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Does trade liberalization help to reduce gender inequality? A cross-country panel data analysis of wage gap*

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Nozomi Kimura†

Master's student, Osaka School of International Public Policy, Osaka University

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Abstract: This paper examines the relationship between trade openness and the gender wage gap using the wage data divided into six sectors and three different skill levels (high-, medium- and low-skill) in 19 developed countries from 1995 to 2005. We apply static and dynamic panel data models to investigate whether greater trade openness has affected the gender wage gap. The results from the fixed effects model indicate that trade openness decreases the wage gap between male and female workers in medium- and low-skill jobs, while the relationship between trade openness and the wage gap is insignificant in high-skill jobs. When the two-step difference generalized method of moments (GMM) is employed, trade openness is found to reduce the wage gap in medium-skill jobs, but its effect on the wage gap is insignificant in high- and low-skill jobs.

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† Corresponding author. Osaka School of International Public Policy, Osaka University, 1-31 Machikaneyama, Toyonaka, Osaka 560-0043, Japan. Email: nozomi.k.120524@gmail.com

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1. Introduction

The gender discrimination is one of the prominent issues that can be seen in the labor market. It contains employment, wage and opportunity differences between male and female due to their sex. This inequality can be observed even in developed countries. World Economic Forum (2014) reports that female workers receive 21% less wages than male workers in Norway, the country with the lowest gender wage gap among the developed nations of this survey, while the difference in wages between male and female exceeds over 50% in Italy, the country with the highest gender wage gap. However, when we look at the difference in the labor force participation rates, the participation ratio of female to male workers is over 80% in almost all of the developed nations in 2014.

How can we approach this inequality problem between male and female workers? Becker (1957, 1971) argues that if employers discriminate against female workers and pay them less than male workers, then under competitive pressure created by greater trade openness the demand for underpaid female labor is expected to grow, bidding up their wage and reducing the wage gap. As shown in Figure 1, trade expansion is observed since the 1970s and the trade to GDP ratio has been increasing except for the financial crisis year of 2008. If his assertion is correct, the employment of women should be improved; however, the real world does not follow it exactly. World Bank (various years) reports the employment to population ratio over 15 years old, the female employment rates of the world and low-medium countries are 25% lower than the male rates and the differences are slightly widening. However, in the OECD member countries, the female employment rate has improved a little (See Figures 2-4). Although a large number of women may get the opportunities to be employed in the paid jobs through trade expansion, the gender discrimination would not be improved if female workers are hired as a substitute of low-cost labor and do not gain equal compensations as males in the same skill level.

The objective of this paper is to investigate whether greater trade openness has actually affected the gender inequality in wage compensations. This study uses the static and dynamic panel models to analyze the relationship between trade openness and gender wage gap between male and female workers for 6 sectors and 3 different skill levels (high-, medium- and low-skill) in 19 developed countries from 1995 to 2005.[1]

The results show that the gender wage gap is reduced in the medium- and low-skill levels when trade openness becomes greater. This outcome supports the Becker's hypothesis that increased competition reduces the wage gap. In the high-skill level, however, the results are not statistically significant. This might be because the gender wage gap in high-skilled jobs is relatively small compared with that in medium- and low-skill jobs.

The contributions of this study are twofold. First, there are relatively small number of studies that have been conducted using cross-country and panel data, as most of the previous research has been undertaken by using micro-data for a single country. Second, this study provides the evidence that trade openness reduces the gender wage gap for medium- and low-skill level workers.

The rest of the paper is organized as follows. Section II provides the literature review of previous studies. Section III describes the data and the methodology, and Section IV presents the estimation results. Section V conducts the robustness check that examines the estimation results obtained in the Section IV. Section VI provides concluding remarks.

2. Literature Review

The relationship between trade expansion and gender inequality was first examined by Becker (1957). Since this study was published, the world has undergone extensive trade liberalization through several rounds of multilateral trade negotiations and numerous free

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[1] Canada's data is available from 1995 to 2004.

trade agreements, and the shares of exports and imports in GDP have increased considerably in emerging and developing countries. So far several studies have conducted to examine whether one of these agreements or structural changes actually affect countries' gender inequality in the labor markets. We divide these previous studies into two types, the cross-country and panel data studies and research based on micro-data.

2.1. Cross-country and panel data studies

Wolszczak-Derlacz (2013) conducts an empirical study on the effects of domestic and foreign competition on male/female wage differentials for 12 manufacturing sectors of 18 OECD countries from 1970 to 2005. She estimates the gender wage gap by the generalized method of moments (GMM), where the endogenous variable is instrumented by its lags. She provides two findings. First, she shows that an increase in sector concentration is associated with gender wage gap growth. Secondly, both import and export penetrations are associated with a reduction of the high-skill gender wage gap growth in concentrated industries. However, there is the opposite effect against medium- and low-skill workers in that the trade penetration widens the growth of gender wage gap.

Saure and Zoabi (2014) challenge the previous studies relied on Stolper-Samuelson-based intuition that female labor force participation rises whenever trade expands those sectors that use female labor intensively. They use bilateral trade data of the United States and Mexico during the period of 1990/1991 to 2006/2007 that distinguishes between female and male intensive sectors. The results of their cross-state regressions suggest that bilateral trade with Mexico increases the gender wage gap and reduce female labor force participation in the United States.

Seguino (2000) investigates the source of different trends in gender wage differentials through analysis of the effects of macro-level processes and policies in South Korea and

Taiwan from 1981 to 1992. She finds that physical capital mobility has contributed to a wider gender earnings gap in Taiwan. This result comes from women's greater concentration in industries where capital is mobile. However, the effect of capital mobility in Korea is different from Taiwan, which may be due to the dissimilar character of outward FDI.

Busse and Spielmann (2006) explore the international linkage between inequality and trade flows of a sample of 29 developed and developing countries in 2000. Their focus is on comparative advantage in labor-intensive manufactured goods. They find that gender wage inequality is positively associated with comparative advantage in labor-intensive goods, for example, countries with a larger gender wage gap have higher exports of these goods. They also find that gender inequality in labor force activity rates and educational attainment rates are negatively linked with comparative advantage in labor-intensive commodities.

Kucera and Milberg (2000) reject the "Wood asymmetry", using disaggregated industry level data of 22 manufacturing for ten OECD member countries during 1978 to 1995. Wood (1991) asymmetry is that trade between developed and developing countries corresponds with an increased female intensity of employment in developing countries and has no noticeable negative symmetric effect on the female intensity of employment in the trade-goods sector of developed countries. The authors' finding is that in most of the countries (in particular Australia, Canada, Japan, the Netherlands, and the United States), trade expansion with non-OECD member countries results in employment declines that disproportionately affected women. In most continental European countries in their sample (France, Germany, and Italy), there are little or no gender bias in the decline in employment associated with the expansion of non-OECD trade. They attribute this result to the relative importance of domestic factors related both to female employment directly and to demand changes occurring as part of the long-term process of economic growth.

