardian hypotheses. We first present some basic rank correlation analysis and then proceed with more appropriate econometric estimations of the models (13) and (14). We test first the *Type-I* and *Type-II* hypotheses on ranked variables in levels in order to study whether productivity differences can explain the current bilateral trade patterns among the EU countries. In the next step, we estimate models in long differences.¹² This serves to show whether the changes in trade specialization of EU countries over time follow the Ricardian pattern.

4.1 Rank correlation analysis

In this Section we first provide some basic correlation results and then proceed with more appropriate econometric estimations. Table 1 shows the correlation matrix of variables that enter our empirical models (13) and (14). Note that we show the correlation matrix of ranking orders of the variables as all subsequent empirical tests are performed with the

¹² Since annual changes may show sometimes extreme variations we are cautious to estimate these models in first-differences. On the other hand, taking the Ricardian theory seriously, long-run changes relative productivity should be reflected in the long-run evolution of countries comparative advantages in bilateral trade.

rank transformation of variables in line with (11) and (12). Table 1 shows very high persistence of bilateral sectoral trade structure relative to the initial period (correlation coefficient equalling to 0.79). This confirms that trade patterns evolve only slowly over time, which is in line with the findings of Proudman and Redding (1998, 2000) for the G-5 countries.¹³ On the other side, this indicates that the bilateral sectoral trade pattern is determined by structural factors affecting the comparative advantage of trading partners. Bilateral sectoral trade pattern among EU countries (T_{kzt} , denoted as *t-ratio* in Table 1) is significantly positively correlated with the bilateral relative sectoral labor productivities (A_{kzt} , denoted as *p-ratio* in Table 1) as well as with the bilateral relative sectoral unit labor cost (U_{kzt} , denoted as *ulc-ratio* in Table 1). The correlation coefficient between *t-ratio* and *p-ratio* is twice that high as the correlation coefficients between *t-ratio* and *ulc-ratio* (0.23 versus 0.12). In addition, correlation coefficients reveal significant negative correlation of relative labor productivities and relative unit labor cost with the rankings of import shares (*imsh*) and a positive correlation with the export shares (*exsh*). Again, the correlation of import shares and export shares is stronger with the *p-ratio* than with the *ulc-ratio* indicating that the relative labor productivities may do a better job in explaining the bilateral trade patterns than the relative unit labor cost.

[Insert Table 1]

On the other side, trade pattern is affected also by the relative GDP per capita (G_{kt} , denoted as *gdp-ratio* in Table 1), which proxies for the overall capital-to-labor ratio. The correlation coefficient between *t-ratio* and *gdp-ratio* is of the same magnitude as the one for correlation between *t-ratio* and *ulc-ratio*. More appropriate econometric test accounting for a variety of other factors and fixed effects, however, have to be used in order to show which of the factors determine the bilateral trade patterns among the EU countries.

4.2 Testing the Ricardian trade patterns with levels of ranked variables

In this Section we run fully specified Ricardian models (13) and (14) to test the *Type-I* and *Type-II* hypotheses. Contrary to the correlation analysis in previous Section, these models control for the initial productivity structure and take into account the country-pair fixed effects and time specific effects. Note that we run both models with the data specified as levels of ranked variables. This serves to study the static dependence of trade patterns on the comparative cost advantages, i.e. to check whether productivity differences can explain the current bilateral trade patterns among the EU countries.

