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Please cite this paper as:

Stone, S., R. Cavazos Cepeda and A. Jankowska (2011-04-01), “The Role of Factor Content in Trade: Have Changes in Factor Endowments Been Reflected in Trade Patterns and on Relative Wages?”, *OECD Trade Policy Papers*, No. 109, OECD Publishing, Paris.
http://dx.doi.org/10.1787/5kgdnq52qxzw-en

OECD Trade Policy Papers No. 109

The Role of Factor Content in Trade

HAVE CHANGES IN FACTOR ENDOWMENTS BEEN REFLECTED IN TRADE PATTERNS AND ON RELATIVE WAGES?

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ABSTRACT

THE ROLE OF FACTOR CONTENT IN TRADE: HAVE CHANGES IN FACTOR ENDOWMENTS BEEN REFLECTED IN TRADE PATTERNS AND ON RELATIVE WAGES?

by
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The pattern of trade analysed from a factor content perspective reflects the relative factor endowments of the countries examined. Although some large economies, such as the United States, seem to exhibit counter-intuitive behaviour, this is reversed when intermediate trade is taken into account. We argue this is a reflection of the changing nature of production processes and trade. The evidence presented here implies factor endowments are undergoing changes that call for careful analysis of the measures commonly used in trade. Acknowledging the role of intermediate goods to understand a country's factor content trade position is one step. Additionally, one must account for the interaction between the domestic determination of employment and wages with international movement of goods and services, and location of tasks.

Key words: Factor content, comparative advantage, intermediate inputs, wages.

JEL Classification: F0, F14, F20

Acknowledgements

This study was prepared by Susan Stone, Ricardo Cavazos and Anna Jankowska under the supervision of Michael Plummer. Clarisse Legendre and Jacqueline Maher provided excellent statistical and administrative support, respectively. The report benefited from discussions with OECD colleagues in the Trade and Agriculture Directorate and the Employment, Labour and Social Affairs Directorate as well as the OECD Working Party of the Trade Committee which has agreed to make the study more widely available through declassification on its responsibility.

Table of contents

Executive Summary 4

I. Introduction 5

II. The Heckscher-Ohlin theory of international trade 6

III. Trends in factor endowments 8
- Relative factor endowments 8
- Trends in factor utilisation in OECD Countries 11
- Capital and labour utilisation in selected emerging markets 12
- Productivity 13

IV. Measuring factor content 13
- Data 14
- How has factor usage within a country changed over time? 15
- How has factor content of trade changed over time? 17
- What role has intermediate inputs played in measuring factor content of trade? 19
- China 20
- United States 21

V. Relationship between trade and relative wages 23

VI. Conclusions and areas of policy consideration 28

References 30

Data Annex 33

Technical Annex 43

Executive Summary

The results of this study show that overall trade patterns reflect the relative factor endowments of the countries under investigation. That is, OECD countries have larger stocks of capital and skilled labour and show relatively intensive use of these factors in their traded goods and services. Selected Emerging Markets (SEMs) have large stocks of unskilled labour and show strong trade surpluses in goods and services using this resource intensively. In this sense, we show that factor content of trade, as measured via factor services, provides useful insights into trade patterns, as predicted by neoclassical trade theory.

However, some large economies, such as the United States and Japan, exhibit counter-intuitive results as illustrated by large factor content of trade surpluses in unskilled labour for Japan and deficits in the capital-content of trade for the United States. Accounting for intermediate trade in our analysis reverses some of these seemingly counter-intuitive results, and in general has a large impact on measured factor content. We argue that this is a reflection of the changing nature of trade, driven by the forces of production fragmentation and offshoring. We contend that these trends reflect a shift away from thinking of trade in terms of domestically-based *factor* (i.e. labour or capital) content, to thinking of trade in terms of internationally mobile *tasks* required to produce output. The evidence presented here implies that factor content patterns are undergoing fundamental changes calling for more careful analysis of the broad measures used in trade. Trade patterns are now just as reliant on the cost of moving goods and tasks, as they are on the particular endowment structure of an economy.

Finally we find little evidence that the changes in trade patterns have had a significant impact on relative wages, or wage inequality, in the time period examined. We speculate that domestic considerations, and the growing influence of tasks as opposed to endowments, play a larger role in determining these outcomes. This is an important finding that argues against the imposition of trade barriers in an attempt to influence either wages or levels of employment, and in favour of pursuing targeted labour market policies that would accommodate, rather than hinder, the process of adjustments, including in the aftermath of trade reforms.

Another implication of this work for policy makers is the need to be aware that the methods used to derive the value for trade balances matter. Those values based on traditional approaches are more of a reflection of historical investments and could lead to ‘lagging’ policy advice, based on past behaviour, rather than the forward looking advice needed to steer an economy into the future.

Acknowledging the role of intermediate goods in understanding a country’s trade position is only the first step. What remains a challenge for policy makers is the need to reconcile the seemingly opposing trends of the domestic (i.e. geographic specific) determination of employment and wages with the international (i.e. non-geographic specific) determination of the movement of goods and services and location of tasks. Thus policy makers should appreciate the limits of using trade policy to influence

domestic issues. Rather they should implement proactive measures– such as greater investment in resource markets through training and education and ensuring well functioning capital markets – that create an environment conducive to taking full advantage of these trends.

I. Introduction

The global economy is entering a new era characterised by a rise in new trade power-houses (such as China) and intensifying competition for new consumer and product markets (such as Asia and renewable energy, respectively). Indeed, there are a growing number of economists who argue that the nature of international trade is changing in fundamental ways (Baldwin and Robert-Nicoud 2010). Thus, it is argued that in an integrated global market, trade is increasingly about intermediates goods and services. Simultaneously, concern remains over the impacts of globalisation including excessive market volatility, increased vulnerability to crises, and the perceived ability of low-wage producers to disrupt domestic labour markets. Calls to "manage" globalisation remain and are unlikely to subside in the context of the current economic uncertainty and stalled DDA talks.

Understanding the fundamental forces behind observed trading patterns has generally been undertaken through what international economic theory would describe as a realisation of comparative advantage; a country exports those goods in which it has a relative cost advantage *vis a vis* its trading partners. This concept has powerful policy implications in that from it stems the basic reasoning that free trade policies are superior to interventionist trade practices.[1] However, comparative advantage evolves for a host of reasons, including endowment structure, technology and the institutional landscape of both domestic and international commerce. That is, comparative advantage can be influenced by domestic policies in the trading countries themselves as well as those in their trading partners. It is not a static concept; it influences, and is influenced by, policy as well as stages of economic development and evolution (Balassa 1979). This interaction provides an interesting and complex context for an empirical study on patterns of specialisation and comparative advantage and underlying policy implications for OECD and non-OECD countries alike.

As per the original scoping paper, *The Effects of Globalisation: Openness and Changing Patterns of Comparative Advantage* (OECD internal document), the project is structured to deliver four consecutive reports, which will constitute its principal direct outputs:

- Production, Consumption and Trade Developments.
- Comparative Advantage and Export Specialisation Mobility in OECD and Selected Emerging Market Economies.
- Have Changes in Factor Endowments been reflected in Trade Patterns and What Effect has this had on Relative Wages?
- Comparative Advantage and Trade Performance: Policy Implications.

1. The gains from an open trading regime have been well documented in the literature. Trade liberalisation and productivity links have been confirmed in a wide range of empirical studies and reviews include Bernard *et al.* (2007) and Nordas *et al.* (2006).

This paper presents the analysis completed under the third instalment of the project examining comparative advantage from the perspective of factor services embodied in traded outputs. It takes a closer look at the underlying forces in factor markets and how they potentially drive Comparative Advantage.

The paper begins with a discussion of the factor content theory of comparative advantage and briefly reviews the empirical literature examining factor content of trade within this framework. It then moves to a review of the trends in resource accumulation and utilisation among OECD and selected non–OECD economies, focusing on capital and labour. The fourth section examines relative resource use and, relationship to endowments and trade. We then apply these insights to the matter of relative wages with an analysis of how the identified trends in productivity, resource endowments and trade have played a role in changes in relative wages. The final section offers some conclusions and areas of policy relevance.

II. The Heckscher-Ohlin theory of international trade

The Heckscher-Ohlin theory of international trade states that comparative advantage is derived from differences in relative factor endowments across countries and relative intensities with which factors are used across sectors.[2] A country will have an advantage, *vis a vis* other countries, in producing goods in those sectors which use factors it holds in relative abundance. Vanek (1968) formalised the link between factors used in the production of a country's goods and services and its trade by comparing the relationship between those factors embodied in a country's production versus those embodied in its consumption. This has become known as Heckscher-Ohlin-Vanek (HOV) model of international trade.

The HOV model has been subject to extensive empirical scrutiny with an uneven record of success. The problem is that the lack of a clearly differentiated framework relating endowments and trade makes it impossible to test HOV against a well-specified alternative. Thus, researchers have been focusing on what version of a constantly evolving HOV model best fits the data. Starting with Leontief (1953) through Trefler (1995), HOV failed most major empirical challenges.[3] Trefler (1995) found that the measured net factor content of trade using a HOV framework is essentially zero, calling this the "case of the missing trade". He then develops a specification that allows for home bias in consumption and international technology differences and the model successfully fits the data. However Gabaix (1997) showed that this improved model is based on a set of carefully chosen specifications and when the estimated parameters are tested to see if they successfully reconcile the predicted with the measured factor content of trade, no real improvement is observed.

Work following Trefler began to focus on why HOV models performed so badly. Measurement error tended to be the most common explanation – factors are not well defined or are not captured well enough in the value of trade (Fisher and Marshall 2008); significant aggregation bias existed in measures of trade used (Feenstra and Hanson 2000); incorrect assumptions were being made regarding returns to scale (Antweiler and

2. The model was originally formulated by Heckscher (1919) and further developed by Ohlin (1933) and formalised by Samuelson through a series of papers between 1948 and 1953. The model is often also referred to as the Heckscher-Ohlin-Samuelson model.

3. For an extensive review of empirical studies during this period see Leamer and Levinsohn (1995).

Trefler 2002) and difference in technology (early examples include Trefler and Zhu 2000, Hakura 2001 and Davis and Weinstein 2001). Romalis (2004) showed that transport costs and monopolistic competition are important determinants of the structure of trade and need to be incorporated into the HOV framework. In the end, what this body of work showed was that by improving specifications and including more realistic elements of trade, the HOV framework performs well.

One of the most active areas of investigation has been testing the HOV assumptions regarding technology. A country's technology matrix is a measure of the units of inputs – both primary inputs such as labour and capital and intermediate inputs that are produced outputs of an industry – that are required to produce each unit of output, thus is an indication of the technology, or production method, used within each sector in an economy. Many early empirical studies had relied on one technology matrix (usually the United States) measuring primary inputs only. Later studies made adjustments for potential differences in the United States and "other" potential technology matrices but these were based on estimated deviations from a US base. A study by Hakura (2001) is an example of an early attempt to use directly observed technology matrices. By utilising four OECD country matrices, this paper found significant improvement in the model's performance. However, this does not provide a "test" of any hypothesis of underlying production (matrices fit the model as a matter of construction), and raised the question as to how differences in these technology matrices occurred and if they systematically related to fundamental characteristics (i.e. endowment structures) of countries in the trading system (Davis and Weinstein 2001).

With the publication of the OECD's Input-Output tables, the academic community "… dramatically improved our ability to test trade theory" (Davis and Weinstein 2001). Using these tables Davis and Weinstein found that allowing for Hicks-neutral productivity differences, industry input usage strongly correlated with country factor abundance, which had not held in conventional HOV model tests to date.[4] However, once again, this modification was relative to a base technology matrix.

Davis and Weinstein (2003) observe that the study of factor content has "become a laboratory to test" ideas about how the elements of endowments, production, consumption and trade fit together in a general equilibrium framework. They suggest that while great progress has been made, a deeper consideration of intermediates inputs, demand side issues (i.e. the differences in patterns of total domestic consumption of final goods and services by a country, otherwise known as "absorption"), and the role of aggregation biases is needed. This last point is echoed in Feenstra and Hanson (2000) who found significant evidence that the factor content of exports differs systemically from domestic production and that as disaggregation increases, the factor content of skill intensity in US trade rises. Reimer (2006) and Trefler and Zhu (2010) are two attempts to directly include traded intermediate inputs into the picture.

In the end, the HOV framework properly measured, has been shown to successfully explain trade patterns through differences in factor scarcities, or on the flip side, factor abundance, between economies. Thus, for our purposes, it remains a useful framework for measurement and analysis. It is not the goal of this paper to reconcile theoretical predictions from the model – there exists a wide body of literature having already done this. Rather, we use this framework to examine measures of factor content across a

4 A Hicks neutral technology change refers to a change that affects both capital and labour in the same way.

variety of OECD and non-OECD economies, carefully incorporating improvements in the specifications of the model identified in the literature.

Before we undertake an analysis of factor content of trade, however, we review the trends in country's underlying endowment structure.

III. Trends in factor endowments

This section examines trends in accumulation of capital and labour and compares changes in stocks with changes in the utilisation of these factors in goods and services over time across OECD and Accession countries[5] (here after referred to as OECD), as well as several Selected Emerging Markets (SEMs).[6]

Relative factor endowments

There is wide variation both within and between the OECD and SEM groupings in their relative endowments of capital and labour, as can be seen through measures of variation. For OECD countries, the coefficient of variation for capital is 25.5% while it is only 4.5% for labour, indicating a great disparity in capital stocks than labour stocks in the region. SEMs show greater dissimilarity for both measures – 43.1% for capital and 15.5% for labour – but the same higher values for capital than labour.

The OECD area is capital abundant, accounting for 80% of the capital available among these countries in 2005.[7] The largest capital stocks are found in the United States and Japan, followed by Germany, France, the United Kingdom, Korea and Italy (Figure A1). Capital stocks grew at an average *per annum* rate of 4.5% in the OECD as a whole during the 1990-2005 period (Table A1), with the highest *per annum* growth rates in Chile (10.4%) and Korea (7.7%). By comparison, in the SEM area capital is relatively scarce. These countries held roughly 20% of total capital measured in 2005 with the largest capital stocks held by China, India, and Brazil (Figure A1). China shows an especially rapid accumulation in capital stocks in the period 1995-2005 with a *per annum* rate of 11.5%, followed by India with a rate of 9.2%. Stocks of capital in the SEM area overall grew at a rate of 8.3% *per annum*, outpacing growth in the OECD.

Conversely, labour is relatively abundant in the SEM area, which accounts for roughly 70% of labour in the total sample. Within the OECD area, the largest stocks of labour are found in the United States and Japan (Figure A2). The largest stocks in the SEMs are in China, India and Indonesia (Figure A2). As with capital, labour stock grew at disparate rates across these two groupings during the 1990-2005 period. In the OECD

5. The Accession grouping originally pertained to Chile, Estonia, Israel, Russia and Slovenia. Chile formally became a member of the OECD on 7 May 2010 and Estonia, Israel and Slovenia were invited to join 10 May 2010.

6. SEMs include the five enhanced engagement economies (Brazil, China, India, Indonesia, and South Africa) as well as Argentina, Malaysia, Thailand, Bangladesh, Hong Kong, Singapore, and Egypt where data is available.

7 This is a share of the total capital stocks for the 38 countries for which data is available. Data was not available for Poland, Turkey, the Slovak Republic, and the Czech Republic. The net capital stocks are calculated from real GFCF series from the World Bank WDI. See data annex for calculation details.

area the labour pool grew at a rate of 0.60% *per annum* while the SEMs increased at the considerably faster annual rate of 2.1% (Table A1).

Decomposing by skill level reveals further differences in labour force characteristics between the OECD area and SEMs (Figures A 3 and 4).[8] Overall, the 2005 total labour force breaks down into a 10% share of skilled workers[9], and 90% share of unskilled workers. The OECD countries accounted for 56% of total skilled labour force, while the SEMs held the remaining 44%. Stocks of skilled labour increased in the OECD area at a *per annum* rate of 3.3% between 1990-2005; more slowly than the SEMS rate of 4.8% per year in the same period. India and China held the bulk of the skilled labour stocks among the SEMs.

The OECD's share of unskilled labour was 25%, while the SEMs accounted for the remaining 75%. Unskilled labour stocks grew at a rate of 0.53% *per annum* in the OECD area, only a third as fast as the rate of 1.7% *per annum* in SEMs during the 1990-2005 period. The US holds the largest stocks among the OECD countries while China and India dominate the SEMs (Figure A4). Thus while OECD countries continue to hold larger stocks of capital and skilled labour endowments, SEMs accumulation rates are much higher for both, indicating that relative abundance may be changing over time. This is especially true in capital and skilled labour and dominated by China and India.

As discussed in Section II, to understand how endowments play a role in a country's trade composition, it is important to understand the way these factors are used. Thus, we look at changes in the amount of capital per worker across these economies. The ratio of capital stock per worker (k/l) provides a direct comparison of factor abundance.[10] Figure A5 shows the k/l ratios for two selected groupings of OECD countries.[11] In line with observed changes in stocks of capital, k/l increased in all OECD countries, except Mexico between 1990 and 2005. The highest values of k/l ratios corresponded to the countries with the largest capital stocks; the United States and Japan (with Japan dominating) and the largest increases in the k/l ratio in occurred in Chile and Korea (Figure A5).

By comparison (Figure A5), the capital per worker ratios in SEMs are small, reflecting the smaller capital base relative to labour abundance in this grouping. Only Argentina and Malaysia fall within a k/l range comparable to some OECD countries. The k/l ratios in SEMs have remained relatively stable during the 1980-2005 period in China, Indonesia, and India, while decreasing over time in Brazil. The largest increases in value of k/l ratio occurred in Argentina, Malaysia and Thailand.

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8. The data for workforce by education level and gender comes from the IIASA and Vienna Institute for Demography data sets for 1970-1995 and 2000-2050, further details on about these datasets can be found in the data annex.

9. Skilled workers are those who have completed tertiary education.

10. Labour ratios are taken from the same source as labour stocks reported above. That is, the working age population (15+) from the IIASA/VID Human Capital and Economic Growth Program. This measure includes all available human capital, and does not distinguish economically active population from those who do not participate. The same ratios were constructed using figures for economically active labour force from the World Bank World Development Indicators, and the resulting ratios demonstrated similar trends.

11. For ease of discussion, we show only selected OECD countries. For a complete table of ratios can be found in the data annex.

According to the HOV framework, these relative endowments are a major determinant of economic activity in which countries will have a comparative advantage. While the above analysis provides an indication of stocks of endowments available within a country, it does not tell us how, or how much, of these stocks are actually utilised in production. While standard HOV assumes full employment, (i.e. all stocks are fully employed), we know this does not hold true, especially in specific periods of time. Thus, to get an idea of how much capital and labour are used in the production process, we examine their share in value added. To focus on the amount of capital being put in place, we look at investment in gross fixed capital formation (GFCF) as a share of value added and examine the role of labour in production by looking at the ratio of total wage bill to value added.[12] [13]

The GFCF and total wage bill to value added ratios for all OECD countries and SEMs[14] are shown in Figures A A6 and A7, respectively. These figures present the average and standard deviation of the two measures for all countries for the 1988-2005 period as well as several sub-periods.[15] The figures depict opposing trends in the shares of capital and labour to value added in total manufacturing with the mean share of capital to value added increasing while the labour share declines slightly across periods. This outcome implies that the capital intensity of manufacturing production increased across the dataset. The overall increase in the divergence of the GFCF to value added ratio, as measured by its standard deviation, comes mainly from the large increase in the post-1997 time period. Prior to that, the deviations among countries appear to have been declining. While a part of this finding can be attributed to an increase in country coverage in the later period, the basic observation of an increase in the divergence of capital utilisation across the economies examined holds. The increasing mean of capital as a share of value added is in line with the growth of capital stocks observed across both regions during this period.

Conversely, the mean wage bill to value added ratio decreased over the period. This result is partially explained by the larger growth in value added in manufacturing relative to the total wage bill but also is in line with trends in production fragmentation utilizing an increasingly diverse pool of cheaper labour in Eastern European OECD and Emerging Markets, as well as the decline in manufacturing employment overall in OECD area (Pilat *et. al*, 2006). The next section examines factor intensity of utilisation in manufacturing across the two country groupings.

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12. An alternative measure of capital used in the production process is to take the residual of the wage bill/value added ratio, or 1-(wage bill/VA). However, as the mirror reflection of the wage bill share, it provides little additional information about changing investment in fixed capital. Thus GFCF was chosen as a better available capital proxy in measuring the factor's intensity in production. However, we use GFCF/VA as a broad indication of the capital usage across all manufacturing activity within an economy and thus it will not capture the expansion or contraction of capital in any particular industry.

13. We also calculated these ratios using units instead of values, applying price indices for capital, labour and output. This yielded no qualitative difference in the results.

14. The countries in this grouping include Argentina, Bangladesh, Brazil, China, Egypt, India, Indonesia, Singapore, South Africa, Thailand and Vietnam.

15. Periods were chosen to reflect economic breaks, i.e. the recession in 1991and the Asian Financial Crisis in 1997.

Trends in factor utilisation in OECD countries

Within the OECD grouping, the average share of capital in value-added (VA) during the 1988-2005 period was 14.5%, and on average has been declining at an annual rate of -0.97% (Figure A6).[16] Driving this average decline is the fact that growth in GFCF is outpacing value added growth in several OECD countries, for example in Mexico, Iceland, Australia, Poland, New Zealand, the Slovak Republic and Hungary. The largest decreases in the overall ratio are observed in Korea and Finland, but decreases were also evident in other member countries including the Netherlands, France, Austria, Belgium, Sweden, Canada, and Ireland. The faster growth in GFCF is not surprising given the changes in economic structure that occurred in Eastern Europe during this period (i.e. the transition to a market based economy in Poland), and the large investment program that occurred in Iceland.[17]

Several trends explain the extent to which the overall decrease in capital intensity in manufacturing in OECD countries appears to be inconsistent with the observed increases in capital stocks per worker in these countries. First, the capital intensity numbers apply only to the manufacturing sector, where the k/l ratios are reported across all economic activity. We know that services are an increasingly important part of overall economic activity, including trade, in many OECD economies.[18] To the extent that this sector has an increasing k/l ratio, one would expect this to influence the overall k/l ratios reported for these economies. Second, to the extent economies with large k/l ratios dominate reported value added totals in the OECD groupings, they will again, unduly influence observed outcomes (e.g. the contribution of the United States versus that of Hungary). Finally, the deviation in the trends of stock accumulation and utilisation may be due to the relative maturity of, and decreasing investment in, certain segments of manufacturing as identified in Interim Report 1.[19]

Figure A7 shows the trends in total wage bill in manufacturing as a share of value added across the economies under examination during this period. The average of the wage bill to value added ratio was 43%, although values for OECD countries in 2005 ranged from a low of 12% in Chile to a high of 65% in Denmark. Growth rate calculations show a decline in the ratio at an average annual rate of -0.34%, with the largest decreases in Japan, Korea, and Canada. This is primarily a reflection of the faster growth rates in value added compared with wages across most OECD economies (with the notable exception of Poland). The relatively small share of wage bill to value added in Japan may be a reflection of its relatively (as shown above) high share of unskilled workers (Figure A4).[20] The decrease in the wage bill to value added is consistent with employment decreases in this sector as labour moved away from manufacturing toward services and other sectors in the economy (Pilat *et al.* 2006). The exceptions to this trend are Luxembourg, New Zealand, Portugal, Sweden, France, Spain and the Russian Federation.

16. Countries are ranked by 2005 capital to value added ratio. Data are missing for Switzerland and Slovenia.

17. For further details regarding investment activity in Iceland, see the OECD (2009) *Iceland Country Study*.

18. Interim Report on Production, Consumption, and Trade Developments (OECD internal document).

19. Interim Report on Production, Consumption, and Trade Developments (OECD internal document).

20. The role of unskilled workers in Japan is discussed in more detail in the next section.

Capital and labour utilisation in selected emerging markets

GFCF to value added ratios for total manufacturing in SEMs are presented in Figure A6. Increased investment activity and expansion of the manufacturing sector in many of these countries is demonstrated by the three times larger average share of GFCF to value added relative to the OECD country grouping. The average ratio is 49.3% with an annual growth rate across these economies in excess of 11%. This growth trend however, was not consistent throughout the SEMs. There appears to be a decline during this period in India, Malaysia and Thailand. At the other extreme, China, Indonesia, and Egypt experienced rapid growth in investment activity leading to GFCF to VA ratios over 100%.

Wage bill to value added ratios (Figure A7) varied considerably across the SEM grouping with Bangladesh and South Africa at the high end of the spectrum and China at the low end. The larger ratios in the case of Bangladesh and South Africa were primarily due to lower value added figures for manufacturing rather than to particularly high wage bills. Wages to value added over the 1990-2005 time period averaged 24% and decreased on average at a rate of -1.5% *per annum*. Significant differences are observed across countries with decreases in India, South Africa, Egypt, and Singapore while Argentina, Thailand, Malaysia and Bangladesh experienced an increase. The relative volatility of values in this area indicates that changes in factor utilisations were occurring rapidly. The decreasing share of Wage Bill in value added is, in part, a reflection of the increasing capital intensity of manufacturing production in SEMs during this period. This is despite the large increase in the stock of labour in the region. As value added increases across most of these country’s manufacturing sector and increasing labour stocks put downward pressure on wages, we would expect to see a further decline in the overall ratio.

This section has shown that while the OECD countries have larger stocks of capital and skilled labour, SEMs are accumulating these factors at a faster rate. We also see that as a whole, capital per worker is increasing in the OECD while it remains flat across many SEMs. This apparently inconsistent outcome could be due to the changing nature of the output in the two regional groupings and the rapid accumulation of both resources in the SEMs. As many OECD economies increase their output in services, they are adding increasing amounts of investment to this sector thus influencing the overall capital to labour ratios reported and potentially offsetting declining shares of capital formation in value added in manufacturing. Also potentially influencing these results is the relative change in demand for labour. For instance, in the OECD context, sectors that employ (unskilled) workers and are capital-intensive (such as construction and light manufacturing) are growing more slowly – or even contracting – shedding labour at a faster rate than capital, thus raising the k/l ratio. Other sectors, such as services, which are increasing their demand for (skilled) labour, are also adding invested capital, thus influencing the overall increase in capital intensity observed here. We do observe, however, that these patterns are not uniform across all OECD economies with more newly industrialised members (such as Poland and Hungary) showing increasing shares of capital in manufacturing value added.

Across the SEMs we observe increasing stocks of both capital and labour and this is reflected in the relatively flat k/l ratios over the period. The shares of capital and labour in value added varies across country and time, reflecting the relative changes in value added, wages and returns to capital, thus complicating any straightforward conclusions to be drawn from the underlying changes observed in capital and labour stocks. Next we explore relative productivity of labour in order gain further insights into what these changes in factor availability and utilisation imply for economic performance.

Productivity

In order to provide a broad consistent measure of labour productivity across the economy as a whole, we look at output per worker, (using GDP as a proxy for output).[21] Productivity within and between the OECD and SEM country groupings vary widely (see Figure A8). Among OECD countries, the highest ratios of output per worker are found in Luxembourg, Norway, Japan and the United States. At the lower end of the spectrum, we find newer Eastern European member states, Turkey and Chile. During the 1990-2005 period, output per worker across the OECD increased at an average *per annum* rate of 1.5% (Figure A8).

In SEMs, labour productivity remains significantly lower on average, with the exceptions of Hong Kong and Singapore (Figure A8). Despite this considerably lower base, productivity growth rates indicate that this is changing rapidly, at an average *per annum* rate of 4.2%, nearly three times faster than the OECD area. The growth was not, however, consistent throughout the grouping. Output per worker declined in Brazil and South Africa during this period.

This comparison underscores the importance of taking into account how factors are utilized and differences in technology of production in order to better understand how factor abundance influences a country's comparative advantage. For example, it has been shown that labour productivity increases with capital investment.[22] Thus, the fast growth rates of labour productivity in SEMs may be a product of the rapid increase in capital formation in these economies observed here. To see how these various, often competing forces, have played out in trade patterns, we now turn to examining the measured factor content of trade.

IV. Measuring factor content

Total endowment stocks have been growing across both OECD and SEMs, with SEMs experiencing faster growth across the board. Within the OECD, skilled labour stocks grew 6.5 times faster than unskilled while the SEMs skilled labour growth rate exceeded its unskilled rate at a slower rate (2.7 times). We also observe diminishing wage bill to value added ratio, on average, across the OECD in manufacturing and a rise in SEMs. However, as stated, this trend more likely reflects a decline in the value added in manufacturing among OECD countries as a whole rather than an absolute decline in labour usage. Indeed, labour productivity continues to grow at a robust rate among OECD countries, especially in Korea, Estonia and Poland. There was also strong productivity growth in China and Vietnam among the SEMs. We now look to see how these trends are reflected in trade patterns.

21. Real GDP measures and total labour force were taken from the World Bank World Development Indicators (2010).

22. There is a vast literature on the relationship between capital and labour productivity. See, for instance, Romer (1990).

We begin our construction of the factor content of trade with the simple HOV model:

$$F^i \equiv AT^i = V^i - s^i V^w \quad (1)$$

The first expression on the right hand side represents the standard HO specification: the factor content of *i*'s trade (F^i) is a function of the inputs used (*A*) times the country's net exports T^i. The final expression comes from Vanek (1968), who showed that the measure of factor content should equal an economy's measure of factor abundance. In this expression, V^i is a measure of factor endowments in country *i*, V^w is the measure of world endowments and s^i is the share of country *i* in world consumption. So, for example, if a country is relatively abundant in labour, the factor content of trade would be positive as the excess of what is produced with the country's labour supply, over what is consumed of labour-intensive goods, is exported. Conversely, if a country is relatively scarce in labour, the value would be negative, as it consumes a greater share of the world's labour endowment.

As pointed out in Trefler and Zhu (2010), the past decade has witnessed an "explosion" of research into the impact of international technology differences on measuring the factor content of trade. However, they argue that this literature has failed to properly account for differences in international technology and address the pivotal issue of traded intermediate inputs. They put forth a theoretical model which does both, providing a complete characterisation of the class of models that are implied by the Vanek prediction of factor content of trade. This section relies upon this model to construct a measure of factor content that is theoretically consistent and accounts for both technological differences across country's production processes while explicitly including trade in intermediate goods.

The work presented here makes two major advancements over these existing measures of factor content. First, as in Trefler and Zhu (2010), we rely on individual countries' technology matrices rather than the existing approach of using a single matrix adjusted for production technology differentials. We then apply a definition of factor content that measures the amount of factors used *worldwide* to produce a country's trade flows, and we apply this across a set of five factors of production, including a breakout of skilled and unskilled labour. Thus we construct a more complete factor requirements matrix for a country's trade by allowing for differentiated production processes including those inputs used in producing intermediate inputs overseas (Deardorff, 1982). Finally, we apply this approach to different time periods to observe how the factor content of trade has changed. By comparing the equations derived without directly accounting for intermediate inputs with those that do, we can analyse the role of intermediate inputs in trade and the determination of a country's comparative advantage.[23]

Data

To implement this approach, it is important we have access to input-output data for as complete and consistent a set of countries as possible. While the OECD input-output tables are a consistent and up-to-date set of information, they cover only a few countries outside the OECD and are limited in their factor input coverage. The GTAP database also provides a consistent measure of trade flows and input data but covers a larger number of

23. See the Technical Appendix for a more detailed explanation of our approach to measuring factor content.

countries globally, as well as a breakdown of skilled and unskilled labour.[24] We use three versions of the database, namely GTAP versions 5, 6 and 7 which correspond to base years of 1997, 2001 and 2004, respectively. The input-output tables contain five primary factors of production: land, unskilled labour, skilled labour, capital and natural resources. Land is defined in GTAP as an agriculture-specific resource and is used only in production in these sectors. Natural resources are associated with extraction industries and are a factor input for the sectors fishery, forestry, coal, oil, gas and other mining. Labour is divided into skilled and unskilled based on the International Labour Organisations (ILO) classification.[25]

How has factor usage within a country changed over time?

As discussed in Section III, capital utilisation has increased and overall labour productivity rates rose over the 1990 – 2005 time period, especially in the emerging OECD and SEM economies. In this section, we apply the factor content of trade definition to explore the relative uses of these factor endowments and how they have changed over time.

