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Intra-Country Wage Inequality in the OECD Countries

Summary: Two reasons are mainly brought to explain the recent increase in intra-country wage inequality in favour of high-skilled labour: Skill-Biased Technological Change (SBTC) and International Trade Liberalisation (IT). Since few empirical studies have attempted to assess both interpretations across a comprehensive sample of countries, we have analysed the impact of both and added some new variables within a unified framework and across 30 OECD countries, between 2001 and 2015. Using panel data, results show that both explanations are crucial. However, considering all 30 OECD countries, the IT argument dominates. Further, we show that seven clusters must be considered in which at least one theory influence the wage gap.

Key words: Skill-biased technological change, International trade, Immigration, Education, Wage inequality, Cluster analysis.

JEL: C23, F41, J31, O33, O50.

Throughout different countries, the intra-country wage premium on skills has been increasing at least since the early 80s (e.g. Stephen Machin and John van Reenen 1998; David H. Autor, Lawrence F. Katz, and Melissa S. Kearney 2008; Óscar Afonso 2012). The concurrence of this trend along with the increase of world trade and with the expansion of skilled-labour supply suggest an even faster expansion of skilled-labour demand. Skill Biased Technological Change (SBTC) and International Trade (IT) are indicated as the main factors explaining the skilled wage gap; indeed, there has been a wide-ranging debate over recent decades on whether the impact of world trade is greater or smaller than the impact of SBTC (Daron Acemoglu 2003; Afonso 2012; Afonso, Ana L. Albuquerque, and Alexandre Almeida 2013).

The SBTC approach is supported on the technological-knowledge biased progress in favour of skilled labour. This bias, arising from both the market-size effect and the price effect induced by the increased skilled-labour supply (e.g. Acemoglu 2003; Afonso 2006, 2012), would lead to a faster productivity growth in skilled labour. The productivity increase, in turn, enlarges college enrolment and thus the market for skill-complementary technologies. This process keeps the expansion of skilled-labour demand ahead of that of skilled-labour supply.

Trade-based explanations stem from the insights of the Stolper-Samuelson theorem derived from the Hechscher-Ohlin-Samuelson theory (e.g. Adrian Wood 1995; George J. Borjas et al. 1997). According to the Stolper-Samuelson theorem, a decrease in the relative price of imported goods must reduce the return on the factor that is used intensively in their production. Hence, developed countries would specialise in skill-intensive goods, thus raising the relative demand for skilled labour and thus its relative wage. In developing countries, the outcome is expectedly symmetrical: here the intensification of world trade will cause a reduction in the wage gap between skilled and unskilled workers, since the relative demand for unskilled workers is expected to rise.

In small countries, the degree of trade openness tends to be higher, as these countries need to take advantage of international markets because their domestic markets are small. In these countries this argument can be verified more consistently.

Despite SBTC's wider acceptance in the literature on the subject (Sebastian Galiani and Pablo Sanguinetti 2003), the theoretical debate dominates empirical research. Moreover, empirical studies usually address manufacturing industries, analyse the impact of just one explanation, ignore cross-country analysis and use indirect proxies for the wage premium.

In this paper, we contribute towards widening the empirical debate by studying the relative importance of SBTC and IT on skill-based wage inequality across a panel data of 30 OECD countries, covering a time span from 2001 to 2015. Therefore, in the light of the main economic theories, our aim is to show which factors contribute the most to explain the differences between wage rates of workers who have completed higher education (skilled labour) and those who have only secondary level education (unskilled labour), in 30 OECD countries. In the estimation approach we also: (i) include new variables related with foreign direct investment (FDI), education expenditure, immigration and GDP *per capita*; (ii) control for the endogeneity of regressors to obtain consistent estimates; (iii) perform a cluster analysis to detect different homogenous groups of OECD countries where seven clusters are identified; (iv) for each identified cluster, and again using panel data, we sought to know the best justification for the wage gap between the two considered classes of workers.

To the best of our knowledge, it is the first time that this subject is being studied empirically in this way making an additional contribution to the study of the wage inequality between skilled and unskilled workers.

In general, our regression results indicate that international trade is the best explanation. The cluster analysis reveals that: (1) there are clusters in which the best explanation for the wage gap is the SBTC theory; (2) there are clusters where the best explanation is the international trade; (3) there is also a cluster in which the two theories occur simultaneously.

The outline of the study is as follows. In Section 1, we briefly refer to the relevant literature explaining the effects caused by SBTC and international trade on the wage differences among countries. Section 2 shows the data and variables description. Section 3 presents the empirical analysis for total data. In Section 4, we perform the exploratory multivariate analysis technique (cluster analysis) and the empirical analysis for each cluster. Section 5 concludes the paper.

1. Relevant Economic Theory

The two most prominent explanations for the rising skill wage gap in the economic literature are the SBTC and IT liberalization. More recently, instead of seeing IT and SBTC as exclusive alternatives, some authors allow trade to have an effect on technological knowledge (Acemoglu 1998, 2003; Elias Dinopoulos and Paul Segerstrom 1999; Afonso 2012). Therefore, it can be stated that the literature on intra-country wage inequality between skilled and unskilled workers has been analysed by three main strands: (a) the IT explanation (Wood 1995); (b) the SBTC approach (Acemoglu 2002); (c) combining both theories, IT and SBTC (Afonso 2012). In addition, other authors suggest that other factors affect intra-country wage inequality (Kevin H. O'Rourke 2001); we take into account immigration, education expenditure, FDI and GDP *per capita*.

The strong increase of IT suggests that trade has an important contribution to the increasing inequality. Heckscher-Ohlin trade models rely on changes in the relative price of skilled and unskilled intensive goods to explain changes in the relative wage of skilled and unskilled workers (Stolper-Samuelson theorem). Indeed, for authors such as Wood (1995); Wenli Cheng and Dingsheng Zhang (2007); Facundo Alvaredo et al. (2013); Piketty, Saez, and Stefanie Stantcheva (2014); Dick Durevall and Farzana Munshi (2015), the best explanation comes from the Stolper-Samuelson theorem, which results from the Hecksher-Ohlin-Samuelson theory (HOS) according to which each country should specialize and export goods that are intensive in the relatively abundant factor, and should import the others. Then, Wolfgang F. Stolper and Paul A. Samuelson (1941) seek to explain the IT effects on the distribution of income due to changes in factor prices following openness: IT reduces (increases) intra-country wage inequality in unskilled (skilled) labour abundant countries. In line with this explanation, Borjas, Freeman, and Katz (1992), between 8% and 15% of the increase in wage differences between university graduates and high-school graduates in the USA was due to IT followed by immigration. In the same line, Freeman (1998) also shows that the increase in wage differences in the USA between 1967 to 1991, is induced by IT that represents 10% to 20% of the total fall in the demand for unskilled labour.

