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Decomposition of wage inequalities: an input-output approach[1]

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Abstract

Income and wealth inequalities, both between and within the advanced and developing countries, have attracted much attention in current economic debates. Wage inequalities appear to play a key role in the generation of final inequalities in terms of households' income, consumption and wealth. In this paper, we propose a decomposition approach based on the input-output analysis that allows us to disentangle the effects on the final inequalities' levels into the contributions of various determinants. So far, the analysis of income and wealth inequalities measured by standard inequality indices, e.g. Gini coefficient, Theil index, has received limited space in the input-output analysis. This does not imply that issues of income and wealth inequalities have been ignored in this stream of research. The focus of the input-output research has however been directed into distinct aspects of inequalities. In one way, researchers have put a lot of effort in the understanding how the income and wealth inequalities influence the structure of final demand of households, and eventually generate ambivalent effects on production, value added and employment. Other stream of research in input-output analysis has paid a lot of attention to inequalities that arise from the distribution of income that goes to labour and capital. We propose to calculate cross-industry and cross-country wage inequalities directly from the input-output tables and analyse the final inequality variations through the lens of changes in the inputs. Detailed industry-level data on employees' wages linked to their hours worked and education attainments, which are covered by the World input-output database, allow us to illustrate the application of proposed methodology on major advanced and developing countries in the world. The analysis contributes to solving the puzzle around the impacts of human capital and technological progress on income inequality but may shed also more light on the rising global inequalities unfolded by international trade and fragmentation of global value chains.

Keywords: wage inequality, input-output analysis, world input-output database, global value chains

JEL codes: C67, D57, D63, I24

Introduction

High division of labour on an international scale leads to the fact that production is increasingly fragmented not only in-between sectors but on a global scale. A country's position in international value chains affects its competitiveness. Traditional comparative advantage measures based on international trade statistics are becoming irrelevant indicators of competitiveness (Deb - Hauk, 2017). Value added in gross export, and not the amount of gross export is important for the development of domestic economy (Koopman et al., 2014). Increase in the international division of labour was made possible by technological advances in transport and information and

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communication technologies, and economic policies that dismantled the barriers to international trade and allowed a free movement of capital and labor. Technological changes that have occurred in recent decades were not neutral and significantly increased the intensity of production based on high skilled labor and capital (Reijnders et al, 2016). Information and communication technologies at the same time speeded up technological progress, which has led to the replacement of routine activities and thus lower demand for semi-skilled labour (Goos et al., 2014). Automation and substitution of capital for labour contributed to a decline in income from labour in total income and a higher share of capital in income. These phenomena have contributed significantly to widening income inequality within countries (both the accumulation of capital income as well as the polarization of income from work). Investigation of the links between the fragmentation of value chains, biased technological progress and income inequalities requires data that would allow to capture them consistently. World input-output database (WIOD) is a useful basis for this type of analysis. It contains a detailed flow of production and value added between industries and countries in the world economy, including socio-economic indicators on labour (for three different qualifications and respective wages), income from capital and fixed capital stock. Through augmented international input-output model, it will be possible to examine the relationship between income inequalities, biased technological change and global value chains.

The paper is organized as follows. In the next section we review the literature dealing with the economic links between wage inequality, international trade and technological changes. Then, we explain the advantages and drawbacks of wage inequality measures based on Socio-economic accounts that are part of WIOD. We discuss the possibilities of a new insights that can be obtained through input-output analysis and structural decomposition. In the last part we present the evolution of world inequality based on WIOD.

International trade, technological change and wage inequalities: a literature review

Modeling the link between wage inequality, technological progress and trade appears to be rather straightforward. Wage inequality is generated through the unequal returns to labor and its composition is to the dominant extent subject to the skills of an individual, known to the literature as well as human capital. Mincer (1956) finds the wage effects of skills twofold: besides the directly proportionate effects the skills work as an accelerating component in the wage decomposition as well (skills brought to the power of two). Benabou (1996) finds that once human capital is accounted for, the returns from both labor and physical capital rise. Tselios (2008) suggests that wage disparities at spatial scale are subject to educational attainment disparities.