To examine a country's relative factor abundance, that is each endowment relative to other endowments within a country, at a point in time, we normalise each factor by its content in consumption and compare across the various factors (Muriel and Terra, 2009). For example, the content of skilled labour in net exports is higher (lower) than the factor content of capital if skilled labour is relatively more abundant (less abundant), when the factor contents are normalised by domestic consumption. We can also restate these values, measuring factor abundance by income rather than consumption, adjusting the value to take account of the trade balance as in Bowen and Sveikaukas (1992). Both measures provide a relative value for factor abundance with respect to other factors within a single country.[26]

We calculate these relative values for each country in the sample for the three time periods: namely 1997, 2001 and 2004 and rank the factors to determine the relative abundance as revealed by the country's trade position, and examine how this has changed over time. The relative factor abundance values and their rankings are presented for OECD and SEM countries in Tables A2 and A3, respectively.[27]

The two tables present three pieces of information: (1) the calculated factor abundance measure for each of the five resources, relative to the other resources within each country; (2) the rankings for each of these factors of production relative to the other factors for each of the three years; and (3) the standard deviation of the factor abundance measures for each year. As shown in the table, in all three years, the relative rankings for most OECD economies have remained consistent which means there have been no significant changes in relative factor endowments within each of these economies in the

24. For complete documentation of the GTAP database see website www.gtap.agecon.purdue.edu/databases/default.asp. Summary details of the data used in our analysis, including on individual input-output tables, can be found in the Data Annex.

25. Completed documentation of the methods used to split total labour payments into skilled and unskilled can be found in Liu, *et al*. (1998a, b).

26. See Technical Annex for details on calculating relative factor usage measures.

27. We report rankings using adjusted income shares. The rankings using consumption shares were qualitatively similar and are available upon request.

time period examined. Most OECD economies consistently rank skilled labour and capital at the top of their relative resource endowments as measured by the factor services employed. The rankings for Mexico, Chile, Hungary, Poland and Turkey show a greater reliance on land and natural resources. Australia also shows a high reliance on natural resources, but unlike the other countries listed, capital and skilled labour are also significant factors. Within their own resource structure, capital ranks first in Austria, France, Germany, Italy and New Zealand for each of the three years examined. Denmark, Sweden, Switzerland, the United Kingdom and the United States all consistently rank skilled labour as number one, relative to their other resource use. These countries show a high use of labour in general, with unskilled labour ranking second.

Despite the relative stability in rankings of endowments in OECD countries, there have been some noteworthy developments among member states. Into the 2000s, both skilled and unskilled labour moved up in ranking over capital for Australia. New Zealand experienced a small change in its endowment rankings with the role of natural resources declining and unskilled labour increasing. Korea shows an increase in the prominence of capital in place of unskilled labour while Japan’s unskilled labour and capital both increase their rank relative to the use of their other resources, namely skilled labour. The increasingly significant ranking of unskilled labour in Japan (as foreshadowed by their large stock of unskilled endowment) is reflected in employment growth patterns. Between 1990 and 2009, the only employment sectors which enjoyed consistent positive growth in Japan were labourers, service workers and professional and technical workers (Statistical Bureau Office of Japan 2010). The first two categories, which experienced the fastest growth, are dominated by unskilled workers. Spain, Poland and Hungary all saw their top ranked resource move from land in 1997 to capital by 2004.

Land and natural resources hold the dominant positions in the SEMs for each of the three time periods (Table A3). As with the OECD, the rankings show little movement over this time. Exceptions are Brazil and South Africa who both experienced a shift away from land and resource extraction to a greater reliance on capital and labour. In both these economies, capital was ranked the highest in 2004. All countries examined show relatively low rankings in the use of skilled labour.

A notable difference between the two country groupings is in the standard deviation of the abundance measure. This measure provides some insights in the changing endowment structure and the relative intensities with which resources are used within each economy examined. The more dominant one or two resources are in terms of their relative intensity, the greater the spread in values among the resources and the greater the standard deviation. Thus, it is interesting to see if these values have changed over the three time periods examined.

We see countries like France, the United Kingdom and Germany with small and fairly constant measures of standard deviation, implying the relative intensity of factor usage has changed little over the three time periods. Greece and Russia exhibit large standard deviations implying dominance in a specific resource – in Russia’s case natural resources. Greece’s standard deviation declined significantly in 2004 as capital and labour began to play a greater role in its economic activities diversifying away from natural resources. Interestingly enough, the United States shows a slightly increasing standard deviation among its factor measures while its actual rankings remain stable. This is due to an increasing use of labour relative to that of capital. Mexico and Chile, on the other hand, experienced a decline in their standard deviation. For Mexico, there was a relatively small change in the use of labour and capital across its economic activities while for Chile the use of labour increased relative to that of capital. What is interesting for Chile is that while the relative rankings of the two labour and capital measures do not change, the relative abundance measure shows a convergence in the intensity of usage.

Among most of the SEMs, there is much greater variation within each country's resource ranking as shown by the standard deviations. The exceptions are Brazil, which has the lowest standard deviation of all economies reported here, and South Africa whose measure substantially declined in 2004. This implies that Brazil has employed the five resources measured here with relatively equal intensity in each of the three time periods. Thailand's standard deviation has increased as evidenced by the large and increasing factor abundance measure for land. This would imply that agricultural products are taking a larger role while capital usage shows a relative decline. India remains dominated by its land usage as does Indonesia. However, Indonesia's factor abundance measures for land and natural resources have declined somewhat indicating a potential increase in the diversity of other resources used.

What the above discussion highlights is a relatively stable factor abundance story for most of the advanced OECD countries.[28] However, the dynamics of changing market structure are evident, as illustrated by the changing ranks and growing dispersion of relative factor abundance measures in, for example, the United States and South Korea. Chile, Mexico and Poland show decreasing variation among measures of factor abundance which could imply, as revealed by factor abundance measures, established production patterns. Turkey, on the other hand, shows increasing dispersion potentially indicating a changing relative factor base.

SEMs, for the three time periods examined, show a relatively consistent factor ranking, still heavily dependent on land (i.e. agricultural) and natural resources. However, movement to capital goods can be observed in the case of Brazil and to a lesser extent, Indonesia. Most countries continue to show a factor endowment story related to agriculture and natural resources.

Overall, these results are consistent with those observed in factor endowment trends. The stability in both groups of countries' rankings is a possible reflection of the large established factor stocks in these economies. That is, the large share of capital and skilled labour stocks in the OECD and the unskilled labour stocks in the SEMs. However, the small shifts in rankings and the changing abundance measures, along with their standard deviations, show an emerging trend of diversification into using capital and skilled labour for SEMs and a subtle shift in the OECD endowment usage as well.

How has factor content of trade changed over time?

We calculate a measure of factor content for each of the five GTAP factors for the three time periods (1997, 2001 and 2004) based on a derivation of the basic equation shown in (1) and presented in Figures A 9 and 10.[29] Positive values are an indication of a

28. While we are able to look at a greater level of factor disaggregation than previous studies, our measures are still quite broad. It is to be expected that if we could conduct this analysis at an even more refined level of inputs (e.g. different types of skilled labour) we may see different patterns emerging.

29. The values at the economy-wide level were scaled by relative income measures to ease comparisons. The authors wish to thank Frank Van Tongeren for providing a crucial piece of code to perform the calculations.

comparative advantage as implied by exporting abundant factors of production, while a negative value reflects a negative factor content of trade.

For ease of discussion, we present a measure of factor content of trade for three factors: skilled labour, unskilled labour and capital, for OECD economies (Figure A9) and SEMs (Figure A10). As expected, most of the OECD countries show a deficit in unskilled labour (panel 1). The notable exceptions are Japan and Korea who have surpluses in each of the three years, as do, albeit to a lesser extent, Australia, Chile, Finland, Ireland, Slovenia, Switzerland, Estonia, Turkey and the United States. This outcome is consistent with the rankings of relative factor abundance presented in the previous discussion. For example, the United States and Japan had the highest OECD stocks of unskilled labour and both show labour in general (skilled and unskilled) as a consistently ranked highly utilised resource relative to the other resources used. A notable exception is Korea. Its unskilled labour stocks were not significantly higher than other OECD countries, showing a trade deficit in this factor (France, for example) yet its relative factor usage ranking for unskilled labour was behind both land and capital in 2001 and 2004 (Table A2). However, broadly speaking these results do reflect the patterns observed in the factor endowment trends noted in section III.

The highly positive values for both Japan and the United States in its factor content of skilled workers shown in the following panel is again a reflection of the abundance of labour reported for these countries. France, Italy and Germany, among others, are all shown to have deficits in their factor content of trade in skilled workers. This is in fact surprising as most OECD countries have a relative abundance of skilled workers *vis-a-vis* the rest of the world and skilled labour ranks as Italy and Germany’s second most intensively used resource (Table A2). However, where these countries show a consistent comparative advantage is in the area of capital, where all three have relatively large positive values (France excepting in 2004). Mexico’s increase in capital stock and its associated increase in relative usage rank are reflected in its positive factor content of trade for capital. This trend is observed despite Mexico’s falling k/l ratio which is more a reflection of faster labour growth than declines in capital stock. While the measure experienced a downturn in 2004, it was strongly positive in 1997 and 2001. Other countries with factor content surpluses in capital include New Zealand, Ireland and Chile and the newly emerging OECD economies of Poland, Hungary, Slovenia, Estonia and Turkey.

The United States and the United Kingdom are shown to have a negative factor content of trade in capital in each time period examined. This could be due to the “de-industrialisation” of these economies as identified in Interim Report 1. The increasing use of resources in the production of services is something that was observed throughout the OECD but especially so in countries such as the United Kingdom and United States. As further noted in Interim Report 1, the share of manufactured exports from the top OECD exporters has been declining over the period 1990-2007. Finally, the United States and United Kingdom were among the lowest ranked OECD economies in measures of GFCF to value added in manufacturing (Figure A6).

The three panels in Figure A10 look at the same measures for the SEMs. As expected, almost all show a comparative advantage in unskilled labour judging by the factor content of their trade. Some countries, Thailand, Russia and South Africa, show a negative factor content of trade in more recent years, but for South Africa and Russia, this is not a consistent pattern and for Thailand, it is decidedly smaller in recent years. Neither South Africa nor Thailand (information was not available for Russia) have large stocks of unskilled labour with respect to other SEMs (Figure A4). Again, as expected, all show a negative balance in skilled labour with the exception of Brazil and Malaysia who both show a positive factor content of trade in this resource in more recent years (2001 and 2004). Interestingly, relative stocks of skilled labour with respect to other SEMs were no higher in these two economies (Figure A3) and skilled labour actually ranked fifth in Malaysia's relative factor usage (Table A3).

Another interesting observation can be seen in the patterns revealed when looking at capital. All of the SEMs show at least one period with positive factor content for capital. This implies that the trade balance in goods using capital is positive and thus these countries have a comparative advantage in this resource. A possible explanation for this pattern is the growing industrial production base of these economies, especially those in Southeast Asia. As observed in Interim Report 1, OECD countries are moving toward services and away from traditional "capital intensive" manufacturing and the slack is being picked up by SEMs. As these countries increase their inflow of FDI and expand their own higher value-added manufacturing processes, the capital content of their trade should necessarily increase. We saw this by the increased rank of capital usage in some of these economies, China especially, implying growing participation of relatively capital intensive goods in their trade.

These outcomes are consistent with the growth in capital stocks in SEMs and a slower investment rate among OECD countries observed above (Figure A1). Further, we see that the majority of OECD countries which have an increase ranking in capital factor usage are emerging OECD economies like Poland, Mexico and Estonia while only a few SEMs show an increased ranking of capital (China, Thailand and South Africa). However, the increase in relative ranking for China is small, indicating that their factor usage is still dominated by other factors, i.e. labour.

When we observe, however, the relative contribution of labour and capital as measured in countries' k/l ratios, we see that capital still dominates among OECD countries. What this implies is that while the production base is shifting, it is shifting slowly. OECD countries still employ a relatively large share of capital reflective of their large capital stocks while SEMs employ larger shares of labour, reflective of their stocks. However, among those sectors seeing the most growth in each region (i.e. services in OECD and manufacturing in SEMs) we see the potential reversal of these resource uses. Overall, the base is dominated by capital in the OECD with changes in labour, while the base is dominated by labour in SEMs and capital is driving the change. This may also imply something about the nature of traded versus non-traded goods. Overall, according to resource rankings, the relative use of labour by OECD countries has remained fairly stable while capital has increased. However, the factor content of resources implies these rankings will change to reflect a declining use of capital among traded goods, and a possible reflection of the shift from manufacturing to services.

What role has intermediate inputs played in measuring factor content of trade?

As stated above, traditional measures of factor content have tended to be based on primary factor services embodied in the trade of final goods and services. We aim to expand this measure to include the factor services embodied in intermediate inputs – imported as well as locally sourced - as well. Thus, equation (1) becomes:

$$F_k^i = D_k^i (I - B^i)^{-1} T_k^i \qquad (2)$$

where *F* is the factor content of input *k* in country *i*; *D* is the vector of factor inputs *k*, *i*'s intermediate inputs matrix *B* is adjusted to fully account for imported intermediates, as outlined in the technical appendix, and *T* is the net trade vector in country *i*.

We can further examine the trends in factor content derived from the traditional HOV specification by comparing the outcomes of an equation which accounts for a country's use of resources embodied in its intermediate inputs with one that does not. This analysis is discussed below. While we developed results at the general country level, we report here those outcomes pertaining to individual sector outcomes.[30]

Including a correctly specified measure of traded intermediates is crucial to a more accurate measurement of factor content. In order to better understand the relative importance of intermediate trade we examine the factor content of trade with and without imported intermediate inputs for China and the United States.[31]

China

We examine the trends in factor content across sectors for three factors of production: skilled labour, unskilled labour and capital. Given that most imported intermediate shares are in the manufacturing sector, we begin our analysis in this area. In addition, because we are comparing with the United States and the changing nature of the two economies stresses the role of services, we include this sector as well.

Figure A11 shows the factor content of Chinese trade for skilled labour in three time periods: 1997, 2001 and 2004. The bars represent the factor content of trade as defined by equation *without* explicitly accounting for intermediate inputs and the dots are defined *with* intermediate inputs. While measures without show a consistently negative balance across both sectors and time periods, there are significant difference when accounting for intermediates.

When examining skilled labour, accounting for intermediate inputs in the calculation of factor content reduces the observed deficit, or creates a small surplus, in almost every sector. Notable exceptions are the chemical and rubber sector (crp) and the trade (retail and wholesale, trd) sector in 2001. Thus, for example, it would appear that the inputs which China accesses from the rest of the world are more skill intensive in the production of electronics and other manufacturing goods. Across the sectors of textiles (tex), wearing apparel (wap) and leather (lea), the same phenomenon is observed, although to a lesser extent. An outlier is the other services sector consisting of public administration and government services (osg). Here, especially in 1997 and 2001, we see a large surplus reduced to a small deficit in 1997, balanced trade in 2001 when accounting for the factor content of intermediate inputs. This would imply that China was importing intermediate inputs that are non-highly skill intensive, or at least less skill intensive than non-traded intermediate inputs. By 2004, this trend had reversed itself and including intermediate imports leads to a slightly larger surplus, implying that more skilled labour was now being sourced internationally.

Turning to unskilled labour, shown in Figure A12, the pattern of comparative advantage appears to be changing regardless of intermediate inputs (although these inputs

30. Table 2 in the Data Annex provides a list of sectors covered.

31. While similar comparisons are available for all covered countries, as two of the largest trading nations, we focus our discussion on these two countries.

impact the results as well). In 1997 and 2001, we observe surpluses in sectors using unskilled labour (before adjusting for intermediate inputs). These include construction (cns), chemicals and rubber, non-metallic minerals (nmm, such as cement, lime and concrete), trade and other business services (obs). By 2004 none of the sectors show a surplus in unskilled labour. This is consistent with the decline in the relative abundance ranking for unskilled labour in China between these two time periods. However, once we account for the factors embodied in intermediate inputs, we observe a number of strong surplus sectors. These include electronics (ele), other manufacturing (omf), textiles, wearing apparel, leather and lumber (lum). Again, this could be an indication of China's own increasing use of production outsourcing, especially in the textiles and electronics sectors.

Capital shows a different story to that of labour (Figure A13). In most of the sectors, in all three time periods, China has a small surplus in capital, and we see this trend strengthening in 2004. However, as distinct from labour, including intermediates creates a smaller surplus and even a deficit in many sectors including paper products (ppp), petroleum and coke (p_c), chemical and rubber, iron and steel (i_s), motor vehicles (mvh), other machinery and equipment (ome) and trade. By 2004 many services sectors see shrinking surpluses when intermediate inputs are accounted for, including finance and banking (ofi) and other business services. As stated above, this implies that most imported intermediate inputs are more capital intensive than other inputs while imported intermediate inputs into chemicals and machinery and equipment, for example, are less capital intensive in 2004. While we do not have detailed source information for intermediate inputs to China, looking at total imports provides some explanation. Japan remains a major source of imports across four of the five sectors in 2004. Taiwan and Korea also contribute significantly to imports of chemicals and rubber and other machinery and equipment while Hong Kong is by far the largest supplier of imports in the trade sector, all sectors with implied higher capital input in imported than domestic intermediates. However, among those sectors which showed lower capital intensity in imports – electronics and other manufacturing – Malaysia, India and Thailand were also significant sources of imports.

The United States

Figure A14 shows the same three sets of graphs for the United States, that is, the evolution of surplus/deficit sectors with and without intermediate inputs for skilled labour. Across all three time periods the United States shows a significant surplus in skilled labour in the services sector with other business services showing particular strength in 2004. Other sectors, such as motor vehicles, other machinery and equipment, chemicals and rubber, construction and trade had shown relatively strong surpluses with smaller values in 2004.

Intermediate inputs make less of a difference in the overall results of the United States data over each successive period. Indeed, by 2004 the only sectors outside services that experience a relatively large shift is other machinery and equipment and, to a lesser extent, chemicals and rubber. These small changes are in contrast to China who shows large changes in each time period. While this does not indicate that the United States has fewer imported intermediate inputs than China (indeed the many cases the United States imports more), rather that the resource profile in the inputs are more similar to those sourced from within the United States.

Much the same pattern holds for unskilled labour in that there are small differences with and without intermediate inputs in sectors outside services (Figure A15). Here, however, many of the sectors go from large surpluses to balanced trade, implying that the United States imports unskilled-intensive intermediates. Sectors that maintain their surplus, albeit at a lower level include other transport equipment (otn), banking and business and government services sectors. Again, this implies that the United States trade in goods using unskilled labour is generally in balance with the exception of a few sectors, and trade in intermediate inputs have only a limited role to play in this story.

As noted above, the role of capital in US trade is not as large as one would have expected *a priori* (Figure A16). Indeed, across the manufacturing sectors there are no significant surplus sectors in any of the three time periods examined with most of these sectors remaining more or less in balance. However, there are significant deficits across many of the services sectors. In 2004, the deficit in other business services sector was particularly large. Indeed, all of the service sectors (with the exception of the transport sectors) show deficits in each period. Thus, it would appear that these sectors are driving the deficit in capital observed for the United States in Figure A9.

When adjusting for intermediate inputs, the deficits in the services sector change considerably. Most of the deficit sectors move to a balanced trade or even surplus as in the case of other business and government services. One of the issues with the measurement of capital is that we are unable to determine what part of the imported intermediate goods are made with the exporting country's capital from that which may be produced with US capital employed overseas. Thus, while it appears that the United Kingdom is a net importer of capital in these sectors, it may be that a large part of the capital is owned by US companies. Grossman and Rossi-Hansberg (2009) show that trade between US companies and their foreign subsidiaries accounted for 47% of US imports in 2005. Further they show that US imports in "Business, Professional and Technical Services" (which overlaps with our other business services) grew in real terms by more than 66% between 1997 and 2004.

From this analysis we can see what has been a growing acknowledgement in trade circles: intermediate trade matters. Further, we see that it affects factors differently. Thus if policy is to be effective, it must rely on analysis which includes intermediate trade and the embodied factor services in this trade, and includes it in a meaningful way, i.e. measured in terms of value added. How this information can be used in the formation of trade policy will be discussed in more detail in the fourth paper of this series. However, before we move to that, we provide some insights into how this information plays a role in analysing a widespread phenomenon across both OECD and SEM economies: that of wage inequality.

V. Relationship between trade and relative wages

The developments in factor content of trade are intertwined with factor returns because the latter function as signals about resource allocation and the former about utilization within a country. Trade literature analyzing factor content links the HOV model to the factor price equalisation (FPE) theorem because equalisation of marginal factor returns would be the expected outcome when two countries with identical technologies but with different factor endowments, producing the same goods or services engage in free trade.[32] The trade literature succinctly summarized in Freeman (1995) has investigated whether factor price equalisation occurs empirically across countries. The main conclusions are that factor price equalisation is a rare occurrence because of its demanding conditions. These conditions include: identical technology and tastes; similar ranking of sectors by skilled to unskilled and capital to labour ratios at all prices; absence of scale effects; and incomplete specialisation by all countries, that is, all countries produce the full set of traded goods. As a consequence of the breakdown in FPE, we need to identify other forces that could explain factor return differentials. This is important because these differentials are at the heart of the North-South development gap; they are also critical in explaining differing equilibrium growth paths across nations, and can exacerbate trade frictions (Trefler, 1993). Moreover, the growing importance of trade of intermediate goods observed above can have a potentially large impact on factor returns, in particular, wages, through production fragmentation and offshoring.

Using data available in Freeman and Oostendorp (2000), we examine the evolution of real wages and wage inequality for a sample of OECD and non-OECD economies. Freeman and Oostendorp standardized the International Labor Organization's (ILO) "October Inquiry" survey to allow for wage comparisons across countries, industries, and occupations.[33] The resulting dataset covers approximately 130 countries and around 161 occupations for the years 1983-2003. Details can be found in the Data Annex.

The data in the sample allows compensation to be disaggregated by industries and occupations to identify those having the lowest and highest wages. Figures A17 and 18 present the frequencies of industries and occupations which reported the lowest compensation in the sample. The occupation Room attendant or Chambermaid in the Restaurant and hotels industry received the lowest wage about 13% of the time across all countries. Other occupations receiving low compensation were Labourer, Field crop farm worker, Cash desk cashier, Sewing machine operator, and Waiter. The corresponding industries for these occupations were Textile (spinning, weaving and finishing), Retail trade (grocery), and Agricultural production. The occupations receiving the highest compensation across all countries were Air transport pilot, General physician, Air traffic controller, and Chemical engineer. The corresponding industries were Air transport and its supporting services; Medical and dental services; and Crude petroleum and natural gas production. Figures A19 and 20 present these occupations and industries.

We next identify the industry/occupation breakdown for OECD and SEM economies. Figures A21 and 22 present the lowest paying industries and occupations for OECD

32. The Factor Price Equalisation Theorem states trade in goods has the ability to equalize factor prices where trade in goods is a proxy for trade in factors of production.

33. This circumvents measurement problems such as different reporting units, quality of reporting sources, wage levels, and other issues, providing the use of a unique standardised dataset.

countries. The occupation Room attendant or Chambermaid was the lowest compensated occupation and the industry was Restaurant and hotels. Other industries receiving the lowest compensation were Retail trade (grocery); Agricultural production (fieldworkers); and Manufacturing of wearing apparel. Note that in our analysis of factor content, we observe some of the most significant shifts in trade positions from including intermediate inputs were in the Textile (including wearing apparel) industry**.** Figures A23 and 24 present the reverse, the highest compensated industries and occupations, in the OECD countries. Air transport pilot, General physician, Air traffic controller, and Chemical engineer were again the highest compensated occupations. The industries were Air transport and supporting services, Medical and dental services, and Manufacturing of industrial chemicals.

Figure A25 shows that Labourer, Field crop farm worker, Plantation worker, and Room attendant or Chambermaids were the lowest compensated occupations in the SEMs. The lowest compensated industries were Textiles, Education services, Printing, Publishing and related industries, and Restaurants and hotels (Figure A26). Finally, the occupations which registered the highest compensation were Air transport pilot, General physician, Accountant, and Air traffic controller. Those industries paying the highest wages included Air transport, Medical and dental services, Construction, and Banking (Figures A 27 and 28). Notably, none of these sectors (with the exception of Textiles) figures prominently in SEMs factor content of trade. This anecdotal evidence provides little incentive to suspect a strong relationship between trade and wages.

To more rigorously examine the influence of domestic and international wage setting mechanisms, we use the concept of factor price equalisation (Freeman 1995). As stated, the conditions for factor price equalisation are demanding and, therefore, observing wage convergence is rare. Moreover, factor price equalisation implies domestic labour market policies have little or no effect on the level of wages. Countries with larger labour forces would have an advantage in setting wage levels and could exert undue influence in determining modifications on wage levels. The exceptions to this potential influence are occupations found exclusively in the non-tradable sector which would not be affected by changes in the international environment.

Figures A29-31 present the logarithmic difference between the wages reported for selected occupations identified as the lowest and highest paying in each country using the United States as reference. In this context, zero implies equality of wages and negative numbers represent wages lower than the United States, and vice versa for positive numbers. No consistent evidence of factor price equalization is shown in the figures.[34] We do observe, however, the emergence of three wage levels, which seem to be associated with the particular country’s development level. For example, in the case of Field crop farm worker the differences in wages between India and Bangladesh with the United States are the largest and maintain a consistent spread. Similarly, for Field worker the differences between Mexico and the United States; are smaller compared to India, Bangladesh, and China, but still maintain a consistent spread. Finally, the differences in wages between Austria, Italy, and Sweden and the United States with respect to Field workers are positive –wages are higher in these countries than in the United States—and consistent in this pattern. The same pattern can be found for Room attendant or Chambermaids. Another example, the case of General physician, shows a repetition of the aforementioned pattern. Countries such as Austria, Italy, and Korea have smaller

34. We examined the evolution of both nominal and real wages. The results are similar.

differences with the United States and consistently higher wage levels compared to China, Hungary, and Mexico.

Finally, regression results looking for convergence effects show no conclusive statistical evidence of convergence in real wages.[35] We analyse different sets of cross-sectional regressions starting with a simple specification where the dependent variable is the percentage change in the real wage as a function of the initial level of development, proxied by the logarithm of gross domestic product per capita, and a constant. A negative and statistically significant coefficient on the logarithm of gross domestic product per capita would suggest a process of wage convergence. More developed countries initially would have their wages grow at a slower rate than less developed countries, thus allowing for catch-up. Table A4 in the Annex presents mixed evidence since the parameter estimates change sign (regressions 1 and 4) and statistical significance (regressions 2 and 5) depending on the estimation method, the time period, and the inclusion of fixed effects.

Next we include a measure of the country's initial level of openness, proxied by the sum of total imports and total exports as a share of gross domestic product, into the regression specification. The objective is to determine if the country's initial exposure to the international economy has any influence on the percentage change in real wages. A positive sign associated with the parameter estimate would indicate greater exposure to the international economy would be correlated with a greater percentage change in real wages. Table A5 in the Annex presents the regression results. The inclusion of the openness measure does not modify the previous conclusion where there is no clear evidence suggesting convergence in real wages between developed and developing economies. In addition, the openness measure itself does not prove to be robust and statistically significant as it is only positive and statistically significant in regressions 7 and 9.

Finally, we construct a concordance between the GTAP sectors and the ILO occupations and associate the industries in the ILO October Inquiry to the GTAP industries. We explore industry heterogeneity in case those industries which are more exposed to international trade show evidence of greater wage volatility. Given we were only able to map 27 GTAP sectors, we re-ran the regression models including these sectors as fixed effects. Table A6 in the Annex presents the parameter estimates. The parameter estimate of the logarithm of real per capita GDP shows mixed results by changing direction (regressions 1 and 2 compared to 3, 4, 5, and 6) from positive to negative and the parameter estimate associated with openness is not consistently statistically significant. All this evidence taken together suggests internal factors have greater influence on the setting and evolution of real wages.

Thus far we have found no significant link between trade and wage determination. However, we have shown that, overall, factor abundance is reflected in a country's trade pattern. Therefore the next logical question is then to what extent does factor abundance influence factor returns. That is, do the returns paid to abundant factors used intensively rise as countries expand trade and fall in those factors that are relatively scarce? In particular, this would imply rising wages for low skilled workers in developing countries and decreasing wages for this type of individuals in developed economies.

To examine this question, we construct yearly wage distributions to obtain more detail about the evolution of wages in the OECD and SEM economies. Figures A32

35. Regression results are reported in Tables 4, 5, and 6 of the Annex.

through 39 present these wage distributions for 1984, 1991, 1997, and 2001.[36] Figure A32 presents the estimated wage distribution for OECD countries in 1984 comparing it to a normal distribution created using the data's observed mean and standard deviation. The distribution is right-skewed with the majority of the mass concentrating at lower wage levels. Similarly, Figure A33 presents the wage distribution for SEM economies for 1984. While the distribution is skewed to the right, it presents different features such as two humps suggesting two major wage levels where most observations concentrate. Like the figure for OECD countries these suggest low paying jobs are more abundant and a smaller group of individuals command high wages. The remaining figures, Figure A34 through Figure A39, are also right-skewed confirming that high paying jobs are relatively scarce.

Figures A32 through 39 do not consistently suggest the presence of a sorting effect related to a skill premium. The skill premium relates to workers possessing a wider set of abilities becoming more valuable to firms. Likewise, more productive firms, paying higher wages, become more selective in their hiring policies (Helpman, Itskhoki, and Redding, 2009). Therefore, if a larger number of skilled individuals command higher wages and firms' hiring policies focus on skills we expect the wage distribution to develop multiple humps. The wages of low skilled workers would be located at the lower end of the distribution and wages for high skilled individuals would be located around the second hump towards the right end of the distribution. We only observe wage distributions with two humps for OECD countries in 1997 and for SEM economies in 1984 and 1997.

Have the changes in wage distribution observed above been a significant development across the OECD and SEMs? Documenting the per cent wage differential across occupations over time in each country allows us to look at within country wage distribution. Such distributions can be considered an outcome of particular labour policies, and can influence the factor content of trade. As these labour market policies, such as education and skill enhancement programs, influence a country's endowment structure, it is important to understand the link between policies which influence endowments, thus trade, and the potential feedback mechanisms which could impact wages.

Figure A40 presents the evolution of the per cent wage differentials across occupations for the countries of interest.[37] Romania presents the biggest percentage spread and the largest changes in the spread, implying growing wage inequality. Other countries which showed increases in wage inequality from 1990 to the year 2000 are Brazil, India, Mexico, Slovakia, Italy, Portugal, and the United States. On the other hand, Canada and China show a decrease in wage inequality in this same period.[38] Finally, the wage distribution behaves in a stable manner in Finland, Iceland, Belgium, Norway, Denmark, The Netherlands, and New Zealand. Norway has the lowest percentage wage differential with this being just over one-half. The increase in the observed wage

36. The starting point is 1984 since there is no available data for SEMs in 1983.

37. There are several countries which are not included because of lack of data. In particular Chile, France, Luxembourg, Switzerland for the OECD group; Indonesia for the Enhanced Engagement group, Egypt, and Malaysia for the other Selected Emerging Market economies.

38. Given the available data for China only goes to the year 2000 we cannot follow-up on developments regarding wage inequality in the subsequent years. However, Wu and Perloff, (2005) report figures that suggest an increase in rural-urban inequality in later years.

differential in most economies over this period correlates with world economic expansion and increased trade in the decade of the 1990s. This of course does not imply a causal link.

Figure A41 shows a detailed picture of the percent wage evolution among OECD countries where data is available. Hungary, Poland, Slovakia, and Turkey experienced an increase in wage inequality, but not the Czech Republic. While Mexico and the United States both saw wage inequality increase, the increase in Mexico was greater. Other OECD countries that have suffered from an increase in wage inequality are Italy, Portugal, and Sweden. On the other hand, Germany, Japan, Austria, Canada, and Korea have managed to make their wage distributions more compact. Thus, on the face of things, increases in wage inequality are not necessarily associated with large trading nations (i.e. difference outcomes for the United States and Germany) nor with those having a particular endowment structure (i.e. similar findings for Japan and Canada, for example).