However, Robert Z. Lawrence et al. (1993), found a small decline of the relative price of skilled and unskilled intensive goods, while Jeffrey D. Sachs and Howard J. Shatz (1996), find that the relative price increased after IT opening. They though concluded that IT liberalization cannot explain the increasing wage gap as the relative price change was too small.

Acemoglu (1998, 2002, 2003), Eli Berman, John Bound, and Machin (1998) and Michael T. Kiley (1999), among others, propose the SBTC as the main reason for the intra-country wage inequality. The technological-knowledge progress as well as its direction increase the aggregate demand for skills, and a sector that uses these skills improves its productivity, and therefore its remuneration rate. This argument seeks to address the contradiction of the increase in skill premium and the relative increase of the supply of skilled workers: the change in technological knowledge triggers an increase in the relative demand for skilled labour, which clearly exceeds the increase in relative supply, thus prompting the increase of skill premium. In Acemoglu (2003), for example, the course taken by the technological knowledge that boosts wage inequality is thus determined by different labour provisions. As a result of an increase in the supply of skilled labour, it is more profitable to invest in technologies used by the skilled labour, i.e. the incentives to invest in R&D directed to the skilled labour are improved, which, in turn, lead to an increase in the relative productivity of the skilled labour, bringing about a greater increase in the demand for skill labour and increasing wage inequality. In the 1990s, the SBTC approach dominated, mainly due to the papers of Katz and Kevin M. Murphy (1992) and Autor, Katz, and Kearney (2008), which led to many studies about SBTC (Alan B. Krueger 1993; Dale W. Jorgenson 2001), being also clear that the impact of the SBTC is hard to quantify empirically.

In turn, Wood (1995) was to some degree opposed to the SBTC argument, noting that the technological-knowledge bias is enabling the drop-in demand for unskilled workers, thus suggesting that the reason for the wage gap should be attributed to the IT.

Due to the lack of consensus, instead of seeing IT and SBTC as exclusive alternatives, Acemoglu (1998, 2003), Dinopoulos and Segerstrom (1999), Mathias Thoenig and Thierry Verdier (2003), Mark P. Moore and Priya Ranjan (2005), Pablo Epifani and Gino Gancia (2008), Almeida and Afonso (2010) allow IT to have an effect on technological knowledge. In particular, Almeida and Afonso (2010), expanded the empirical debate on this topic by studying the relative importance of SBTC literature and of world trade on wage inequality in the OECD countries. They concluded that IT gives a better explanation of wage inequality in developing countries, whereas SBTC explains this inequality better in developed countries. Acemoglu (2003) and Bulent Unel (2010), on the other hand, suggest that the increase in world trade can be one of the main reasons why wage inequality has increased, because it leads to SBTC.

Still these models were not able to explain the simultaneous increase of inequality in two trading countries as found, for example, by Eric A. Verhoogen (2008). Standard trade theory models have difficulties to provide an explanation for the increasing inequality when two very similar countries trade. As a result, some additional causes are considered (O'Rourke 2001); between them immigration, FDI and education expenditure are usually emphasized, as will become clear in the following paragraphs.

Concerning the immigration, for example, Borjas, Freeman, and Katz (1992), found that only modestly affects inequality, and Lawrence and Autor (1999) show that the SBTC is one of the demand side reasons for wage inequality alongside with immigration, which, instead, is a cause on the supply side. David Card (2009), on a study for the US economy in the period 1980-2000, show that immigrant skills tend to be concentrated at the highest and lowest level of skills, and have also higher residual inequality. Gianmarco I. P. Ottaviano and Giovanni Peri (2012) got a similar result, arguing that immigrants are absorbed by demanding labour sectors that partially offset the effect on the labour supply; that is, firms have absorbed immigrants by adopting appropriate technologies and expanding production such that the demand side offsets the supply side. Christian Dustmann, Tommaso Frattini, and Ian P. Preston (2013) point another explanation for the case of the UK, between 1997 and 2005: although immigrants are better educated than natives, they depress the wages of unskilled workers because they occupy jobs below their skills. Many other European country studies confirm this result (Mette M. Deding et al. 2010; Sandro Favre 2011).

Regarding the contribution of FDI, the existing empirical studies usually analyze either developed or developing countries. In general terms, Dirk Willem te Velde (2003) point out that FDI could induce skill-specific technological change and thus benefiting the skill premium. Paolo Figini and Holder Görg (1999) show that FDI was associated with skill upgrading and increased wage inequality in Irish manufacturing over the period 1979-1995. Nigel Driffield and Karl Taylor (2000) find significant effects of FDI on wage dispersion in UK manufacturing. However, Bruce A. Blonigen and Matthew J. Slaughter (2001) find that FDI was not significantly correlated with skill upgrading within US manufacturing sectors over the period 1977-1994. With regards to the evidence for developing countries, Liugang Sheng and Dennis T. Yang (2017) indicate that FDI explains a large fraction of the recent increase in the Chinese college wage premium. Robert C. Feenstra and Gordon H. Hanson (1997) find that inward FDI increased the relative demand for skilled labour in Mexican manufacturing over the period 1975-1998. Te Velde and Oliver Morrissey (2004) provide macro evidence for the effects of FDI on wages and wage inequality in Korea, Singapore, Hong Kong, Thailand and Philippines. In general, the evidence for East Asia (Atsuko Matsuoka 2001; Frederick Sjöholm and Robert E. Lipsey 2006) supports the hypothesis that, on average, foreign firms pay higher wages to their workers but that skilled workers are the main beneficiaries of such pay premia. Hence, wage differentials tend to differ according to skill level. Such static effect would *ceteris paribus*, raise wage inequality. In turn, Martin Rama (2003) finds no evidence for a consistent relationship between FDI and wage inequality in a large sample of developing countries.

Concerning the impact of education expenditure on intra-country wage inequality, it should be stressed a plethora of studies showing that they affect income equality through enhancing human-capital accumulation, improving the access to capital for entrepreneurial activity, and changing the sectoral composition of employment (Thorsten Beck et al. 2008; Demirguc-Kunt and Levine 2009). Most of the empirical literature concludes that education expenditure lowers income inequality over the long term (Abhijit V. Banerjee and Andrew F. Newman 1993; Oded Galor and Joseph Zeira 1993; George R. G. Clarke, Lixin Colin Xu, and Heng-Fu Zou 2006), except at the very early stages of development (Jeremy Greenwood and Boyan Jovanovic 1990). However, since the distribution of capital income is significantly more unequal than the distribution of labour income, the concentration of wealth could become one of the root causes of income inequality over time (David J. McKenzie and Christopher Woodruff 2006; Raghuram G. Rajan 2010). Moreover, the large extent of variation in net income inequality across countries, suggests that education expenditure can influence the distribution of income (Daniel R. Feenberg and James R. Poterba 1993; Gerard Auten and Robert Carroll 1999; Roland Benabou 2000; Leonel Muinelo-Gallo and Oriol Roca-Sagalés 2011).