The role of human capital in technological progress is widely acknowledged by the human capital theory (Griliches 1979). The role of skills in the generation of knowledge as part of technological progress is also safely anchored in the both theoretical and empirical literature (Jones 1995, Puskarova 2015). The key feature of human capital remains that it exhibits increasing returns to scale (Castello-Kliment and Domenech 2014). Thus the investments into further training of skilled labor generate higher returns to scale than the investments into turning unskilled labor into skilled labor. Unskilled workers are trapped in a vicious cycle of low returns to their labor – low wages and the inequality gap between high and low skilled labor widens. Moreover, the role of human capital in technology spillovers is essential. A strand of literature on innovation systems stress the abilities of labor to imitate existing knowledge (Fagerberg, Srholec and Verspagen 2010) or follow up with new innovations (Jones 1995).

In the global value chains, we have to account for the factor movements and offshoring activities of multinationals. Here, international theories of trade provide us with useful insights. In line with the Stolper-Samuelson theorem and considering two production inputs – high- and low-skilled labor, an increase in the relative price of a skill-intensive good (for example due to lowering trade barriers and facing higher prices of skill-intensive good abroad) will in the long run perspective increase the real wages of high-skilled labor and decrease the real wages of low-skilled labor. In developed countries which tend to be relatively abundant in high-skilled labor wages would opening up to trade lead to increases in high-skilled wages and developing countries, the low-skilled labor would profit at the expense of high-skilled labor. The same can be applied to companies. Companies producing high-skilled products would grow wage inequality since high-skilled labor would benefit at the expense of low-skilled labor and vice versa for companies generating low-skill-intensive production.
Global value chains however are more characterized by offshoring decisions. The existence of the trade in intermediary products undermines traditional assumptions of different kinds of labor being confined to a particular economy. Countries are no longer bound to the base of production factors of a one country but can easily offshore a task to skilled or low-skilled labor abroad. Companies save and the type of labor they seek for might gain. However, offshoring carries along the effects other than those arisen along the regular trade with final production and are in compliance with the Stolper-Samuelson theorem. Since offshoring comes hand in hand with imports of intermediaries, adding the value and then exporting them further, it involves technology spillovers and productivity increases but also worsening the terms of trade (Rossi and Hansberg 2008). The final effect depends on which effects prevail. Offshoring low-skilled labor may lead to increases of wages of low-skilled labor and decreasing wage inequality, but also to lowering the wages of low-skilled labor and increases in wage gap. Zhu and Trefler (2005) argue that offshoring leads to greater inequality in both developed and developing countries since it raises the skill premium in both.
The empirical literature is mostly focused on the impacts of income inequality rather than wage inequality. In general, studies find that the role of trade on inequality is small and often insignificant (OECD 2011). In the same line of studies, Lopez Gonzalez et al. (2015) come to the conclusion that participation in global value chains is not the main driver of wage inequality – it plays a relatively small part even though countries that engage more in global value chains tend to have less wage inequality.
The role of technology as a determinant of wage inequality remains unsolved. Michaels, Natraj and Van Reenen (2010) for example examined the impact of ICT solutions on skill-biased technological change and came to results that ICT can be a cause of greater inequality. Figini and Gorg (2007) argue that technology transfers may benefit also low skilled labor and eventually lead to wage inequality drops.

Methodology and empirical applications

The World input-output database consists of three distinct types of data:

- World input-output tables
- Socio-economic accounts
- Environmental accounts.

Socio-economic accounts and Environmental accounts are consistent with world input-output tables and can be used for augmented input-output analysis. In 2013 release, WIOD covers 40 countries in the world economy and the rest of the world (RoW), and data are split in 35 different industries.