Turning to the SEMs, Romania and Brazil have experienced significant increases in wage inequality, while wage inequality in India, Singapore, and China had been falling up to the year 2000 (Figure A42). Focusing on Enhanced Engagement and Accession economies, Brazil had the highest level of wage inequality followed by India, and Russia. Brazil’s percent differential between the lowest and the highest wage was almost 28 times.

No clear linkage between factor content of labour (either in ranking or intensity) and wage inequality emerges from this analysis. Thus, while trade expansion has occurred during this period of overall wage inequality growth, circumstantial evidence does not indicate a strong link to trade.[39]

Overall, while we do not explicitly test for FPE, we did not observe trends which would suggest factor price equalisation in workers’ wages. The differential in wages is consistently maintained leading to the improbability of factor return convergence. Stated in other terms, wages in developed countries do not seem to be converging towards wage levels observed in developing countries with large labour endowments. This was not unexpected due to reasons described above, not the least of which is the differences in labour productivity noted in Section III. What these various trends do suggest is that differences in labour (reflected in different wage levels) lead to the application of different technology matrices (which we have shown to play a major role in correctly analysing the factor content of trade). We also do not observe reductions in wage inequality in unskilled labour abundant countries (SEMs) where this factor of production is shown to be used intensively. We observe evidence of a skill premium in the wage distributions for 1997 in both OECD and SEMs, but such phenomenon does not appear consistently in the figures. However, as Helpman, Itskhoki, and Redding (2009) state, firms appear to have changed their hiring practices focusing on hiring workers with a wider set of skills. This opens the door to explore and examine the impact of economic policies on the domestic labour market of these countries and the effective development of a labour endowment.

39. It is possible to try and establish a more robust link between wage inequality and factor content through more sophisticated econometrics, but that is beyond the scope of this paper and left to future research

VI. Conclusions and areas of policy consideration

We observe that overall, factor content is reflected in changing trade patterns while the link to relative wages appears to be limited.

OECD economies as a whole continue to hold the lion's share of capital and skilled labour endowment stocks while SEMs hold more unskilled labour. Overall, measures of factor content of trade reflect these holdings. However, while OECD countries have been shown to be accumulating capital stocks at a rapid rate, over 4% *per annum* for the past 15 years, SEMs have been doing so at an even faster rate, over 11% over the same time period. The same observation can be made for skilled labour; OECD stocks growing at over 3% while SEMs are growing at an annual rate of almost 5%.

Capital/labour (k/l) ratios show that OECD economies remain relatively capital intensive, and this is confirmed in the relative rankings of the intensity of this resource use in traded goods. Capital consistently ranks high, as does skilled labour. For SEMs, we see smaller k/l ratios and these factors rank lower in their relative usage; unskilled labour ranks high, but natural resources and land figure prominently in the relative intensity of factor usage for SEMs as well. There are broad exceptions (such as Australia for natural resources and Brazil for capital) but overall these results hold.

If, however, we look a little deeper at movements in the rankings and relate them to the observed difference in factor accumulation across the country sample, we see increasing use of unskilled labour in OECD countries and capital increasing its intensity among SEMs.

These changing dynamics are reflected in the total factor content for trade for capital, skilled labour and unskilled labour. However, the analysis did yield some unexpected results. Among the OECD economies, the two largest capital stock holders – Japan and the United States – show deficits in the trade of capital embodied goods. More in line with expectations, newly emerging OECD economies such as Hungary, Chile and Poland, all show strong surpluses. We see an increase in the use of unskilled labour embodied in the United States and Japanese trade, but also in Korea and Australia. SEMs show a strong surplus in unskilled labour trade across the board. Finally, skilled labour stocks are strongest in the United States and Japan and both show a sizable surplus in the factor content of skill embodied trade while only Malaysia and Brazil among the SEMs show a surplus here.

The picture emerging among the OECD economies is thus more varied and nuanced than that among the SEMs. Part of the explanation for the OECD results could be the manner in which we think and account for factors. That is, whether the traditional method of measuring actual units of capital and labour, located with the geographic boundaries of a country, is still appropriate. Rather, we should be looking at more refined measures of individual tasks and factors roles in intermediate inputs, which are not necessarily defined by geographic boundaries. The large literature on production fragmentation and offshoring attest to this trend. Trade, even factor content, can no longer be thought of as a function of the endowments located solely within a country's borders, but rather can be seen as a function of trade-in-goods and trade-in-tasks where the level and direction of this trade are a function of the changes in the costs of moving goods and particular tasks and ideas, rather than "jobs."

Baldwin and Robert-Nicoud (2010) present a model which attempts to integrate these new patterns of firm behaviour into traditional trade theory like HOV. They argue that this movement of tasks creates ‘shadow migration’ and changes the way factors are characterised in standard trade theory. This, they argue, explains why standard trade theory presents so many ‘unexpected’ results.

This observation can be inferred from the analysis of trends in factor content with and without fully accounting for imported intermediate trade flows. We observe shifting patterns in comparative advantage depending on whether we account for worldwide use of resources, regardless of location. In the United States we see changes mainly across the services sector, while China experiences large differentials in the outcome of their manufacturing sector – both of these dynamic and growing sectors in the respective economies.

Finally, when exploring the impact of these trends on wages, and wage differentials, we find little evidence of a strong link. This is especially true when we look at trends in wage inequality where it appears that domestic conditions have a greater bearing on outcomes than trade patterns in general, and factor endowments in particular. For policy makers, the complexity of the endowment/trade/wages link means careful analysis is required of any policies attempting to affect labour market outcomes through trade.

As the driving forces behind trade patterns change, so must the approach to measuring these patterns. We have shown that intermediate goods play an important role in the analysis driving policy advice. In addition, inferred here is the importance of foreign direct investment and the role domestic capital, employed overseas, can make to notions of trade deficits or surpluses. Thus, policy advice based on simplistic measures of trade can be misleading.

Given that resource stocks are still a major driver of trade patterns, policies that develop and enhance these stocks will help countries shape their future comparative advantage.

We have shown that factor content is an important determinant of comparative advantage and that comparative advantage, in turn, drives trade patterns. What is important for policymakers is the fact that this directional flow - endowments to comparative advantage to trade – does not work in the reverse order. Targeting industries and “picking winners” is inefficient in the long run, because it is inconsistent with this basic causal flow. Therefore, trying to impact endowment sectors – such as employment – through trade policy is counter-productive. That is not to say that a country cannot have an influence on its comparative advantage, rather this is best accomplished by developing factors more broadly. A major policy implication of this work is that the best approach to influencing trade outcomes is to invest in resource market enhancement, such as education and training for labour and transparency and availability for capital.

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Data Annex

Capital and LabourStocks for both capital and labour are expressed in units. The capital stocks were calculated with the perpetual inventory method using real gross fixed capital formation flows from the World Bank World Development Indicators. For the base stock in 1980, an average of Gross Fixed Capital Formation (GFCF) flows was calculated from 1978 to 1982 to limit year specific anomalies and multiplied it by two. The depreciation rate used was 7%. The stocks were adjusted with the price of investment from the Penn World Tables to convert the PPP values into units of capital. Data for stocks were unavailable for Poland, Slovak Republic, Turkey, Slovenia, Singapore, and Israel.

Labour stocks were taken from the IIASA and Vienna Institute for Demography data sets. Labour stocks are defined as total population over the age of fifteen, providing information about the total human capital available, but not differentiating between economically active and those that are unable or choose not to work. These data report populations by age, sex and level of educational attainment for 120 countries for 1970-2000 using demographic back projection methods. Skilled labour includes the population with completed tertiary education. This data set takes into account fertility, mortality, and migration rates for improving the accuracy of population projections by education level. The data and methodology paper can be accessed at: www.iiasa.ac.at/Research/POP/edu07/index.html?sb=12.

Given actual observation for 2005 are unavailable, the data for 2005 was taken from the Education Forward Projections dataset for 2000-2050. The data was based on the Global Education Trend Scenario series which assumes that a country’s educational expansion will converge on an expansion trajectory based on the historical global trend. Identification of the global trend is based on a data driven-judgmental analysis.

To minimise inconsistencies and promote analysis based on real trends as opposed to difference in accounting methods, we focused on obtaining data from sources which covered as many countries as possible, over as long a time period as possible. We examined flows of capital and labour relative to their contribution to output. All measures for flows are in US dollars (USD). For annual expenditures on capital and labour, we used GFCF and Total Wage Bill to Value Added. The majority of the data for OECD countries was taken from the OECD Structural Analysis database (STAN) whenever available. Gaps in this data and information for non-OECD countries were supplemented from the UNIDO Industrial Statistics database and the World Bank Trade Production and Protection database. Remaining gaps in the data were supplemented from national sources. For Brazilian GFCF, we utilised information from the Annual Industrial Survey (Pesquisa Industrial annual) from the IBGE website (www.ibge.gov.br). Firm level data for manufacturing companies was used summing new capital formation with improvement to existing capital less depreciation. These capital figures were then converted to USD using OECD MEI exchange rate figures for this period. For South Africa, GFCF figures were taken from the South African Reserve Bank reporting GFCF by Economic Activity and these figures were also converted using MEI exchange rates.

GFCF, Value Added, and employment for China were gathered from the National Bureau of Statistics of China from the Statistical Yearbooks. The Employment data was collected from the employment breakdown by sector for manufacturing, the GFCF was taken from the GDP by expenditure series, and Value Added were supplied by the OECD's Economics Department from staff calculations based on other national sources. Indian employment data were taken from the IPUMS micro data set put together by the University of Michigan. This survey data provided employment information by sector for 1983, 1987, 1993, 1999, and 2004. Despite these efforts, some gaps in the data persist. Data for GFCF was unavailable for Switzerland, Russia and Slovenia. For Total Wage Bill data is missing for Switzerland.

For the labour productivity calculations of output per worker, we used World Bank World Development Indicators of total labour force and GDP in constant USD 2000. Ideally, a measure of GDP per hour worked would have been useful, but no complete cross country data on this was available at this time.

Table 1. K/L Ratios (units of capital per worker)

	1990	1995	2000	2005
Argentina	25,027.71	24,963.70	29,031.27	50,603.00
Australia	47,984.56	61,242.59	88,428.75	86,917.43
Austria	57,194.21	58,169.80	93,797.58	85,366.51
Belgium	50,858.29	54,773.70	87,223.29	82,072.87
Brazil	14,132.71	13,384.56	17,211.65	15,265.45
Canada	50,295.96	68,773.98	80,592.82	86,509.98
Chile	11,684.57	16,876.81	28,857.29	39,020.01
China	2,952.20	5,395.86	8,058.30	12,227.42
Denmark	39,962.64	46,209.82	79,870.82	79,840.02
Egypt	76,815.51	225,185.86	241,848.62	480,194.61
Finland	43,975.70	57,751.91	83,365.83	80,671.47
France	45,368.80	50,476.94	77,715.92	70,750.18
Germany	48,851.79	49,130.41	81,723.22	78,734.96
Greece	37,986.96	37,348.82	51,380.99	52,461.02
Hong Kong	75,947.57	72,881.85	89,190.55	145,027.86
Hungary	20,165.43	20,435.05	30,742.68	25,484.41
India	1,850.13	2,881.34	3,984.30	4,886.38
Indonesia	4,281.83	5,651.73	6,874.12	6,363.64
Ireland	61,722.61	64,024.78	81,884.87	69,686.52
Italy	44,856.61	63,760.25	83,875.00	74,241.22
Japan	100,880.79	85,978.13	113,901.52	154,905.53
Korea	33,734.85	47,120.84	74,320.59	84,208.53
Luxembourg	80,649.34	86,609.02	149,730.57	156,249.59
Malaysia	15,195.45	21,906.55	34,021.57	39,200.30
Mexico	29,410.47	31,616.46	27,388.87	29,331.40
Netherlands	44,255.00	47,810.81	81,938.65	74,322.11
New Zealand	31,235.44	31,388.73	51,478.27	44,276.85
Norway	76,736.90	84,318.14	119,675.21	103,074.56
Philippines	8,861.40	6,830.86	9,543.59	11,249.90
Portugal	36,187.41	40,573.54	62,153.61	56,041.40
South Africa	8,494.66	8,133.53	11,114.74	9,628.17
Spain	37,803.89	49,149.74	70,906.96	59,273.93
Sweden	35,430.95	47,968.19	64,550.95	67,691.21
Switzerland	67,252.81	77,852.19	113,644.83	110,233.74
Thailand	14,866.11	21,422.33	28,313.13	27,519.37
United Kingdom	33,708.74	47,202.73	57,644.77	63,919.79
United States	64,482.50	77,559.25	94,770.41	118,937.69

Trends in factor content

This section relies primarily on data from the Global Trade Analysis Project (GTAP). This publicly available, completely documented (Dimaranan and McDougall (2002) and Badri and Walmsley (2008)) database provides input-output tables for between 45 and 85 countries (depending on the database version), 57 sectors and five factors of production. It consists of independently complied country-specific input-output tables (thus allowing us to recover country-specific technology matrices) which are reconciled to bilateral trade data and other statistics. The data have been through seven public releases and have been extensively tested by members of the GTAP consortium and other researchers.

In order to observe the factor content in different time periods, we use three of the GTAP databases to derive the necessary components of this part of our analysis. These databases are version 5, corresponding to a base year of 1997; version 6 corresponding to a base year of 2001 and version 7, corresponding to a base year of 2004. To cover as many countries and sectors in a consistent manner, GTAP measurements are made in value terms (US$). This allows the consistent basis from which to compare outcomes across countries. While we do acknowledge the well known shortcomings of measuring economic variables in USD (as well as the shortcomings of other measures such a PPP), we believe the value in obtaining an internally consistent database outweighs any potential bias introduced in our figures.

Table 2 presents the primary regions covered in our analysis and the corresponding year of the base input-output data for each database version. Table 3 presents the sectors included in the analysis.

Table 2. Country and input/output table coverage

		GTAP7.1	GTAP6	GTAP5
Code	World Economy	2004	2001	1997
ARG	Argentina	2000	2000	**
AUS	Australia	1997	1997	1994
AUT	Austria	2000	1983	1983
BEL	Belgium	2000	1995	1995
BGD	Bangladesh	1994	1994	1994
BRA	Brazil	1996	1996	1996
CAN	Canada	2003	1990	1990
CHE	Switzerland	2005	1990	1990
CHL	Chile	2003	1996	**
CHN	China	2007	1997	1997
DEU	Germany	2000	1995	1995
DNK	Denmark	2000	1992	1992
ESP	Spain	2000	1994	1994
EST	Estonia	2000	1997	1997
FIN	Finland	2000	1995	1995
FRA	France	2000	1992	1992
GBR	United Kingdom	2000	1990	1990
GRC	Greece	2000	1995	1995
HKG	Hong Kong	1988	1988	1988
HUN	Hungary	2000	1996	1991
IDN	Indonesia	2004	1995	1995
IND	India	2000	1994	1994
IRL	Ireland	2000	1990	1990
ITA	Italy	2000	1992	1992
JPN	Japan	2000	2000	1995
KOR	Korea	2003	2000	1995
LUX	Luxembourg	2000	1995	1995
MEX	Mexico	2002	2002	**
MYS	Malaysia	1995	1995	1995
NLD	Netherlands	2000	2001	1995
NOR	Norway	2004	2002	1995
NZL	New Zealand	1996	1996	1993
POL	Poland	2000	1997	1997
PRT	Portugal	2000	1993	1993
RUS	Russian Federation	2003	1997	1997
SGP	Singapore	1995	1995	1995
SVK	Slovakia	2000	1997	1997
SVN	Slovenia	2000	1997	1997
SWE	Sweden	2000	1985	1985
THA	Thailand	1995	1995	1995
TUR	Turkey	1998	1995	1995
USA	United States of America	2002	1996	1996
VNM	Vietnam	2003	1996	1996
ZAF	South Africa	2005	1995	1995

** not explicitly stated. Adjustments are made to ensure that the I-O table matches the external macroeconomic, trade, protection and energy data (GTAP documentation chapter 19). The I-O tables only contain data on the aggregate value of labour. Using other data sources, skilled and unskilled labour were split as well as revisions made to primary factor usage in agriculture and resource-intensive industries (GTAP documentation chapter 18.C and 18.D). Source: GTAP, https://www.gtap.agecon.purdue.edu/databases, various years.

Table 3. GTAP sector coverage

Code	Description
pdr	Paddy Rice: rice, husked and unhusked
wht	Wheat: wheat and meslin
gro	Other Grains: maize (corn), barley, rye, oats, other cereals
v_f	Veg & Fruit: vegetables, fruitvegetables, fruit and nuts, potatoes, cassava, truffles,
osd	Oil Seeds: oil seeds and oleaginous fruit; soy beans, copra
c_b	Cane & Beet: sugar cane and sugar beet
pfb	Plant Fibres: cotton, flax, hemp, sisal and other raw vegetable materials used in textiles
ocr	Other Crops: live plants; cut flowers and flower buds; flower seeds and fruit seeds; vegetable seeds, beverage and spice crops, unmanufactured tobacco, cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form of pellets; swedes, mangolds, fodder roots, hay, lucerne (alfalfa), clover, sainfoin, forage kale, lupines, vetches and similar forage products, whether or not in the form of pellets, plants and parts of plants used primarily in perfumery, in pharmacy, or for insecticidal, fungicidal or similar purposes, sugar beet seed and seeds of forage plants, other raw vegetable materials
ctl	Cattle: cattle, sheep, goats, horses, asses, mules, and hinnies; and semen thereof
oap	Other Animal Products: swine, poultry and other live animals; eggs, in shell (fresh or cooked), natural honey, snails (fresh or preserved) except sea snails; frogs' legs, edible products of animal origin n.e.c., hides, skins and furskins, raw , insect waxes and spermaceti, whether or not refined or coloured
rmk	Raw milk
wol	Wool: wool, silk, and other raw animal materials used in textile
frs	Forestry: forestry, logging and related service activities
fsh	Fishing: hunting, trapping and game propagation including related service activities, fishing, fish farms; service activities incidental to fishing
col	Coal: mining and agglomeration of hard coal, lignite and peat
oil	Oil: extraction of crude petroleum and natural gas (part), service activities incidental to oil and gas extraction excluding surveying (part)
gas	Gas: extraction of crude petroleum and natural gas (part), service activities incidental to oil and gas extraction excluding surveying (part)
omn	Other Mining: mining of metal ores, uranium, gems. other mining and quarrying
cmt	Cattle Meat: fresh or chilled meat and edible offal of cattle, sheep, goats, horses, asses, mules, and hinnies. raw fats or grease from any animal or bird.
omt	Other Meat: pig meat and offal. preserves and preparations of meat, meat offal or blood, flours, meals and pellets of meat or inedible meat offal; greaves
vol	Vegetable Oils: crude and refined oils of soya-bean, maize (corn),olive, sesame, ground-nut, olive, sunflower-seed, safflower, cotton-seed, rape, colza and canola, mustard, coconut palm, palm kernel, castor, tung jojoba, babassu and linseed, perhaps partly or wholly hydrogenated,inter-esterified, re-esterified or elaidinised. Also margarine and similar preparations, animal or vegetable waxes, fats and oils and their fractions, cotton linters, oil-cake and other solid residues resulting from the extraction of vegetable fats or oils; flours and meals of oil seeds or oleaginous fruits, except those of mustard; degras and other residues resulting from the treatment of fatty substances or animal or vegetable waxes.
mil	Milk: dairy products
pcr	Processed Rice: rice, semi- or wholly milled
sgr	Sugar

Table 3. GTAP sector coverage (*cont.*)

Code	Description
ofd	Other Food: prepared and preserved fish or vegetables, fruit juices and vegetable juices, prepared and preserved fruit and nuts, all cereal flours, groats, meal and pellets of wheat, cereal groats, meal and pellets n.e.c., other cereal grain products (including corn flakes), other vegetable flours and meals, mixes and doughs for the preparation of bakers' wares, starches and starch products; sugars and sugar syrups n.e.c., preparations used in animal feeding, bakery products, cocoa, chocolate and sugar confectionery, macaroni, noodles, couscous and similar farinaceous products, food products n.e.c.
b_t	Beverages and Tobacco products
tex	Textiles: textiles and man-made fibres
wap	Wearing Apparel: Clothing, dressing and dyeing of fur
lea	Leather: tanning and dressing of leather; luggage, handbags, saddlery, harness and footwear
lum	Lumber: wood and products of wood and cork, except furniture; articles of straw and plaiting materials
ppp	Paper & Paper Products: includes publishing, printing and reproduction of recorded media
p_c	Petroleum & Coke: coke oven products, refined petroleum products, processing of nuclear fuel
crp	Chemical Rubber Products: basic chemicals, other chemical products, rubber and plastics products
nmm	Non-Metallic Minerals: cement, plaster, lime, gravel, concrete
i_s	Iron & Steel: basic production and casting
nfm	Non-Ferrous Metals: production and casting of copper, aluminium, zinc, lead, gold, and silver
fmp	Fabricated Metal Products: Sheet metal products, but not machinery and equipment
mvh	Motor Vehicles: cars, lorries, trailers and semi-trailers
otn	Other Transport Equipment: Manufacture of other transport equipment
ele	Electronic Equipment: office, accounting and computing machinery, radio, television and communication equipment and apparatus
ome	Other Machinery & Equipment: electrical machinery and apparatus n.e.c., medical, precision and optical instruments, watches and clocks
omf	Other Manufacturing: includes recycling
ely	Electricity: production, collection and distribution
gdt	Gas Distribution: distribution of gaseous fuels through mains; steam and hot water supply
wtr	Water: collection, purification and distribution
cns	Construction: building houses factories offices and roads
trd	Trade: all retail sales; wholesale trade and commission trade; hotels and restaurants; repairs of motor vehicles and personal and household goods; retail sale of automotive fuel
otp	Other Transport: road, rail ; pipelines, auxiliary transport activities; travel agencies
wtp	Water transport
atp	Air transport
cmn	Communications: post and telecommunications
ofi	Other Financial Intermediation: includes auxiliary activities but not insurance and pension funding
isr	Insurance: includes pension funding, except compulsory social security
obs	Other Business Services: real estate, renting and business activities
ros	Recreation & Other Services: recreational, cultural and sporting activities, other service activities; private households with employed persons (servants)
osg	Other Services (Government): public administration and defense; compulsory social security, education, health and social work, sewage and refuse disposal, sanitation and similar activities, activities of membership organizations n.e.c., extra-territorial organizations and bodies
dwe	Dwellings: ownership of dwellings (imputed rents of houses occupied by owners)

Source: GTAP, *www.gtap.agecon.purdue.edu/databases/contribute/detailedsector.asp.*

Trends in relative wages

The Occupational Wages around the World dataset by Richard Freeman and Remco Oostendorp was used to examine wages and occupations. Freeman and Oostendorp transformed the International Labour Organization's October Inquiry Survey into a consistent data file on pay for 161 occupations in over 150 countries from 1983 to 2003. The standardization allowed for comparison across countries circumventing measurement problems such as differences in reporting units, quality of reporting sources, wage levels, and any other country specific issues. The wages are reported in domestic currency units and in US dollars. The figures employed were in US dollars and deflated using the deflators in the Penn World Tables to account for purchasing power parity issues. The following tables present the countries, industries, and occupations used in the wage analysis.

Table 4. Countries and Industries – wage

Country Name
Argentina
Austria
Australia
Bangladesh
Belgium
Bulgaria
Brazil
Canada
Chile
China
Czechoslovakia
Czech Republic
Germany
Denmark
Estonia
Finland
France
United Kingdom
Hong Kong
Hungary
Ireland
India
Iceland
Italy
Japan
Korea, Republic of
Kazachstan
Luxembourg
Mexico
Netherlands
Norway
New Zealand
Philippines
Poland
Portugal
Romania
Russian Federation
Sweden
Singapore
Slovakia
Thailand
Turkey
Taiwan
Ukraine
United States
South Africa

Industry Name
Agricultural production (field crops)
Plantations
Forestry
Logging
Deep-sea and coastal fishing
Coalmining
Crude petroleum and natural gas production
Other mining and quarrying
Slaughtering, preparing and preserving meat
Manufacture of dairy products
Grain mill products
Manufacture of bakery products
Spinning, weaving and finishing textiles
Manufacture of wearing apparel (except footwear)
Manufacture of leather and leather products (except footwear)
Manufacture of footwear
Sawmills, planing and other wood mills
Manufacture of wooden furniture and fixtures
Manufacture of pulp, paper and paperboard
Printing, publishing and allied industries
Manufacture of industrial chemicals
Manufacture of other chemical products
Petroleum refineries
Iron and steel basic industries
Manufacture of metal products (except machinery and equipment)
Manufacture of machinery (except electrical)
Manufacture of electronic equipment, machinery and supplies
Shipbuilding and repairing
Electric light and power
Construction
Wholesale trade (grocery)
Retail trade (grocery)
Restaurants and hotels
Railway transport
Passenger transport by road
Freight transport by road
Maritime transport
Supporting services to maritime transport
Air transport
Supporting services to air transport
Communication
Banks
Insurance
Engineering and architectural services
Public administration
Sanitary services
Education services
Medical and dental services
Repair of motor vehicles

Table 5. Occupations in the occupational wages around the world*

Farm supervisor	Mixing- and blending-machine operator	Bus conductor
Field crop farm worker	Labourer	Automobile mechanic
Plantation supervisor	Mixing- and blending-machine operator	Motor bus driver
Plantation worker	Packer	Urban motor truck driver
Forest supervisor	Labourer	Long-distance motor truck driver
Forestry worker	Controlman	Ship's chief engineer
Logger	Occupational health nurse	Ship's steward (passenger)
Tree feller and bucker	Blast furnaceman (ore smelting)	Able seaman
Deep-sea fisherman	Hot-roller (steel)	Dock worker
Inshore (coastal) maritime fisherman	Metal melter	Air transport pilot
Coalmining engineer	Labourer	Flight operations officer
Miner	Metalworking machine setter	Airline ground receptionist
Underground helper, loader	Welder	Aircraft cabin attendant
Petroleum and natural gas engineer	Bench moulder (metal)	Aircraft engine mechanic
Petroleum and natural gas extraction technician	Machinery fitter-assembler	Aircraft loader
Supervisor or general foreman	Labourer	Air traffic controller
Derrickman	Electronics draughtsman	Aircraft accident fire-fighter
Miner	Electronics engineering technician	Post office counter clerk
Quarryman	Electronics fitter	Postman
Butcher	Electronic equipment assembler	Telephone switchboard operator
Packer	Ship plater	Accountant
Dairy product processor	Power distribution and transmission engineer	Stenographer-typist
Grain miller	Office clerk	Bank teller
Baker (ovenman)	Electric power lineman	Book-keeping machine operator
Thread and yarn spinner	Power-generating machinery operator	Computer programmer
Loom fixer, tuner	Labourer	Stenographer-typist
Cloth weaver (machine)	Building electrician	Card- and tape-punching- machine operator
Labourer	Plumber	Insurance agent
Garment cutter	Constructional steel erector	Clerk of works
Sewing-machine operator	Building painter	Computer programmer
Tanner	Bricklayer (construction)	Government executive official:
Leather goods maker	Reinforced concreter	Stenographer-typist
Clicker cutter (machine)	Cement finisher	Card- and tape-punching- machine operator
Laster	Construction carpenter	Office clerk
Shoe sewer (machine)	Plasterer	Fire-fighter
Sawmill sawyer	Labourer	Refuse collector
Veneer cutter	Stenographer-typist	Mathematics teacher (third level)
Plywood press operator	Stock records clerk	Teacher in languages and literature (third level)
Furniture upholsterer	Salesperson	Teacher in languages and literature (second level)
Cabinetmaker	Book-keeper	Mathematics teacher (second level)
Wooden furniture finisher	Cash desk cashier	Technical education teacher (second level)
Wood grinder	Salesperson	First-level education teacher
Paper-making-machine operator (wet end)	Hotel receptionist	Kindergarten teacher
Journalist	Cook	General physician
Stenographer-typist	Waiter	Dentist (general)
Office clerk	Room attendant or chambermaid	Professional nurse (general)
Hand compositor	Ticket seller (cash desk cashier)	Auxiliary nurse
Machine compositor	Railway services supervisor	Physiotherapist
Printing pressman	Railway passenger train guard	Medical X-ray technician
Bookbinder (machine)	Railway vehicle loader	Ambulance driver
Labourer	Railway engine-driver	Automobile mechanic
Chemical engineer	Railway steam-engine fireman	Pattern makers (wood)
Chemistry technician	Railway signalman	Permanent way labourers
Supervisor or general foreman	Road transport services supervisor	Labourers (unskilled, public parks and gardens)

* Dataset by Freeman and Oostendorp.

Source: Occupational Wages around the World Dataset.

Table 6. Concordance between GTAP and occupational wages around the world industry classifications

Industry Name	GTAP sectors	ISIC-88 rev 3
Agricultural production (field crops)	nc available	11
Plantations	nc available	11
Forestry	nc available	2
Logging	nc available	2
Deep-sea and coastal fishing	fsh	5
Coalmining	col	101
Crude petroleum and natural gas production	oil	111/112
Other mining and quarrying	omn	141/142
Slaughtering, preparing and preserving meat	nc available	1511
Manufacture of dairy products	nc available	152
Grain mill products	nc available	1531
Manufacture of bakery products	nc available	1541
Spinning, weaving and finishing textiles	tex	171
Manufacture of wearing apparel (except footwear)	wap	181
Manufacture of leather and leather products (except footwear)	lea	191
Manufacture of footwear	lea	192
Sawmills, planing and other wood mills	lum	201
Manufacture of wooden furniture and fixtures	omf	361
Manufacture of pulp, paper and paperboard	ppp	211
Printing, publishing and allied industries	ppp	22
Manufacture of industrial chemicals	crp	241
Manufacture of other chemical products	crp	242
Petroleum refineries	p_c	232
Iron and steel basic industries	i_s	271+2731
Manufacture of metal products (except machinery and equipment)	fmp	28
Manufacture of machinery (except electrical)	ome	29
Manufacture of electronic equipment, machinery and supplies	ome	31
Shipbuilding and repairing	otn	351
Electric light and power	ely	401
Construction	cns	45
Wholesale trade (grocery)	trd	512
Retail trade (grocery)	trd	522
Restaurants and hotels	trd	55
Railway transport	otp	601
Passenger transport by road	otp	6021
Freight transport by road	otp	6023
Maritime transport	wtp	611
Supporting services to maritime transport	otp	630
Air transport	atp	62
Supporting services to air transport	otp	6303
Communication	cmn	64
Banks	ofi	651
Insurance	isr	660
Engineering and architectural services	nc available	742
Public administration	osg	75
Sanitary services	osg	90
Education services	osg	80
Medical and dental services	osg	851
Repair of motor vehicles	trd	502

Technical Annex

The theory

The theory of trade and comparative advantage has a long tradition in the economics profession. Starting with Ricardo (whose theory predicts that a country will export products in which it has a comparative advantage, that is, where its labour productivity is high relative to its labour productivity in other products. The theory moved on to Heckscher (1919) and Ohlin (1933) who emphasized the role of labour, capital and land in explaining how their availability shapes a country's pattern of specialisation and hence their comparative advantage. Samuelson (1948) (and others) developed the two-factor, two-sector model that became the standard for trade theory leading to the version of the H-O model where a capital rich country – that is, one that has more capital per worker than its trade partners – should export capital-intensive products.

Leontief (1953) calculated the labour-output and capital-output ratios for various sectors in the United States economy and then calculated how much of these factors were embodied in US exports and imports. He found that the capital-labour ratio of US imports exceeded the ratio embodied in exports by 60%. This finding became known as the "Leontief paradox". While the next several decades were devoted to solving this paradox, a test of the generalised H-O theory was elusive due to the fact that the theory predicts the relationship between endowments and trade within a certain technological structure. Thus to test the theory, one needs information on technology, endowments and trade.

Vanek (1968) shows that under the HO model's assumptions, using a common technology matrix, the Leontief measure of factor content should equal the economy's measure of factor abundance. That is, the total factor content of a country's production (equal to that country's endowments) minus the factor content of its consumption should provide a measure of factor abundance where those factors that are relatively abundant are exported and those that are scarce are imported. This became known as the HOV model.