[Insert Table 2]

Table 2 shows results of the *Type-I* Ricardian test. We show results for the pooled set of all countries and separately for each individual country. A striking feature that shows up in the results is a strong auto-regressive process in the trade patterns. The coefficients on *t-ratio_0* in the range [0,74, 0,90] indicate that the current bilateral trade pattern is strongly dependent on the initial trade pattern. In other words, this speaks of the structural nature of the trade patterns. This structural nature of trade patterns may well be explained by the underlying comparative cost differences. The differences in the sectoral unit labor

¹³ France, Germany, Italy, UK and US.

cost (*ulc-ratio*) are found to significantly positively affect the bilateral sectoral trade ratios in 14 out of 21 EU countries. In other words, the *Type-I* Ricardian hypothesis can explain bilateral trade patterns in 67 per cent of the EU countries included in our study. It is only the United Kingdom where the relationship between comparative unit labor cost and bilateral trade patterns seems to run in the perverse way, i.e. contrary to the *Type-I* Ricardian predictions. On the other side, differences in comparative GDP per capita, which proxy for comparative capital-to-labor ratios, are found to have no big impact on bilateral trade patterns. The coefficient on *gdp-ratio* is significant in 3 out of 21 countries only – and having a negative sign. These are high-income countries Belgium, Denmark and Netherlands.

[Insert Table 3]

Table 3 presents results of the *Type-II* Ricardian test, which relates bilateral trade patterns to differences in comparative labor productivities. The results show that the *Type-II* Ricardian hypothesis is also quite well explaining the bilateral trade patterns among EU countries. Coefficient on relative labor productivities (*p-ratio*) is found significant in 13 out of 21 countries, of which in 2 countries the coefficient is negative. In addition to the United Kingdom, this coefficient has turned to a negative sign also for Spain. Again, a very strong dependence of current trade pattern on the initial trade pattern is found, while - with the exception of the three high-income countries – it does not seem to be affected by the differences in capital-to-labor ratios.

Summarizing the results so far and comparing the results to the previous rigorous tests of the Ricardian model (McGilvray and Simpson, 1973) and of the Heckscher-Ohlin model (Bowen, Leamer and Sveikauskas, 1987), one can conclude that the Ricardian hypotheses are explaining the bilateral trade patterns of the EU countries surprisingly well. The *Type-I* hypothesis, which relates bilateral trade patterns to differences in comparative unit labor cost, is particularly good at it finding statistical confirmation in 14 out of 21 EU member countries.

4.3 Testing the dynamic trade patterns

While Ricardian trade model is static in terms of the pattern of specialization, the models of endogenous growth and trade imply that patterns of trade are dynamic and comparative advantage develop endogenously over time. Proudman and Redding (1998) find evidence of substantial mobility of comparative advantages in the United Kingdom and Germany in the period 1970–93. In their more recent paper studying the evolution of comparative advantage, Proudman and Redding (2000) find significant differences in international trade dynamics among the G-5 countries. They claim sector-specific learning by doing and technology transfer to be responsible for initial patterns of trade to persist or exhibit mobility over time. This finding is consistent with the Ricardian framework as the latter attempts at explaining the patterns of international specialization with differences in comparative productivities, but does not explain what drives the evolution of these productivity differences. Harrigan (1999) finds large and persistent productivity differences across a group of high-income countries in the 1980s. He finds support for the hypothesis that these productivity differences are driven by the constant returns/different technology, which is in line with the Ricardian model.

Previous Section has shown a strong persistence of initial comparative advantages across EU countries. However, with the coefficient of initial relative trade patterns in the range [0,74, 0,90] one can observe that initial comparative advantages are gradually unwound with the passage of time. In this Section we try to account for whether this dynamics in trade pattern is associated with the changes in relative productivities. We therefore estimate models (13) and (14) specified in differences:

Type-I hypothesis

$$(15) \quad \Delta T_{kzt} = \alpha + \beta_1 U_{kzt_0} + \beta_2 \Delta U_{kzt} + \beta_3 \Delta G_{kt} + \beta_4 P_i * S + \beta_5 R_h * S + \delta T + \varepsilon_{kzt}$$

Type-II hypothesis

$$(16) \quad \Delta T_{kzt} = \alpha + \beta_1 A_{kzt_0} + \beta_2 \Delta A_{kzt} + \beta_3 \Delta G_{kt} + \beta_4 P_i * S + \beta_5 R_h * S + \delta T + \varepsilon_{kzt}$$