Moreover, we believe that countries should be divided in homogeneous groups, performing cluster analysis, and the explanation could be different between groups. The cluster analysis, firstly developed by Robert C. Tyron 1939, consists in including in the same group/cluster the entities that have similar characteristics, according to a given set of variables; thus, each group/cluster presents internal homogeneity (i.e. minimum variance) and external heterogeneity (i.e. maximum variance between clusters) - e.g. Brian S. Everitt 1993.

Finally, in order to represent the level of economic development of a country, we considered GDP *per capita*. As suggested by the Kuznets hypothesis, increases in the GDP *per capita* should be associated with reductions in wage inequality. We have decided to consider this variable in order to obtain more robust results since the OECD countries have different economic characteristics reflected in this variable. For example, as emphasized by Simon Kuznets (1955), as the economic development of a country advances, there will be gains in education and people will seek more qualifications. Then, the proportion of skilled labor increases relative to the unskilled, reducing, by the supply-side effect, the wage inequality (Kuznets 1955). For this reason, many authors used GDP *per capita* to study skill premium. For example, England Gregory Clark (2007) found a negative link between the skill premium and the GDP *per capita*, and Jan Luiten van Zanden (2009) have observed that the relationship between both variables is not the same for all countries - in the Americas, Asia and Africa is lower than in the rest of the world.

2. Data and Variables Description

The sample we use in the empirical analysis covers 30 OECD countries and the time spans from 2001 to 2015. Countries like Chile, Iceland, Israel and Mexico are excluded from this sample due to the lack of data on some variables considered in the estimated models. Statistical information is not uniformly given for the whole period for countries like Turkey, Greece, Luxembourg, Japan, Estonia and Slovakia. Having these statistical limitations in mind the empirical analysis uses an unbalanced panel data estimation approach with a total of 396 observations.

Table 1 explains the variables used in the empirical analysis, units of measurement and the data source. Table 2 reports the average values of the same variables by country. The dependent variable (WPT-WPS) in Table 1 expresses the wage gap (an index) between college degree workers and high school workers, and this variable will be explained by a set of other explanatory variables reported in the rest of the table. As Table 2 shows, countries like Portugal (92.5), the USA (90.3), Hungary (80.3), Slovakia (86.6) and Greece (76.8) show a higher wage gap than countries like Finland (8.5), Estonia (11.4), Belgium (14.1), Sweden (20.7) and Denmark (24.6). The wage gap average in this set of countries is about 48 points between workers that completed college education and those who completed secondary education. In all cases the wage gap is positive as expected, showing that college-degree workers enjoy higher work remuneration than the secondary-school workers. By just observing the average data we are not able to infer whether less developed countries exhibit higher wage gap in comparison to the more developed countries.

As the literature review suggests skill-biased technological change (SBTC) is one of the main factors that could explain this wage gap, and this variable is measured by the R&D spending as a share of GDP (e.g. Machin and Van Reenen 1998) in each country. From Table 2 we can infer that export oriented countries like Sweden (3.7%), Finland (3.4%), Korea (3.1%), Japan (3.4%), the USA (2.69%) and Germany (2.55%) spend more on innovation activities in comparison to countries like Greece (0.48%), Slovakia (0.57%), Turkey (0.69%), Portugal (0.95%) and Hungary (0.94%) which are the least developed countries. The average R&D spending ratio in this set of countries is about 1.82% of GDP.

Table 1 Variable Definition and Data Source

Variable	Definition	Unit	Source
$WPT_{i,t}$ -$WPS_{i,t}$	Wage gap between university graduates and high school graduates in country *i* and year *t*, in real terms	Index	OECD Education at a glance
$SBTC_{i,t}$	Research and development spending as a percentage of GDP in country *i* and year *t*	Percentage	OECD World Bank
$Trade_{i,t}$	International trade measured by the degree of openness, i.e. the sum of exports and imports as a percentage of GDP, in country *i* and year *t*	Percentage	OECD World Bank
$FDI_{i,t}$	Share of stock of foreign direct investment on GDP in country *i* and year *t*	Percentage	OECD World Bank
$Immigration_{i,t}$	Total number of immigrant workers as a percentage of the labour force in country *i* and year *t*	Percentage	OECD World Bank
$Education_{i,t}$	Education expenditure as a percentage of GDP in country *i* and year *t*	Percentage	OECD World Bank
$GDPpc_{i,t}$	Gross domestic product *per capita* in country *i* and year *t*, in real terms	Value in dollars	OECD World Bank

Source: Authors' elaboration.

Another argument in the relevant literature is that international trade is also a contributing factor for explaining the wage differences between the more-skilled and least-skilled workers and this variable is measured by the degree of openness (Trade) to express trade intensification (e.g. Mathias Thoenig and Thierry Verdier 2003). From Table 2 it can be seen that small-size countries as Luxembourg (291%), Slovakia (163%), Ireland (162%), Belgium (154%) and Hungary (144%) are more open economies than large-size countries as the USA (25%), Japan (31%), Australia (41%), France (53%) and the UK (56%). The average rate of the openness ratio is about 93% in this set of the OECD countries.

Foreign direct investment is supposed to transfer technology in the host country and requires high-skill labour affecting therefore the wage gap. The share of stocks of foreign direct investment on GDP (FDI) is used in this study to measure its impact on the wage rate differentiation between more and less skilled workers in each country. Table 2 shows that countries with a high stock of FDI/GDP ratio are Luxembourg (376.9%), (Belgium (12%), the Netherlands (8.25%), Ireland (7.62%) and Switzerland (6.77%) and countries with low FDI ratio are Greece (0.47%), Korea (0.49) and Japan (0.92). The average FDI ratio is about 16% but this is overvalued because of the Luxemburg as exceptional case.

Three other factors are also used to explain the wage gap, one related to immigration, one related to education expenditure and the other to GDP *per capita*. Total number of foreign workers as a percentage of the labour force (Immigration) is used to measure the immigration impact, education expenditure as a percentage of GDP (Education) to measure the education impact on wage gap, and GDP *per capita* measured in real terms to represent the level of economic development. As Table 2 shows, countries with high immigration ratio are Luxemburg (41%), Switzerland (20%), Estonia (16%) and New Zealand (15%) while low immigration ratio is found in countries like Turkey (0.3%), Poland (0.1%), Slovakia (1.17%), Hungary (1.4%) and Japan (1.7%). The average value of the immigration rate is around 8% in the whole sample. On the other hand, high education expenditure countries are mostly the Scandinavian countries like Denmark (8.29%), Sweden (7.12%), Norway (7.11%) and Finland (6.24%) in contrast to low education expenditure countries such as, Turkey (3.15%), Greece (3.25%), Luxembourg (3.54%) and Japan (3.67%). The average education expenditure ratio is around 5.2% in this sample. Not surprisingly, the countries with higher GDP *per capita* between 2001 and 2015 (average values) are Luxembourg, Norway and Switzerland. Countries with lower GDP *per capita* are Turkey, Hungary and Poland.