Work that followed focused on identifying the gap between measured factor content of trade and the HO theoretically predicted value. Trefler (1995) was one of the first to show clearly the ways in which the data used to measure the theory deviates from the predictions of the model. Most of the subsequent work focused on the deviation of the common technology matrix and the inclusion of trade in intermediate inputs. This body of work (see, for example Davis and Weinstein (2001), Hakura (2001), Trefler and Zhu (2000, 2010) and Reimer (2006)) has shown the importance of incorporating these aspects when examining factor content of trade.

The model

We start with the Heckscher-Ohlin-Vanek (HOV) model which is set in a multi-good, multi-factor world and focuses on the factor service content, such as labour, capital and land that are embodied in the exports and imports of countries. Vanek (1968) showed that a country's net factor content of trade equals its own factor endowments minus its share of the world factor endowments, share being based on the country's share of world expenditures. So for country *i*, $F^i = V^i - s_i V^W$, where F^i is the factor content of its net trade, V^i, V^W, its and the world's factor endowments respectively and s_i its share of world expenditures. Measuring factor content of trade using expenditure shares, however, does not capture the true factor services utilised by a particular country (Deardorff, 1982). Thus, a better measure of factor content is using consumption shares.

Thus, the HOV model of international trade can be stated as:

$$F^i \equiv AT^i = V^i - s^i V^w, \qquad \text{(A1)}$$

In this specification, *A* is the input requirements matrix, *T* is the vector of net trade for *i*, such that *F* is the vector of factor content in net exports. V^i is the vector of factor endowments in country *i*, V^w is the vector of world factor endowments and s^i is country *i*'s share of total world consumption. According to equation (A1) net exports for each factor is positive (negative) if, and only if, the country's endowments of the factor are greater (lower) than the content of its total domestic consumption of that factor.

As stated above, studies have shown that the simple HOV model is strongly rejected by the data. However a model that allows for technological differences, a breakdown in factor price equalization, the existence of nontraded goods and the costs of trade is consistent with data (Davis and Weinstein 2001). Further work on the importance of intermediates in trade has shown the importance of incorporating these flows into the basic HOV framework (Reimer (2006) and Trefler and Zhu (2010)). We will take these issues in turn.

Common technology matrix

Attempts to accommodate differing technology matrices have been limited. Many studies (Davis and Weinstein (2001), Reimer (2006) and Bowen *et al.* (1997) for example) use both a simple adjustment to account for potential measurement error across economies. Aside from these simple adjustments, studies (Davis and Weinstein (2003) and Trefler and Zhu (2010) and Reimer 2006)) also adjust the technology matrices for productivity differentials, using the United States as a base. Under this hypothesis, the technologies of countries differ only by a Hicks-neutral shift parameter that can be characterised by a country-specific technology shift with respect to the United States. Finally, there are examples where researchers have incorporated specific country technology matrices in the analysis. For example, Hakura (2001) used OECD input output tables to allow for varying technology across four OECD members and found this improved the fit of the model significantly. However, this was applied to a subset of trading nations and applied a common technology to *all* inputs (domestic as well as imported).

In the approach applied in this paper we make no adjustment for productivity differences among countries.

First, studies examining the factor content generally look at a subset of countries and thus apply a common reference base (either technology matrix or productivity adjustment). For example, Reimer examines the factor content of trade in the context of two entities: the United States, and an agglomeration of technology matrices for the rest of the world (ROW). He then adjusts this ROW matrix for productivity differences with respect to the base country, the Unites States. In this study, we apply country-specific technology matrices for each of the economies examined and thus the differences in the technologies applied in each region are captured in their own technology matrices.

On a more practical basis, the primary reason for the implementation of this adjustment in the literature is to improve the performance of their measured factor content when tested against the theoretically predicted value. It is not the purpose of this work to test the validity of the HOV model. Indeed, as briefly outlined above and in much more detail in the various works cited, this service has been performed. Rather we are using the model to measure factor content and fully expect these values to diverge precisely based on their productivity differentials. To do a prior adjustment for these differences is to reduce the information available in the measured values themselves.

Factor price equalisation

The failure of factor price equalisation (FPE) can lead to important differences in the technology matrices for traded and nontraded goods. The input coefficients differ in tradables because the failure of FPE has led countries to specialise in different goods. They differ in nontradables because the same goods are produced with different factor proportions. To the extent that FPE breaks down, the standard HOV needs to be adjusted to account for departures in the factor usage of nontrables goods from world averages.

The need to make this adjustment is tied to the standardisation of technology matrices across countries. Again, we are not applying world averages when inputting our technology matrices so the adjustment is not as critical for our database. However, this issue does come into play when determining which data measurement (i.e. values versus units) arises. If the only reason that factor prices differ is due to factor-augmenting productivity differences, then we can use the reported values as representative of efficiency-adjusted factor usage as this measure is well suited for calculations of the input matrices. However, it is well acknowledged that FPE breaks down for reasons beyond quality differences. To the extent this breakdown is not captured, it is preferable to measure factor usage in terms of physical units and adjust for international quality differences in a different manner.

Converting to physical units poses several problems for the analysis presented here. First, it dramatically reduces the number of factors available for examination to those with relevant, observable price information, i.e. total labour and capital. It also removes a source of information on factor-augmenting productivity differences which, as explained above, we purposefully make no adjustment for. Finally, as stated above, studies of factor content are designed to test the differential between fit of the theorectically-constrained model (for example, under assumptions of the realisation of factor price equalisation) and measured values. We, on the other hand, are interested in what measured values say about revealed patterns of trade between countries. The theory often factors away the exact differences we hope to observe. Thus, we maintain measurement using values as opposed to units.[40]

Intermediates

While previous studies have incorporated intermediates into their analysis, they are generally treated as non-traded (for example Davis and Weinstein (2001) and Hakura (2001)). Reimer developed an approach allowing for internationally traded intermediate inputs in to the calculation of factor content. Theoretical proofs for such an approach were further provided in Trefler and Zhu (2010), that demonstrated the class of models that completely characterises, and are implied by, the Vanek prediction of the factor content of trade, including a traded intermediate sector. This section relies upon these theoretical developments to construct measures of factor content that accounts for both technological differences across country's production processes while explicitly including trade in intermediate goods that does not impose the importing country's technology, but rather allows for the producing a country's choice in techniques.

Consider an economy with *k* factors and *i* goods so that the Leontief matrix is:

$$D(I - B)^{-1} \qquad (A2)$$

Where each column of the *k* x *i* matrix *D* consists of primary factor inputs and each column of the *i* x *i* matrix $(I - B)^{-1}$ captures the total intermediate inputs in the production of a good or service.[41] Proper measurement of *B* ensures that the matrix of direct and indirect factor requirements includes all the services of *k* endowments. In addition, by defining each *D* and *B* matrix through each country's unique input-output structure, we capture the technological differences in production needed to completely define the factor content approach.

Referring back to the original HOV equation (1), we can restate it as follows:

$$F_k^i \equiv AT_k^i$$

A now defined as

$$A^i \equiv D^i (I - B^i)^{-1} \qquad (A3)$$

thus:

$$F_k^i = D_k^i (I - B^i)^{-1} T_k^i \qquad (A4)$$

Trefler and Zhu (2010) argue while several studies have applied equation (A4) to measure factor content, they have not done so consistently, nor fully accounting for international technological diversification. They show that the definition of factor content of trade needs to satisfy three criteria: 1) must be Vanek-relevant, that is consistent with the Vanek prediction that factor content is defined as in *(A1)*; 2) the definition has a clear

40. As a means of comparison we adjusted for prices in the capital resource using data from two different sources: the Penn World Tables (as in Trefler and Zhu (2006)) and prices derived directly from the GTAP database (as in Reimer (2006)) and found no substantial qualitative differences in the results at the sector level.

41. See Trefler and Zhu (2010) for the technical proof.

and useful economic interpretation; and 3) the definition does not require restrictions on the form of international choice of technology. However, arriving at such a definition of factor content when international technology matrices are allowed to vary has proven difficult.

As stated above, Reimer (2006) does allow for internationally determined and traded intermediate inputs in his model. He uses a horizontal concatenation of country-specific direct factor input matrices to construct *B* in equation (A4) and thus provide an indication of how much of the world's factor *k* is embodied in *i*'s production of a good. However, Reimer's model consists of two countries: the United States and the ROW and two factor inputs, labour and capital. Thus, it does not completely specify a variety of international technological choices. As we are attempting to measure the factor content (and thus input matrices) for 44 regions and five factors of production, applying such an approach becomes unwieldy, not to mention involving the loss of a tremendous amount of detail.

Trefler and Zhu (2010) developed a more generalised approach relying on the proportionality assumption to recover a *B* matrix that is consistent with their three criteria. They derive an adjustment parameter, θ to recover the share of domestic consumption, including intermediates, sourced locally. [42] Thus, we are able to estimate the world trade in intermediate inputs – that is, those sourced (and produced) locally and those sourced (and produced) overseas – by defining *B* as:

$$\mathrm{B}_{\mathrm{j}}^{\mathrm{i}} = \mathrm{B}^{\mathrm{i}} * \theta_{\mathrm{j}}^{\mathrm{i}} \qquad \text{(A5)}$$

Where $\mathrm{B}_{\mathrm{j}}^{\mathrm{i}}$ is the input matrix of *i* sourced from *j* and θ is defined as:

$$\theta_{\mathrm{j}}^{\mathrm{i}}(g) \equiv \frac{M_j^i(g)}{\mathrm{Q_i(g)+M_i(g)-X_i(g)}} \quad \text{for all } \mathrm{j} \neq \mathrm{i} \qquad \text{(A6)}$$

Where *Q* is output of good *g* in *i*, *M* is imports of good *g* (in the numerator into *i* from *j*, and the denominator is *i*'s total imports of *g*) and *X* is the exports of *g* from *i*. Thus $\theta_{\mathrm{j}}^{\mathrm{i}}$(g) is the share of domestic absorption that is sourced from country *j*. Summing over all *j* sources and subtracting from 1 provides the share of good *g* that is sourced locally.

Referring explicitly to an intermediate input matrix of dimensions *g, h* (input of good *g* into industry *h*), we define $\mathrm{B}_{\mathrm{j}}^{\mathrm{i}}$ *(g,h)* as elements of $\mathrm{B}_{\mathrm{j}}^{\mathrm{i}}$ and $\hat{B}_i$ *(g,h)* as elements of $\hat{B}_i \equiv \sum_j B_j^i$. We then have:

$$\sum_{j \neq i} B_j^i(g,h) = \hat{B}_i(g,h) \sum_{j \neq i} \theta_j^i(g) \text{, (imported intermediates)}$$

$$B_i^i(g,h) = \hat{B}_i(g,h)\theta_i^i(g) \text{, (local intermediates)} \qquad \text{(A7)}$$

And further, a simple extension leads us to:

$$B_j^i(g,h) = \hat{B}_i(g,h)\theta_j^i(g) \text{ for all } i \text{ and } j \qquad \text{(A8)}$$

42. Again, Trefler and Zhu (2010) report the details on the derivation of θ.

As expressed in equation (A5), where equation (A5) suppresses the (*g*,*h*) reference to industries. When Trefler and Zhu (2010) applied this adjustment to data for 41 countries, focusing on labour inputs, their results show a 95% consistency rate with predicted values, as opposed to the 34% reported in previous studies.

By measuring the amount of factors used *worldwide* to produce a country's trade flows, we can say that the factor requirements matrix for country *i*'s trade is constructed accounting for the complete production process of each good that enters into net exports and adding up the factors actually used, including those used in producing intermediate inputs overseas (Deardorff 1982). This will further allow us to analyse the role of intermediate inputs in trade, by comparing the *F* derived in equations (A1) with its counterpart expressed generally in equation (A4), and adjusted by (A5).

Ranking factor content

In order to better understand the potential drivers of the factor content of trade, it is important to understand the relative factor endowment structure both within, and between, countries, and how that has changed over time. According to equation (A1), net exports of a factor is positive (negative) if the country's endowment of the factor is great (lower) than its content of total domestic consumption, that is if $V^i_k - s^i V^w_k > 0$, for factor *k*. Additionally, it is possible to look at a country's relative factor abundance (each endowment relative to other endowments within a country) by examining the variables normalised by the factor content of the country's consumption. Again, from equation (A1) we can define the following:

$$c_k = V_k^w * s \qquad \text{(A9)}$$

where *s* remains the country's share of world consumption, V^w_k is the world endowment of factor *k* and c_k is the content of factor *k* in domestic consumption (Muriel and Terra 2009). The factor abundance test can be compared across the various factors *k* such that:

$$\frac{V_k^i}{c_k} > \frac{V_{k'}^i}{c_{k'}} \qquad \text{(A10)}$$

The relationship in (9) states that the content of factor *k* in net exports is higher (lower) than that of factor *k'* if factor *k* is relatively more abundant (less abundant); where factor contents are normalised by domestic consumption. We can also restate these values, measuring factor abundance by income rather than consumption, adjusting this value to take account of the trade balance as in Bowen and Sveikauskas (1992). To account for a country's income level (Y_i) adjusted by the trade balance (b_i) we can restate c_k as follows:

$$c_k^b = \frac{Y_i}{Y_i - b_i} * c_k \qquad \text{(A11)}$$

and rank each factor accordingly.

Data

In order to derive the various data points needed to obtain a HOV-consistent measure of factor content of trade, we need to have consistent measures of world output, consumption, trade, factors of productions and intermediate inputs. One source which provides such a database is the Global Trade Analysis Project (GTAP). The details of this data can be found in the Data Annex.

Wage regressions

The specification for the cross-sectional wage regressions is:

$$y_{ik} = X\beta + \varepsilon_{ik} \qquad \text{(A12)}$$

where *i* indexes occupations and *k* countries;

y_{ik} is a vector of observations containing the growth rate of real wages by occupation by country in the sample;

X is a matrix of observations with its first column containing a vector of ones, the logarithm of GDP per capita in 1984, and the logarithm of total trade as a share of GDP in 1984;

ε_{ik} is the regression's error term; and

β is a vector of parameters to be estimated.

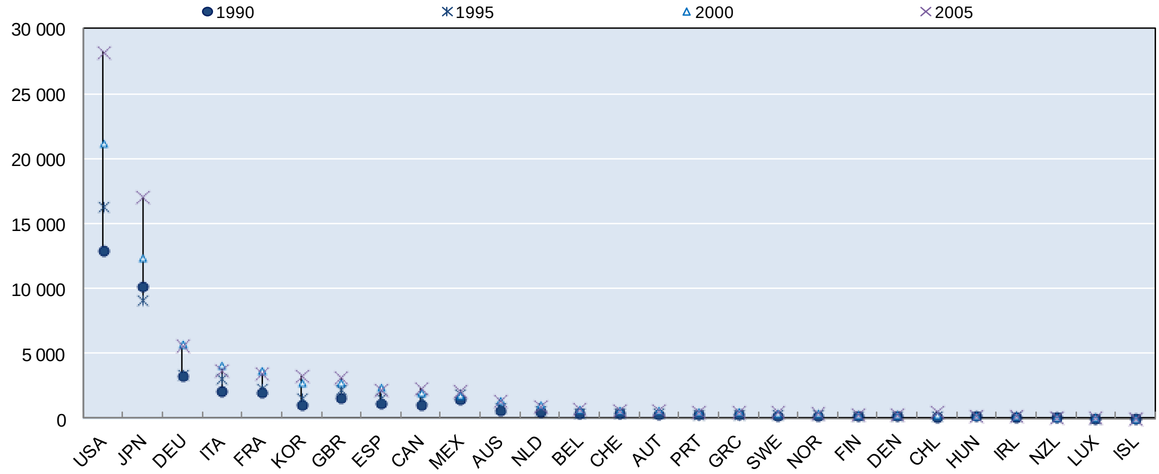
The parameter estimates are presented in Tables A4, A5, and A6 of the Annex Tables and Graphs.

Annex Tables and Graphs

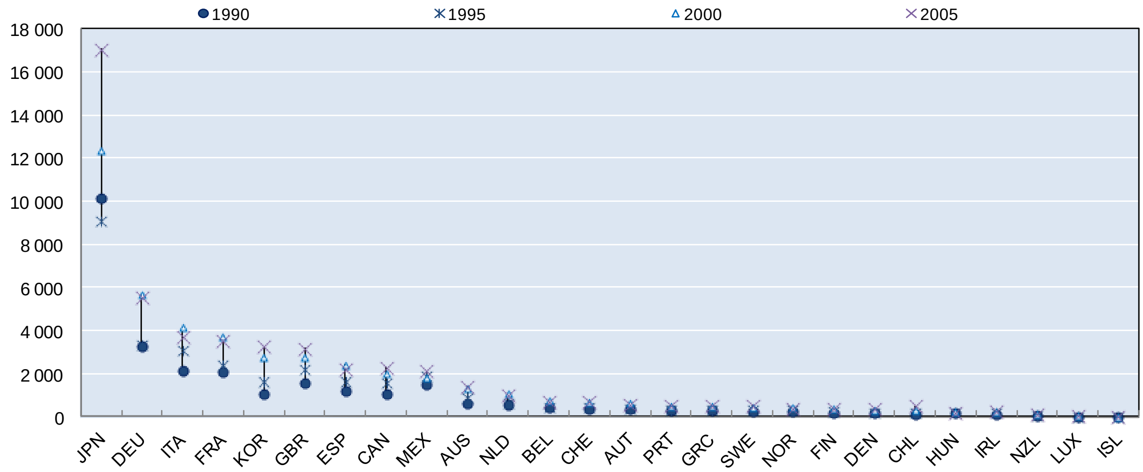
Figure A1. Capital Stocks

In billion

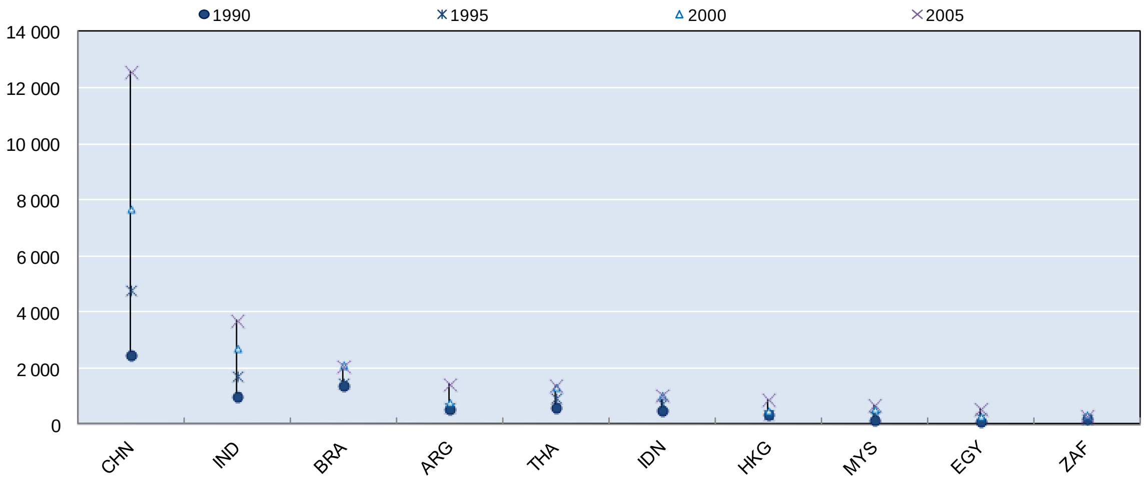
A. OECD



B. OECD without United States



C. Selected emerging markets

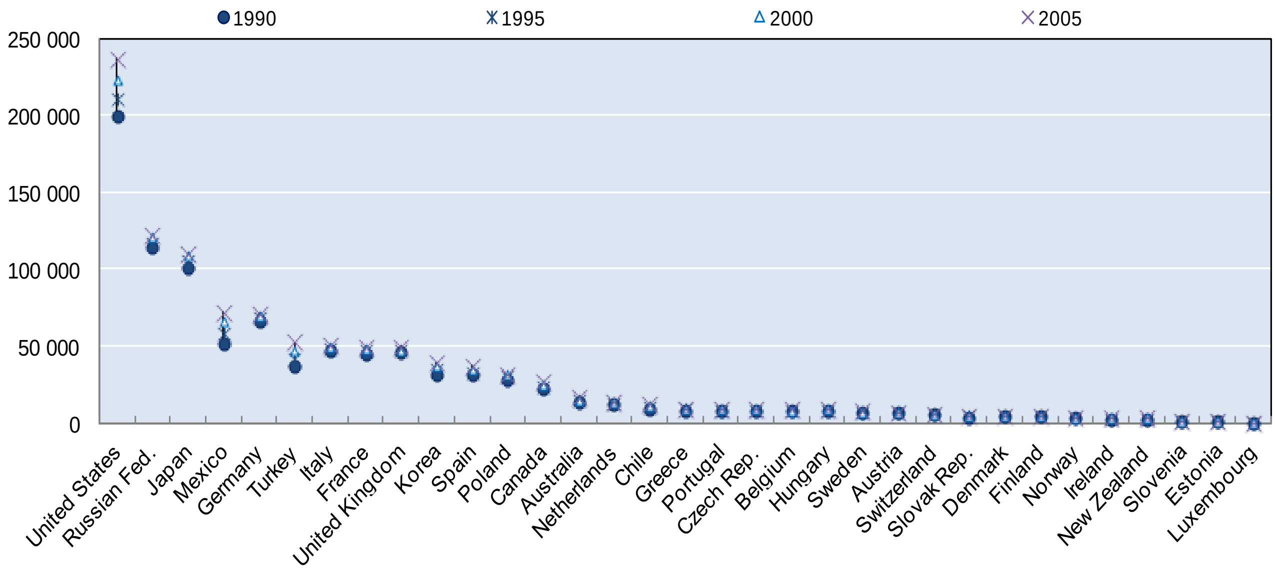


Source: WDI, author's calculations.

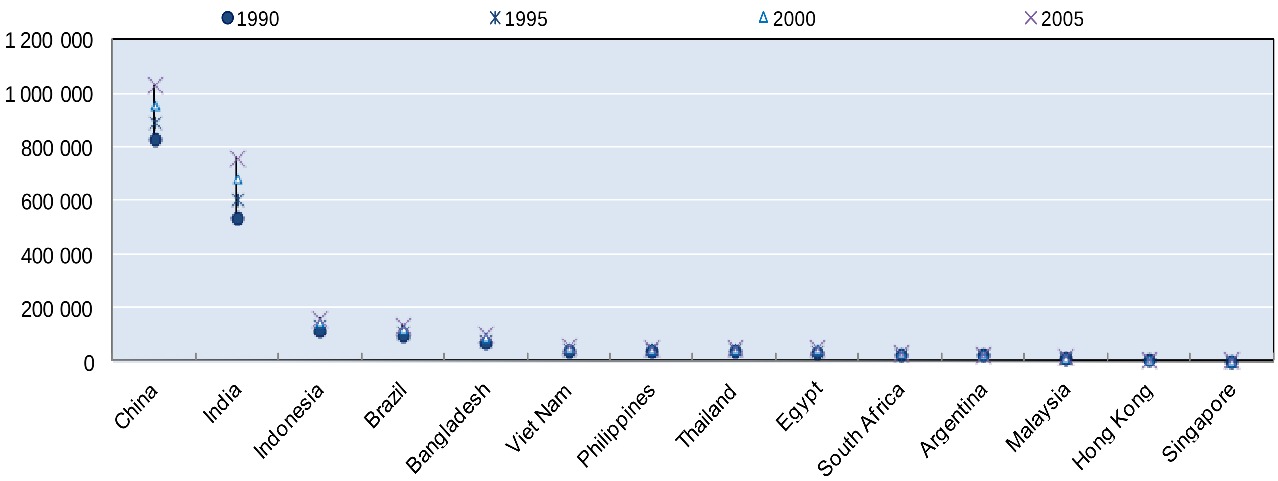
Figure A2. Total labour force

In million

A. OECD



B. Selected emerging markets

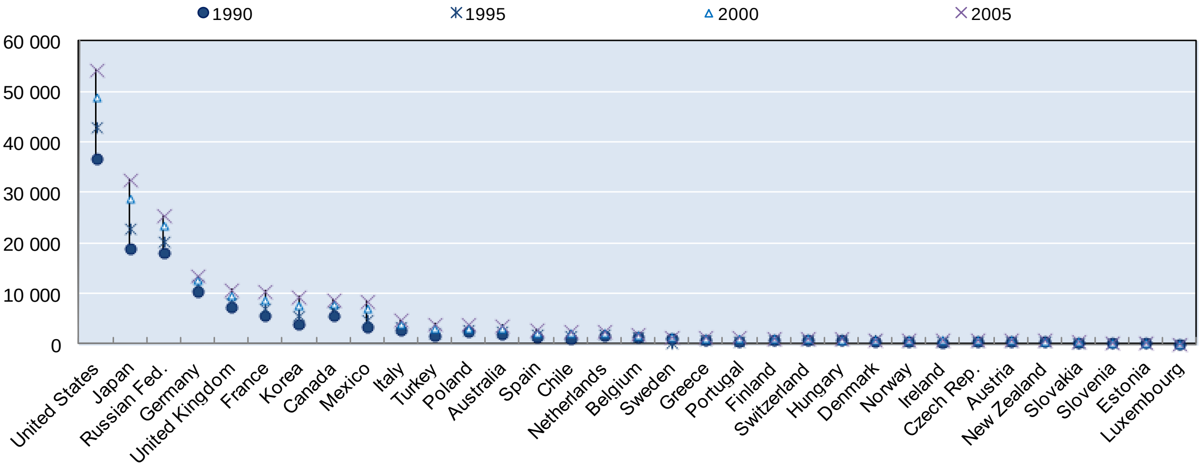


Source: IIASA/VID.

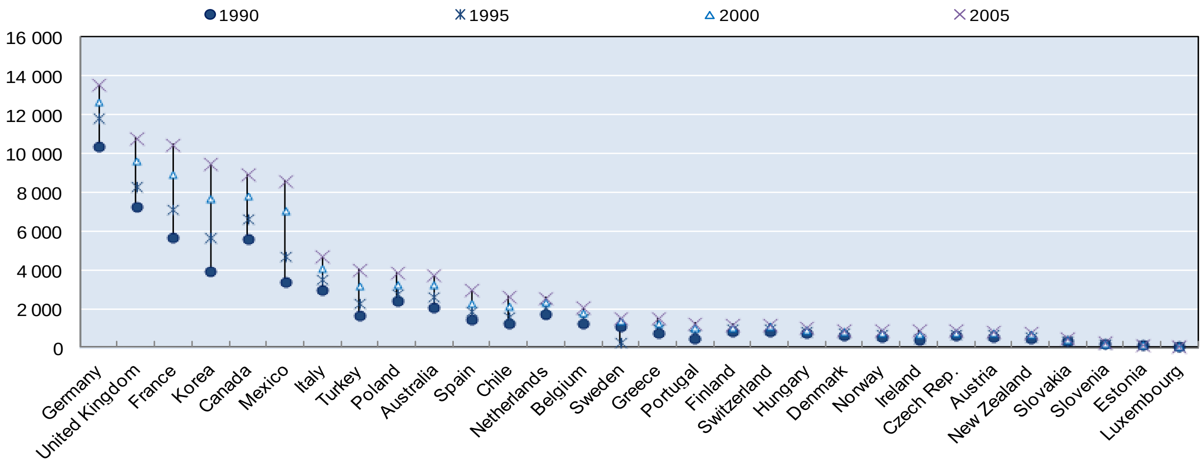
Figure A3. Skilled Labour Stocks

In thousands

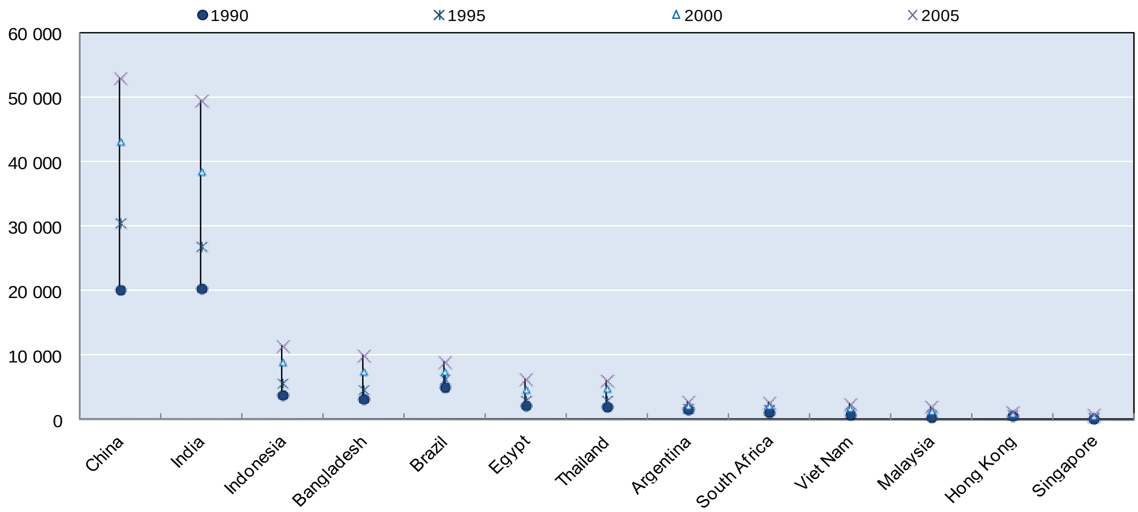
A. OECD



B. OECD without United States, Japan and Russian Federation



C. Selected emerging markets

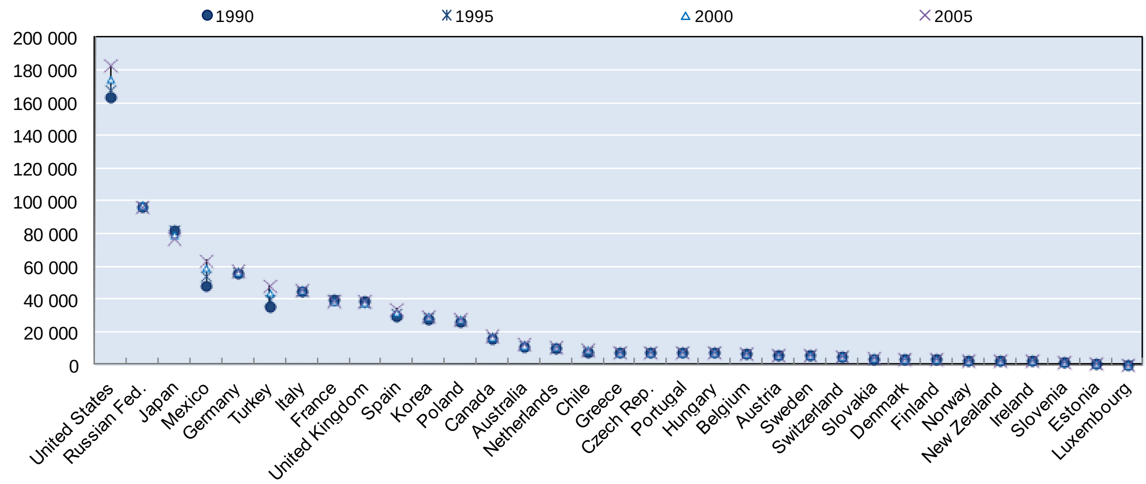


Source: IIASA/VID.