The difference of the models (15) and (16) with respect to (13) and (14) is that main variables of interest, such as trade patterns, relative productivities and bilateral GDP ratios are now specified in differences of ranks over time. This allows us to take account of the fact that when a particular product in bilateral trade between two countries is moved up the rank (i.e. one country is strengthening its revealed comparative advantage in a particular good), this should go along with the moving-up of the rank of particular relative bilateral productivity in producing this good. The bilateral GDP ratio in the form of differences is included in order to check whether the changes in trade patterns are also associated with the changes in capital-to-labor ratios over time and not only with the changes in relative productivities. The intuition behind it is that an increase in the relative capital-to-labor ratio may shift country's comparative advantage towards more capital intensive goods. Hence, a positive coefficient on the change in bilateral GDP ratio indicates a move of country's comparative advantage towards more capital intensive goods, and a negative coefficient implies a shift towards more labor intensive trade structure.

We estimate both models in the form of long-differenced variables. In the main test we calculate the long differences as changes in ranks between the initial and the final year observations. However, as particular initial and final year values might be subject to time specific shocks, we also provide a robustness check. In doing this, we first calculate the average ranks of each variable in the first three and in the last three years and then calculate the difference between the initial and the final period. This may prevent from possible extreme values and assure that the calculated long differences of variables will be more robust.

[Insert Table 4]

Table 4 presents our main results on *Type-I* hypothesis, i.e. that changes in trade patterns are driven by the changes in relative sectoral unit labor cost. Though smaller in size than in case of levels, the coefficients on initial trade patterns are still significant and positive, which implies autoregressive, structural nature of countries' comparative advantages. Comparative advantages of countries do only slowly change over time. These changes, however, are unlikely to be driven by long-run changes in the relative unit labor cost. There are only two countries (Spain and UK), where significant, but negative,

coefficients are found. On the other hand, long-term changes in comparative advantage among EU countries can neither be attributed to the long-term changes in capital-to-labor ratios. Here, significant and positive results are found in 3 out of 21 countries only. Almost identical results are found also when testing the *Type-II* hypothesis (see Table A1 in Appendix). Again, long-run changes in relative labor productivities are significant in two countries only, while long-term changes in capital-to-labor ratios are significant in one country only.

[Insert Table 5]

Table 5 presents the results obtained with alternatively specified long differences of variables, i.e. calculated as the difference between the initial three years and the final three years. The results, however, do not change much. In the test of *Type-I* hypothesis, long-run changes in relative unit labor cost are significantly (negatively) associated with long-run changes in comparative advantages in four countries, while long-run changes in capital-to-labor ratios are significant (and positive) in two countries only. Similarly, in the test of *Type-II* hypothesis, long-run changes in relative labor productivities are significant in two and long-term changes in capital-to-labor ratios are significant in one country only.

We can conclude, hence, that long-term changes in trade patterns among EU countries can neither be attributed to long-term changes in relative productivities (in the form of unit labor cost or labor productivity) nor to the changes in capital-to-labor ratios.

5 Conclusions

The paper examines the so-called “*Type-I*” and “*Type-II*” Ricardian hypothesis on bilateral trade flows between EU-member states. We test whether two measures of productivity – unit labor cost and labor productivity – can effectively explain the pattern of bilateral trade flows between 21 EU member states for the period 1994-2004 at the NACE 2-digit industry aggregation. We compare the matchings between relative bilateral sectoral productivity rankings and bilateral sectoral exports-to-imports ratio rankings for each of 21 x 20 country pairs.

We find that bilateral trade patterns are surprisingly well explained by the relative sectoral productivities. In particular, the relative unit labor cost (i.e. Ricardian *Type-I* hypothesis) is doing a good job in explaining sectoral comparative advantage in bilateral trade among EU member states. It is found to be positive¹⁴ and significant in 67 per cent of country pairs in the period 1994-2004. Relative sectoral labor productivity (i.e. Ricardian *Type-II* hypothesis) as an alternative measure of productivity performs a bit poorer in explaining bilateral trade patterns. On the other side, mobility of comparative advantages over time is hardly to be explained by the changes in relative productivities among countries. Neither relative unit labor cost nor relative labor productivity is efficient in explaining the long-term changes in comparative advantage among EU countries. We also tested the impact of changes in capital-to-labor ratios (measured with relative GDP per capita) across countries on the mobility of comparative advantage.