Key variables that allow us to calculate the inequality measures directly from WIOD are taken from Socio-economic accounts in this early release, while the new release of the data does not cover detailed classification based on skills. These are:

- Labour compensations (in millions of national currency)
- Total hours worked by persons engaged (millions)
- High (medium and low) skilled labour compensation (share in total labour compensation)
- Hours worked by high (medium and low) skilled persons engaged (share in total hours)

In order to convert labour compensations from national currency to USD, we can use the exchange rates used in constructing the International SUTs and WIOTs.
Using the data on shares in total labour compensation and shares in total hours worked by persons according to different skills allows us to calculate wages paid and total hours worked by skill groups. These data are provided for 35 different industries. Dividing the amount of wages paid to different skill groups by the number of hours worked allows us to calculate average wages paid to them. Thus, for each country we have 3 distinct types of workers in 35 industries with corresponding wages. These data can be used to construct several inequality measures that will be consistent with world input-output tables. Taking the data for all 40 countries into account we have 3x35x40=4200 data points for each year to calculate the global wage inequality from WIOD.

Drawbacks of inequality measures based on World input-output database

While the idea to construct the inequality measures directly form WIOD is very appealing, we must be aware of its limitations. There are several points of criticism.

- Large aggregation level of the underlying data
- Top (bottom) incomes are not considered
- Not original data but data based on models

Usually, inequality measures are calculated from detailed survey data or various kinds of tax receipts and social payments. These types of data allow for a detailed information on income and wages for representative pool of households. Socio-economic accounts in WIOD are based on EU KLEMS database and are rather aggregated. Inequality measures for each individual country can be calculated from maximum of 3x35=105 data points so a lot of viability within skill groups and across industries will be hidden. So, we are not able to capture the inequality led by Top (bottom) income groups. This is a relevant criticism in the light of recent work done by Atkinson – Piketty – Saez (2011) that point out on the importance of top incomes inequality (Top 10 %, Top 1%, Top 0,1 % incomes). Another relevant point for criticism arises from the mere fact that data in Socio-economic accounts have to be harmonized with world input-output tables that requires several assumptions and modelling (estimation) approach. Then, input-output analysis based on inequality measures calculated from Socio-economic accounts relies on models (assumptions) that brings another source of uncertainty in the results. With respect to uncertainty, another concern is that it cannot be taken into account explicitly because we do not have any measure of variation that could give us some confidence intervals at the end.

Trade, global value chains and wage-income inequality: an econometric approach

The first study (to our best knowledge), that analysed the relations between wage-income inequality, trade and global value chains based in inequality measures from world input-output and Socioeconomics accounts was published by the group of OECD experts (Gonzalez et.al., 2015). Their objective is to revisit the link between wage inequality and the proliferation of global value chains. They calculate the inequality measures directly from Socio-economic accounts and try to identify its main determinants using in econometric evidence. Set of indicators that could explain the inequality is chosen on the criteria of data availability and what theory suggests. They focus on participation in global value chains as one of the potential determinant and show how it affects the inequality. In order to show the robustness of their results, they take another data sources for inequality measures as a dependent variable as well.

Even though this type of analysis is very useful and several policy implications can be drawn from the analysis, according to us they do not make use the full potential of the available data. This is, the consistency with world input-output tables. If data from Socio-economic accounts are only taken with an objective to calculate the inequality measures, then other data sources provide more reliable data on the extend a development of economic inequality as we discussed above. Though in many cases they do not cover all the countries or data form some points in time are missing, data in Socio-economic accounts are estimated for some years, countries, skill types and industries as well. The good news is that Gonzalez et.al (2015) show that their results are robust to different data sources. On the other side, this is an argument to stick to other data sources rather than to Socio-economic accounts.

The main potential of the inequality measures based on Socio-economic accounts that was not elaborated yet is their compatibility with world input-output tables. This allows to decompose the inequality into the contribution of several determinants that are commonly analysed through the standard input-output analysis and structural decomposition techniques. We will elaborate some examples in the following sections.