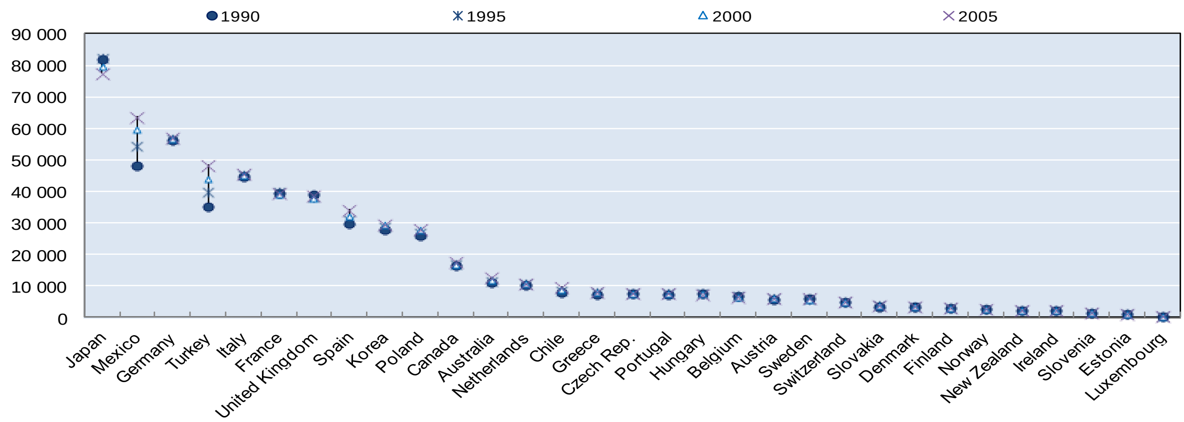
Figure A4. Unskilled labour stocks

In thousands

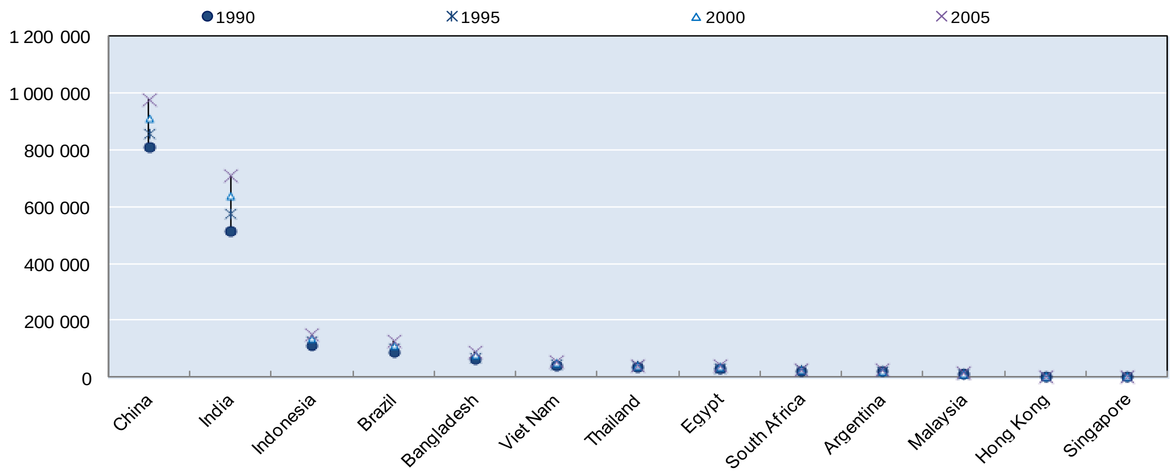
A. OECD



B. OECD without United States and Russian Federation



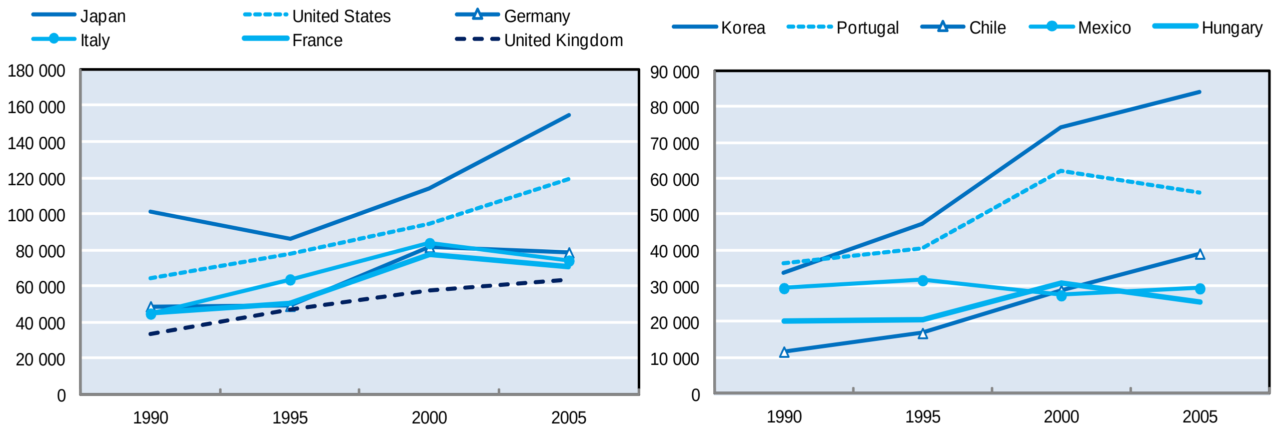
C. Selected emerging markets



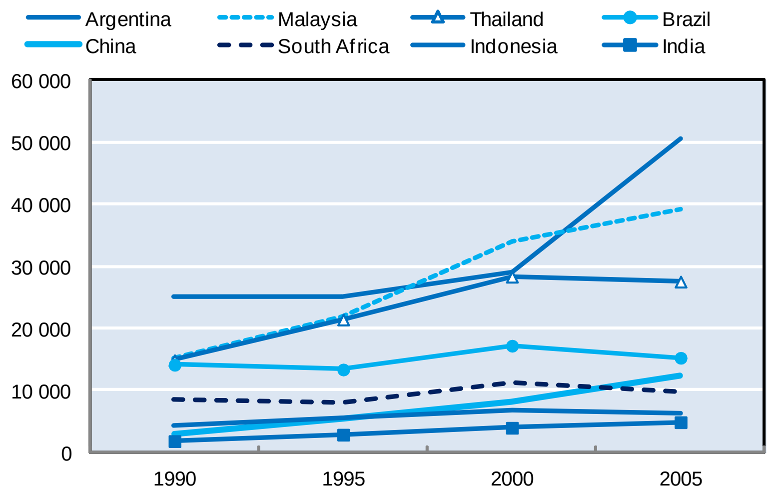
Source: IIASA/VID, 1970-2000, 2000-2050 datasets.

Figure A5.Capital-labour ratios

A. Selected OECD countries



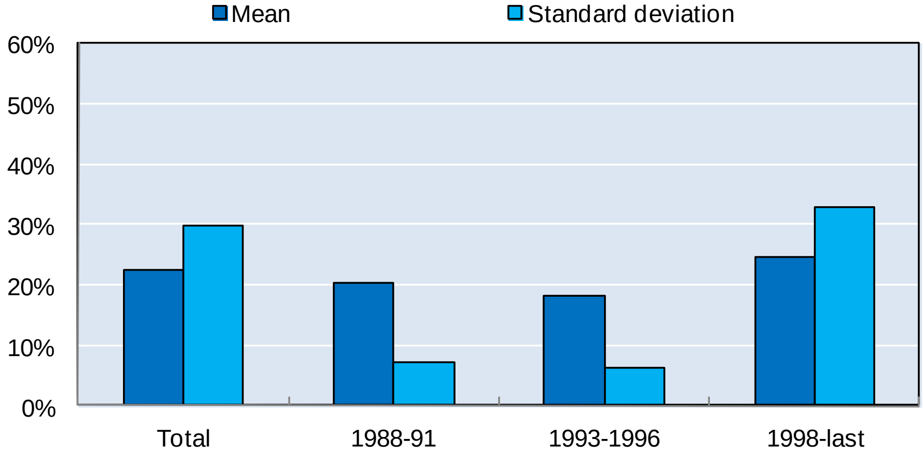
B. Selected emerging economies



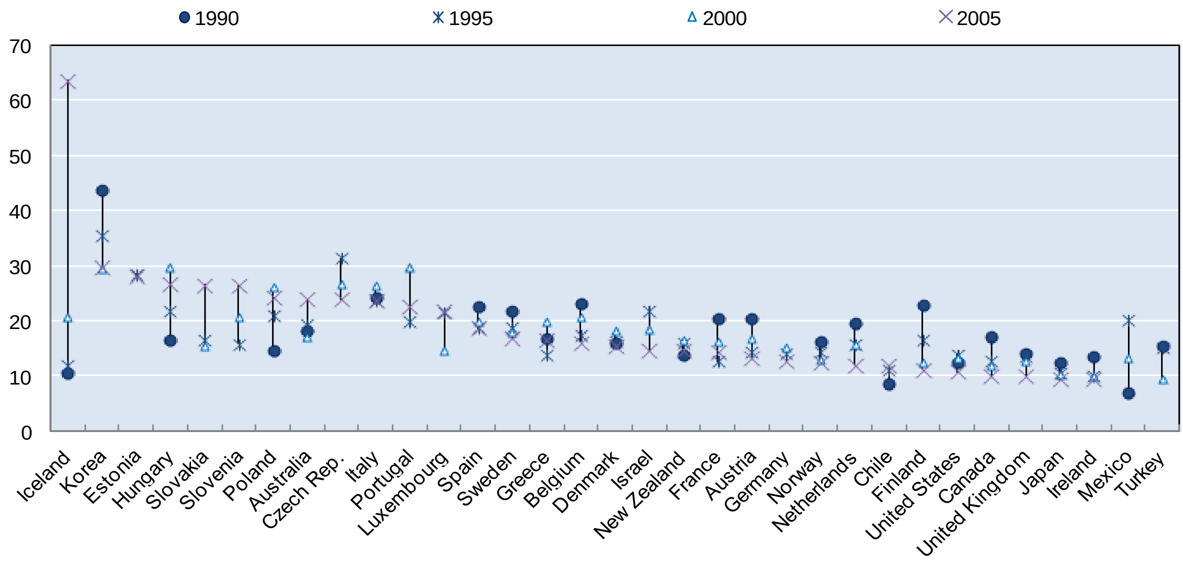
Source: WDI for capital and IIASA/VID for labour stocks, author's calculations. Ratios using WDI values for both capital and labour are qualitatively the same.

Figure A6. GFCF to VA

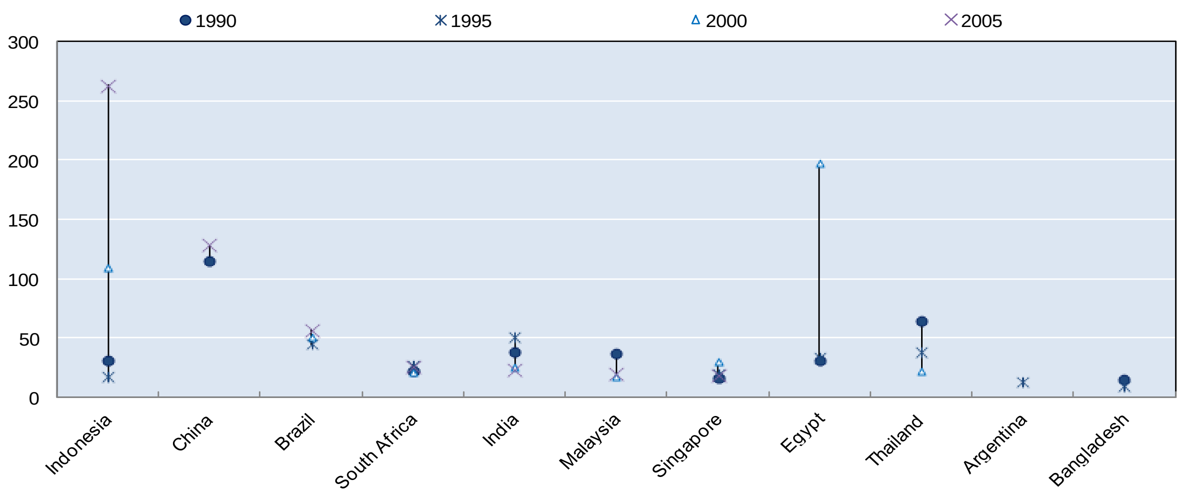
A. GFCF to Value Added for Total Sample



B. OECD



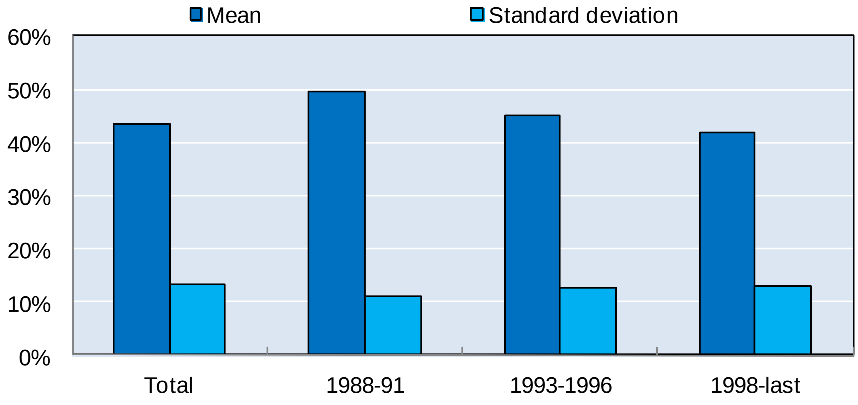
C. Selected emerging markets



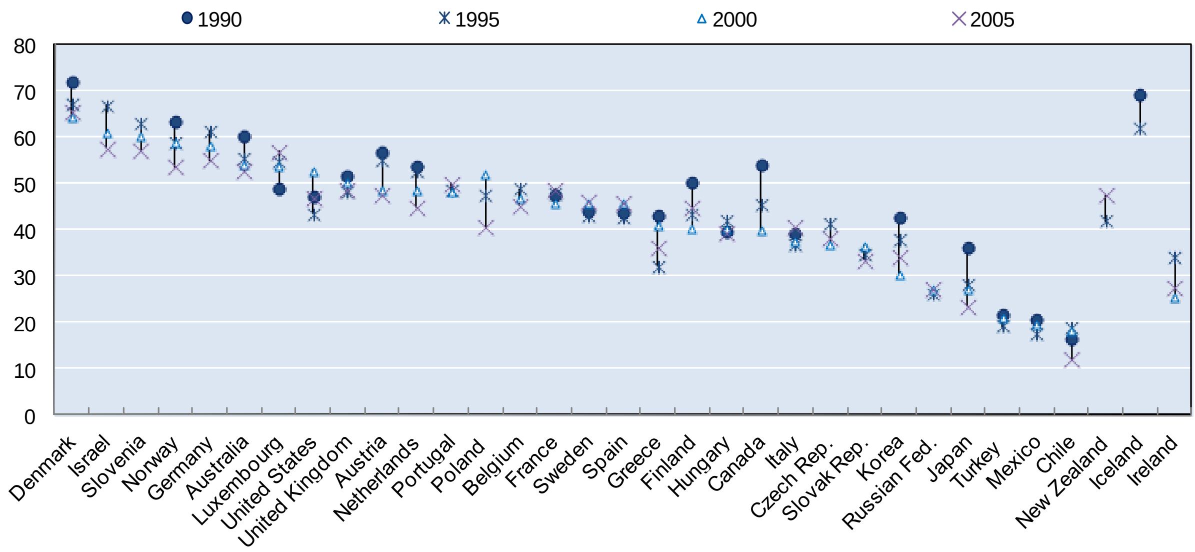
Source: OECD STAN, UNIDO Industrial Statistics, WB TPP and National Sources.

Figure A7. Total Wage Bill to VA

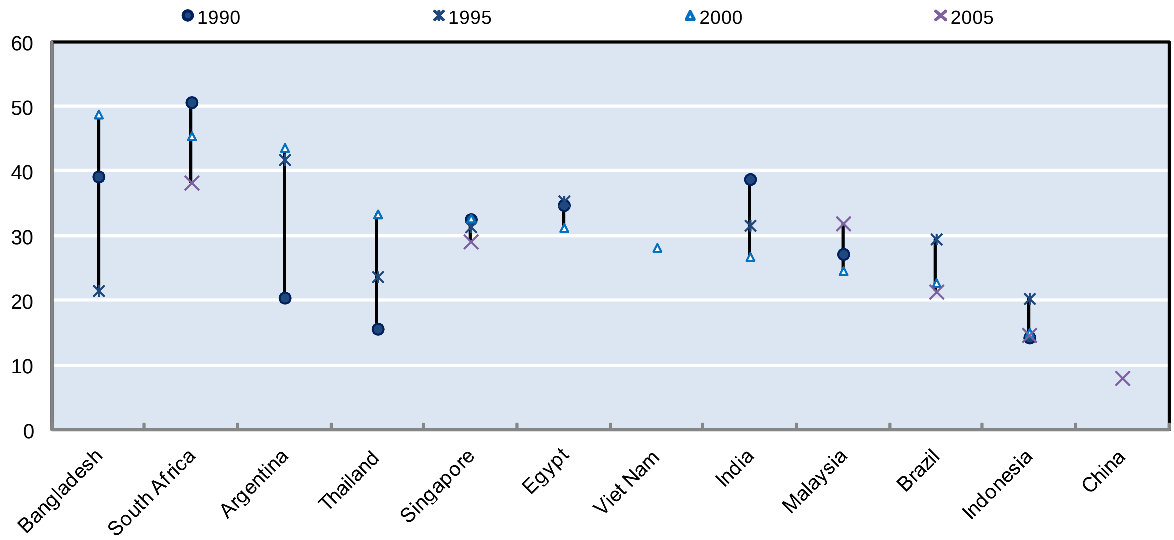
A. Total Wage Bill to VA for Total Sample



B. OECD



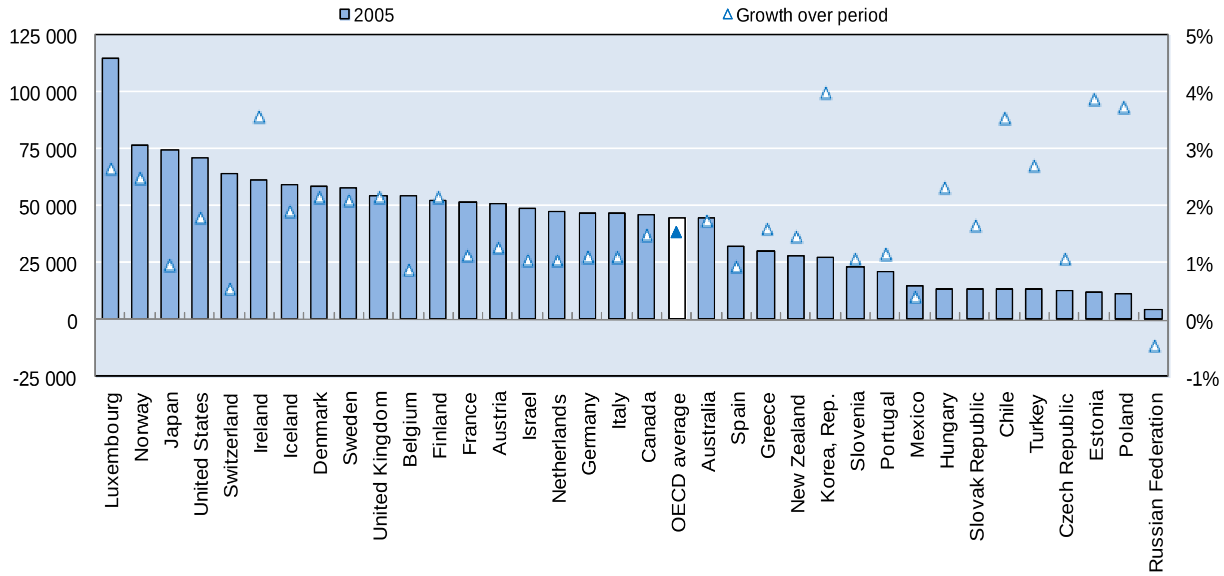
C. Selected emerging markets



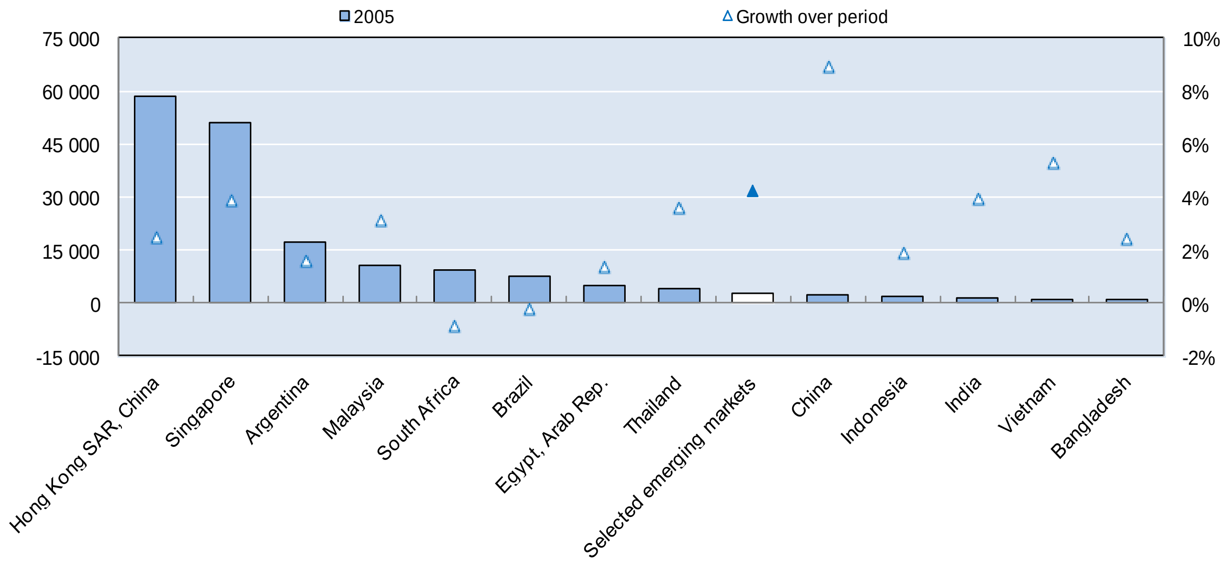
Source: OECD STAN, UNIDO Industrial Statistics, WB TPP and National Sources.

Figure A8. GDP per worker

A. OECD



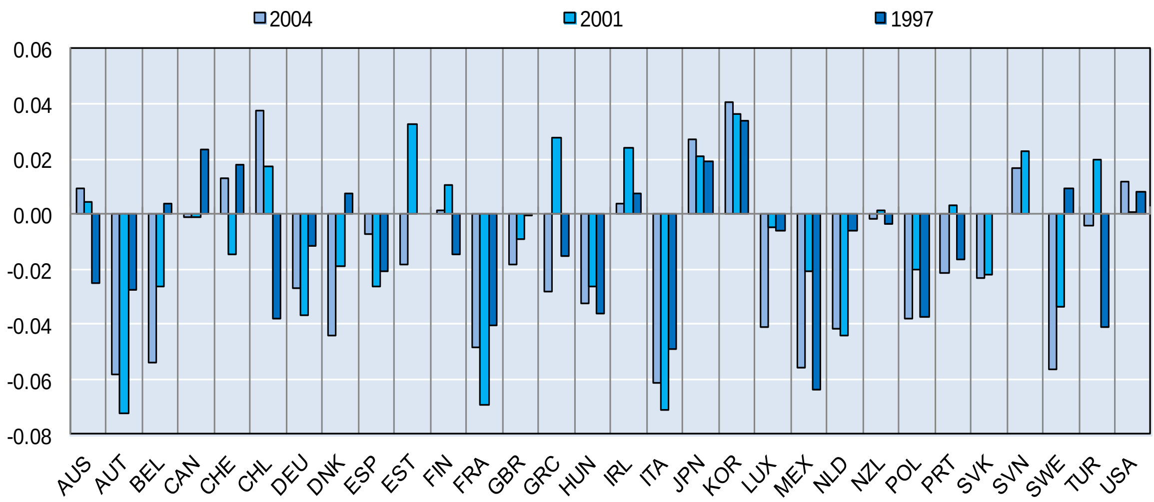
B. Selected emerging markets



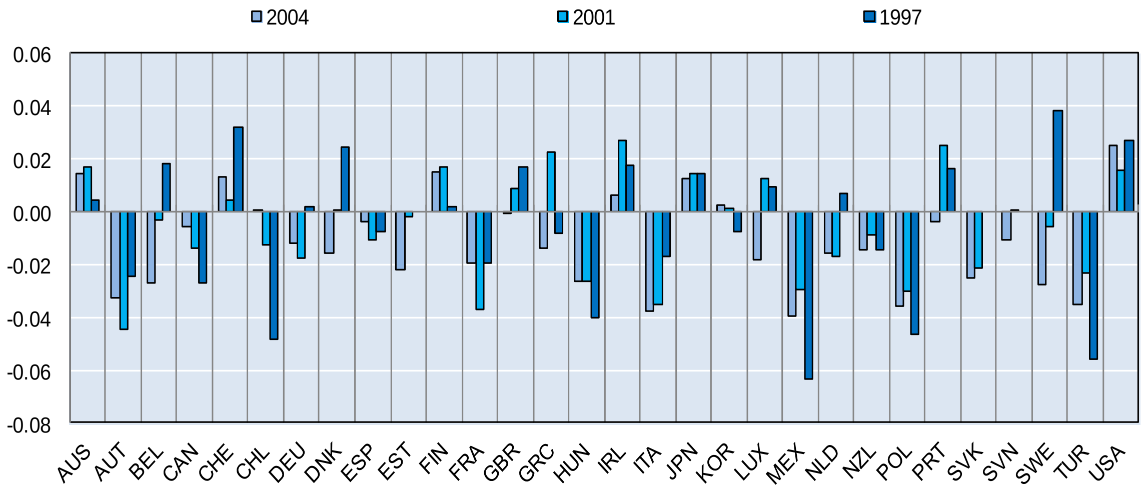
Source: WDI.

Figure A9. Country level measures of factor content, OECD countries

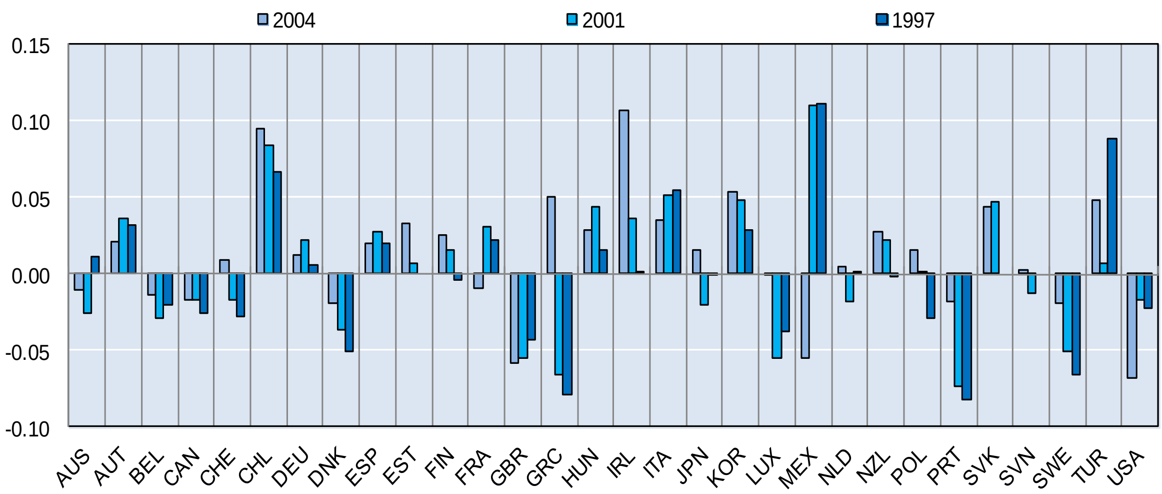
A. Unskilled labour



B. Skilled labour



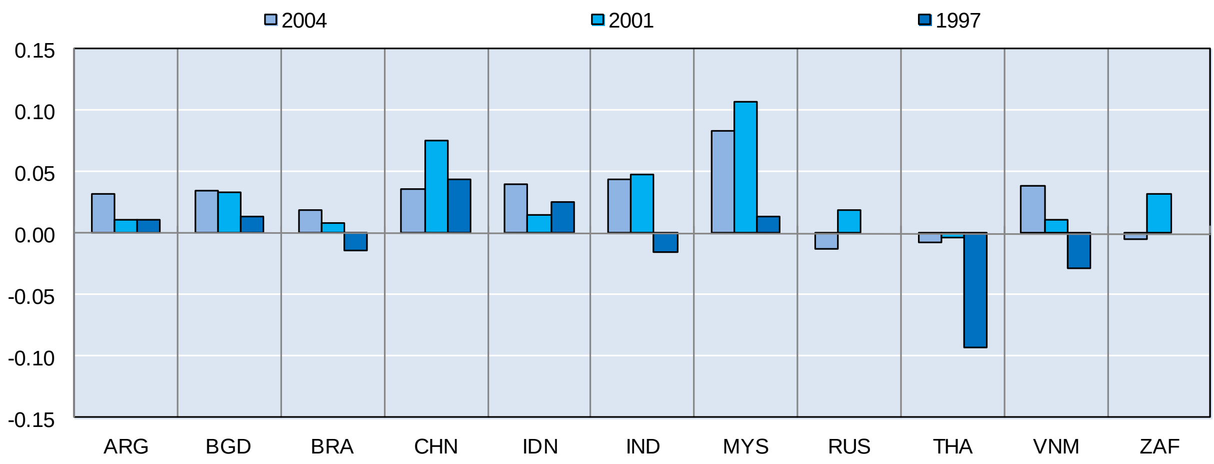
C. Capital



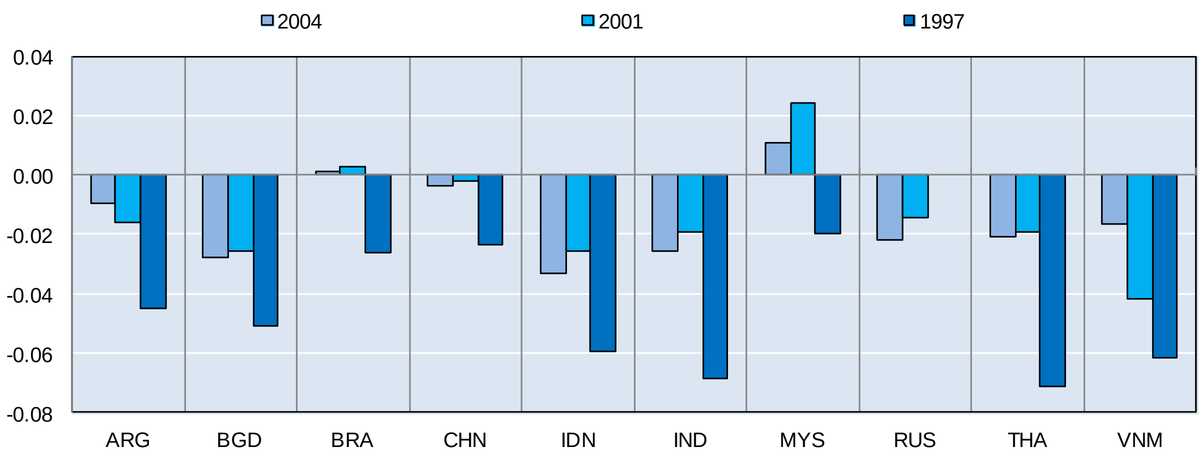
Source: Author's calculations based on GTAP database versions 5, 6 and 7.1.