According to economic literature the SBTC variable is expected to widen the wage gap between the more-skilled and the least-skilled workers. Countries that spend more on innovation, invest on high-skilled workers whose job remuneration is higher than the least-skilled workers. The impact of international trade on the wage gap is dubious depending on the country's specialization. If a country specializes in the production of low value-added products (low-tech products) then one could expect that trade would reduce wage differentiation. Countries producing and exporting high-tech products the demand for more-skilled labour will increase, widening therefore the wage gap between the more-skilled and least-skilled workers. The impact of education expenditure (as a percentage of GDP) is expected to be positive on the wage gap, since higher spending on education represents an investment on human capital qualification. The impact of immigration could also be positive on the wage gap since immigrants normally accept lower salaries (and low-skilled jobs) widening therefore the wage differential between the more-skilled and least-skilled workers. Foreign direct investment (FDI) is expected to have a positive impact on the wage gap since this kind of investment requires high-skilled labour able to adapt to new technologies. In relation to *per capita* GDP, according to Kuznets (1955), a negative coefficient is expected, as explained above.

Table 2 Average of Variables for Each OECD Country (2001-2015)

Country	WPT-WPS	SBTC	IT	Immigration	Education	FDI	GDPpc
Australia	33.3947	1.8214	0.4078	0.2247	4.9667	2.8552	38999.3
Austria	75.3830	2.2838	0.9736	0.0959	5.6687	3.0800	40085.7
Belgium	14.1448	1.9415	1.5462	0.0907	6.1900	12.0364	37542.6
Canada	39.0111	1.9533	0.7182	0.0934	5.1346	3.5423	38458.8
Czech Republic	73.4576	1.3150	1.2209	0.0288	4.1427	2.9733	25683.4
Denmark	24.6312	2.5379	0.8989	0.0527	8.2900	3.8073	39462.6
Estonia	11.4032	1.6878	1.4930	0.1641	5.6800	4.2000	20478.8
Finland	8.5151	3.3638	0.7617	0.0213	6.2431	4.3231	36241.5
France	26.9906	2.1626	0.5283	0.0585	5.8323	4.0769	34223.1
Germany	28.6245	2.5464	0.7424	0.0838	4.6613	2.5400	37874.9
Greece	76.8557	0.4830	0.5398	0.0710	3.2472	0.4734	26420.7

Hungary	80.3444	0.9394	1.4393	0.0144	5.0813	3.8967	19974.6
Ireland	35.9138	1.2862	1.6181	0.0699	4.8643	7.6193	44345.3
Italy	50.8265	1.0923	0.5139	0.0366	4.5600	1.3250	33093.2
Japan	36.4698	3.3856	0.3088	0.0168	3.6700	0.9200	33951.4
Korea	66.2112	3.0682	0.8466	0.0135	4.5545	0.4912	27565.0
Luxembourg	55.916	1.6260	2.9083	0.4093	3.5427	376.9273	80468.3
Netherlands	30.4001	1.8919	1.3044	0.0424	5.3229	8.2500	42170.9
New Zealand	33.9172	1.1479	0.5939	0.1469	6.6000	2.4380	29658.9
Norway	33.858	1.6172	0.7213	0.0491	7.1136	3.1571	54162.4
Poland	36.427	0.6099	0.7252	0.0013	5.1850	2.2917	18348.5
Portugal	92.506	0.9455	0.6677	0.0353	5.3179	2.4571	25037.0
Slovakia	86.6301	0.5665	1.6261	0.0117	4.0750	1.5750	21483.7
Slovenia	68.7206	1.6487	1.2503	0.0328	5.6309	1.8273	26421.6
Spain	36.317	1.0842	0.5647	0.0785	4.4293	4.2214	30194.3
Sweden	20.7474	3.6590	0.8687	0.0548	7.1229	6.5500	39272.9
Switzerland	51.5686	2.7018	0.8621	0.2030	5.2820	6.7733	49422.3
Turkey	65.7066	0.6899	0.4927	0.0030	3.1543	1.2286	15802.0
The United Kingdom	72.2204	1.7731	0.5639	0.0517	5.1679	5.1571	34931.4
The USA	90.2564	2.6902	0.2536	0.0684	5.3127	1.6600	46925.8

Source: Authors' calculations.

3. Empirical Analysis for the Whole Sample

3.1 Model Specification and Estimation Methods

As we explained before we use unbalanced panel data to estimate the model that explains the wage gap between the more-skilled and least-skilled workers in 30 OECD countries over the period 2001-2015. We assume a *log-log* model specification therefore, the estimated coefficients represent the constant elasticities showing the percentage change in dependent variable due to a percentage change in the explanatory variables. The model takes the following form:

$$\ln(WPT_{i,t} - WPS_{i,t}) = \alpha_i + \beta_1 \ln SBTC_{it} + \beta_2 \ln Trade_{it} + \beta_3 \ln Immigration_{it} + \\ + \beta_4 \ln Education_{it} + \beta_5 \ln FDI_{it} + \beta_6 \ln GDPpc_{i,t} + u_{it}. \quad (1)$$

Three methods of estimations can be used to estimate Equation (1) with panel data. The simple OLS approach on the pooled model which assumes not country and time specific effects. However, this method of estimation is more appropriate to a set of homogeneous countries which is not our case since our sample includes less and more advanced countries with different structures and levels of development. An alternative estimation approach that captures country specific heterogeneity is the Fixed Effects (FE) model capturing the country specific heterogeneity in the constant part (a_i is different from country to country) as it is shown in Equation (1). This model can be estimated by the LSDV (Least Squares Dummy Variables) method assuming country specific dummy variables or alternatively by the time-demeaned estimation approach – both approaches are identical (see Jeffrey M. Wooldridge 2013). Using the FE method an explicit hypothesis is made that fixed effects are not correlated (that is $\text{cov}(\alpha_i, X_{it}) = 0$ where X_{it} is any explanatory variable) with the explanatory variables and under this condition FE estimates are consistent. The third estimation method applied to panel data is the Random Effects (RE) approach considering that country's heterogeneity is not observable and captured in the error term. If we assume that $\alpha_i = a + v_i$ in Equation (1) the RE model will have an error term $w_{it} = v_i + u_{it}$, where v_i is the unobserved country specific effect, and u_{it} the idiosyncratic error term. The estimation method used is GLS (Generalized Least Squares) applied to the partial demeaned model (see Wooldridge 2013). Using this method, the hypothesis that the unobserved error term is not correlated with the explanatory variables (that is $\text{cov}(v_i, X_{it}) = 0$) is crucial to obtain unbiased and consistent estimates.