2.2. Micro-data studies

Juhn et al. (2013) examine the effect of trade liberalization on gender employment inequality in Mexico through participating in the NAFTA using the firm-level data of 1992 and 2001. In their analysis, they divide labor force into three categories, white-collar, blue-collar and all to measure the growth of female-male labor ratio. They find that firms experiencing larger declines in export tariffs are more likely to hire blue-collar women and to pay them higher wages. However, there is no similar effect in white-collar occupations, where the relative importance of physically demanding skills is less likely to have changed. These improvements in blue-collar women's labor market outcomes are driven by firms newly entering the export markets who upgraded their technology towards new computerized production machinery.

Chen et al. (2013) investigate the link between globalization and gender inequality in the Chinese labor market in 2004. They measure the female employment share and the gender wage gap of domestic and foreign firms in China using the first national economic census conducted by the National Bureau of Statistics of China. Their single year econometric estimation finds that foreign and exporting firms employ more female workers than domestic non-exporters. However, they also show that foreign and exporting firms have larger gender wage and productivity gaps than domestic non-exporters and suggest that it mainly reflects the difference in gender productivity.

Black and Brainerd (2004) test the Becker's hypothesis by examining the impact of globalization on gender wage discrimination in manufacturing industries in the United States between 1976 and 1993. They measure the change in the residual gender wage gap by using the industry concentration ratio, the import share change and price-cost margin as explanatory variables in their industry-level regressions. Their finding is that while trade increases wage inequality by reducing the relative wages of less-skilled workers modestly, at the same time it appears to benefit for women by reducing the ability of firms to discriminate.

Chamarbagwala (2006) investigates widening skill wage gap and narrowing gender wage differentials from 1983 to 2000 that coincides with the economic liberalization in India by using the individual-level data from the Employment and Unemployment Schedule of the National Sample Survey Organization. She applies the nonparametric analysis that provides a framework for decomposing the extent to which relative supply and demand changes contributed to the relative wage changes in India. Her finding is that relative demand shifts contributed to relative wage shifts and that increases in the demand for skilled labor were mostly caused by skill upgrading within industries. In assessing the contribution of external sector reforms to demand for skilled labor, she also finds that international trade-in manufactures benefited skilled men but hurts skilled women, whereas outsourcing of services generated a demand for both female and male college graduates.

3. Data and Methodology

In this study, we use the labor and trade data that are matched at the industry level. To construct the wage and the sector concentration variables, we solely use the EU KLEMS database that contains the capital and the labor data inputs for 30 developed countries from 1970 to 2012.[2] The database is separated into each sex, three kinds of skill levels (high-, medium- and low-skills) and three age groups (15-29, 30-49 and over 50 years-old). It is also divided into 72 industries depended on the European NACE revision 1 classification that is very close to the International Standard Classification (ISIC) Rev. 3 (EU KLEMS, 2007). The skill levels are split based on the educational attainments. According to EU KLEMS (2007), the high-skill level is equivalent to a worker with bachelor's or higher degree, the medium-

[2] The EU KLEMS data are available at http://www.euklems.net/. An overview and methods are provided in Timmer et al. (2007) and O'Mahony et al. (2008).

skill level is associated with high (secondary) school, junior college or vocational school graduate level, and the low-skill level is associated with educational attainment below the medium-skill level. Since the EU KLEMS database is constructed by data of each country's national accounts, the method of separating the skill level varies on a yearly basis. The labor compensation and the hours of workers are also split into the same way as above. To create the gender wage gap variable, we utilize the hours and labor compensations of workers in each skill level and gender category for 19 developed countries from 1995 to 2005, and calculated as follows. The list of countries is shown in the Table 1. First, we calculate the hourly wages for each gender and each skill level,

$$W_{ij,t}^{F,S} = \frac{LAB_{ij,t}^{F,S} \times LAB_{ij,t}}{H_{ij,t}^{F,S} \times H_{ij,t}} \tag{1}$$

where i denotes sector, j indicates country, t is time and S is the skill category of workers. $LAB_{ij,t}$ is the value of total labor compensation in a given sector and country, and $LAB_{ij,t}^{F,S}$ is the share of labor compensation obtained by female with given skills. $H_{ij,t}$ means the total number of hours worked by all persons engaged in a given sector i and $H_{ij,t}^{F,S}$ is the share of hours worked by females of all ages for a given skills level. Since superscript F indicates female, equation (1) gives the hourly wages for female workers for a given skill level. Similar computations are made to obtain the hourly wages for male workers.

Regarding the industry sectors, we apply the aggregated sectoral level data that is summarize in Table 2 (see United Nations Statistics Division, 2015). Due to the availability of trade value data, the number of sectors that we cover is limited. We follow the gender wage difference calculation of Wolszczak-Derlacz's (2013), which can be expressed as follows:

$$\mathrm{w}_{\mathrm{ij,t}}^{\mathrm{S}} = \ln W_{ij,t}^{M,S} - \ln W_{ij,t}^{F,S} \tag{2}$$

where i denotes sector, j is country, t is time and S is the skill category of workers. Figures

5-7 plot the gender wage differentials between male and female workers of the manufacturing sector by each skill and country. In these figures, each point shows the wage gap in the manufacturing industry.[3] The x-axis is the time periods and the y-axis indicates the size of the gender wage gap. When the point marks zero at the y-axis, it means that there is no wage difference between male and female. If the points is positive, it means that male workers earn higher wages than female workers. If the point is negative, the opposite holds. The country abbreviation are provided in Table 1.

Comparing Figures 5, 6 and 7, the gender wage gaps are relatively large in the low-skill level and relatively small in the high-skill level. In the high-skill level, there is almost no wage difference between male and female workers in Austria and Italy, whereas the wage gaps are relatively large in Czech Republic (until 2001), Spain, Finland, Germany, Japan, Korea, Poland and Slovakia (Figure 5). Eight countries, including Australia and Czech Republic, experience diminishing gender wage gap and three countries, namely Japan, the United States and Spain, do not have significant changes from 1995 to 2005.

In the medium-skill level, again there is almost no gender wage gap in Austria and Italy, whereas the wage gaps are relatively large in Czech Republic (until 2001), United Kingdom, Germany, Japan and Korea (Figure 6). Seven countries, such as Czech Republic and Great Britain, experienced declining gender wage gap but the rate of change is not so large in the medium-skill level. Most of the countries show that the gender inequality situation has not improved and male workers earn 20-60% higher than female workers, with the exception of Austria and Italy.

In the low-skill level, Austria is the only country where there is almost no gender wage gap. The wage gaps are relatively low in Denmark, Finland, Hungary, the Netherlands and Slovenia, whereas they are relatively high in Japan and Korea (Figure 7). Most of these gaps

[3] The wage gaps in other industries in 19 countries for the period 1995-2005 are available from the author.

relatively constant over time except for Czech Republic and Italy. In Czech Republic, the gender wage gap improved by more than 20% during the 1995-2005 period. In contrast, it increased by about 30% in Italy. In Italy, the gender wage gaps in high- and medium-skill jobs are close to zero, they are considerable in low-skill jobs.