Figure A10. Country level measures of factor content, selected emerging economies

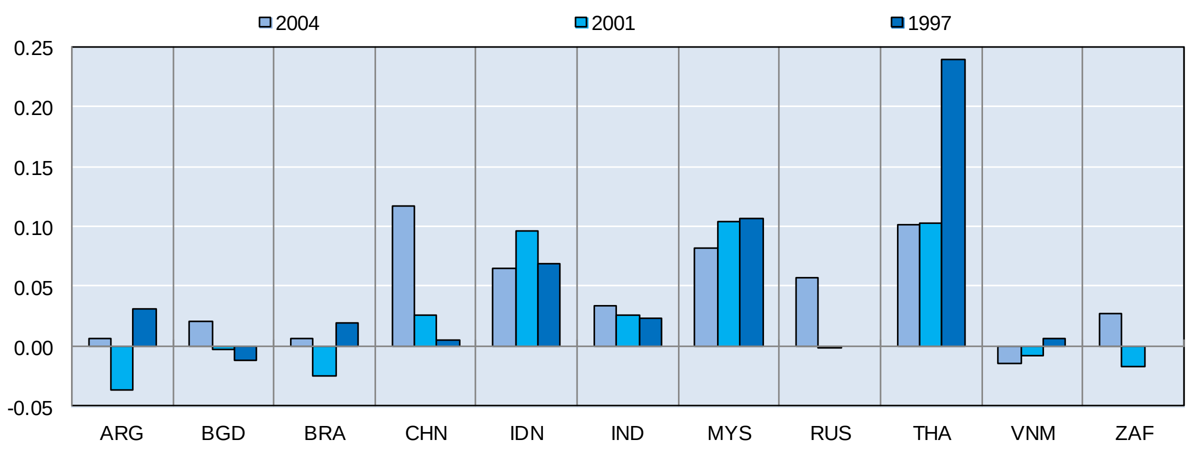
A. Unskilled labour



B. Skilled labour



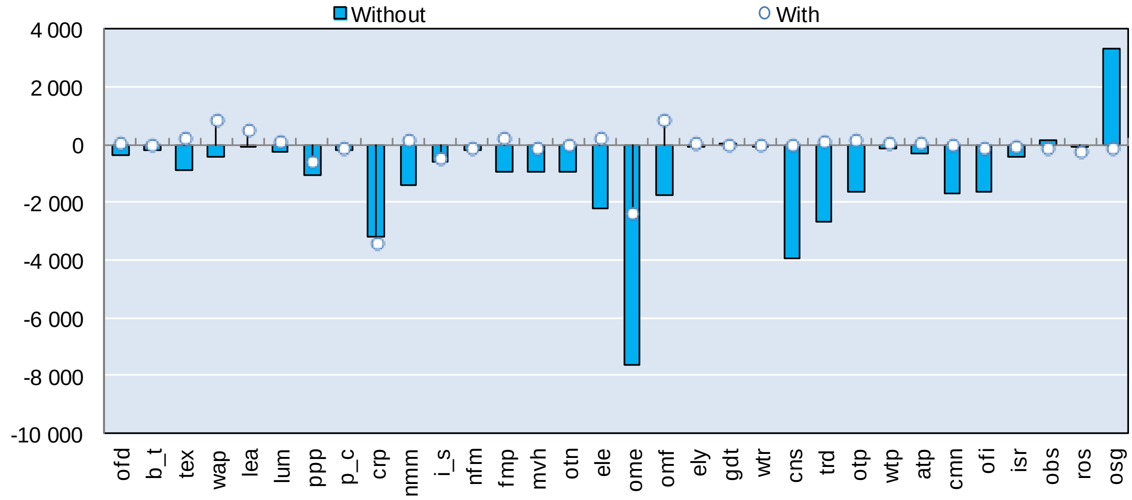
C. Capital



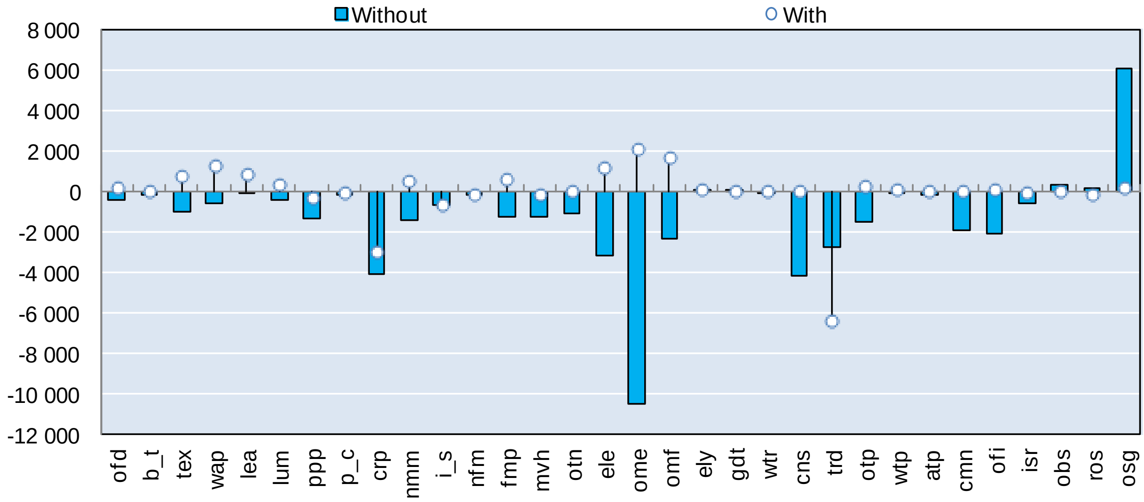
Source: Author's calculations based on GTAP database versions 5, 6 and 7.1.

Figure A.11. China skilled labour

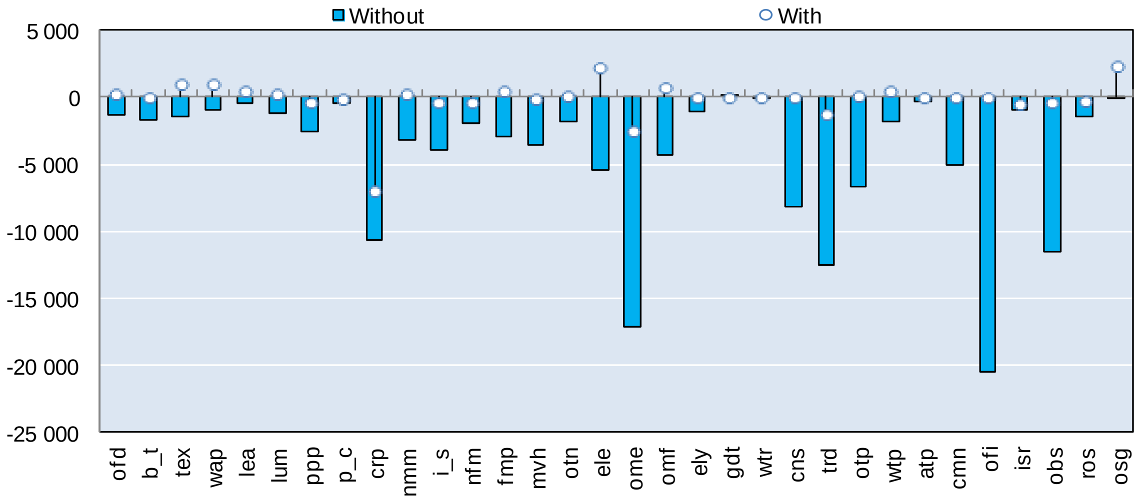
A. 1997



B. 2001



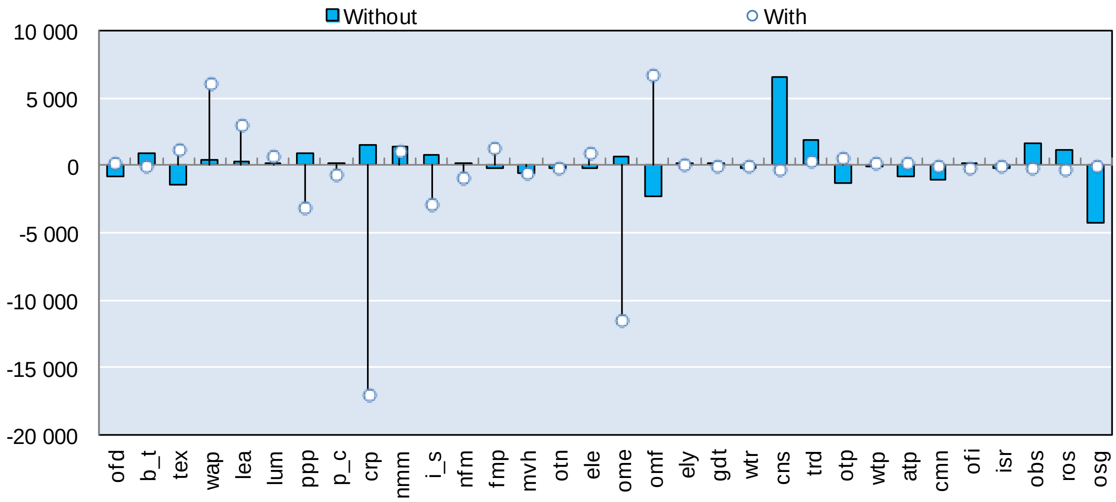
C. 2004



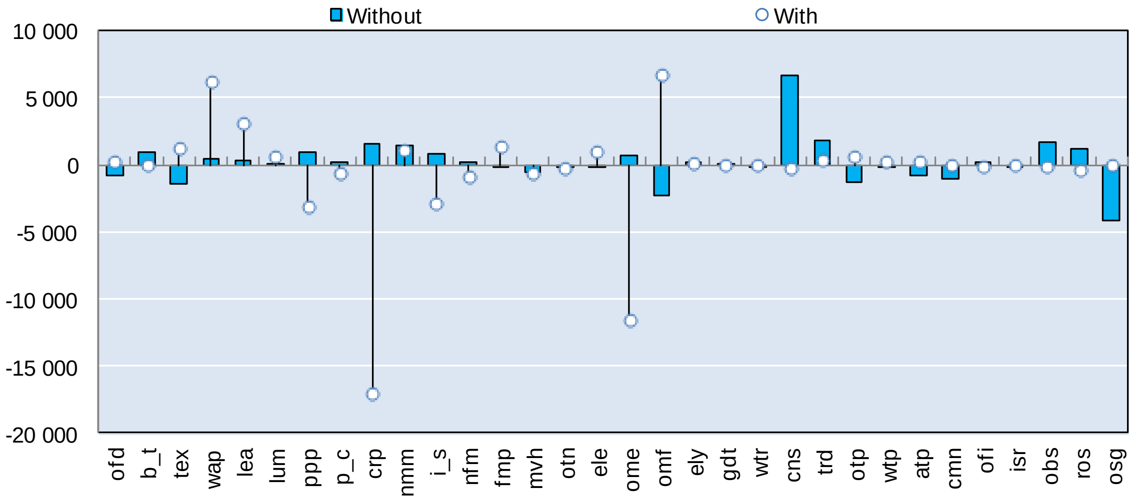
Source: Author's calculations based on GTAP database versions 5, 6 and 7.1.

Figure A12. China unskilled labour

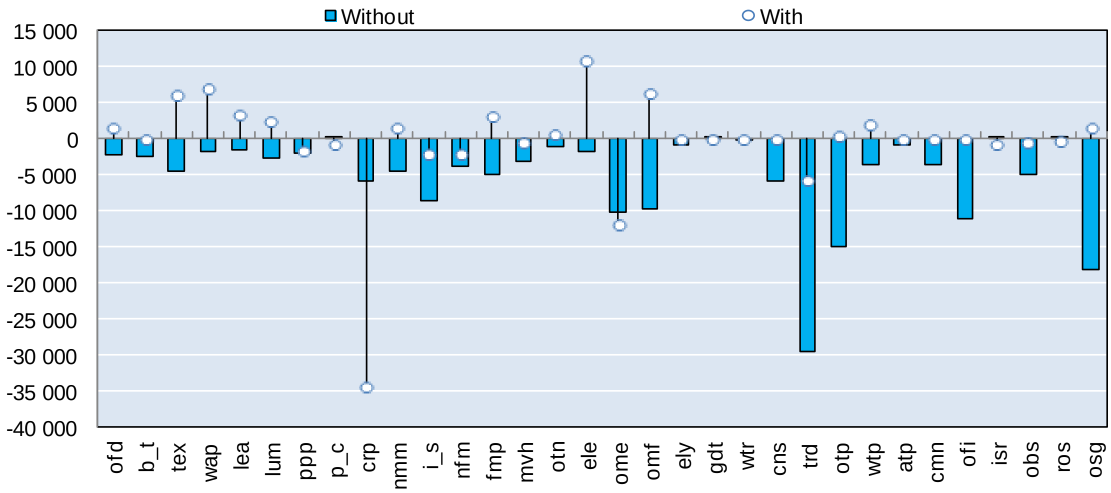
A. 1997



B. 2001

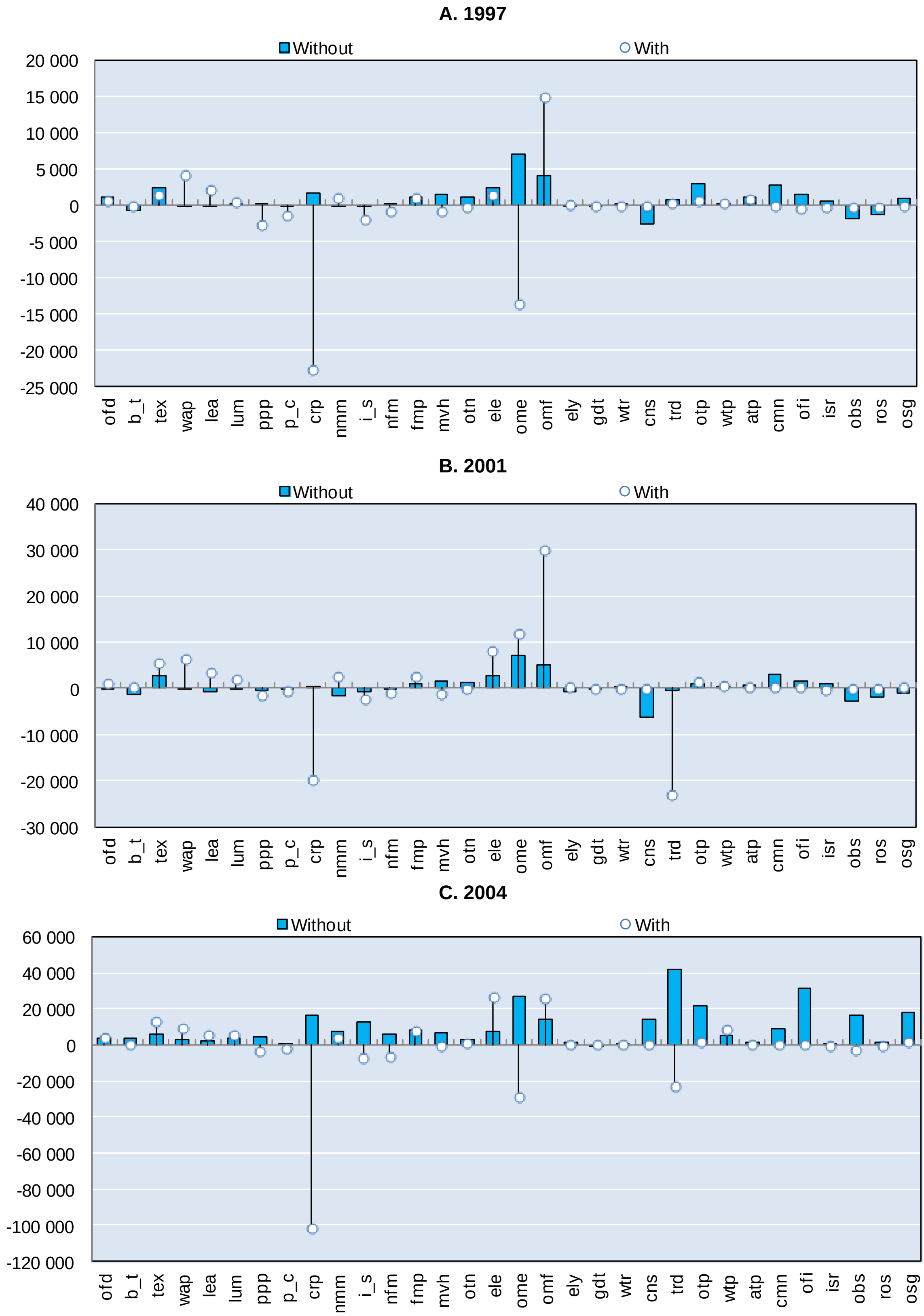


C. 2004



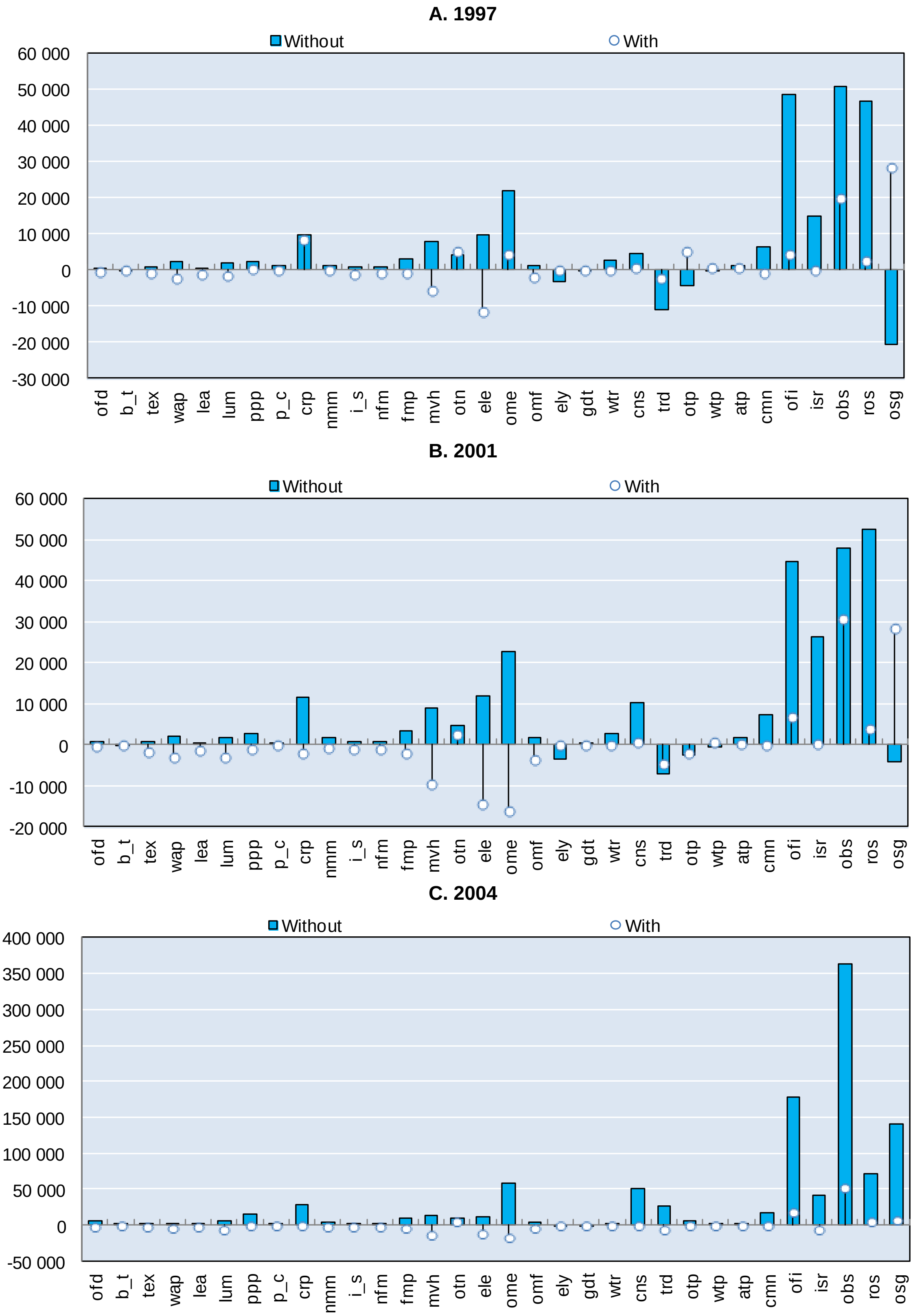
Source: Author's calculations based on GTAP database versions 5, 6 and 7.1.

Figure A13. China capital



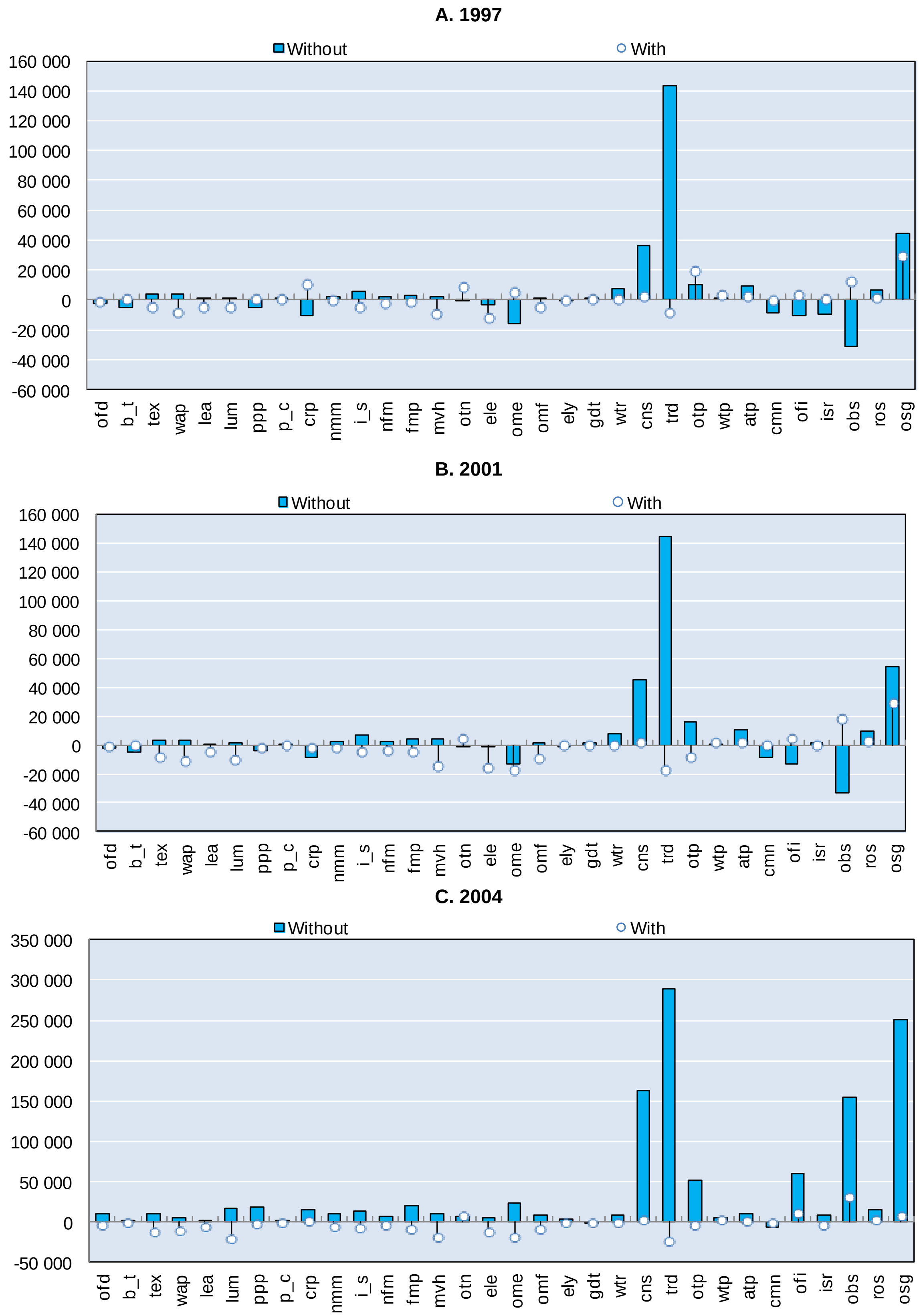
Source: Author's calculations based on GTAP database versions 5, 6 and 7.1.

Figure AUS skilled labour



Source: Author's calculations based on GTAP database versions 5, 6 and 7.1.

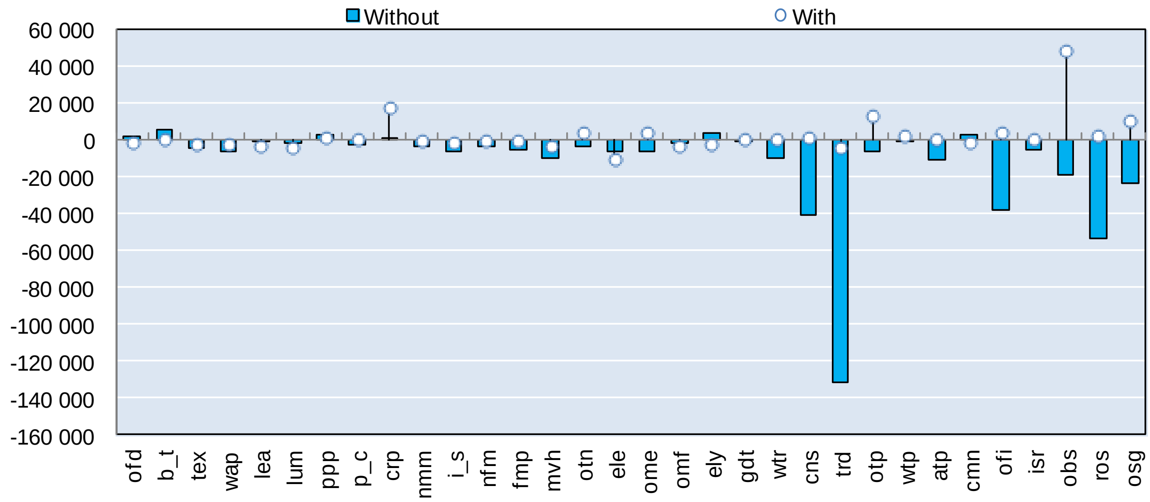
Figure A15. US unskilled labour



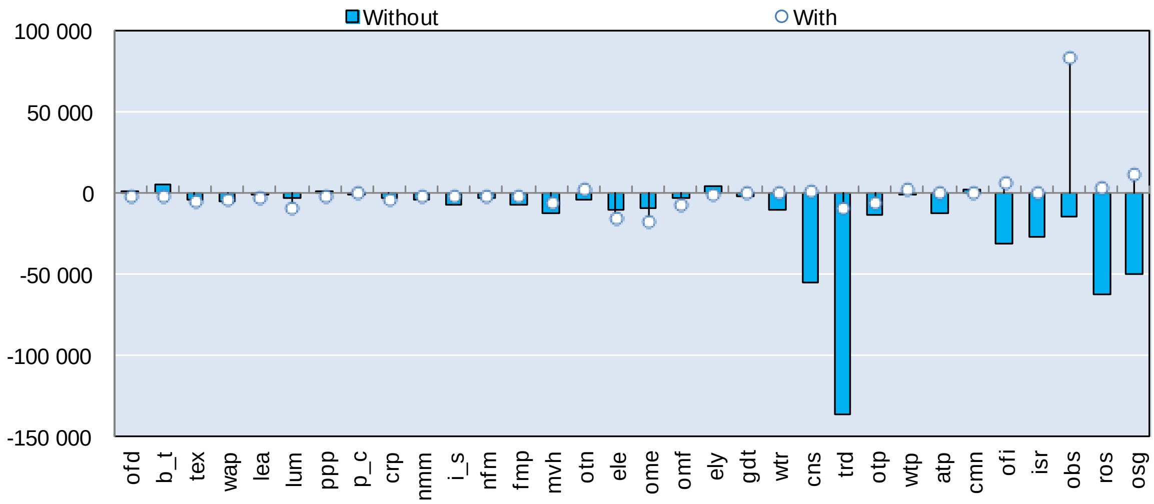
Source: Author's calculations based on GTAP database versions 5, 6 and 7.1.

Figure A16. US capital

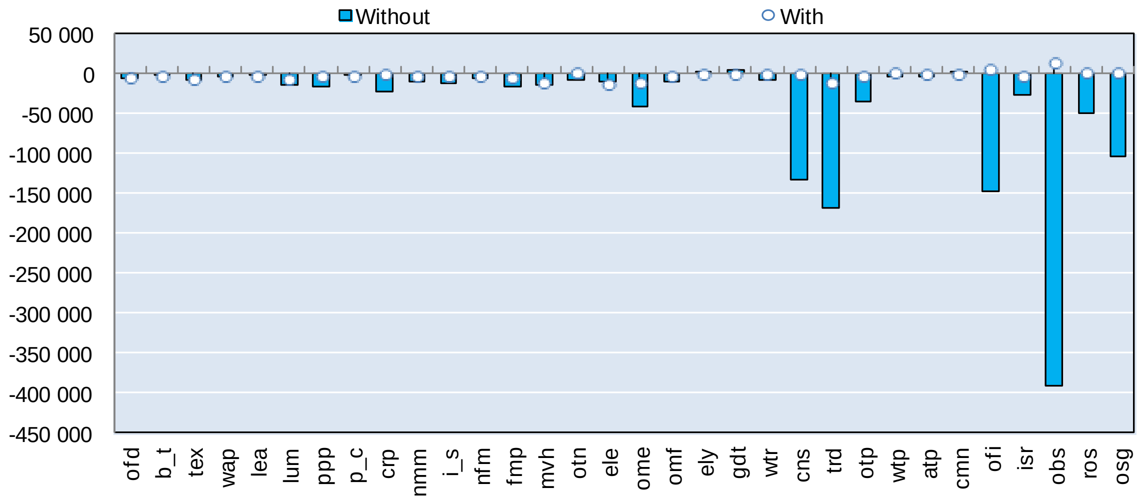
A. 1997



B. 2001

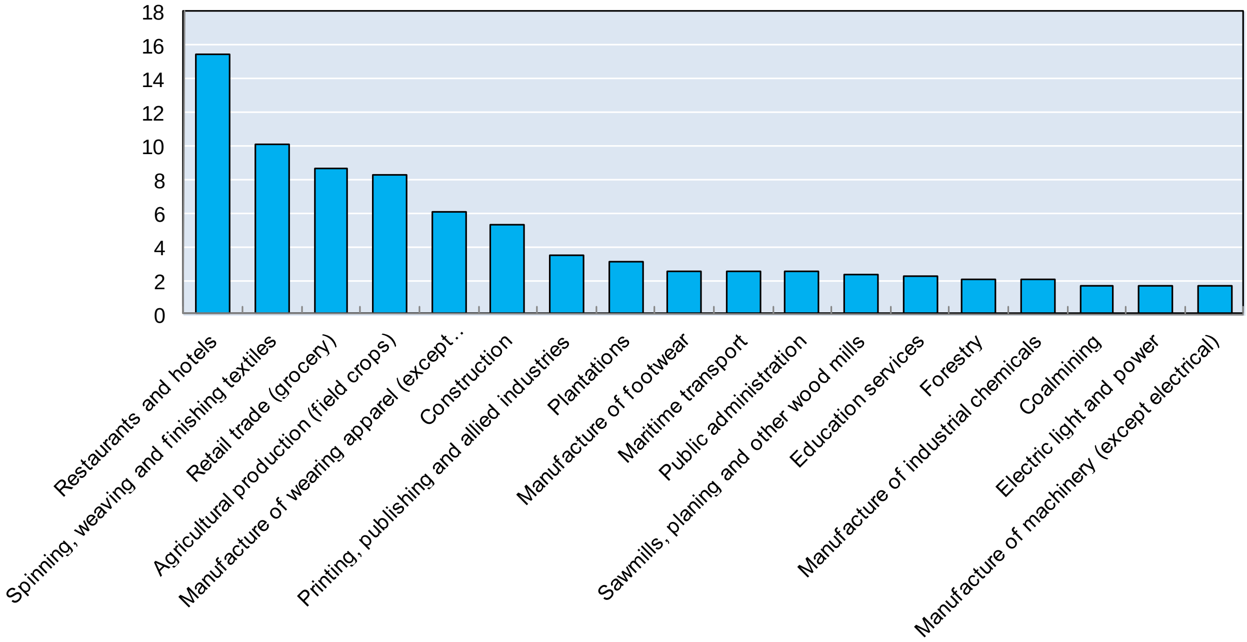


C. 2004



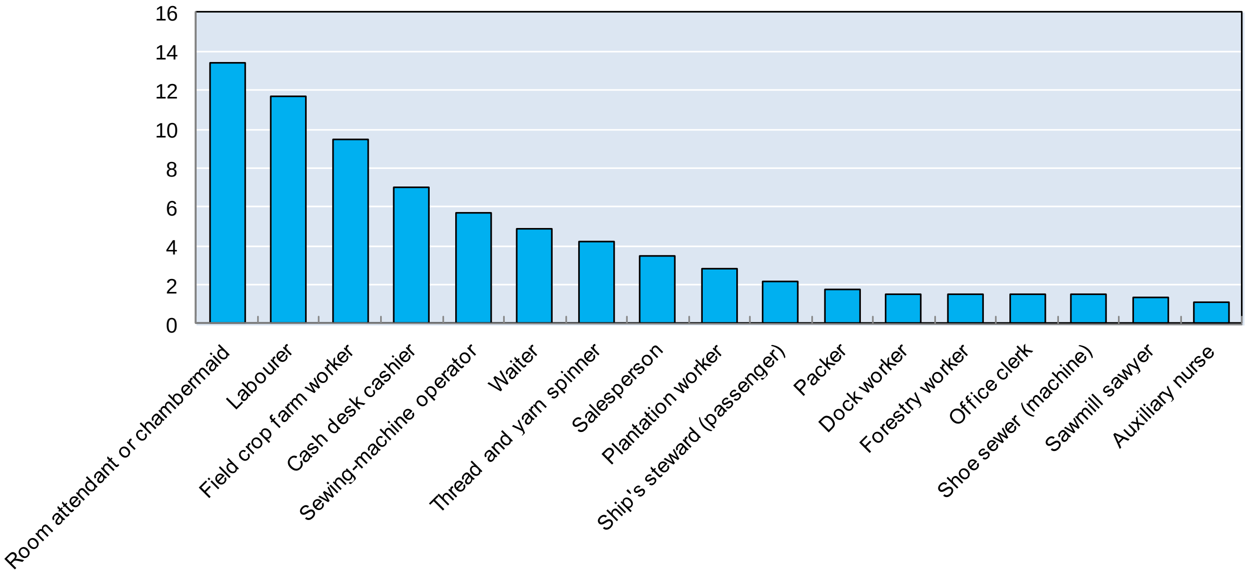
Source: Author's calculations based on GTAP database versions 5, 6 and 7.1.