In order to decide which estimation method to perform (OLS, LSDV or GLS) three statistical tests are normally contacted. The F-test testing the pooled model *versus* the FE model, the Breush-Pagan LM test testing the pooled model *versus* the RE model and the Hausman test testing the RE model *versus* the FE model. Performing the three statistical tests the FE model is the most appropriate specification to adopt.

3.2 Results from the Fixed Effects Model

Table 3 reproduces the results of the theoretical model explained before, which aims to analyse the relative importance of SBTC, of international trade, and of a set of four control variables on the formation of the wage gap between more-skilled workers (WPT) and least-skilled workers (WPS).

Table 3 Results from the Fixed Effects Model

Fixed-effects, 396 observations; Included 30 cross-sectional units; Time-series length: min. 4, max. 15; Dependent variable: ln (WPT-WPS)

	Coefficient	**Std. Error**	***t*-ratio**	***p*-value**
Intercept	3.24697	0.42458	7.648	< 0.0001***
ln SBTC	-0.10505	0.04161	-2.525	0.0120**
ln Trade	0.15941	0.04509	3.535	0.0005***
ln Immigration	0.02845	0.01431	1.988	0.0564*
ln Educationexpenditure	0.30307	0.07126	4.253	< 0.0001***
ln FDI	0.00414	0.00723	0.572	0.5678
ln GDPpc	-0.06504	0.03590	-1.812	0.0709*
LSDV R-squared	0.947271			
Statistic: F (6, 360) = 10.4809;	p = P(F(6, 360) > 10,4809) = 1,00738e-010			

Note: ***, **, and * denote statistical significance at the 1%, 5% and 10% level of significance, respectively.

Source: Authors' estimations.

Thus, the model that relates the formation of the wage difference logarithm of more-skilled workers to that of least-skilled workers, with the logarithm of the set of independent variables, is as follows:

$$\ln(WPT - WPS)_{i,t} = 3.24697 - 0.105048 \ln SBTC_{i,t} + 0.159411 \ln Trade_{i,t} + \\ + 0.0284464 \ln Immigration_{i,t} + 0.303073 \ln Education.expenditure_{i,t} - \\ - 0.00413531 \ln FDI_{it} - 0.0650369 \ln GDPpc_{i,t} + \varepsilon_{it}. \quad (2)$$

3.3 The Endogeneity of Regressors

One of the initial basic assumptions of OLS regression recognises the lack of correlation between explanatory variables and the error term $\mathrm{cov}(X_{it}, u_{it}) = 0$, thus making the explanatory variables exogenous. The hypothesis of exogeneity of the explanatory variables is often violated, making the calculation of the least squares method (OLS) unsuitable. So, the values of the least squares estimators do not converge asymptotically to the real value of the population parameters, in other words the estimates are not considered to be BLUE (Damodar N. Gujarati and Dawn C. Porter 2009).

The method of instrumental variables (estimators IV) must be used when there is suspicion that the explanatory variables are correlated with the error term. This method consists in finding instruments (exogenous variables) highly correlated to the endogenous explanatory variables, but not correlated with the equation's error term. Estimator IV can be obtained by applying the two-stage least squares estimation approach.

We performed the Hausmam test[1] to check the hypothesis of exogeneity or endogeneity of the independent variables of our model. To this end, we created 30-unit root variables. The remaining independent variables were also used as instruments, as well as the variable being tested, although with a time lag. Moreover, to assess the validity of instruments we included another instrument: the FDI variable. We conclude that all variables are endogenous, checking their *p-values* which are respectively, 0.00353 for *SBTC*, 0.00178 for *International trade*, 1.32e-05 for *Immigration*, 9.04e-011 for *Education expenditure*, 0.006 for *FDI*, and 2.99e-08 for *GDPpc*. In all these cases, the null hypothesis is rejected, that there is no correlation with the error term, therefore the instrumental variable estimation approach should be employed to obtain consistent estimators. Performing the Sargan test[2] we confirm that all instruments used are valid, as indicated by the *p*-values which are all higher than the 5% conventional significance level.

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[1] The Hausmam endogeneity test considers the following hypotheses: H_0: $\mathrm{cov}(x_{it}, u_{it}) = 0$ (exogeneity hypothesis) and H_A: $\mathrm{cov}(x_{it}, u_{it}) \neq 0$ (endogeneity hypothesis). If the null hypothesis is not rejected, then the OLS method can be used to estimate the structural equation. If the null hypothesis is rejected, then the instrumental variable approach is suitable to obtain consistent estimators. In practical terms, it becomes evident that regressors are endogenous when p value <0.05.

[2] The test used, known as the over identification test, assumes that: H_0: instruments are not correlated with the error term, $\mathrm{cov}(Z_{ti}, u_{it}) = 0$ *versus* H_A: instruments are correlated with the error term, $\mathrm{cov}(Z_{ti}, u_{it}) \neq 0$. To perform the test, the following statistic must be used $LM = T * R^2 \sim x_q^2$, where $q = k - n$ with k the number of instruments and n the number of regressors. $T * R^2 < x_q^2$, or p-value >0.05 indicates that instruments are valid.

According James H. Stock, Jonathan H. Wright, and Motohiro Yogo (2002), weak instruments can lead to serious problems in IV regression: biased estimates and/or incorrect size of hypothesis tests based on the covariance matrix, with rejection rates well in excess of the normal significance level. The test for weak instruments is given by the F-test of joint significance of instruments applied to the reduced form (first stage) of the estimated model. Employing the F-test we conclude that instruments are not weak since the hypothesis of joint insignificance of instruments is rejected in all cases (F-statistic = 455.687 for the case of the *SBTC* variable, 135.328 for the case of the *International trade* variable, 238.528 for the case of the *Immigration* variable, 385.324 for the case of the *Education expenditures*, 157.957 for the case of the *FDI*, and 287.658 for the case of *GDPpc*).

3.4 Two-Stage Least Squares Estimation Approach

The model we consider as the most reliable is the one obtained through the two-stage least squares estimation approach, which produces unbiased and consistent estimators.

In order to understand if the economic and financial crisis of 2007-2008 had any impact on the formulation of the wage gap, the model was tested, creating two-time dummies for those years. We observe that these variables are not statistically significant (p-values: 0.54 and 0.72, with simultaneous estimation of the two variables, and p-values: 0.57 and 0.78, with separate estimation). Hence, we concluded that the economic and financial crisis of 2007-2008 did not influence the formulation of the wage gap between skilled and unskilled workers.