The notable difference compared to other previous studies is that we use trade openness as an explanatory variable. When we examine the relationship between export and wage gap differences, the export of crude oil is zero in Japan. However, workers engaged for the commodity and the labor compensation actually exist since Japanese firms import and refine petroleum. Therefore, we consider using either import or export value as an explanatory variable may not be able to fully account for the relationship between trade and gender wage differentials. Wolszczak-Derlacz (2013) provides me a good insight in that point that including both imports and exports in the same equation may cause multicollinearity. To avoid this problem and to take into consideration the trade balance within the country, we decide to introduce the trade openness index. Following Giovanni and Levchenko (2009) and Yanikkaya (2003), trade openness, one of the most basic measures of trade intensity, is the ratio of exports plus imports to output for each sector. Then the equation of trade openness is derived by

$$\mathrm{Trade}_{ij,t} = \frac{\mathrm{Exports}_{ij,t} + \mathrm{Imports}_{ij,t}}{\mathrm{GO}_{ij,t}} \qquad (3)$$

where $GO_{ij,t}$ is the gross output at current basis price in a given sector i in country j. The OECD (2011) and the World Bank also employ this formula as a trade openness index that takes the simple ratio of total trade to GDP. However, while the value of $\frac{Exports_{ij,t}}{Go_{ij,t}}$ will be always between zero and one, the value of $\frac{Imports_{ij,t}}{Go_{ij,t}}$ can become significantly greater than one when domestic production of product i is very small and a large percentage of this commodity is imported, such as crude oil and natural gas in Japan. Thus, a better measurement of trade openness is

$$Trade\ openness_{ij,t} = \frac{Imports_{ij,t}}{Total\ demand_{ij,t}} + \frac{Exports_{ij,t}}{Total\ output_{ij,t}} \qquad (4)$$

where total demand = demand for domestically produced output + import value, and total output = output supplied to the domestic market + exports. In equilibrium, demand for domestically produced output = output supplied to the domestic market (i.e. demand = supply). When domestic output is zero and the country completely relies on imports, the value of $\frac{Imports_{ij,t}}{Total\ demand_{ij,t}}$ becomes one. Thus, $Trade\ openness_{ij,t}$ defined by equation (4) is the sum of the import penetration ratio and the export penetration ratio, which appears to be a better index than the one given by equation (3). To obtain the export and import values, we use the UN Comtrade of the World Integrated Trade Solution (WITS) in the ISIC Rev. 3. The gross output data is reported in EU KLEMS (2007). Demand for domestically produced output, which is also equal to output supplied to the domestic market, is computed as the difference between gross output and exports. Total demand is the sum of demand for domestically produced output and imports. Trade openness in 1995 and 2005 for six industries in 19 countries are summarized in Table 6. From this table, we can observe that trade openness in the mining and manufacturing sectors increased in the large majority of the countries during 1995-2005. The values of the mining sector in Belgium, Hungary and Slovak Republic and the manufacturing sector in Belgium exceed 100%. The reason why trade openness exceeds 100% is because those countries highly rely on imports of mining products. Regarding the manufacturing sector of Belgium, the values of import, export and gross output are almost same and in that case, trade openness is close to 100%. In public utilities, business activities and other service sectors, the values of trade openness are either zero or very small. In those industries, the import and export values are considerably smaller than gross output, which is related with the characteristic of services trade.

We also include the sector concentration as an explanatory variable that is derived from the following equation.

$$Con_{ij,t} = \frac{VA_{ij,t} - LAB_{ij,t}}{GO_{ij,t}} \qquad (5)$$

where $VA_{ij,t}$ is the gross value added at current basis prices and $LAB_{ij,t}$ refers to labor compensation. This calculation is based on Aghion et al. (2008) that the sector concentration is driven from the difference between the value added (VA) and the labor compensation (LAB) as a proportion of the gross output (GO). This variable can measure how the gender wage gap is affected by the market concentration of a specific sector.

Finally, we apply the fixed effects model, and which can be defined as follows.

$$w_{ij,t}^{S} = \beta_1 Trade\ openness_{ij,t} + \beta_2 Con_{ij,t} + \alpha_{ij}^{S} + u_{ij,t}^{S} \qquad (6)$$

where α_{ij}^{S} is fixed effects that is different from each skill, *S*, sector, j and country i. u_{ij}^{S} is time-varying error that changes over time and affects $w_{ij,t}^{S}$. In the fixed effects model, the unobserved effect, α_{ij}^{S} is correlated with explanatory variables in any time periods. The motive we employ the fixed effects model is there should be unobserved effect that cannot be explained by independent variables such as geographic features, peoples' attitude against trade and so on.

4. Results

4.1. Results of static panel analysis

The summary statistics and the estimation results are provided in Tables 4-6. The feature of this estimation is that we can measure the gender wage gap of the high-, medium- and low-skill levels separately.

From the first to third columns of Table 6, the coefficients of trade openness are negative and statistically significant at the 1% level in the medium- and low-skill levels. These results suggest that greater trade openness reduces the gender wage gap of medium- and low-skill workers. This result is consistent with the Becker's hypothesis that trade expansion promotes to decrease gender discrimination. On the other hand, the relationship between trade openness and the wage gap is insignificant in the high-skill level.

As for the sector concentration, the estimated coefficients are not statistically significant even at the 10% level in any skill levels. This suggests that sector concentration does not affect gender wage gap, which is contrary to Wolszczak-Derlacz's study revealing the sector concentration increases the gender wage gap for all skill levels.

In Table 6, it also reports the results of the random effects model that the unobserved effect of α_{ij} on equation (6) is uncorrelated with each explanatory variable;

$$\mathrm{Cov}\left(Trade\ openness_{ij,t}, \alpha_{ij}\right) = 0$$

$$\mathrm{Cov}\left(Con_{ij,t}, \alpha_{ij}\right) = 0$$

From the estimation results of the random effects model, the coefficients of trade openness in the medium- and low-skill levels are also negative and significant at the 1% level and this result is consistent with the fixed effects model. The estimated coefficients of trade openness in the medium-skill level in both models are similar. In contrast to the results of the fixed effects model, the estimated coefficient on trade openness in the high-skill level is significant at the 10% level in the random effects model. However, in the Wald test that examines whether all the coefficients in the model are different from zero, it shows the value of chi-squared is 0.2081, which is not significant even at the 10% level. Therefore, I do not adopt the high-skill level result. Regarding the sectoral concentration, all of the coefficients are insignificant. We conduct the Hausman test that the null hypothesis is the preferred model is the random effects model to the fixed effects model. The values of chi-squared are 0.0124 and 0.000 in the medium- and the low-skill levels, respectively. Therefore we can reject the null hypothesis at the 1% significance level, which indicates that the preferred model is the fixed effects model.

The result that greater trade openness reduces the gender wage gaps of medium- and low-skill workers is consistent with Becker's hypothesis. Nevertheless, we still wonder whether this study is able to explain his theory accurately. The degree of trade openness has been increasing as it is mentioned in the previous section and Table 6, and the countries with increasing trade openness may have been experiencing greater competitive pressure. To survive and prosper under the competitive environment, firms may be more willing to hire female workers while maintaining the share of each skill level of workers.