¹⁴ Note that the unit labor cost variable is defined as an inverse.

When testing the models across countries, the long-term changes between the two are almost completely unrelated.

These results imply that comparative advantages of countries seem to be very robust, structural in nature, and that their evolution is hardly to be explained by the long-run changes in relative productivities or long-run changes in capital-to-labor ratios. Of course, a dataset covering a much longer period, such as three or four decades, would probably be more successful in explaining long-term changes in comparative advantages with either the Ricardian differences in relative productivity or the Heckscher-Ohlin differences in capital-to-labor ratios. On the other hand, one may also think of the possibility that neither of both can be taken as a good explanation of comparative advantages of countries. This, however, is at odds with our finding in the static framework, where both Ricardian hypotheses have been shown to explain the bilateral trade patterns of the EU countries surprisingly well. This gives rise to the conclusion that further work and more detailed data on productivity at the product level is needed to study the Ricardian trade hypotheses. The latter, however, will be a tough job for international statistics as presently there is no internationally comparable data for measures of productivity available for sectors beyond the Nace 2-digit level. The situation is even worse with the data on capital-to-labor ratios. What remains is a hope that in the future researchers will be able to obtain adequate internationally comparable data for measures of productivity and capital-to-labor ratio at a more detailed aggregation level.

6 References

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Tables to be included into text

Table 1: Correlation matrix of ranked variables for pooled EU-21 countries, period 1994-2004

	t-ratio	t-ratio_0	p-ratio	ulc-ratio	gdp-ratio	imsh	exsh
t-ratio	1						
t-ratio_0	0.7865*	1					
p-ratio	0.2326*	0.2562*	1				
ulc-ratio	0.1164*	0.1092*	0.5198*	1			
gdp-ratio	0.1160*	0.1085*	0.1220*	0.1233*	1		
imsh	-0.3491*	-0.2887*	-0.0962*	-0.0343*	0.1154*	1	
exsh	0.3760*	0.3152*	0.1263*	0.0641*	0.1154*	0.5836*	1

Notes: Number of observations = 45,709. *t-ratio* is bilateral sectoral exports-to-imports ratio; *t-ratio_0* is *t-ratio* in $t=0$; *p-ratio* is bilateral relative sectoral labor productivities; *ulc-ratio* is bilateral relative sectoral unit labor cost; *gdp-ratio* is bilateral relative GDP per capita; *imsh* is sectoral bilateral import shares; *exsh* is sectoral bilateral export shares.

* denotes significance at 5 per cent.

Source: Eurostat and EU KLEMS; own calculations.