The power of inequality measures in world input-output database: few examples

The main advantage of wage inequality measures based on world input-output database is their consistency with world input-output tables. The inequality measures from other data sources do not allow a straightforward application of input-output analysis into the search for the main drivers of inequality. This is one of the reasons why we find very limited contribution of input-output research into the discussion of recent inequalities. The input-output studies so far focused more on the distribution income between labour and capital, or on the effects of different structure of final demand according to income levels of various household types.

The input-output analysis does not allow to analyse the determinants of differences in average wages directly. But is has a useful technique that allow us to determine the extent of inequalities as a result of the number of workers receiving certain wage. Leontief input-output model provides a link between final demand, wages paid to persons and the number of hours worked, that goes through the production effects. The standard representation of input-output model is as follows

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{y} \tag{1}$$

where $\mathbf{x}$ is a vector of total production of commodity i=1…n, $\mathbf{y}$ is a final demand vector and $(\mathbf{I} - \mathbf{A})^{-1}$ is a Leontief inverse matrix calculated from identity matrix $\mathbf{I}$ and matrix of domestic flow-based input-output coefficients $\mathbf{A}$. The key part of the model is the so-called Leontief inverse matrix that shows the total production of commodity i in order to satisfy the final demand for one unit of commodity j.

We can extend the model for the effects on hours worked by persons engaged $\mathbf{h}$ and wages paid to these workers $\mathbf{w}$ by the calculation of labor requirements in terms of one unit of production in industry *j* ($\mathbf{h}_c$)and wages paid per one unit of production in industry *j* ($\mathbf{w}_c$)as well. Formally,

$$\begin{aligned} \mathbf{h}'_c &= \mathbf{h}'\hat{\mathbf{x}}^{-1} \\ \mathbf{w}'_c &= \mathbf{w}'\hat{\mathbf{x}}^{-1} \end{aligned} \tag{2}$$

The hours worked and wages generated in particular industries by final demand $\mathbf{y}$ are then given by

$$\begin{aligned} \mathbf{h} &= \hat{\mathbf{h}}_c(\mathbf{I}-\mathbf{A})^{-1}\mathbf{y} \\ \mathbf{w} &= \hat{\mathbf{w}}_c(\mathbf{I}-\mathbf{A})^{-1}\mathbf{y} \end{aligned} \tag{3}$$

If we take the whole final demand as an exogenous determinant of hours worked and wages paid to the workers, we will end up with original data from Socio-economic accounts.

Input-output analysis allows us to calculate the extent of inequalities caused by different final demand categories. Even though the average wages will not be affected by the structure of final demand according to its categories, the differences in inequalities can arise from different structure of final demand within these categories that translates to distinct amount of wages paid to different types of workers. For example, we can split the final demand into its domestic demand component ($\mathbf{y}^{dd}$) and export ($\mathbf{y}^{ex}$). They will generate some number of hours worked and wages accordingly and thus influence the overall inequality. The effects given by domestic final demand are given by following equations

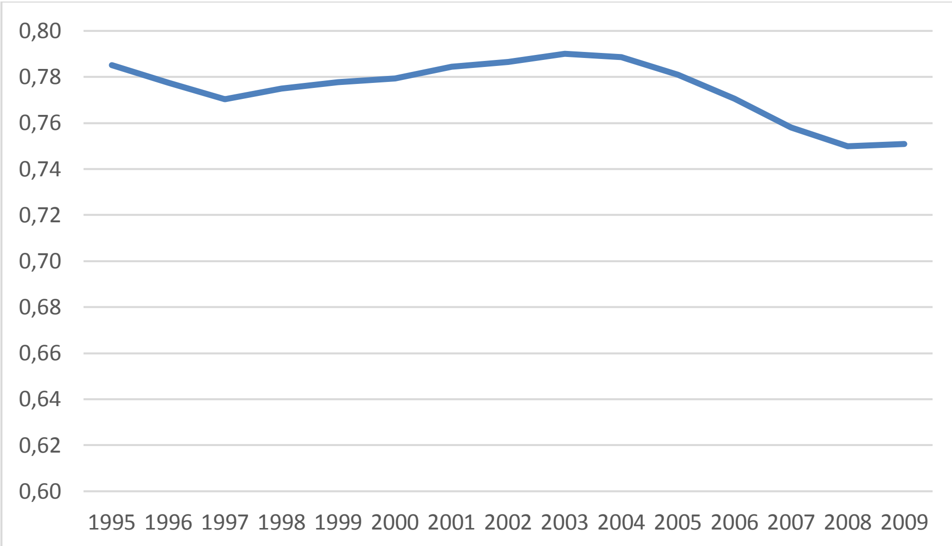
$$\begin{aligned} \mathbf{h}^{dd} &= \hat{\mathbf{h}}_c(\mathbf{I}-\mathbf{A})^{-1}\mathbf{y}^{dd} \\ \mathbf{w}^{dd} &= \hat{\mathbf{w}}_c(\mathbf{I}-\mathbf{A})^{-1}\mathbf{y}^{dd} \end{aligned} \tag{4}$$