According to the results, trade openness does not affect the gender wage gap of high-skill workers. This might be explained by differences in the gender wage gap and labor mobility across skill levels. First, as mentioned earlier, the gender wage gap (in percent deviations) is smaller for high-skill jobs, compared with medium- and low-skill jobs. Secondly, medium- and low-skill labor might be more mobile than high-skill labor. Medium- and low-skill workers seldom obtain powerful authorities in their tasks such as taking managerial position unless they start their own business. Therefore, they are likely to be flexible to move to other jobs when the condition of the new job is better than the current one. By contrast, high-skill workers are required to have specific skills and are generally offered their positions based on their education and experience. Thus, it might be more difficult to change their jobs frequently compared to medium- and low-skill workers. Juhn et al. (2013) show similar results as this study in that firms experiencing tariff reductions pay higher wages for blue-collar female workers, but not for white-collar female workers. They explain that this is because of technology upgrading in exporting firms, which enables blue-collar female workers to fill the gap of requirements with male workers. Conversely, they suggest that the requirements in white-collar works are unlikely to change. Unfortunately, we do not include the variables on labor mobility or technological change to confirm Juhn et al.'s (2013) finding.

4.2. Results of dynamic panel analysis

In this section we examine whether the estimation results obtained using the fixed effects model is consistent with results using a different specification. We use two-step difference generalized method of moments (GMM) in which the lags of explanatory variables are used as instrument variables. The objective for using dynamic panel estimation is that it enables us to observe the linkage with the past, since the present gender wage gap is assumed to have been influenced from the past. The GMM is one of the useful methodologies to estimate dynamic panel and it is not necessary to specify the distribution of error terms. In particular, "two-step GMM" is adopted since Windmejier (2005) finds that it performs better than one-step GMM in estimating coefficients, with lower bias and standard errors.

The estimation model can be defined as follows.

$$\Delta \mathrm{w}^{\mathrm{S}}_{\mathrm{ij,t}} = \alpha^{\mathrm{S}}_{\mathrm{ij,t}} + \beta_1 \Delta \mathrm{w}^{\mathrm{S}}_{\mathrm{ij,t-1}} + \beta_2 \Delta \mathrm{Trade\ openness}_{\mathrm{ij,t}} + \beta_3 \Delta Con_{ij,t} + \varepsilon^{\mathrm{S}}_{\mathrm{ij,t}} \qquad (7)$$

where $\Delta \mathrm{w}^{S}_{ij,t}$ is the first difference in the gender wage gap defined in the equation (2). $\Delta \mathrm{Trade\ openness}_{\mathrm{ij,t}}$ is the first difference in trade openness in equation (4), and $\Delta Con_{ij,t}$ is the first difference in the sector concentration in equation (5). $\alpha^{\mathrm{S}}_{\mathrm{ij,t}}$ is time invariant effect that is different from each skill, sector and country. We follow the idea of Wolszczak-Derlacz that the estimated coefficient of the lagged wage differential is an indicator of the conditional convergence; if it is negative, a gender wage gap approaches its steady state.

Table 7 shows the estimation results for robustness check. From the first row for trade openness, the estimated coefficient is only significant in the medium-skill level. Regarding the medium-skill level, the coefficient is negative and significant at the 10% level, thereby suggesting that trade openness reduces the gender wage gap for that skill level. We confirm the Arellano-Bond test for AR (1) in the first difference is rejected at the 1% level for the null hypothesis is that there is autocorrelation in $\varepsilon^{S}_{ij,t}$. We also check the Hansen test cannot be rejected even at the 10% level for the null hypothesis that the lagged instruments as a group are exogenous. Therefore we can accept the null hypothesis. In the Sargan test, it can be rejected at the 1% level. However, Roodman (2009) discusses that the Hansen statistic of a two-step estimate is theoretically superior over-identification test when the errors are non-spherical and the Sargan statistic is not consistent. Contrary to the trade openness coefficient of medium-skill, the column 1 and 3 of Table 7 indicates that it does not have a significant relationship with gender wage gap in the high- and low-skill level.

The estimated coefficients of sector concentration are not statistically significant even at the 10 % level and this result is consistent with the fixed effects model.

The coefficients of the lagged gender wage gap are positive for all skill levels and significant at the 1% level. According to Wolszczak-Derlacz's (2013), the estimated coefficient of the lagged wage differentials is an indicator of the conditional convergence. If it is negative, a gender wage gap approaches its steady state. However, since it is positive in our results, the gender wage gap has not reached its steady state yet.

5. Conclusion

We have examined how trade openness affects the gender wage inequality associated with three different skill levels of labor in six industries. The results of the fixed effects model suggest that greater trade openness reduces the gender wage gap in medium- and low-skill jobs. The robustness of our estimation results for medium-skill jobs is confirmed using the two-step GMM. Thus, the Becker's hypothesis that increasing trade openness induces competitive pressure for employers and helps to reduce the gender wage gap is supported to some extent in this study. The causal relationship between trade and the gender wage gap in high-skill jobs is not found. Although previous studies apply imports, exports or tariff rates as an explanatory variables, using either import or export values as an explanatory variable cannot fully capture the relationship with wage inequality. Furthermore, the tariff rates do not accurately measure the extent of a country's trade barriers, because there are nontariff barriers (NTBs), such as quantitative restrictions, technical barriers, safeguard measures and anti-dumping duties. Thus, even when tariff rates fall, it does not necessarily imply that the magnitude of trade barriers has decreased because the extent of NTBs might have increased at the same time. One of the contributions of this study is that a new index of trade openness, one that is superior to the conventional index, is introduced and used as an explanatory variable.

There are several points that need to be considered for future analysis. First, from the low value of R-squared (R^2) in the estimation using the fixed effects model, the independent variables may not fully explain the dependent variable. We suspect that there might be other variables that explain the gender wage gap, such as productivity and the number of years of schooling. Secondly, due to the data availability, only developed countries are covered in this study. However, since the emerging countries such as China and other East Asian countries have experienced a significant increase in economic openness, we should try to include those countries to capture the trend of gender wage inequality in a broader perspective.

A policy implication from this study is straightforward: the government should promote trade liberalization and at the same time tackle the gender wage inequality issue using more direct domestic policies. Reducing inequality of wages between male and female workers will help to achieve one of the UN millennium development goals, i.e., promoting gender equality and empowerment of women.