Table 2: Test of *Type-I* hypothesis for EU-21 countries, levels, 1994-2004

	t-ratio_0	t	ulc-ratio	t	gdp-ratio	t	No. obs.	R-sq.
Pooled	0.788 [282.56]***		0.029 [9.69]***		-0.126 [1.45]		45170	0.63
AT	0.736 [53.67]***		0.053 [3.62]***		-0.799 [1.19]		2662	0.55
BE	0.738 [56.26]***		0.048 [3.50]***		-1.221 [1.82]*		2711	0.57
CZ	0.857 [58.13]***		-0.014 [0.91]		-3.507 [1.07]		1396	0.73
DE	0.875 [86.10]***		0.030 [2.86]***		0.766 [1.59]		2360	0.78
DK	0.751 [57.29]***		0.056 [3.93]***		-1.026 [1.92]*		2626	0.59
EE	0.747 [44.32]***		0.036 [2.10]**		0.442 [0.47]		1884	0.56
ES	0.764 [62.87]***		0.030 [2.40]**		-0.733 [0.79]		3047	0.59
FI	0.800 [68.72]***		0.038 [3.12]***		0.249 [0.36]		3018	0.63
FR	0.845 [80.21]***		-0.003 [0.30]		-0.655 [1.24]		2875	0.70
HU	0.775 [50.60]***		0.028 [1.71]*		-1.681 [0.57]		1995	0.59
IE	0.738 [52.50]***		0.089 [5.58]***		-0.162 [0.31]		2655	0.60
IT	0.864 [90.45]***		0.028 [2.80]***		-0.011 [0.02]		3048	0.75
LT	0.746 [45.74]***		0.048 [2.77]***		-1.142 [0.60]		1886	0.56
LV	0.806 [52.34]***		0.014 [0.81]		2.052 [1.71]*		1823	0.66
NL	0.814 [68.55]***		0.007 [0.54]		-1.322 [2.61]***		2773	0.66
PL	0.816 [51.54]***		0.015 [0.86]		-2.827 [0.58]		1425	0.67
PT	0.813 [65.70]***		0.066 [5.26]***		-1.174 [1.33]		2662	0.66
SE	0.778 [63.11]***		0.052 [4.00]***		0.642 [0.88]		2768	0.63
SI	0.801 [44.73]***		0.028 [1.42]		1.806 [0.65]		1211	0.66
SK	0.768 [50.55]***		0.053 [3.16]***		-1.565 [0.64]		1851	0.63
UK	0.835 [71.30]***		-0.081 [6.82]***		-0.75 [1.08]		2861	0.66

Notes: Test according to model (13). Dep.variable is *t-ratio*. Rank transformation of variables. ***, ** and * denote significance at 1, 5 and 10 per cent, respectively.

Table 3: Test of *Type-II* hypothesis for EU-21 countries, levels, 1994-2004

	t-ratio_0	t	p-ratio	t	gdp-ratio	t	No. obs.	R-sq.
Pooled	0.790	[275.71]***	0.032	[10.11]***	-0.136	[1.56]	44520	0.64
AT	0.733	[55.63]***	0.106	[7.50]***	-0.784	[1.23]	2809	0.58
BE	0.741	[54.69]***	-0.017	[1.23]	-1.277	[1.90]*	2687	0.57
CZ	0.851	[54.33]***	0.017	[1.04]	-3.353	[1.02]	1396	0.73
DE	0.879	[84.66]***	0.001	[0.09]	0.744	[1.57]	2286	0.78
DK	0.755	[59.49]***	0.060	[4.31]***	-1.025	[1.94]*	2790	0.60
EE	0.752	[43.10]***	-0.020	[1.12]	0.600	[0.62]	1819	0.56
ES	0.773	[63.84]***	-0.021	[1.70]*	-0.864	[0.94]	3013	0.59
FI	0.798	[65.13]***	0.073	[5.78]***	0.529	[0.64]	2703	0.67
FR	0.848	[80.01]***	0.008	[0.65]	-0.649	[1.24]	2839	0.71
HU	0.765	[48.50]***	0.064	[3.79]***	-1.380	[0.47]	1923	0.60
IE	0.743	[53.06]***	0.081	[5.08]***	-0.181	[0.34]	2630	0.60
IT	0.870	[88.67]***	0.005	[0.46]	0.001	[0.00]	3015	0.75
LT	0.732	[43.03]***	0.057	[3.08]***	-1.454	[0.74]	1823	0.56
LV	0.781	[47.04]***	0.100	[5.41]***	1.472	[1.22]	1775	0.68
NL	0.835	[69.06]***	0.010	[0.76]	-1.214	[2.01]**	2482	0.69
PL	0.825	[49.37]***	-0.005	[0.27]	-2.871	[0.59]	1353	0.68
PT	0.803	[63.49]***	0.057	[4.40]***	-1.182	[1.34]	2636	0.66
SE	0.779	[61.13]***	0.043	[3.22]***	0.614	[0.85]	2734	0.64
SI	0.807	[43.70]***	0.035	[1.72]*	2.156	[0.79]	1147	0.68
SK	0.758	[49.21]***	0.099	[5.76]***	-1.474	[0.60]	1791	0.64
UK	0.852	[69.48]***	-0.043	[3.41]***	-0.370	[0.43]	2537	0.69

Notes: Test according to model (14). Dep.variable is *t-ratio*. Rank transformation of variables. ***, ** and * denote significance at 1, 5 and 10 per cent, respectively.