Similarly, we can calculate the effects of export on the number of hours worked and wages paid in distinct industries and then calculate the wage inequalities given by export.

Besides the measures of wage inequality, we can calculate the overall average wage determined by domestic demand and export and analyze whether the trade-off between wage inequality and efficiency (in terms of overall average wage) is present countries and what is the role played by domestic demand and export in this phenomenon.

Furthermore, structural decomposition technique can be applied in diverse direction to get additional insights on the determinants of wage inequality within and across given countries.

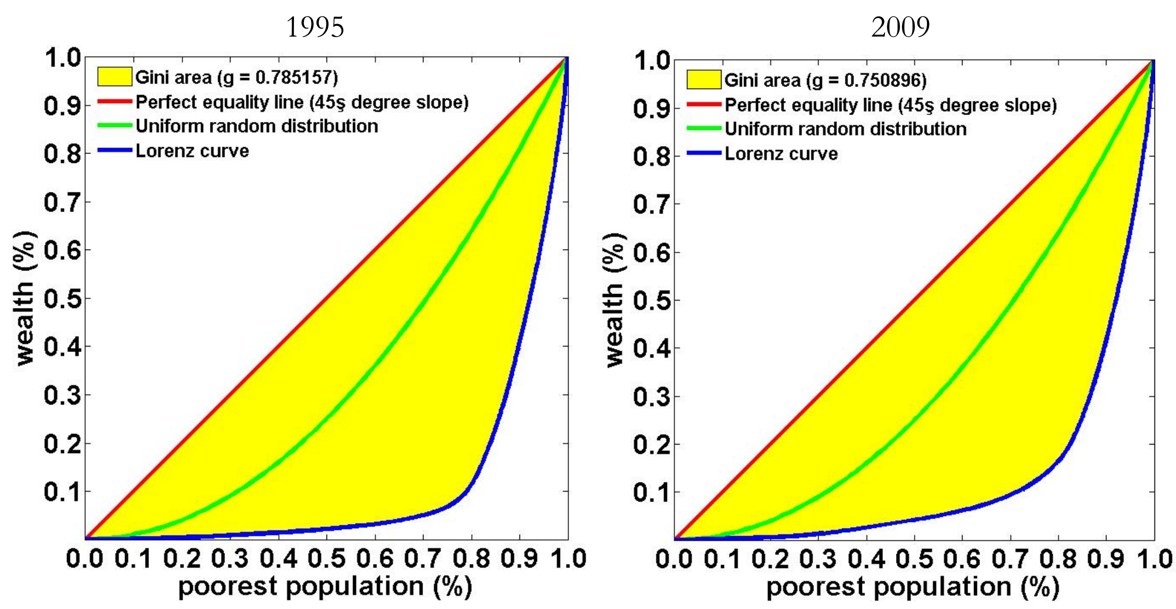
Figure 1 Global wage inequality measured by gini coefficient, 1995-2009



Source: Authors´ calculation based on WIOD.

Figure 1 shows the global wage inequality measured by Gini coefficient based on World input-output database. Overall wage inequality decreased between 1995 and 1997. Then it began to rise again and peaked around 2003 and 2004. Relatively steep decline in wage inequality was stopped by economic crises in 2008 and 2009.