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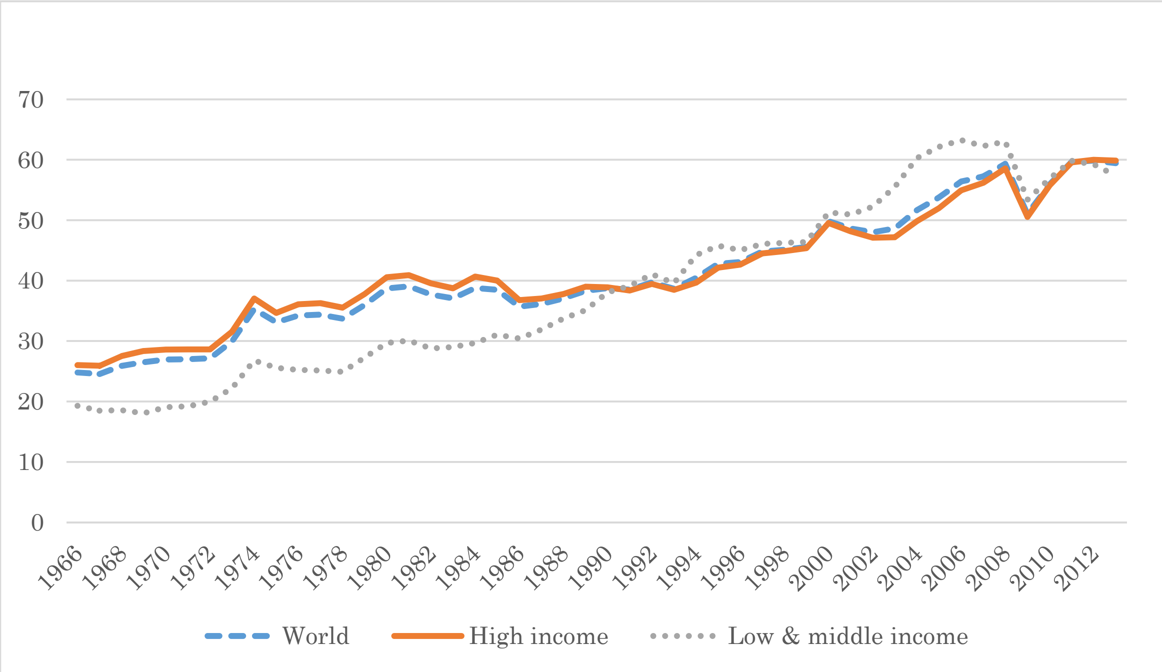
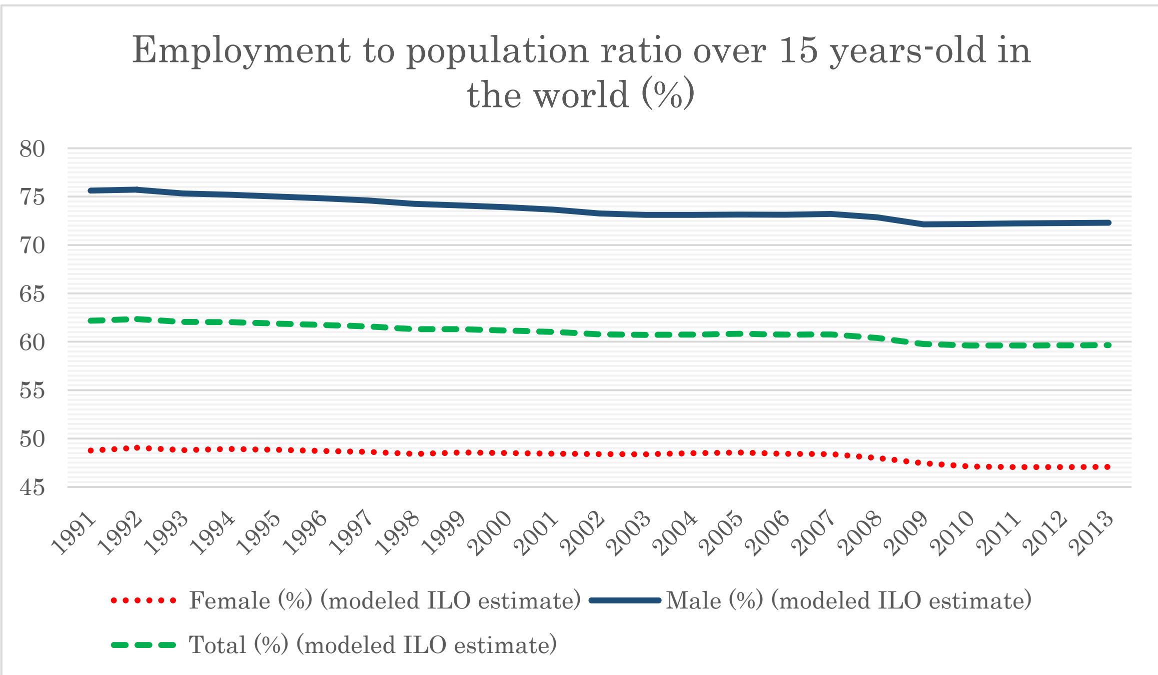
Figure 1: Trade to GDP ratio (%)



Note: The ratio is computed as (Exports + Imports)/GDP.

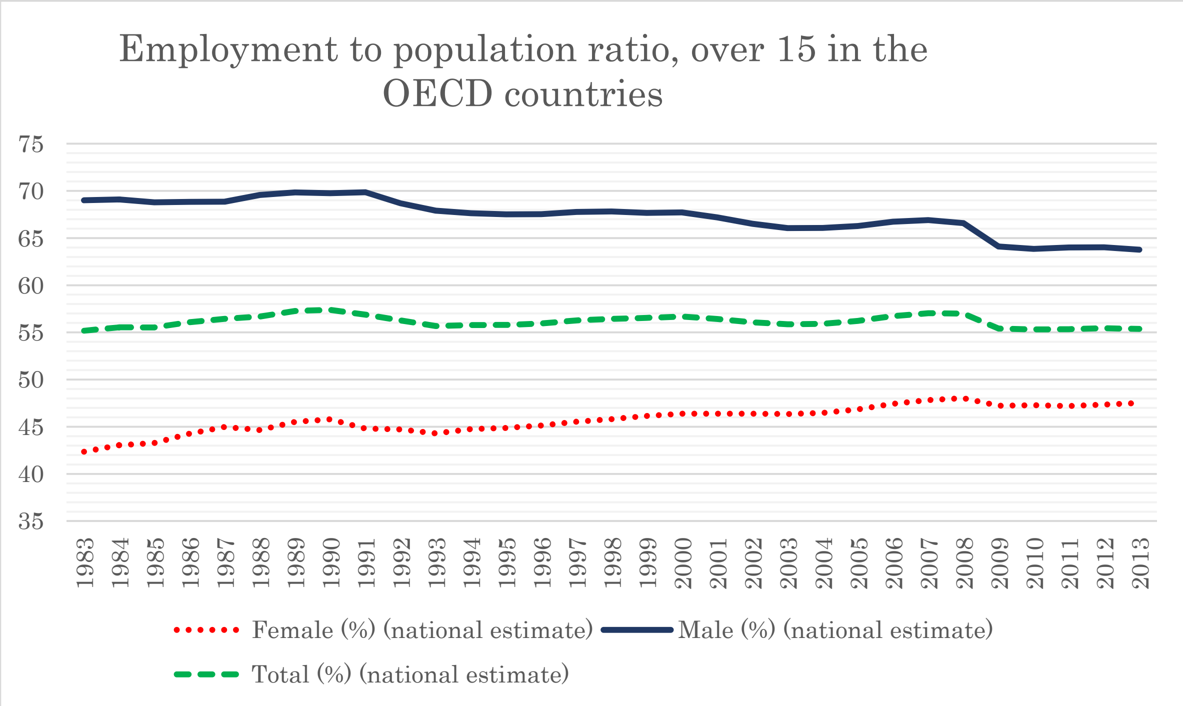
Source: World Bank (various years).