Figure A17. Percentage of lowest paid wage by industry across countries and years



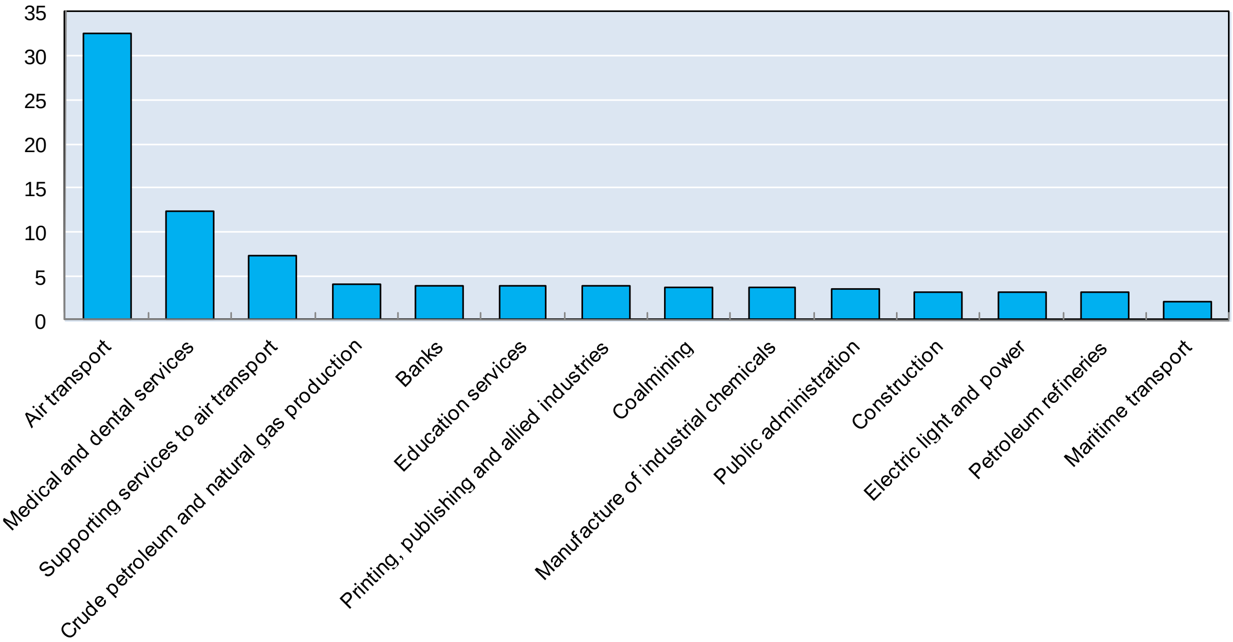
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A18. Percentage of lowest paid wage by occupation across countries and years



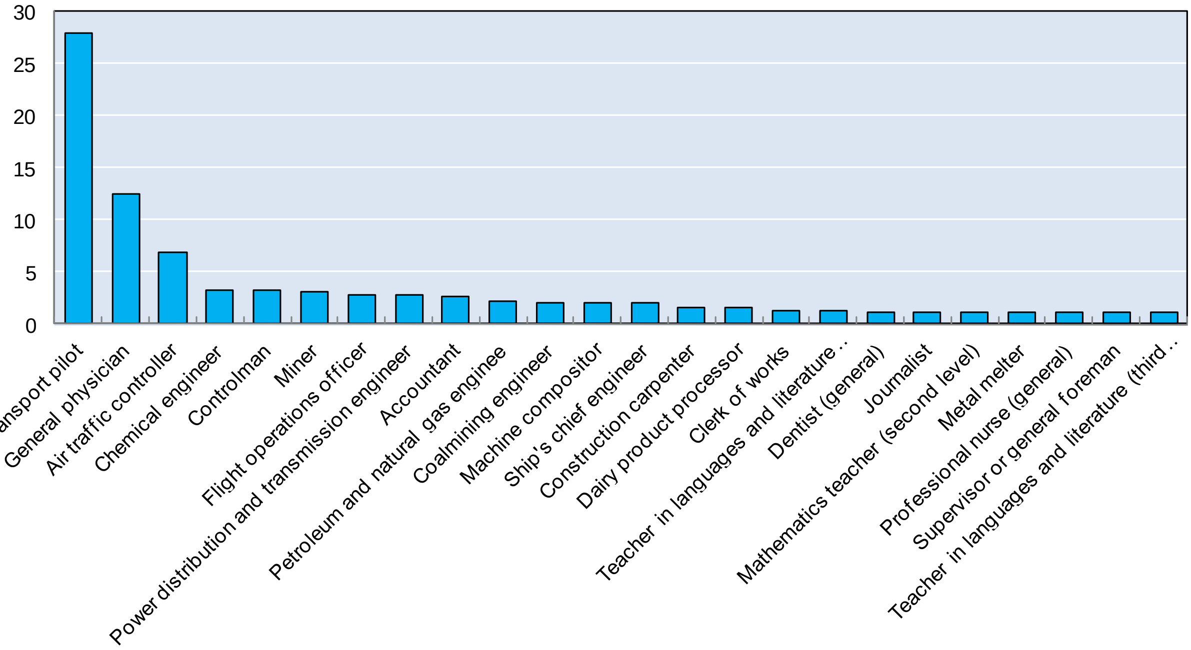
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A19. Percentage of highest paid wage by industry across countries and years (selected)



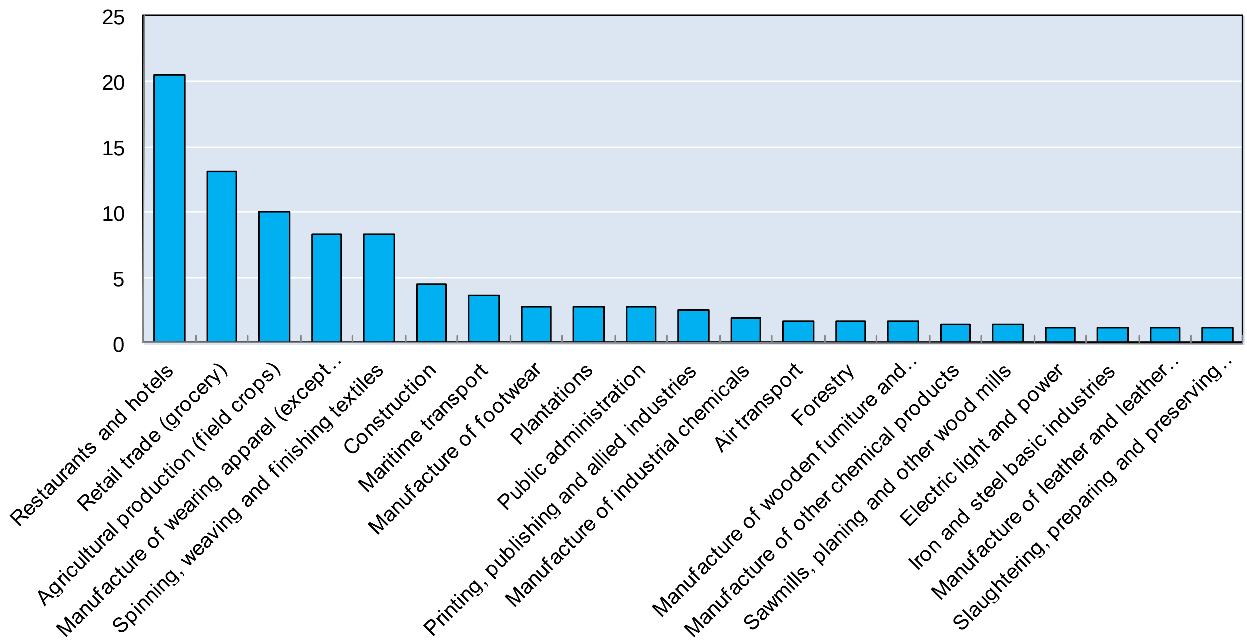
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A20. Percentage of highest paid wage by occupation across countries and years



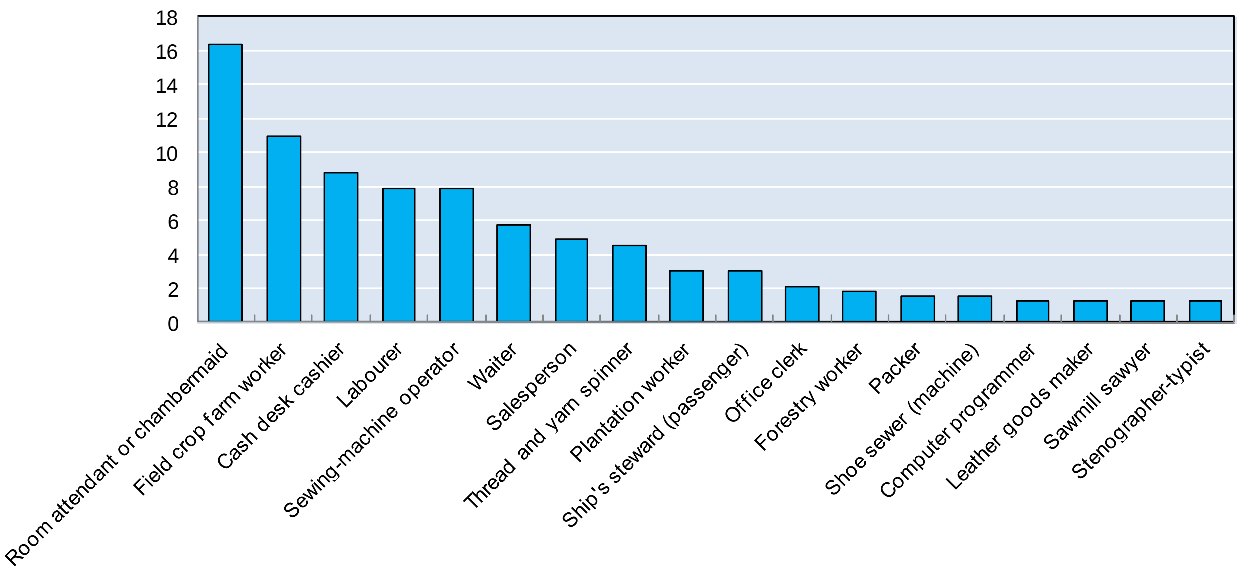
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A21. Percentage of lowest paid wage by industry across countries and years, selected OECD countries



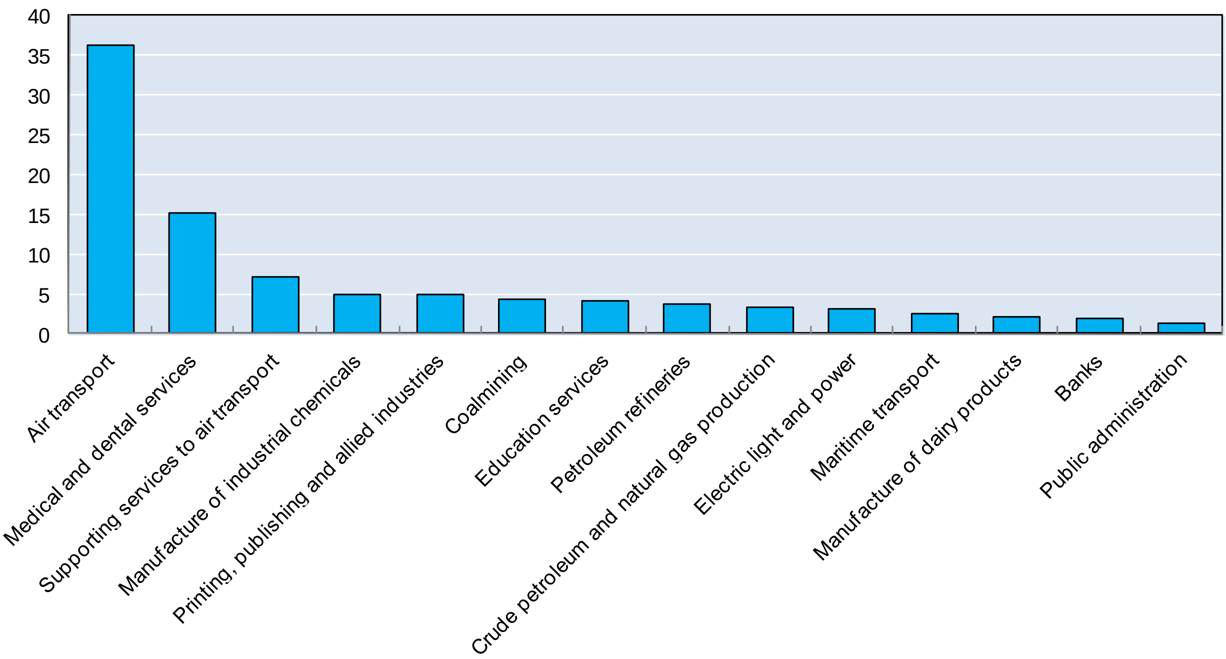
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A22. Percentage of lowest paid wage by occupation across countries and years, selected OECD countries



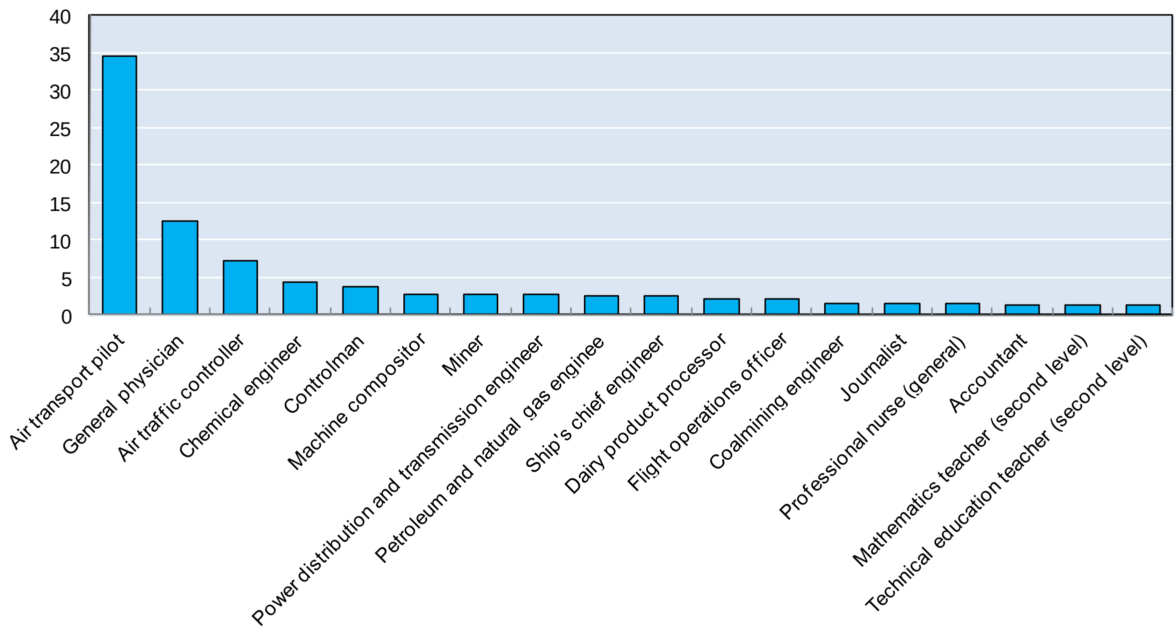
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A23. Percentage of highest paid wage by industry across countries and years, selected OECD countries



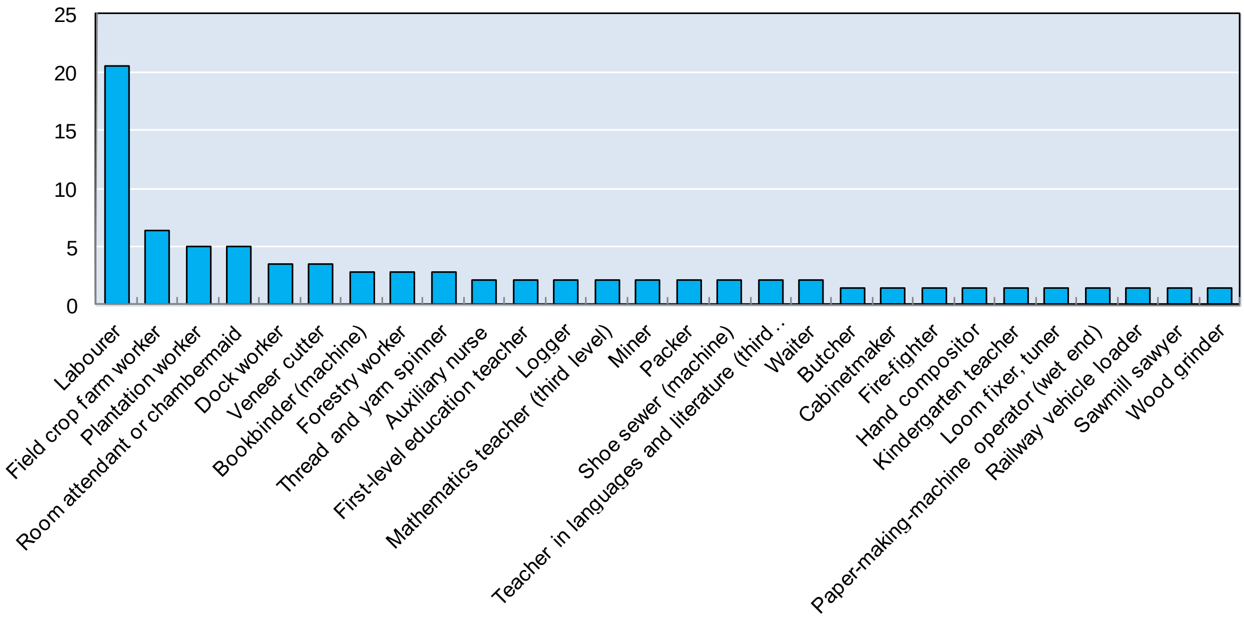
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A24. Percentage of highest paid wage by occupation across countries and years, selected OECD countries



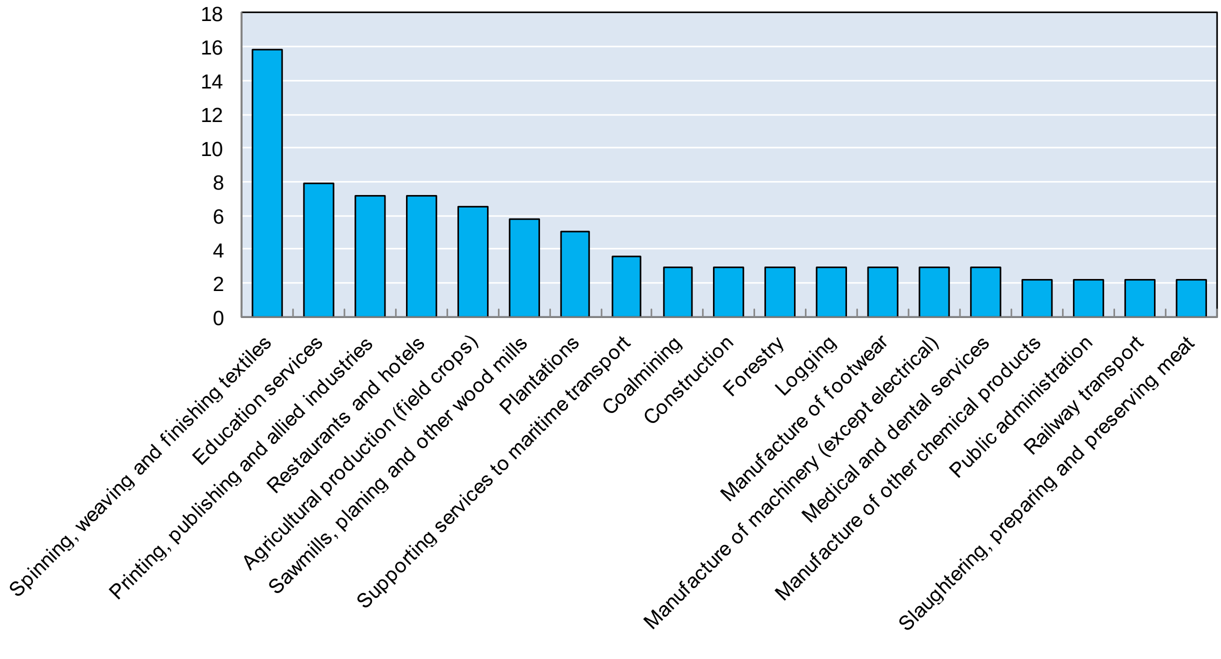
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A25. Percentage of lowest paid wage by occupation across countries and years, selected emerging markets



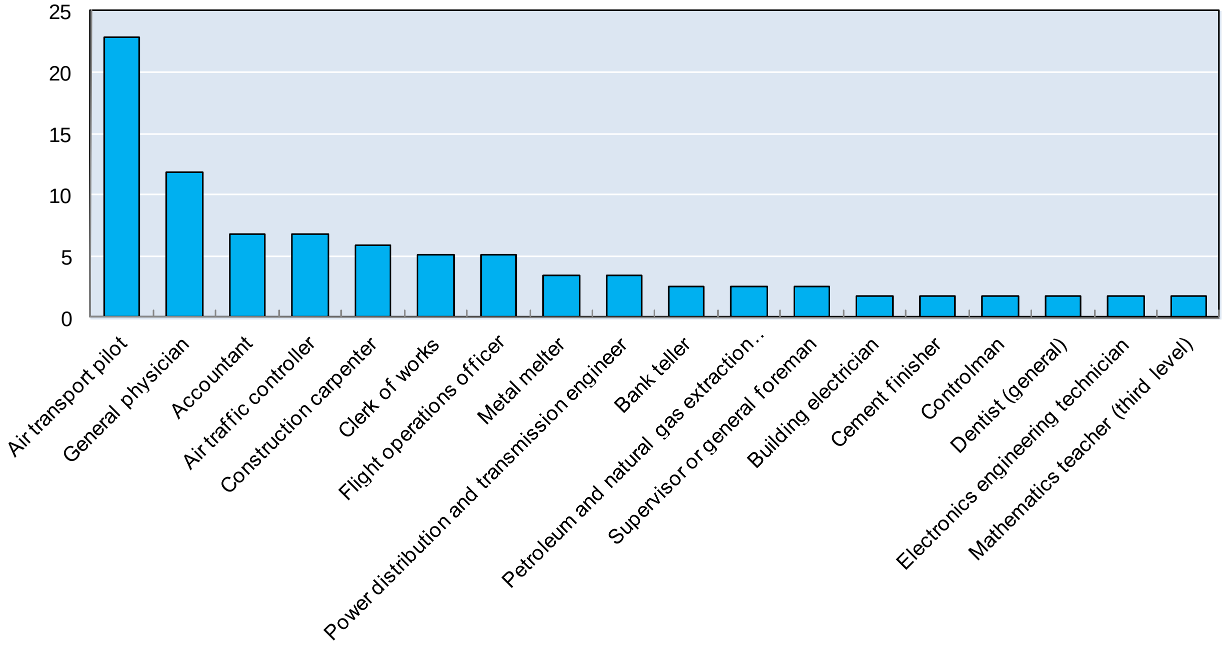
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A26. Percentage of lowest paid wage by industry across countries and years, selected emerging markets



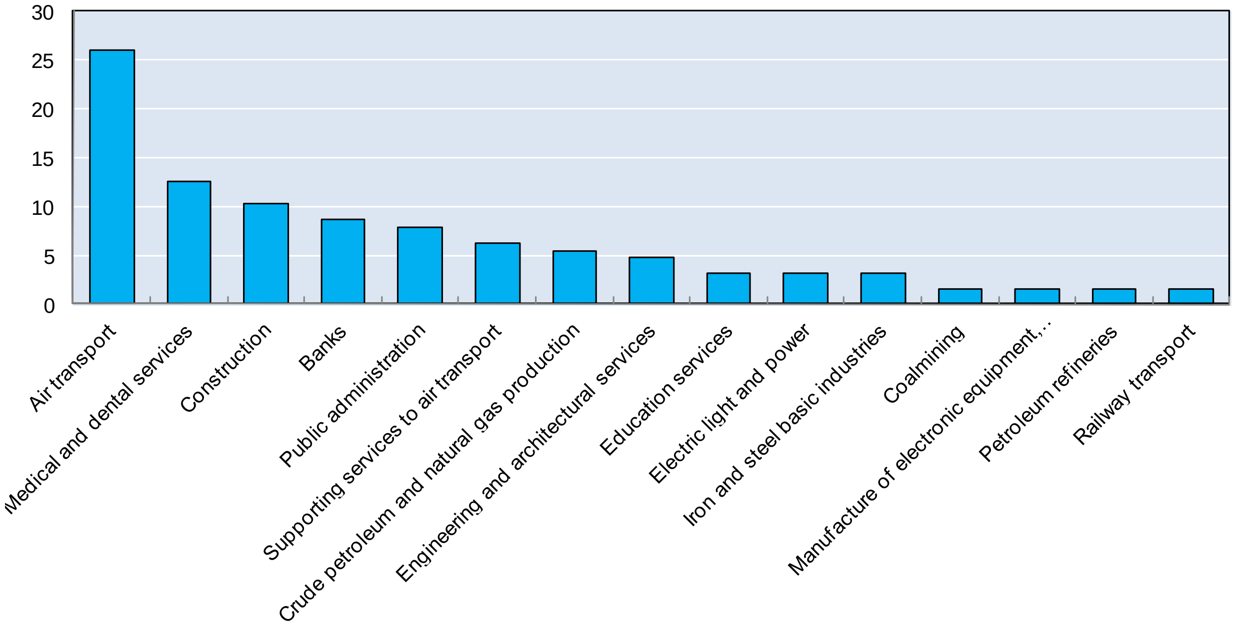
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A27. Percentage of highest paid wage by occupation across countries and years, selected emerging markets



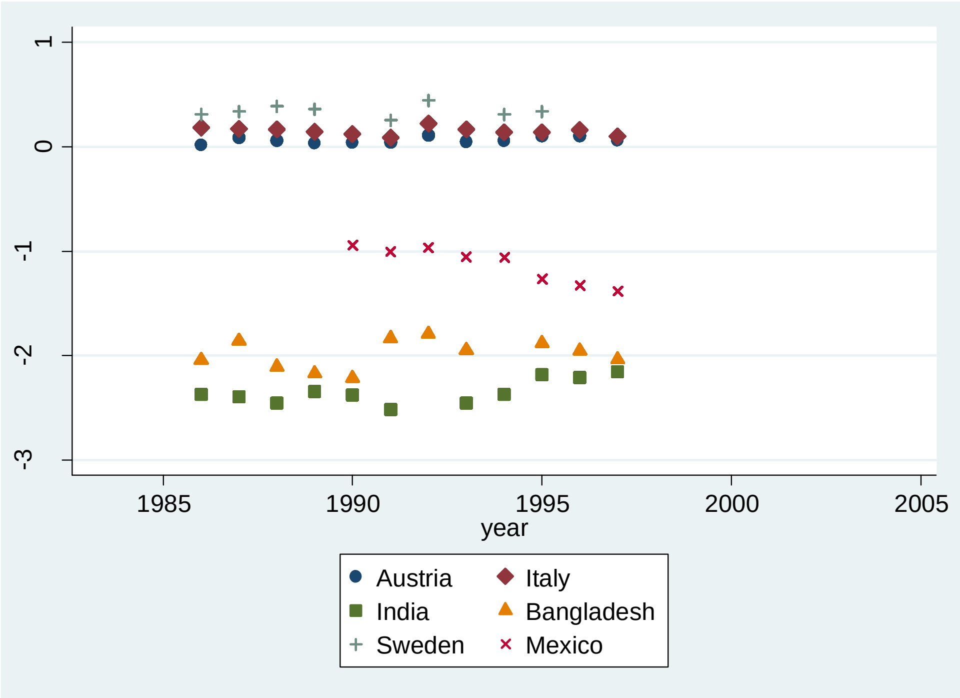
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A28. Percentage of highest paid wage by industry across countries and years, selected emerging markets



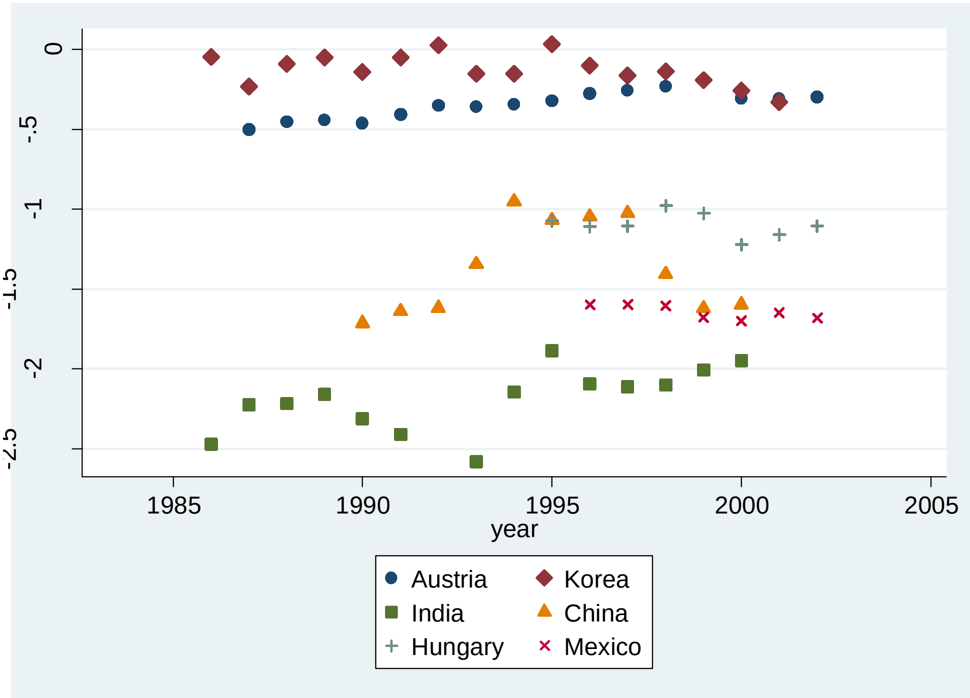
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A29. Real Relative Wages Field Crop Farm Worker