Figure 2 Lorenz curves for world wage inequality



Source: Authors´ calculation based on WIOD.

Lorenz curve for the years 1995 and 2009 are shown in Figure 2. Again, we see the decrease in overall inequalities. As mentioned before, WIOD allows us to calculate the Gini coefficients within each individual country that is covered by the database. Gini coefficients for 40 countries for the period 1995 and 2009 are reported in Annex A.

Conclusions

Economic inequalities, both between and within the advanced and developing countries, have attracted much attention in current economic debates. Wage inequalities appear to play a key role in the generation of final inequalities in terms of households' income, consumption and wealth. In this paper, we proposed a decomposition approach based on the input-output analysis that allows us to disentangle the effects on the final inequalities' levels into the contributions of various determinants. So far, the analysis of income and wealth inequalities measured by standard inequality indices, e.g. Gini coefficient, Theil index, has received limited space in the input-output analysis. We discussed both advantaged and drawbacks of the proposed approach and the reason why we should be careful when we calculate and try to decompose the wage inequalities based on World input-output tables.
More detailed structure of the labour income by different groups of workers will allow researchers to get more heterogenous picture of the economy that reflects more precisely the distribution of incomes in particular countries. While the new release of WIOD does not cover wages by skill groups we suggest to apply the proposed approach to national input-output tables extended for employment and incomes by different groups of workers (that have different average wages).