Figure 2: Employment to population ratio in the world (%)



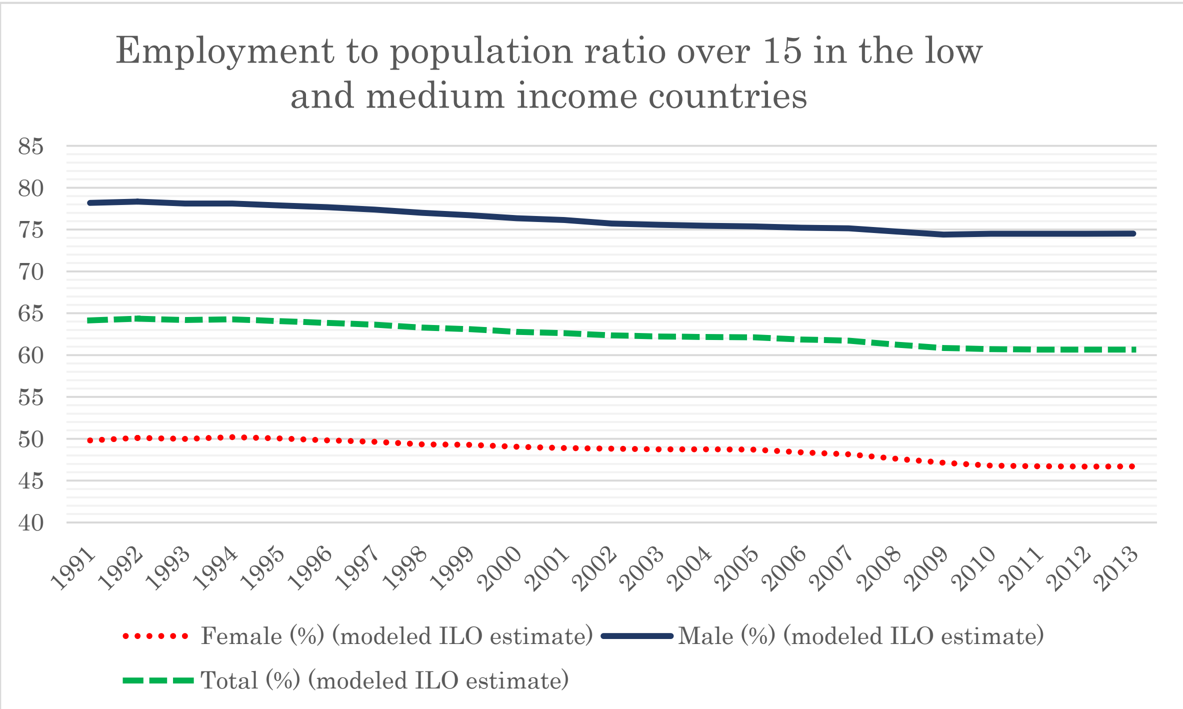
Source: World Bank (various years).

Figure 3: Employment to population ratio in the OECD member countries (%)



Source: World Bank (various years).

Figure 4: Employment to population ratio in the low and medium income countries (%)



Source: World Bank (various years).

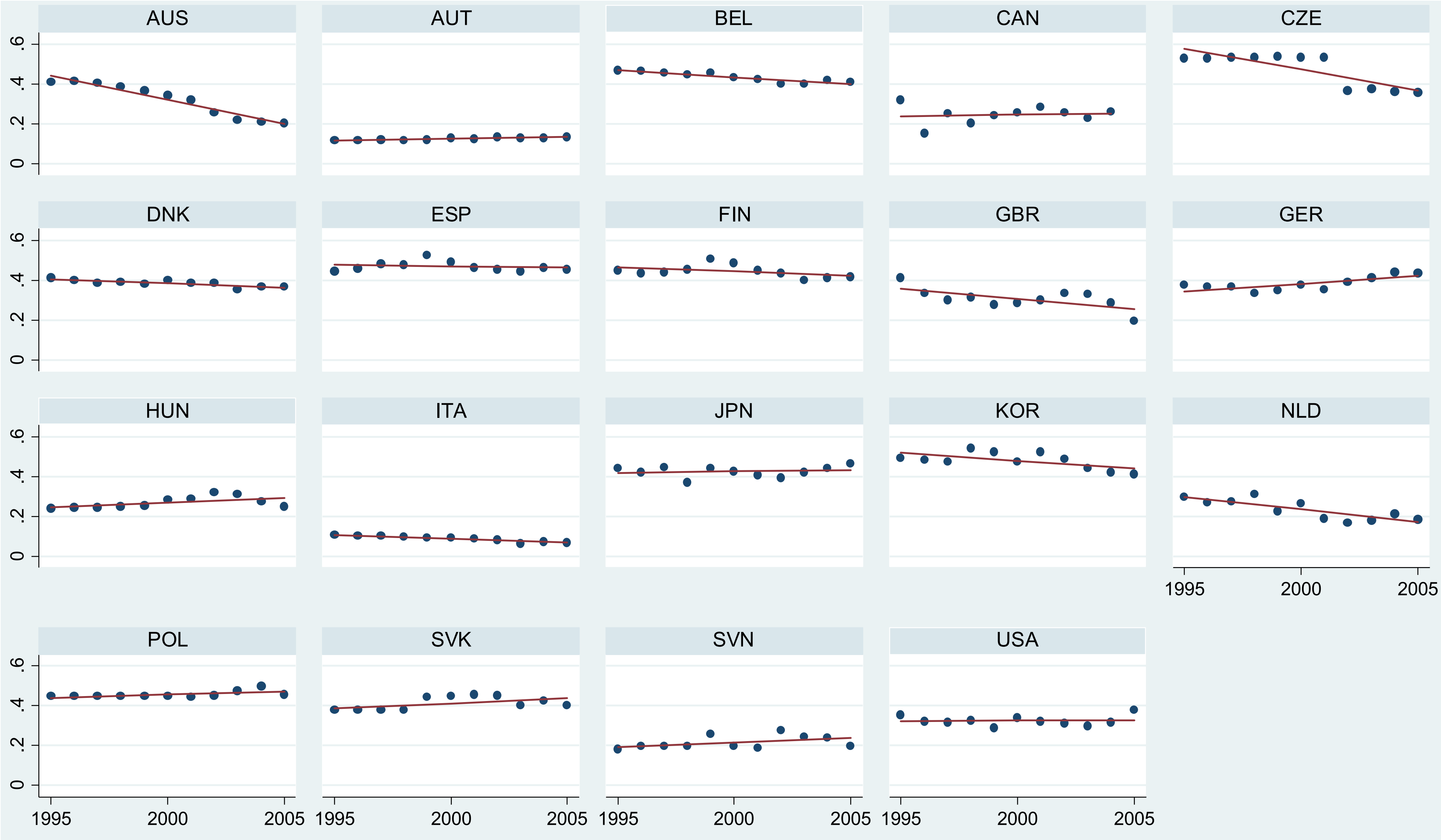
Table 1: County list

Country	Abbreviation
Australia	AUS
Austria	AUT
Belgium	BEL
Canada	CAN
Czech Republic	CZE
Denmark	DNK
Finland	FIN
Germany	GER
Hungary	HUN
Italy	ITA
Japan	JPN
Netherlands	NLD
Poland	POL
Slovak Republic	SVK
Slovenia	SVN
South Korea	KOR
Spain	ESP
United Kingdom	GBR
United States	USA