Table 4: Test of *Type-I* hypothesis for EU-21 countries, long differences, main results[#], 1994-2004

	t-ratio_0	t	dulc-ratio	t	dgdg-ratio	t	No. obs.	R-sq.
Pooled	0.330	[38.30]***	-0.017	[1.79]*	0.673	[6.12]***	7551	0.17
AT	0.414	[8.05]***	-0.027	[0.54]	0.384	[0.19]	304	0.27
BE	0.358	[8.36]***	0.008	[0.18]	2.471	[1.44]	373	0.23
CZ	0.296	[7.41]***	0.052	[1.01]	0.001	[.]	363	0.21
DE	0.225	[6.65]***	-0.038	[0.89]	0.496	[0.13]	387	0.21
DK	0.326	[7.80]***	-0.031	[0.66]	-0.005	[0.00]	366	0.22
EE	0.410	[8.54]***	-0.060	[1.28]	0.319	[0.51]	358	0.26
ES	0.376	[8.56]***	-0.097	[1.89]*	2.640	[1.51]	382	0.25
FI	0.279	[7.04]***	-0.069	[1.57]	6.504	[1.69]*	380	0.19
FR	0.264	[6.73]***	0.024	[0.51]	0.047	[0.01]	364	0.20
HU	0.395	[8.76]***	-0.070	[1.23]	-2.824	[1.46]	374	0.29
IE	0.406	[8.63]***	-0.125	[1.58]	0.824	[1.17]	336	0.31
IT	0.200	[5.98]***	0.036	[0.95]	1.698	[0.49]	382	0.17
LT	0.461	[9.40]***	-0.036	[0.86]	-0.639	[0.42]	351	0.30
LV	0.329	[6.75]***	-0.002	[0.02]	0.915	[1.98]**	317	0.25
NL	0.257	[6.89]***	-0.013	[0.32]	1.978	[0.82]	366	0.24
PL	0.288	[7.51]***	0.067	[1.43]	3.154	[1.60]	373	0.24
PT	0.352	[7.53]***	0.052	[1.08]	0.761	[1.58]	352	0.26
SE	0.327	[8.03]***	-0.038	[0.90]	6.959	[2.27]**	371	0.27
SI	0.302	[7.17]***	0.010	[0.20]	0.472	[0.41]	345	0.22
SK	0.363	[8.18]***	0.081	[1.41]	-0.204	[0.15]	342	0.27
UK	0.228	[6.04]***	-0.075	[1.92]*	2.498	[0.80]	365	0.18

Notes: Test according to model (15). Dep.variable is *dt-ratio*. All variables, except *t-ratio_0*, in long differences. Differences are specified as changes in ranks over time. [#] Long differences are calculated between the first and the last year in the sample. ***, ** and * denote significance at 1, 5 and 10 per cent, respectively.