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ANNEX A

Within country Gini coefficients calculated from WIOD, 1995 - 2009

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AUS	0,18	0,18	0,19	0,19	0,19	0,19	0,20	0,20	0,20	0,21	0,21	0,21	0,20	0,21	0,20
AUT	0,23	0,23	0,22	0,22	0,21	0,21	0,21	0,21	0,19	0,21	0,21	0,21	0,22	0,23	0,23
BEL	0,17	0,17	0,17	0,17	0,17	0,17	0,17	0,17	0,16	0,17	0,17	0,17	0,17	0,17	0,17
BGR	0,28	0,28	0,28	0,25	0,25	0,25	0,28	0,28	0,25	0,27	0,26	0,26	0,26	0,27	0,26
BRA	0,56	0,56	0,56	0,56	0,56	0,54	0,54	0,53	0,52	0,52	0,51	0,51	0,49	0,48	0,48
CAN	0,19	0,20	0,20	0,20	0,20	0,19	0,19	0,20	0,20	0,20	0,20	0,19	0,20	0,19	0,19
CHN	0,34	0,33	0,35	0,37	0,38	0,41	0,44	0,47	0,47	0,46	0,44	0,41	0,42	0,42	0,42
CYP	0,31	0,31	0,31	0,32	0,31	0,31	0,31	0,32	0,33	0,33	0,33	0,34	0,35	0,35	0,36
CZE	0,17	0,18	0,18	0,18	0,19	0,18	0,18	0,18	0,17	0,19	0,19	0,19	0,19	0,19	0,20
DEU	0,20	0,21	0,21	0,21	0,21	0,22	0,22	0,22	0,22	0,22	0,22	0,24	0,23	0,24	0,24
DNK	0,13	0,13	0,13	0,13	0,13	0,13	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14	0,14
ESP	0,27	0,27	0,26	0,26	0,25	0,22	0,22	0,22	0,20	0,21	0,21	0,20	0,20	0,20	0,20
EST	0,27	0,27	0,27	0,25	0,26	0,27	0,26	0,27	0,26	0,26	0,25	0,24	0,21	0,20	0,20
FIN	0,16	0,15	0,15	0,15	0,16	0,16	0,16	0,16	0,15	0,16	0,16	0,17	0,17	0,17	0,17
FRA	0,22	0,22	0,21	0,22	0,20	0,21	0,21	0,20	0,17	0,18	0,18	0,18	0,18	0,18	0,18
GBR	0,17	0,17	0,17	0,18	0,17	0,18	0,17	0,17	0,17	0,17	0,17	0,17	0,17	0,17	0,17
GRC	0,30	0,30	0,32	0,30	0,29	0,28	0,27	0,27	0,25	0,24	0,24	0,22	0,23	0,22	0,25
HUN	0,27	0,28	0,28	0,28	0,30	0,31	0,30	0,31	0,29	0,31	0,31	0,31	0,32	0,31	0,31
IDN	0,44	0,42	0,41	0,37	0,32	0,33	0,37	0,37	0,38	0,38	0,46	0,46	0,51	0,51	0,50
IND	0,43	0,43	0,46	0,49	0,50	0,51	0,49	0,49	0,50	0,50	0,52	0,52	0,50	0,50	0,50
IRL	0,22	0,22	0,22	0,21	0,20	0,20	0,20	0,21	0,21	0,20	0,21	0,23	0,22	0,22	0,21
ITA	0,21	0,22	0,23	0,23	0,23	0,23	0,23	0,23	0,22	0,23	0,22	0,23	0,22	0,21	0,21
JPN	0,25	0,24	0,24	0,24	0,24	0,24	0,25	0,25	0,25	0,26	0,25	0,25	0,25	0,25	0,25
KOR	0,33	0,33	0,34	0,34	0,32	0,30	0,32	0,33	0,32	0,32	0,33	0,33	0,33	0,34	0,34
LTU	0,29	0,34	0,25	0,28	0,28	0,26	0,25	0,25	0,25	0,24	0,24	0,25	0,21	0,22	0,23
LUX	0,24	0,22	0,22	0,22	0,24	0,25	0,24	0,24	0,21	0,25	0,25	0,25	0,25	0,24	0,25
LVA	0,24	0,26	0,24	0,25	0,25	0,25	0,23	0,26	0,22	0,23	0,24	0,23	0,23	0,25	0,26
MEX	0,46	0,45	0,45	0,45	0,45	0,44	0,44	0,44	0,45	0,45	0,44	0,44	0,45	0,45	0,45
MLT	0,32	0,31	0,30	0,30	0,30	0,30	0,29	0,29	0,27	0,30	0,31	0,31	0,35	0,40	0,38
NLD	0,15	0,15	0,15	0,16	0,16	0,16	0,16	0,17	0,14	0,17	0,18	0,18	0,17	0,17	0,17
POL	0,26	0,23	0,22	0,22	0,24	0,21	0,21	0,21	0,19	0,23	0,22	0,22	0,22	0,22	0,22
PRT	0,31	0,31	0,31	0,31	0,31	0,32	0,32	0,32	0,31	0,33	0,33	0,32	0,31	0,31	0,32
ROU	0,24	0,23	0,24	0,22	0,22	0,23	0,20	0,19	0,19	0,21	0,20	0,23	0,22	0,22	0,24
RUS	0,45	0,46	0,43	0,43	0,44	0,46	0,45	0,44	0,42	0,43	0,45	0,44	0,44	0,43	0,43
SVK	0,15	0,16	0,16	0,16	0,17	0,18	0,18	0,17	0,16	0,18	0,19	0,20	0,18	0,19	0,20
SVN	0,21	0,21	0,21	0,21	0,21	0,22	0,22	0,21	0,21	0,21	0,22	0,20	0,20	0,20	0,20
SWE	0,12	0,12	0,12	0,12	0,12	0,12	0,12	0,13	0,11	0,12	0,12	0,12	0,11	0,12	0,12
TUR	0,33	0,34	0,34	0,31	0,37	0,33	0,36	0,31	0,32	0,32	0,32	0,32	0,33	0,34	0,35
TWN	0,33	0,33	0,33	0,33	0,32	0,33	0,33	0,34	0,35	0,35	0,34	0,34	0,33	0,32	0,32
USA	0,20	0,20	0,20	0,20	0,21	0,22	0,23	0,23	0,24	0,24	0,24	0,25	0,24	0,24	0,25

Source: Authors´ calculation based on WIOD.