Table 4 reproduces the result of the explanatory theoretical model estimate and aims to analyse the relative importance of SBTC, of international trade, and of a set of four control variables present in the formation of the wage gap between more-skilled workers (WPT) and least-skilled workers (WPS), now estimated using the two-stage least squares estimation. So, our model is as follows:

$$\begin{aligned} \ln(WPT - WPS)_{i,t} = {} & 3.03216 - 0.107704 \ln SBTC_{i,t} + 0.146062 \ln Trade_{i,t} + \\ & + 0.0086986 \ln Immigration_{i,t} + 0.24814 \ln Education.expenditure_{i,t} - \\ & - 0.0075206 \ln FDI_{it} - 0.0903912 \ln GDPpc_{i,t} + \varepsilon_{it}. \end{aligned} \tag{3}$$

Table 4 shows that as regards the total sample into account the coefficients associated to the international trade, education expenditure, GDP *per capita* and SBTC variables are statistical significance. Wald's statistics shows a p-value less than 0.05, meaning that the dependent variables are, overall, statistical significance.

Table 4 Results from the Fixed Effects Model, Two-Stage Least Squares Estimation

Fixed-effects, TSLS 365 observations; Endogenous: ln SBTC, ln Trade, ln Immigration, ln Education, ln FDI, ln GDPpc; Instruments: ln SBTC_1, ln Trade_1, ln Immigration_1, ln Education_1, ln FDI_1, ln GDPpc_1
Dependent variable: ln (WPT-WPS)

	Coefficient	Std. Error	*t*-ratio	*p*-value
Intercept	3.03215	0.41085	7.380	< 0.0001***
ln SBTC	−0.10770	0.03912	−2.753	0.0059***
lnTrade	0.14606	0.04191	3.485	0.0005***
ln Immigration	0.08699	0.02103	0.414	0.6792
ln Educationexpenditure	0.24814	0.06768	3.667	0.0002***
ln FDI	−0.00752	0.00709	−1.060	0.2891
ln GDPpc	−0.09039	0.03487	−2.592	0.0095***

Wald chi-square (5) = 47.1581 with *p*-value = 0.0000
Statistic: F (6, 358) = 30.8145 with *p*-value = P(F(6, 358) > 30.8145) = 0.0000

Note: ***, **, and * denote statistical significance at the 1%, 5% and 10% level of significance, respectively.

Source: Authors' estimations.

3.5 Interpreting the Sign and Significance of Coefficients

Regression coefficient signs associated to the independent variables international trade, education expenditure and GDP *per capita* are in line with the economic theory, although not all have always statistical significance (e.g. immigration and FDI). The variable SBTC, surprisingly presents a negative coefficient, which is contrary to the expected and pointed in the literature. One possible explanation for this may be the significant increase in the number of skilled workers in the OECD countries, which can affect negatively the skill premium through the supply-side effect.

Having analysed the results, we can say the marginal effect of SBTC in the formation of the wage gap between the more-skilled (WPT) and the least-skilled workers (WPS) is negative. It is expected that, *ceteris paribus*, an increase of 1% in the SBTC variable will cause a decrease of 0.107% in the wage gap.

As regards international trade, the effect is positive (in line with the Heckscher-Ohlin-Samuelson Theorem) and more pronounced than in the case of SBTC. It is estimated that, *ceteris paribus*, an increase of 1% in the international trade variable ratio will cause a 0.146% increase in the wage gap between more-skilled workers (WPT) and least-skilled workers (WPS).

The education expenditure variable contribution to the wage gap under study is quite strong and positive. In the set of considered variables is the one that contributes most to the wage gap. It is estimated that, *ceteris paribus*, an increase of 1% in the education spending variable ratio as a percentage of GDP will cause an increase of 0.248% in the wage gap under study. A country's investment in education must produce effects on the wage rates of its more-skilled workers.

In relation to GDP *per capita*, an increase of 1% in GDP *per capita* decreases the wage gap by 0.09% in line with, for example, Kuznets (1955).

4. Exploratory Multivariate Analysis Technique

In this section we will get the ideal number of clusters for the homogeneous division of the OECD countries. After this division and using the panel data methodology, we will individually estimate each cluster to observe if it is either the SBTC theory or the international trade one that best explains the formulation of the wage difference between the most skilled and less skilled workers in the countries of the OECD, in the period 2001-2015.

4.1 Obtaining the Ideal Number of Clusters

To carry out the cluster analysis (which is considered an exploratory multivariate analysis technique), we have considered the mean observations available for each country, for each of the variables, as shown in Table 2. As the variables were not expressed in the same unit of measurement, the first step was to standardize the mean variable values for each OECD country.

The hierarchical class aggregation method of classes we will use is the Ward method, the most commonly used as it is regarded as the most robust. The distance measurement used is the Euclidean distance, and the software package used is SPSS version 25.

The hierarchical analysis (Figure 1) shows us that the ideal number of clusters is seven. So, using the non-hierarchical method we will test whether the hypothesis of seven clusters is confirmed, or whether it would be better if we split the countries into five clusters, in other words, which solution is more homogeneous.

Table 6 shows that, in both cases, one of the clusters will consist of a single country, the Luxembourg (outlier), and that the seven clusters solutions create a more spread division of the countries across the clusters. Although some literature considers that outliers should be taken out of the analysis, we chose not to do so because the FDI is high in the Luxembourg due to high financial flows from legal, non-creative, transactions. In both cases, and through the Anova statistical analysis, we can conclude that the null hypothesis is rejected (p-value less than 0.05); that is, the *clusters* show mean differences between them.

Table 5 Number of Countries per Cluster

	Number of countries		Number of countries
Cluster 1	4	Cluster 1	5
Cluster 2	9	Cluster 2	2
Cluster 3	8	Cluster 3	1
Cluster 4	1	Cluster 4	4
Cluster 5	8	Cluster 5	4
		Cluster 6	9
		Cluster 7	5
Valid	30	Valid	30
Missing	0	Missing	0

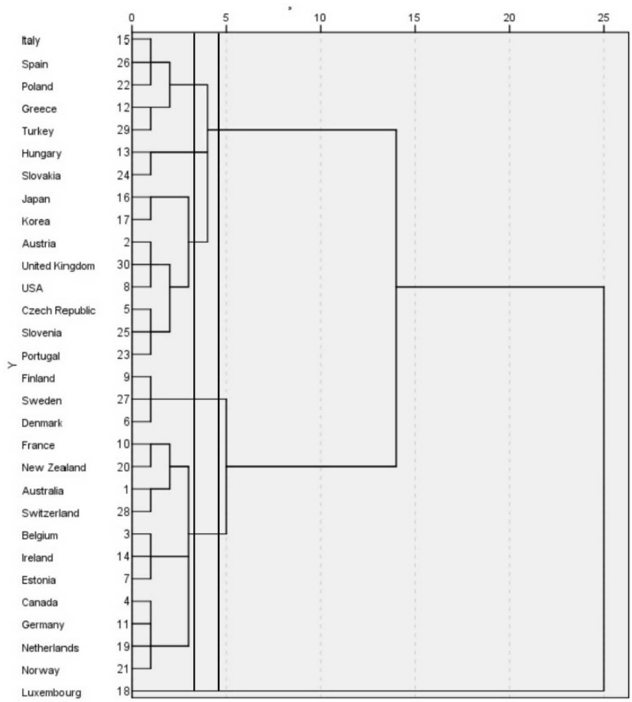
Source: Authors' elaboration.