Table 5: Test of *Type-I* hypothesis for EU-21 countries, long differences, robustness check[#], 1994-2004

	t-ratio_0	t	dulc-ratio	t	dgdp-ratio	t	No. obs.	R-sq.
Pooled	0.247	35.84***	-0.022	[2.31]**	0.822	[7.17]***	7551	0.16
AT	0.327	[7.46]***	-0.010	[0.20]	1.010	[0.36]	304	0.24
BE	0.276	[7.73]***	0.011	[0.24]	1.948	[1.24]	373	0.22
CZ	0.209	[6.83]***	0.074	[1.17]	-17.050	[1.14]	363	0.21
DE	0.170	[6.36]***	-0.041	[0.96]	-3.752	[0.57]	387	0.19
DK	0.264	[7.54]***	-0.014	[0.32]	0.610	[0.18]	366	0.21
EE	0.316	[8.24]***	-0.096	[1.85]*	0.272	[0.44]	358	0.25
ES	0.293	[8.14]***	-0.091	[1.94]*	1.859	[0.96]	382	0.24
FI	0.204	[6.37]***	-0.051	[1.23]	6.270	[1.34]	380	0.17
FR	0.197	[6.48]***	0.033	[0.74]	-6.437	[1.18]	364	0.20
HU	0.301	[8.02]***	-0.091	[1.65]	-1.615	[0.65]	374	0.25
IE	0.307	[8.07]***	-0.168	[2.24]**	0.627	[0.74]	336	0.31
IT	0.138	[5.17]***	-0.001	[0.02]	1.949	[0.53]	382	0.17
LT	0.324	[8.40]***	-0.039	[0.88]	0.898	[0.52]	351	0.28
LV	0.241	[6.08]***	-0.042	[0.63]	1.325	[2.59]**	317	0.24
NL	0.200	[6.65]***	-0.017	[0.41]	1.871	[0.55]	366	0.25
PL	0.178	[7.37]***	0.069	[1.51]	2.844	[1.51]	373	0.24
PT	0.265	[7.07]***	0.026	[0.54]	0.792	[1.65]*	352	0.27
SE	0.248	[7.33]***	-0.061	[1.42]	4.459	[1.10]	371	0.24
SI	0.210	[6.91]***	-0.024	[0.51]	1.693	[1.42]	345	0.23
SK	0.295	[8.37]***	0.133	[1.99]**	-0.005	[0.00]	342	0.28
UK	0.163	[5.42]***	-0.031	[0.78]	2.001	[0.63]	365	0.14

Notes: Test according to model (15). Dep.variable is *dt-ratio*. All variables, except *t-ratio_0*, in long differences. Differences are specified as changes in ranks over time. [#] Long differences are calculated between the first three and the last three years in the sample. ***,** and * denote significance at 1, 5 and 10 per cent, respectively.

Appendix

Table A1: Test of *Type-II* hypothesis for EU-21 countries, long differences, main results[#], 1994-2004

	t-ratio_0	t	dp-ratio	t	dgdg-ratio	t	No. obs.	R-sq.
Pooled	0.332	38.76***	-0.006	[0.53]	0.659	[5.97]***	7689	0.17
AT	0.397	[8.54]***	0.012	[0.24]	1.380	[0.79]	360	0.25
BE	0.361	[8.62]***	0.087	[1.57]	2.311	[1.34]	385	0.24
CZ	0.297	[7.43]***	0.052	[0.81]	0.000	[.]	363	0.21
DE	0.227	[6.72]***	-0.040	[0.98]	0.270	[0.07]	387	0.21
DK	0.329	[7.84]***	-0.003	[0.06]	-0.087	[0.04]	369	0.21
EE	0.407	[8.45]***	-0.071	[0.93]	0.323	[0.51]	358	0.26
ES	0.373	[8.48]***	-0.026	[0.54]	2.268	[1.30]	384	0.24
FI	0.298	[7.37]***	0.032	[0.57]	6.893	[1.76]*	382	0.19
FR	0.262	[6.85]***	0.032	[0.73]	-0.072	[0.02]	382	0.19
HU	0.401	[8.94]***	-0.009	[0.16]	-2.916	[1.50]	374	0.29
IE	0.400	[8.69]***	-0.219	[2.46]**	0.846	[1.23]	338	0.32
IT	0.204	[6.08]***	0.008	[0.19]	1.960	[0.56]	384	0.17
LT	0.457	[9.31]***	-0.011	[0.14]	-0.584	[0.39]	351	0.29
LV	0.330	[6.99]***	-0.027	[0.40]	0.932	[2.02]**	317	0.25
NL	0.263	[7.09]***	-0.078	[1.50]	2.254	[0.92]	370	0.24
PL	0.287	[7.48]***	0.029	[0.46]	3.144	[1.59]	373	0.24
PT	0.368	[7.98]***	-0.042	[0.77]	0.806	[1.66]*	370	0.26
SE	0.328	[8.08]***	-0.064	[1.35]	7.125	[2.32]**	372	0.27
SI	0.303	[7.19]***	-0.000	[0.00]	0.513	[0.45]	345	0.22
SK	0.360	[8.10]***	0.072	[1.14]	-0.082	[0.06]	342	0.26
UK	0.227	[6.10]***	-0.081	[1.79]*	2.718	[0.86]	383	0.18