Table 2: Sector description

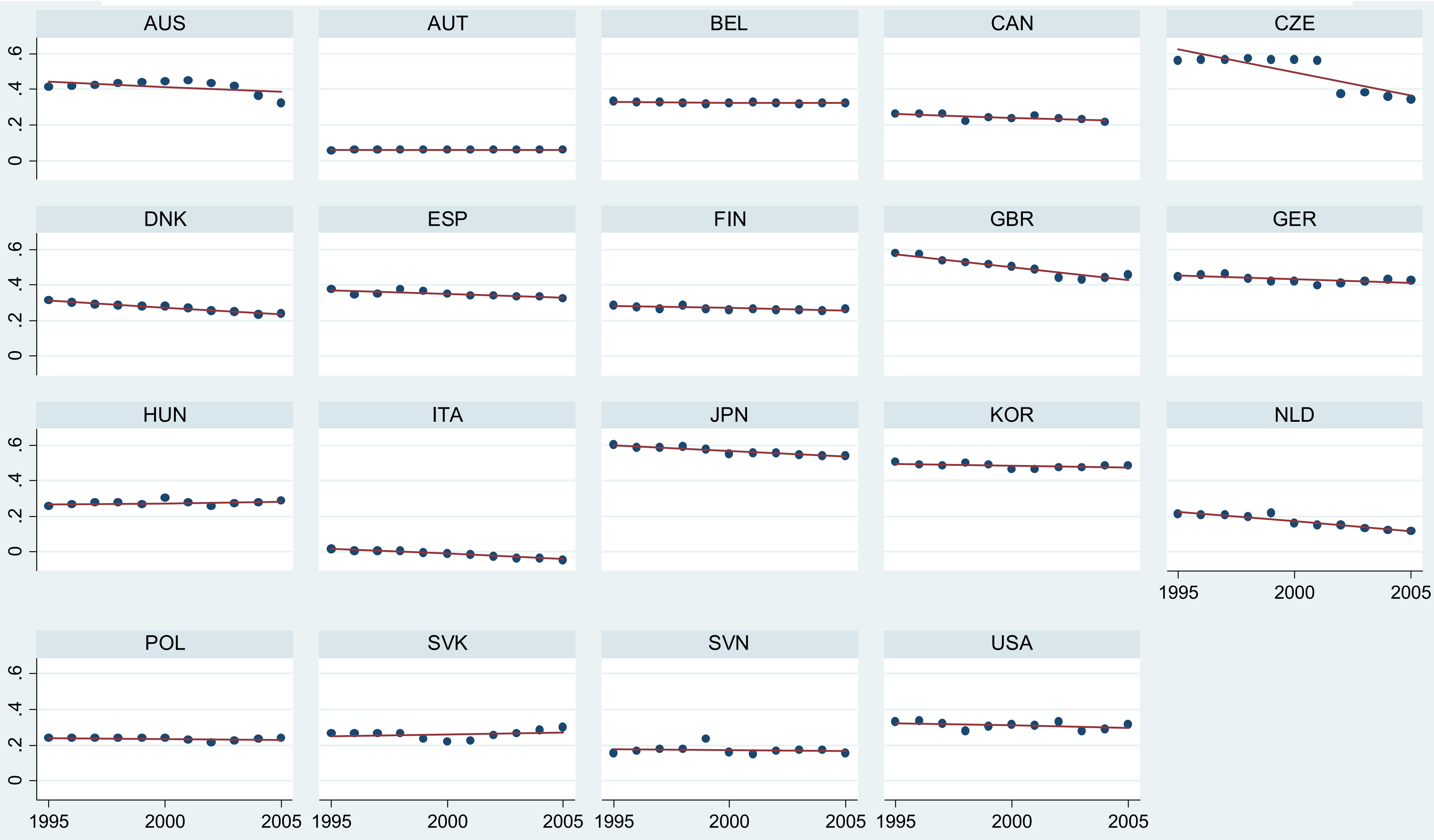
code	Description of Sectors
AtB	C01-C05: Agriculture, Hunting, Forestry and Fishing
C	C10-14: Mining and Quarrying
D	C15-37: Manufacturing
E	C40-41: Electricity gas and water supply
K	C70-74: Real estate, renting and business activities
O	C90-93: Other community, social and personal service activities

Figure 5: Gender wage gap between male and female in the high-skill level in the manufacturing sector from 1995 to 2005



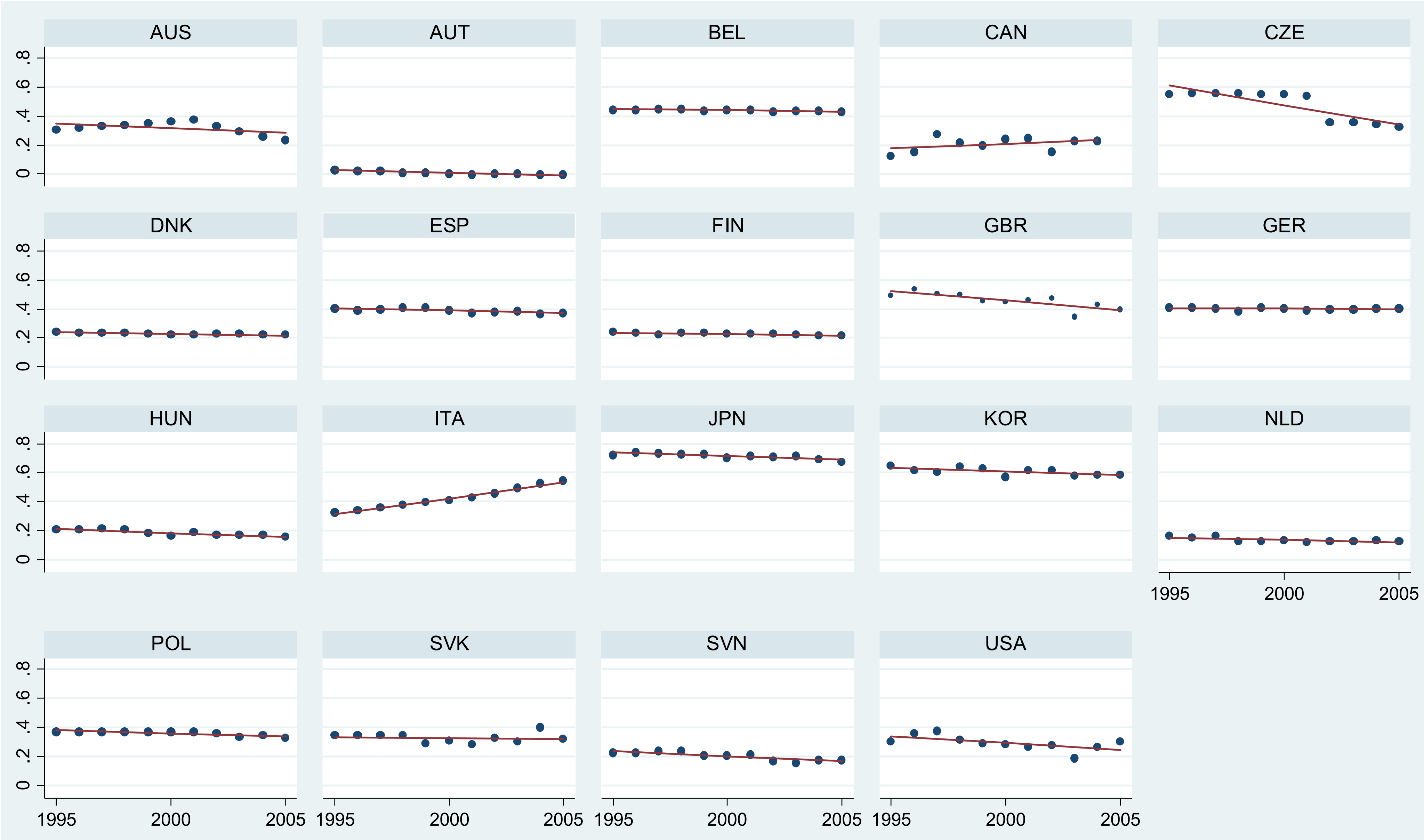
Source: Author's calculation based on data from the EU KLEMS (2008).