We can group the OECD countries into the following five clusters:

(1) *Cluster* 1: Hungary, Ireland, Poland and Slovakia;
(2) *Cluster* 2: Belgium, Denmark, Estonia, Finland, France, Netherlands, New Zealand, Norway and Sweden;
(3) *Cluster* 3: Czech Republic, Greece, Italy, Portugal, Slovenia, Spain, Turkey and the United Kingdom;
(4) *Cluster* 4: Luxembourg;
(5) *Cluster* 5: Australia, Austria, Canada, the USA, Germany, Japan, Korea and Switzerland.

For the seven clusters division, the countries would be split as follows:

(1) *Cluster* 1: Australia, Canada, Estonia, New Zealand and Switzerland;
(2) *Cluster* 2: Slovakia and Hungary;
(3) *Cluster* 3: Luxembourg;
(4) *Cluster* 4: the USA, Germany, Japan and Korea.
(5) *Cluster* 5: Czech Republic, Greece, Portugal and Turkey;
(6) *Cluster* 6: Austria, France, Ireland, Italy, Netherlands, Poland, Slovenia, Spain and the United Kingdom;
(7) *Cluster* 7: Belgium, Denmark, Finland, Norway and Sweden.



Source: Authors' results.

Figure 1 Dendrogram Using the Ward Linkage

To help us decide on the number of clusters, we use the Tadeusz Calinski and Joachim Harabasz (1974) Criterium. This criterium is sometimes called the Variance Ratio Criterium (VRC), and index is defined as:

$$VRCk = \frac{SSB}{SSW} \times (\frac{N-K}{K-1}), \tag{4}$$

where *SSB* is the overall between clusters variance, *SSW* is the overall within cluster variance, *k* is the number of clusters and *N* is the number of observations.

Well defined clusters have a large between cluster variance (SSB) and a small within cluster variance (SSW). The larger the *VRCk* ratio the better the data partition. To determinate the optimal number of clusters, we need to maximize *VRCk* with respect to *k*. According to Calinski and Harabasz (1974), the optimal number of clusters is the solution with the highest index value. In our case, *VRC5* = 33.25 and *VRC7* = 40.39. Hence, in line with Calinski and Harabasz (1974), the optimal number of clusters is seven. The division into seven clusters presents better homogeneity within each group, and heterogeneity between each cluster.

Table 6 Average Observations in Each Cluster

Cluster	WPT-WPS	SBTC	IT	Immigration	Education	FDI	GDPpc
Cluster 1	33.8590	1.8624	0.8150	0.1040	5.5327	3.9618	35403.6
Cluster 2	834873.	0.7530	1.5327	0.0131	4.5782	2.7210	20729.2
Cluster 3	55.9160	1.6260	2.9083	0.4093	3.4527	376.9273	80468.3
Cluster 4	55.3905	2.9226	0.5379	0.0456	4.5496	1.4028	36579.3
Cluster 5	77.1315	0.8584	0.7303	0.0345	3.9655	1.7831	23235.8
Cluster 6	48.1332	1.5374	0.8936	0.0520	5.1846	4.2054	33757.2
Cluster 7	20.3793	2.6239	0.9594	0.0537	6.9919	5.9748	41336.4

Source: Authors' results.

The analysis of the seven clusters shows that (Table 6):

- *Cluster* 1 is formed by Australia, Canada, Estonia, New Zealand and Switzerland. This set of countries presents a low wage difference between more and skilled and lesser skilled workers. Except for Luxembourg, it is the cluster that has the highest percentage of immigrants in relation to its working-age population, where there is a high value of education expenditure, and a high value of expenses in research and development, suggesting that the SBTC theory is one of the explanations for the formulation of the wage difference in this cluster.
- *Cluster* 2 is composed only by Slovakia and Hungary, which share a border of almost 700 km between them. It is the cluster that presents the greatest wage inequality between the more and the lesser qualified workers. It presents the lowest rate of research and development in relation to GDP, the lowest average GDP *per capita*, and the higher degree of openness to international trade (except for Luxembourg).
- *Cluster* 3 is composed only by Luxembourg. Luxembourg is primarily characterised by its financial services and, due to this fact, it is the head-office of many multinational firms; hence the huge discrepancy of the FDI variable compared to the

other OECD countries. This cluster has the highest percentage of immigrants in relation to its working-age population, and the highest GDP *per capita*.

- *Cluster* 4 is composed by the USA, Germany, Japan and Korea, and is the one with the highest rate of research and development, which may suggest that the SBTC theory is an explanation for the wage gap formulation. It is the group of countries with the lowest rate of FDI, probably because the wage level is higher in these countries.
- *Cluster* 5 is composed by the Czech Republic, Greece, Portugal and Turkey and shows a high wage inequality between more and lesser skilled workers, as well as the lowest GDP *per capita*.
- *Cluster* 6 includes Austria, France, Ireland, Italy, the Netherlands, Poland, Slovenia, Spain and the UK. It has a high immigration value in relation to the totality of its working class and has a high FDI.
- *Cluster* 7 comprises Belgium and the Nordic countries. It has the lowest wage inequality between more and lesser skilled workers, as well as a high rate of research and development. It also has a significant expenditure in education, captures the highest FDI and presents a high value of GDP *per capita*.

4.2 Individual Estimation for Each Cluster Using the Panel Data Methodology

In order to decide the performed estimation method (OLS, LSDV or GLS), we use the *F*-test testing the pooled model *versus* the FE model, the Breush-Pagan LM test testing the pooled model *versus* the RE model and the Hausman test testing the RE model *versus* the FE model. Performing the three statistical tests the FE model is the most appropriate specification to adopt to all clusters.