Notes: Test according to model (16). Dep.variable is *dt-ratio*. All variables, except *t-ratio_0*, in first differences. Differences are specified as changes in ranks over time.[#] Long differences are calculated between the first and the last year in the sample. ***,** and * denote significance at 1, 5 and 10 per cent, respectively.

Table A2: Test of *Type-II* hypothesis for EU-21 countries, long differences, robustness check[#], 1994-2004

	t-ratio_0	t	dp-ratio	t	dgdg-ratio	t	No. obs.	R-sq.
Pooled	0.249	36.25***	-0.014	[1.31]	0.810	[7.03]***	7689	0.16
AT	0.315	[8.01]***	0.025	[0.50]	1.845	[0.78]	360	0.23
BE	0.283	[8.07]***	0.086	[1.59]	1.737	[1.09]	385	0.23
CZ	0.210	[6.88]***	0.066	[0.92]	-18.350	[1.22]	363	0.20
DE	0.171	[6.43]***	-0.054	[1.32]	-3.860	[0.58]	387	0.20
DK	0.267	[7.63]***	0.006	[0.10]	0.543	[0.16]	369	0.20
EE	0.310	[8.08]***	-0.064	[0.85]	0.229	[0.37]	358	0.25
ES	0.293	[8.14]***	-0.051	[1.16]	1.585	[0.82]	384	0.23
FI	0.216	[6.59]***	-0.018	[0.32]	6.479	[1.35]	382	0.17
FR	0.197	[6.58]***	-0.003	[0.09]	-6.337	[1.15]	382	0.19
HU	0.308	[8.23]***	-0.003	[0.06]	-1.810	[0.72]	374	0.25
IE	0.298	[7.97]***	-0.191	[2.13]**	0.667	[0.79]	338	0.31
IT	0.142	[5.27]***	-0.003	[0.07]	1.948	[0.53]	384	0.17
LT	0.319	[8.34]***	-0.058	[0.71]	0.978	[0.56]	351	0.28
LV	0.249	[6.47]***	-0.089	[1.22]	1.340	[2.64]***	317	0.24
NL	0.205	[6.87]***	-0.084	[1.73]*	2.143	[0.63]	370	0.26
PL	0.178	[7.36]***	0.040	[0.64]	2.823	[1.49]	373	0.23
PT	0.276	[7.48]***	-0.085	[1.70]*	0.824	[1.71]*	370	0.26
SE	0.249	[7.35]***	-0.094	[1.97]*	4.604	[1.13]	372	0.25
SI	0.209	[6.87]***	-0.001	[0.01]	1.633	[1.37]	345	0.23
SK	0.287	[8.14]***	0.050	[0.71]	0.255	[0.17]	342	0.27
UK	0.163	[5.43]***	-0.019	[0.42]	2.107	[0.65]	383	0.15

Notes: Test according to model (16). Dep.variable is *dt-ratio*. All variables, except *t-ratio_0*, in long differences. Differences are specified as changes in ranks over time.[#] Long differences are calculated between the first three and the last three years in the sample. ***,** and * denote significance at 1, 5 and 10 per cent, respectively.