Figure 6: Gender wage gap between male and female in the medium-skill level in the manufacturing sector from 1995 to 2005



Source: Author's calculation based on data from the EU KLEMS (2008).

Figure 7: Gender wage gap between male and female in the low-skill level in the manufacturing sector from 1995 to 2005



Source: Author’s calculation based on data from the EU KLEMS (2008).

Table 3: Trade openness (%)

	Agriculture		Mining		Manufacturing		Public utilities		Business activities		Other services	
	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005
AUS	19.4	19.2	33.5	40.8	41.4	48.5	0.0	0.0	0.0	0.0	0.4	0.4
AUT	27.5	30.2	89.0	95.6	83.5	79.5	5.4	30.8	0.1	0.0	1.9	1.0
BEL	94.4	92.8	186.2	193.0	104.9	104.2	0.2	9.9	1.1	0.0	0.6	1.2
CAN	29.1	27.5	47.3	47.5	66.2	65.2	4.0	7.4	0.0	0.0	0.6	0.5
CZE	23.8	28.6	66.5	72.5	61.3	72.1	1.6	5.8	0.1	0.0	4.8	0.2
DNK	28.7	41.5	57.6	50.8	66.4	83.5	3.0	10.7	0.0	0.0	0.6	0.6
ESP	34.9	34.3	81.4	96.1	50.8	51.4	1.0	2.0	0.0	0.0	0.5	0.6
FIN	24.3	21.4	94.2	93.7	66.2	59.0	4.9	8.0	0.0	0.0	0.2	0.1
GBR	23.7	31.0	49.0	66.9	53.6	66.6	1.0	0.9	0.0	0.0	4.7	4.5
GER	43.8	41.8	61.2	94.6	60.9	60.8	2.1	2.2	0.0	0.0	0.8	0.5
HUN	17.2	19.9	80.4	113.0	56.1	79.0	1.8	6.9	0.1	0.0	0.2	0.1
ITA	28.9	25.1	73.3	87.9	48.9	46.6	0.0	3.1	0.0	0.0	0.2	0.5
JPN	12.3	12.4	75.9	92.7	18.5	24.5	0.0	0.0	0.0	0.0	0.2	0.1
KOR	14.0	14.1	82.3	96.1	37.9	41.7	0.0	0.0	0.1	0.2	1.2	0.8
NLD	71.9	64.5	86.8	68.8	95.1	92.9	1.6	3.3	0.0	0.0	0.6	0.6
POL	8.9	14.4	39.4	59.7	41.6	61.1	1.1	2.5	0.1	0.0	0.1	0.1
SVK	19.0	25.0	88.4	112.4	60.1	83.8	1.0	0.0	0.2	0.0	1.8	0.0
SVN	39.0	27.8	70.3	73.3	106.8	82.3	16.3	28.2	0.1	0.0	0.2	0.1
USA	15.4	12.2	27.8	44.1	27.4	35.2	0.3	0.9	0.0	0.0	0.9	1.0

Source: Author's calculation based on data from WITS and EU KLEMS.

*Canada's 2005 data is 2004 one since the EU KLEMS does not report Canada's 2005 data.

Table 4: Summary statistics of main variables

Variable	Observations	Mean	Std. Dev.	Min	Max
cou_code	1248	57.673	32.905	1	114
Wage gap (High skill)	1248	0.323	0.254	-0.598	4.061
Wage gap (Medium skill)	1248	0.266	0.190	-0.589	0.752
Wage gap (Low skill)	1248	0.346	0.312	-0.325	3.483
Sector concentration	1248	0.210	0.236	-1.686	0.856
Trade openness	1248	0.286	0.355	0	1.930

Table 5: Summary statistic of subsidiary variables

Variable	Observations	Mean	Std. Dev.	Min	Max
Log(High-skill male wage)	1248	4.531	1.866	2.115	10.123
Log(High-skill female wage)	1248	4.208	1.837	-0.029	9.611
Log(Medium-male wage)	1248	4.031	1.881	1.311	9.969
Log(Medium-female)	1248	3.766	1.847	1.196	9.588
Log(Low-male wage)	1248	3.753	1.951	0.558	9.882
Log(Low-female wage)	1248	3.407	1.956	-0.029	9.508
Imports	1248	33684.44	113632.4	0	1409146
Exports	1248	30508.36	98885.18	0	921389
Gross output	1248	200603.7	581153.4	137.379	4867028

*The units of Imports, Exports and Gross output are millions of US dollars.

Table 6: Estimation results (Dependent variable: Gender wage gap in a given skill level)

	Fixed effects model			Random effects model		
VARIABLES	High	Medium	Low	High	Medium	Low
Trade openness	0.123	-0.161***	-0.791***	0.0715*	-0.111***	-0.152***
	(0.129)	(0.0320)	(0.140)	(0.0419)	(0.0270)	(0.0568)
Concentration	0.0368	-0.0325	0.114	0.0361	-0.0271	0.110
	(0.123)	(0.0305)	(0.133)	(0.0589)	(0.0283)	(0.0771)
Constant	0.280***	0.319***	0.549***	0.295***	0.303***	0.366***
	(0.0457)	(0.0113)	(0.0494)	(0.0237)	(0.0201)	(0.0323)
Observations	1,248	1,248	1,248	1,248	1,248	1,248
R-squared	0.001	0.023	0.028			
Number of country-code	114	114	114	114	114	114

(Standard errors in parentheses: ***: p<0.01, **: p<0.05, *: p<0.1)

Table 7: Robustness check (Dependent variable: ΔGender wage gap)

	(1)	(2)	(3)
VARIABLES	High-skill	Medium-skill	Low-skill
Trade openness	0.722	-0.287*	-0.206
	(0.666)	(0.169)	(0.238)
Concentration	-0.315	0.129	0.524
	(2.172)	(0.129)	(0.512)
$w^{S}_{ij,t-1}$	0.288***	0.759***	0.590***
	(0.0406)	(0.0973)	(0.0413)
Observations	1,020	1,020	1,020
Number of country-code	114	114	114
Sargan test for overid	0.000	0.002	0.002
Hansen test for overid	0.761	0.366	0.101
Arellano-Bond test for AR(1)	0.114	0.000	0.095
Arellano-Bond test for AR(2)	0.159	0.487	0.505

(Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1)

* Using two-step difference GMM by taking the second lags and introducing wage differential and concentration as exogenous variables.