Analysing Table 7, in *Cluster* 1 the SBTC theory is verified and the expected signal of the coefficient of this variable is, in line with the literature, positive. Under a *ceteris paribus* condition, an increase of 1% in the R&D/GDP ratio implies an increase of 0.137% in the wage inequality between more and lesser skilled workers. Improvements in the technological-knowledge progress benefit more the skilled workers since the R&D is biased towards these workers. In this cluster, immigration, education expenditures, FDI and GDP *per capita* also have statistical significance, all of which show expected signs of the respective coefficients according to the literature.

Cluster 2, which is composed only of Slovakia and Hungary. The coefficient associated with the SBTC variable shows a negative and statistically significant signal, in disagreement with the skill-biased technological change literature. In this cluster the Heckscher-Ohlin-Samuelson theory (HOS) is verified. For each 1% increase in the degree of international trade opening of these economies, wage inequality increases by 0.21%. In this cluster, where the education expenses are higher, an increase of 1% in education expenditure as a percentage of GDP causes an increase in wage inequality of 0.53%. Investment in education is then converted into a pay premium for qualified workers. In this cluster composed of small countries, it is verified that international trade is of great importance in the formulation of this wage gap.

Table 7 Results of the Estimation for Each Cluster

Cluster	Cluster 1	Cluster 2	Cluster4	Cluster 5	Cluster 6	Cluster 7
Intercept	1.70945***	5.45850***	1.12967***	3.35345***	4.940560***	1.48756***
ln SBTC	0.13709*	-0.17500***	0.09896	-0.24427***	-0.125594	0.02273**
lnTrade	-0.17323	0.21008**	0.15382***	0.32377***	0.100570**	0.01155*
ln Immigration	0.14482*	-0.23277	0.04319	-0.20730**	0.044640	0.10837
ln Educationexpenditures	0.16350**	0.53210***	0.23913***	0.12108*	0.183565***	0.38735***
ln FDI	0.02502*	-0.00600	-0.01072	-0.03339	0.006579	0.00344
ln GDPpc	-0.18603**	-0.08400***	-0.07350**	-0.04046**	-0.016350**	-0.05735***
LSDV R-squared	0.87007	0.94020	0.89247	0.73867	0.931454	0.98056
F-statistic (*p*-value)	0.00112	<0.00010	<0.00010	<0.00010	<0.000100	<0.00010

Note: ***, **, and * denote statistical significance at the 1%, 5% and 10% level of significance, respectively. We do not consider the analysis for cluster 3 since it is composed by just one country and presents an insufficient number of observations to obtain estimates.

Source: Authors' results.

Cluster 4 is composed of highly industrialized countries. The Heckscher-Ohlin-Samuelson (HOS) theory is clearly verified, namely the Stolper-Samuleson theorem: imports of goods produced by unskilled labour force reduce unskilled wages in the skilled abundant country. Under a *ceteris paribus* condition, it is estimated that an increase of 1% in the degree of international trade openness of these economies, causes a 0.153% increase in wage inequality. Also, with statistical significance are the coefficients associated with education expenditures and GDP *per capita*.

Cluster 5 is composed by countries with the lowest OECD *per capita* GDP. The SBTC theory surprisingly presents a negative signal, in disagreement with the theory. International trade in turn has a strong impact on the formulation of the wage gap. It is estimated, under a *ceteris paribus* condition, that an increase of 1% in the degree of openness causes an increase of 0.323% in the wage inequality. With the exception of Turkey, the other countries in this group are small, so here too international trade is of great importance in formulating the wage gap between the more-skilled and less skilled workers. The coefficient associated to the immigration variable presents statistical significance, but negative. One possible explanation for this signal is the tradition of these countries as emigrants. This may lead to a shortage of unskilled workers, which, by the supply channel, increases the wage of these workers.

As for *Cluster* 6, the Heckscher-Ohlin-Samuelson (HOS) theory is also verified, being thus the international trade explanation the primarily responsible for the observed wage gap. Under a *ceteris paribus* condition, it is estimated that for each increase of 1% in the degree of international trade opening the wage gap increases 0.1%. Also, important variables to explain the wage gap in this cluster are education expenditures and GDP *per capita*.

Finally, in *Cluster* 7, which remember is dominated by Nordic countries, the two explanations are verified (SBTC and international trade), but the one with the highest intensity is the SBTC theory (0.0227). The coefficients associated with the variables education expenditures and GDP *per capita* are also statistically significant.

5. Conclusions

R&D efforts are generally accepted as an important driving force for innovation, competitiveness, productivity and, thus, for wages and economic growth. This paper presents some theories that explain the path of the wage inequality. In particular, the usual two main theories are tested: the openness to international trade and the SBTC literature. The literature shows that, although in some countries the supply of skilled labour increased, the skill premium did not, and *vice-versa* (this is true, for example, in Holland and Hungary, respectively). We have performed several empirical specifications that showed that indeed both theories are not always reflected in reality. Thus, concerning the question: what factor shapes wages of skilled and unskilled workers in the OECD countries between 2001 and 2015, the international trade, the SBTC, or both?

We show that, for all sample, the marginal effect of the SBTC channel in the wage gap between skilled and unskilled workers is negative. Since in the OECD countries the number of skilled workers is increasing, and scale effects are not important, this may indicate that the market-size effect on the SBTC is dominated by the price effect thus lowering the relative wage of skilled workers. The increase in the international trade favors the increase in the wage gap under study, following the Heckscher-Ohlin-Samuelson theory and, in particular, the Stolper-Samuelson theorem. As regards education expenditure, it comes as no surprise that the more a country invests in the education of its students, the greater the skills they will have; as a result, when they enter the labour market they will receive higher wages than the unskilled ones. Regarding the explanatory variable GDP *per capita*, its coefficient is negative in line with the literature. By raising the average income level of a country, unskilled workers are endowed with additional training and benefit from a minimum wage - in Austria, Denmark, Finland, Germany, Italy, and the Netherlands, for example, welfare benefits are automatically related with the *per capita* income by law, and in Spain and France the minimum wage is linked to *per capita* income by law - which contributes to a decrease in the wage gap.

Regarding cluster analysis, the ideal cluster number is seven. By performing the regressions for each one different results are obtained. In *Cluster* 1 and 7, which is composed of countries with more developed OECD economies, the SBTC theory is important in formulating the wage gap and assumes a positive value, in line with the literature. In the other clusters, international trade is the main explanation for the formulation of the wage gap. For example, in *Cluster* 4, which contains highly industrialized and economically developed countries, international trade is the predominant theory in the formulation of the wage gap. In all clusters education expenditures are responsible for increasing the wage gap, while GDP *per capita* is responsible for decreasing it.

To sum up, in terms of the two main theoretical strands studied here – international trade and SBTC – we can conclude that international trade is the most significant contributor to the observed wage gap between skilled and unskilled workers, when taken together the OECD countries. Through the separate estimation for each cluster, the conclusions are already different, given the economic reality of each group of countries.

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