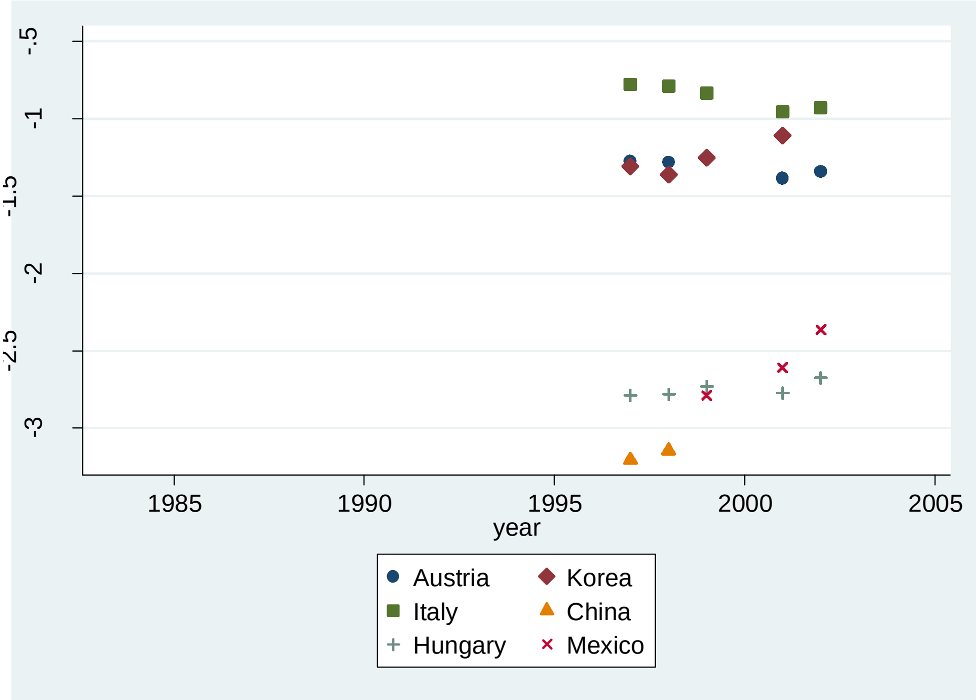
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A30. Real Relative Wages Room attendant or Chambermaid



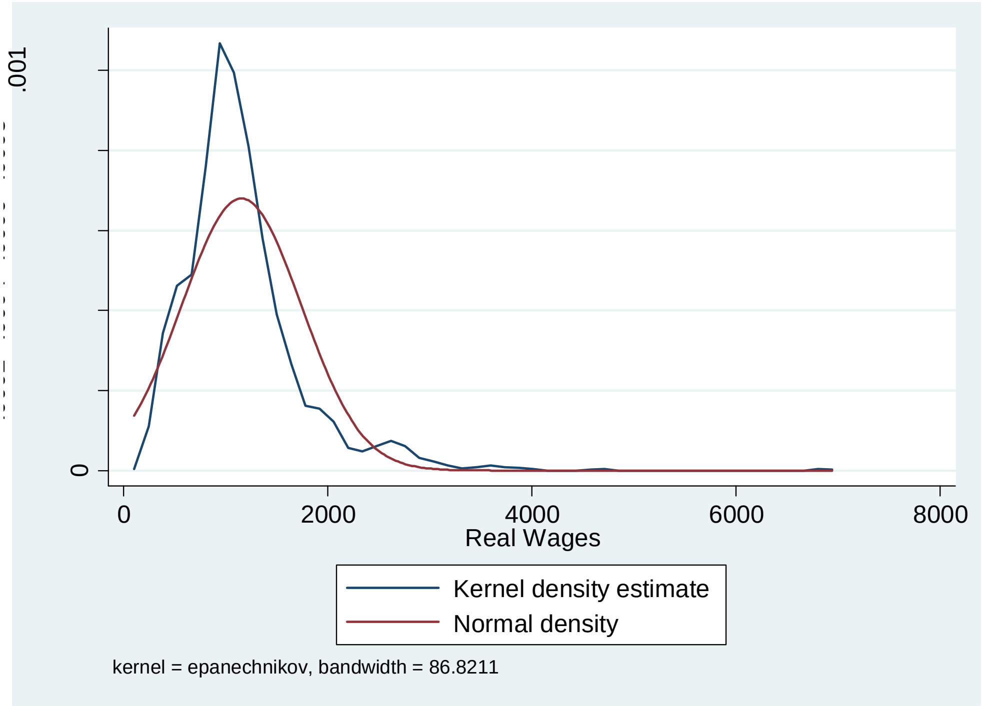
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A31. Real Relative Wages General Physician



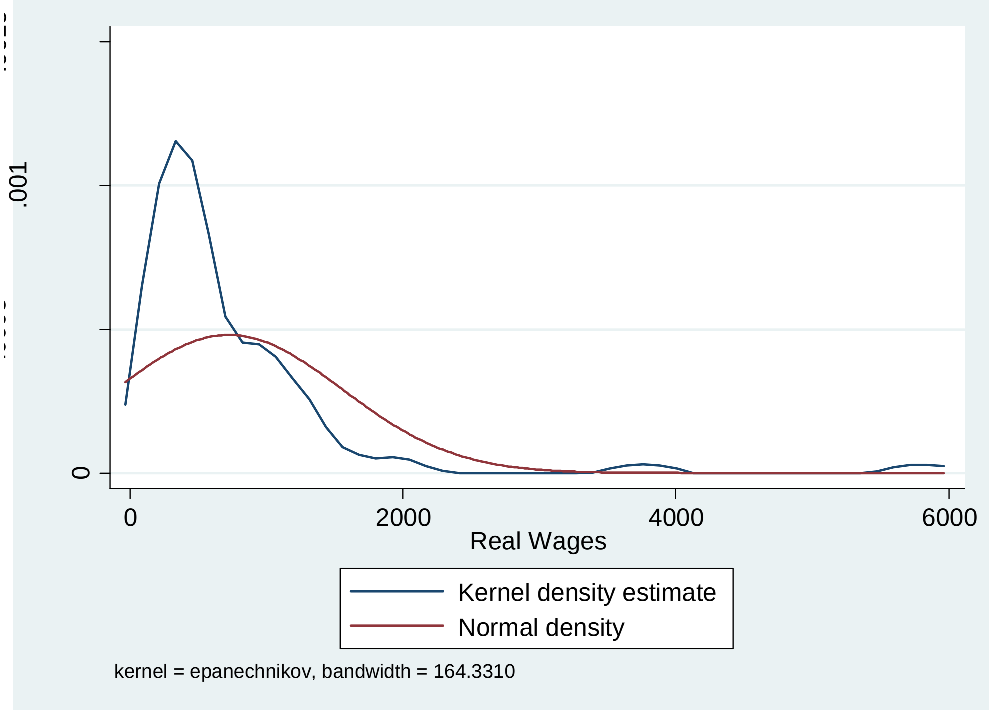
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A32. Real Wage Distribution OECD Countries 1984



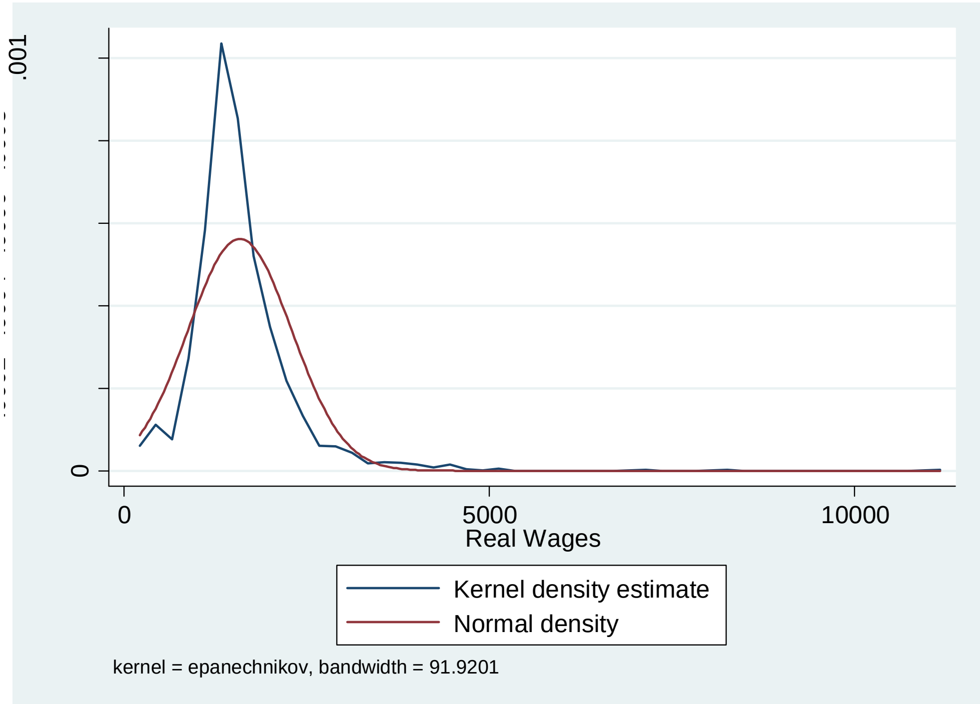
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A33. Real Wage Distribution SEM Countries 1984



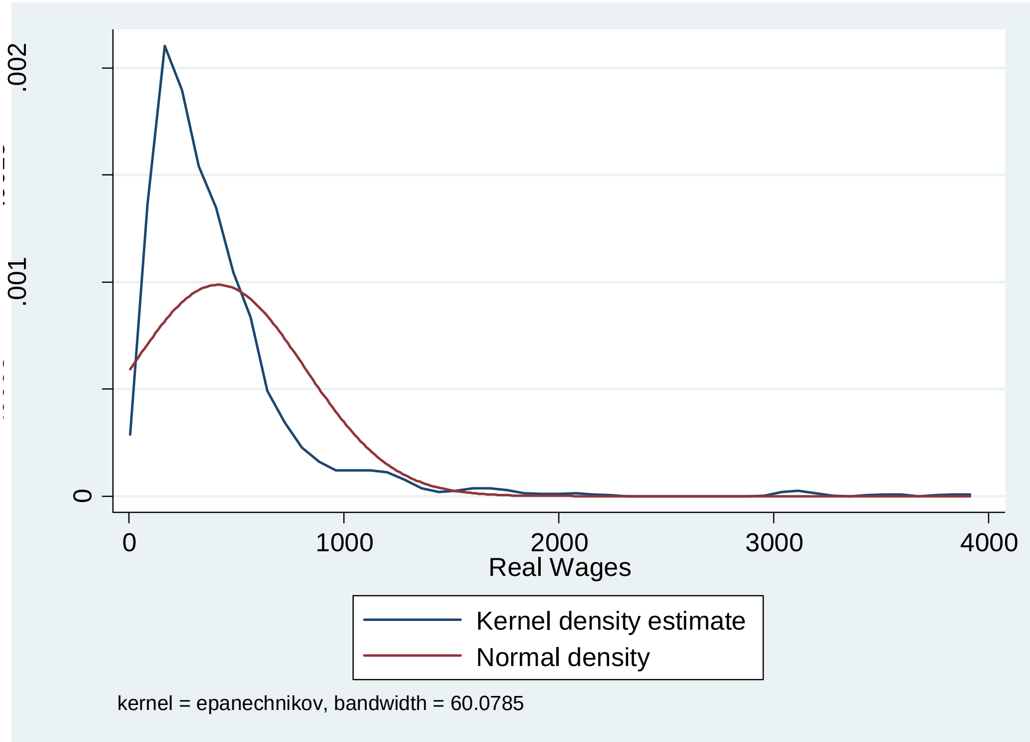
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A34. Real Wage Distribution OECD Countries 1991



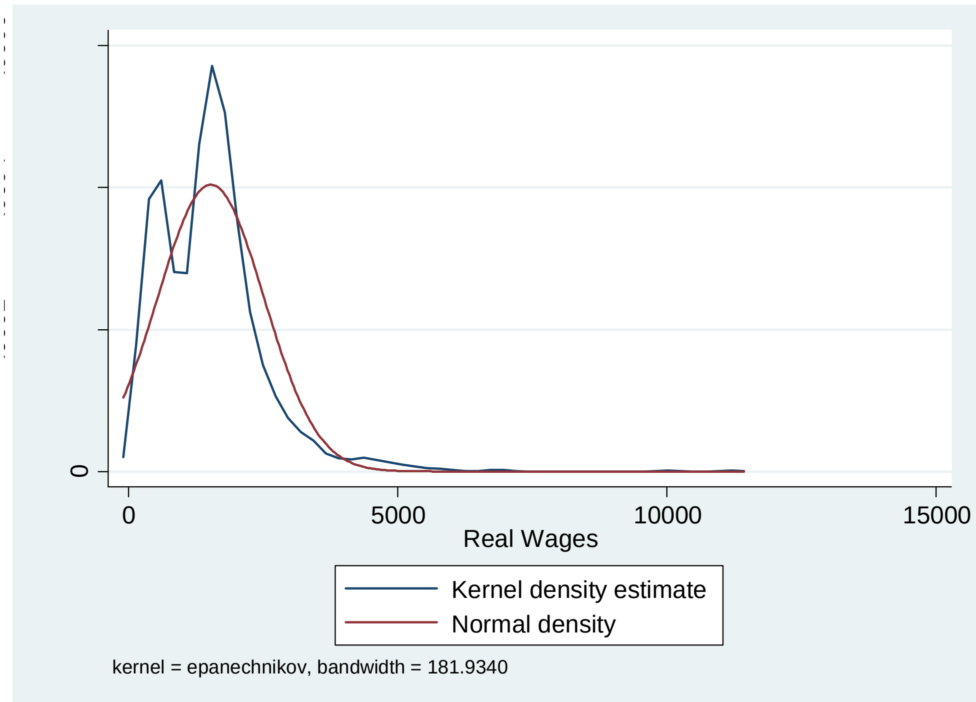
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A35. Real Wage Distribution SEM Countries 1991



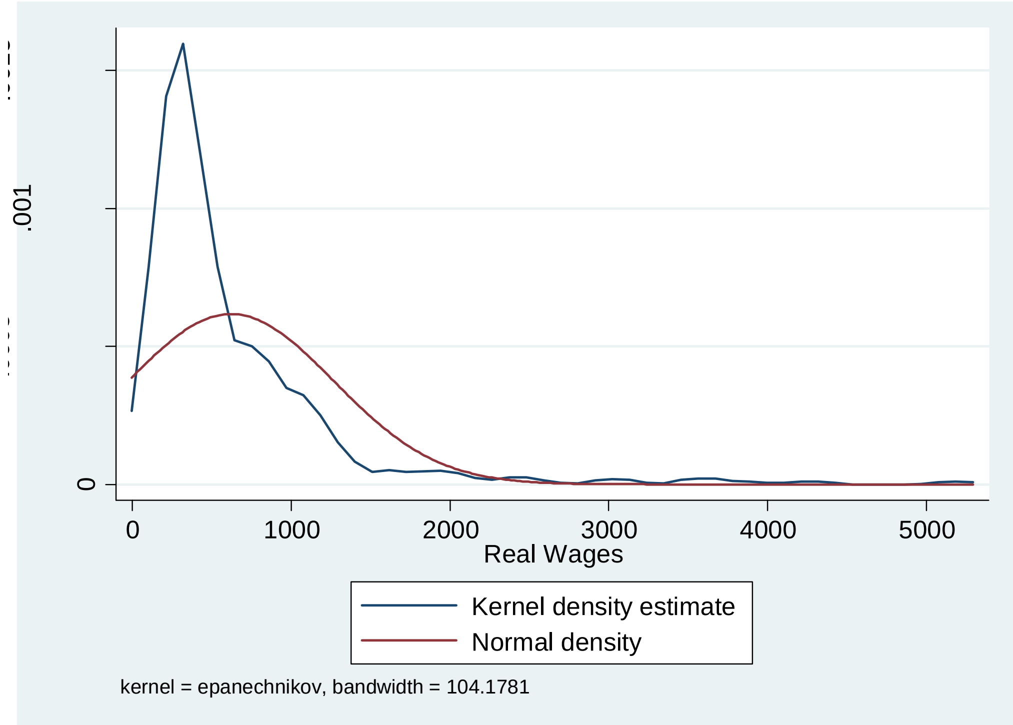
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A36. Real Wage Distribution OECD Countries 1997



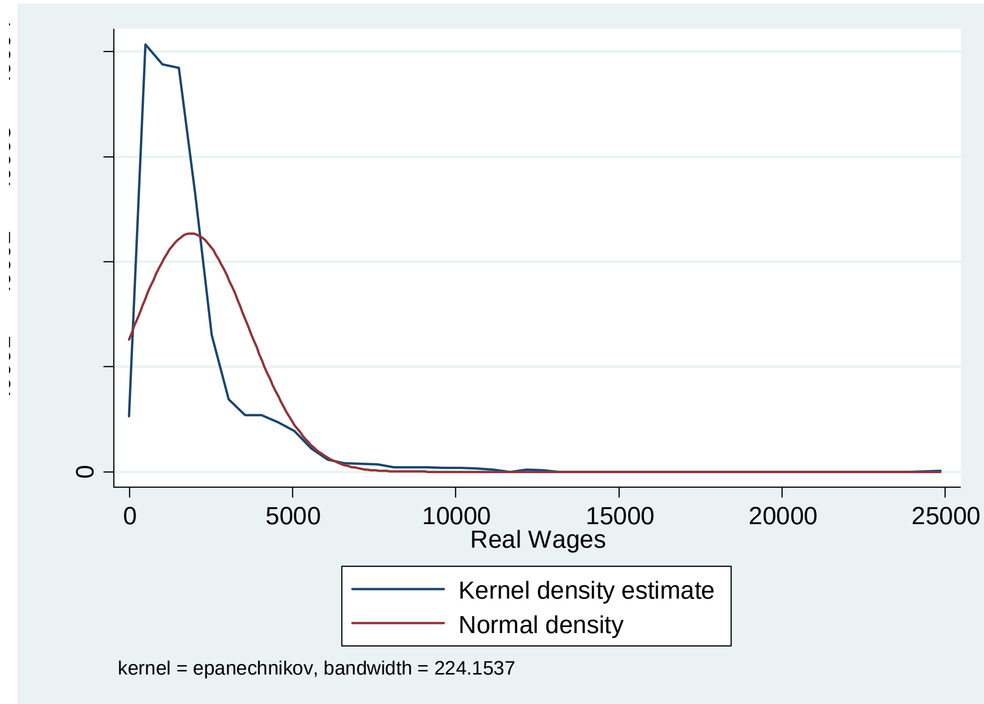
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A37. Real Wage Distribution SEM Countries 1997



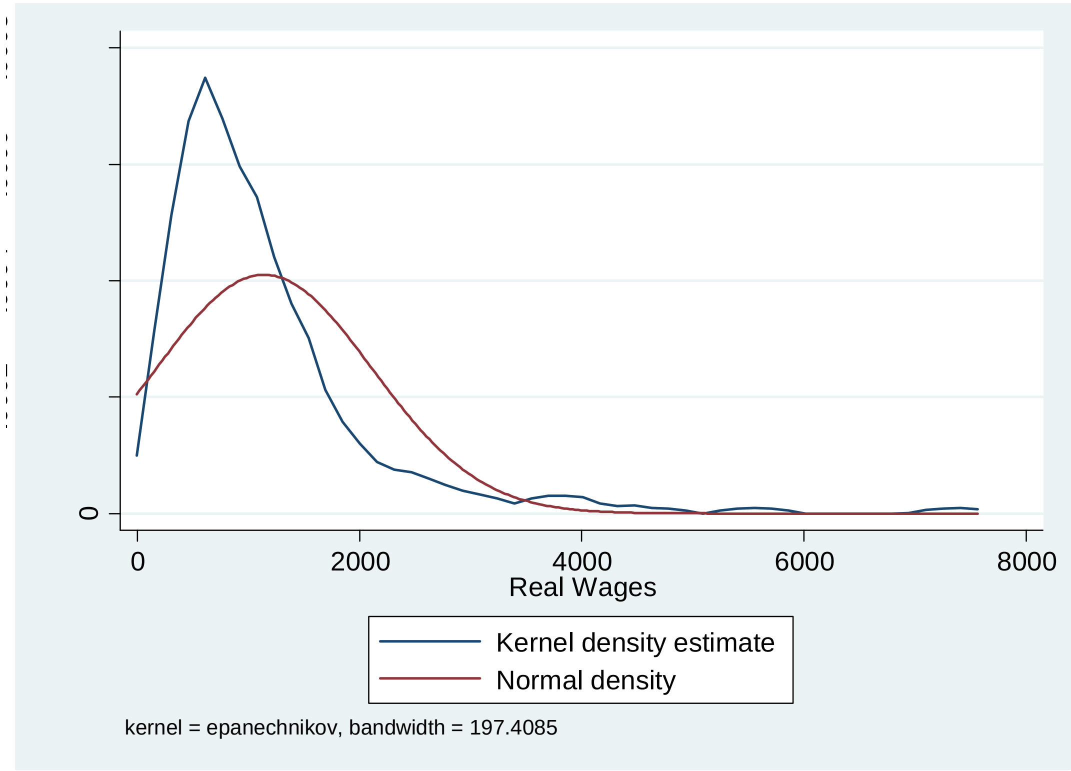
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A38. Real Wage Distribution OECD Countries 2001



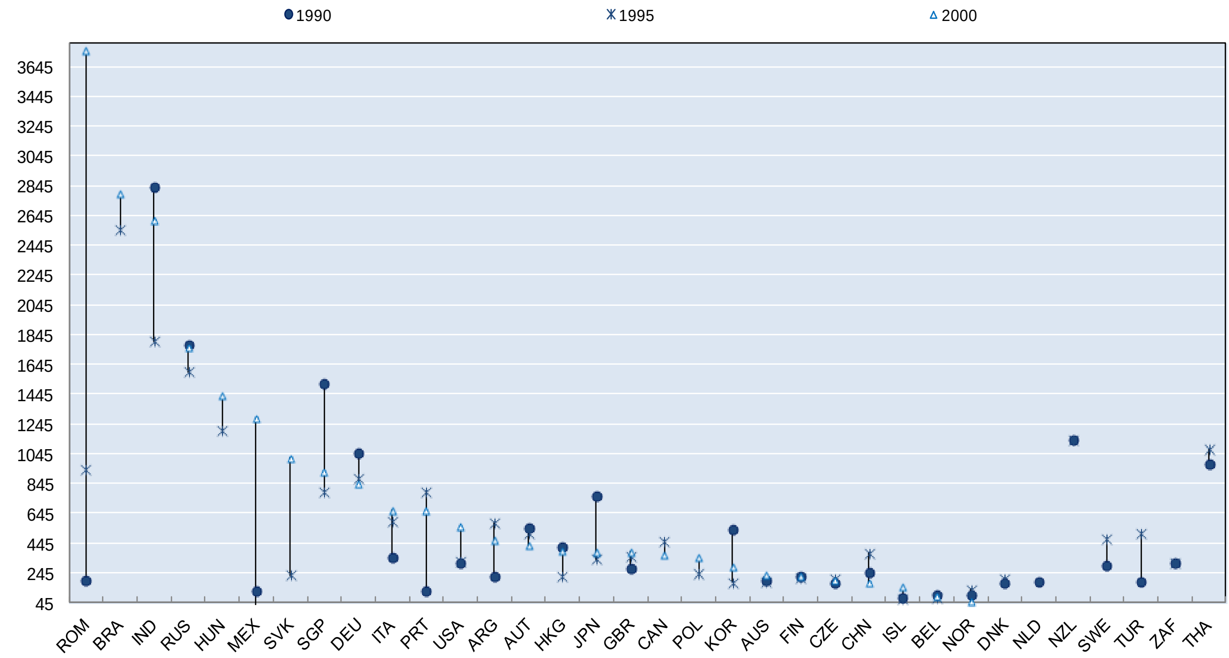
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A39. Real Wage Distribution SEM Countries 2001



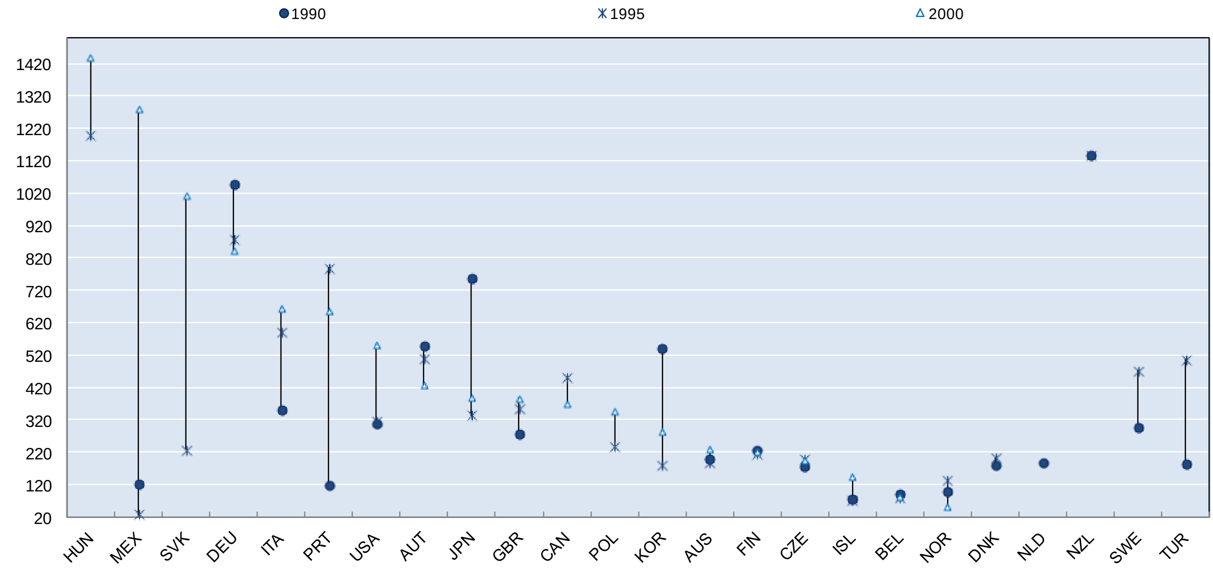
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A40. Percentage Wage Differential OECD and SEM Countries



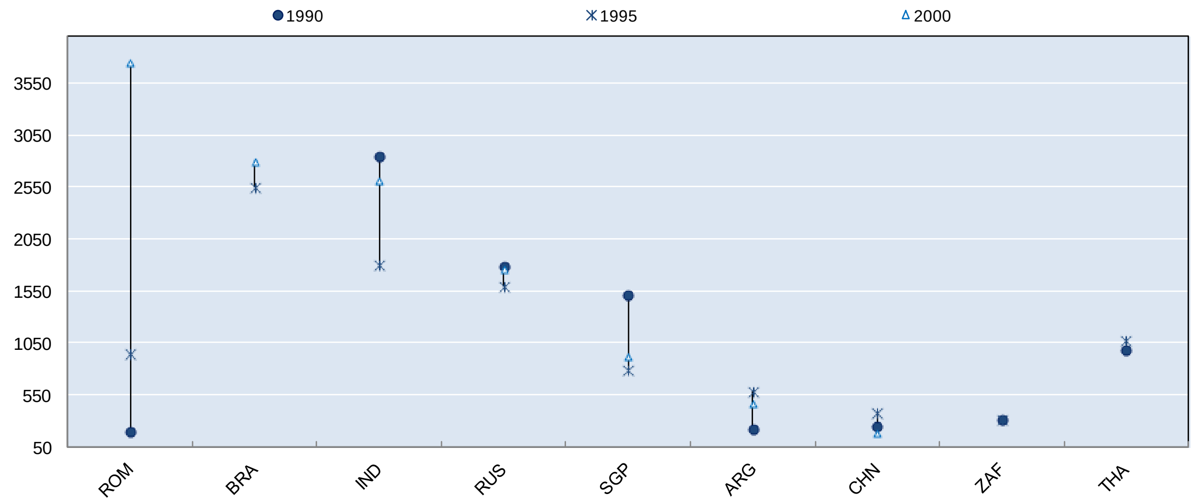
Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A41. Percentage Wage Differential OECD Countries



Source: Occupational Wages around the World Dataset; Author's calculations.

Figure A42. Percentage Wage Differential SEM Countries



Source: Occupational Wages around the World Dataset; Author's calculations.

Table A1. Capital and labour stock growth, 1990-2005

Annual Per cent

	OECD	SEM
Capital stocks	4.45	8.32
Total labour	0.60	2.11
Skilled labour	3.14	4.75
Unskilled labour	0.48	1.73

Source: WDI, IIASA/VID, authors' calculations.

Table A2. Factor rankings, OECD countries

		Land	Rank	Unskilled labour	Rank	Skilled labour	Rank	Capital	Rank	Natural resources	Rank	Std Dev.
Australia	1997	0.617	5	0.862	4	1.048	3	1.056	2	1.758	1	0.380
	2001	0.881	5	1.103	3	1.288	2	0.909	4	2.297	1	0.522
	2004	0.731	5	1.179	3	1.278	2	1.015	4	1.456	1	0.246
Austria	1997	0.459	4	0.888	2	0.808	3	1.197	1	0.124	5	0.370
	2001	0.560	3	0.582	2	0.545	4	1.210	1	0.136	5	0.344
	2004	0.782	2	0.642	4	0.712	3	1.117	1	0.136	5	0.316
Belgium	1997	0.248	4	1.035	2	1.186	1	0.913	3	0.045	5	0.453
	2001	0.225	4	0.907	2	1.107	1	0.877	3	0.052	5	0.416
	2004	0.287	4	0.690	3	0.846	2	1.007	1	0.213	5	0.310
Canada	1997	0.351	5	1.093	2	0.728	4	0.854	3	1.718	1	0.453
	2001	0.520	5	1.078	2	0.866	4	0.879	3	1.634	1	0.366
	2004	0.304	5	1.088	2	1.001	3	0.893	4	1.713	1	0.450
Chile	1997	1.816	1	0.796	4	0.541	5	1.351	3	1.527	2	0.470
	2001	2.321	1	0.876	4	0.608	5	1.283	3	1.625	2	0.600
	2004	1.412	1	0.989	4	0.709	5	1.354	3	1.386	2	0.277
Denmark	1997	1.024	2	0.985	3	1.153	1	0.732	4	0.510	5	0.230
	2001	0.592	5	1.152	2	1.343	1	0.774	3	0.727	4	0.282
	2004	0.595	5	0.983	2	1.217	1	0.870	3	0.855	4	0.202
Estonia	1997	..	..	..	..	..	..	..	..	..	..	..
	2001	1.361	2	1.307	3	0.859	5	0.967	4	1.436	1	0.229
	2004	0.785	3	0.906	2	0.704	5	1.312	1	0.737	4	0.222
Finland	1997	1.179	1	0.840	4	0.937	2	0.902	3	0.411	5	0.250
	2001	0.669	4	0.948	3	1.072	1	0.977	2	0.441	5	0.233
	2004	1.135	1	0.919	4	1.090	2	1.082	3	0.288	5	0.316
France	1997	0.688	4	0.768	3	0.811	2	1.068	1	0.095	5	0.322
	2001	0.568	2	0.518	4	0.565	3	1.121	1	0.090	5	0.328
	2004	0.682	3	0.624	4	0.771	2	0.944	1	0.102	5	0.283
Germany	1997	0.303	4	0.918	3	1.003	2	1.009	1	0.202	5	0.358
	2001	0.410	4	0.734	3	0.786	2	1.026	1	0.219	5	0.286
	2004	0.339	4	0.798	3	0.855	2	0.962	1	0.155	5	0.316
Greece	1997	2.807	2	1.044	4	1.053	3	0.754	5	4.834	1	1.549
	2001	1.049	4	1.228	3	1.281	2	0.814	5	5.263	1	1.676
	2004	1.361	2	0.849	4	0.879	3	1.387	1	0.298	5	0.400
Hungary	1997	1.618	1	0.823	3	0.618	4	1.155	2	0.423	5	0.422
	2001	1.607	1	0.781	3	0.562	4	1.255	2	0.318	5	0.468
	2004	1.213	2	0.768	3	0.666	4	1.229	1	0.153	5	0.398
Ireland	1997	0.694	4	0.969	2	1.107	1	0.929	3	0.257	5	0.298
	2001	0.767	4	1.093	2	1.284	1	1.074	3	0.214	5	0.375
	2004	0.754	4	0.847	3	0.903	2	1.420	1	0.221	5	0.382
Italy	1997	0.832	2	0.714	4	0.818	3	1.208	1	0.122	5	0.351
	2001	0.522	4	0.602	3	0.717	2	1.246	1	0.128	5	0.361
	2004	0.599	4	0.614	3	0.653	2	1.237	1	0.114	5	0.357
Japan	1997	0.217	4	1.092	2	1.123	1	0.976	3	0.177	5	0.428
	2001	0.221	4	1.064	2	1.071	1	0.914	3	0.190	5	0.401
	2004	0.237	4	1.111	1	1.031	3	1.089	2	0.118	5	0.443
Korea	1997	2.200	1	1.273	2	0.887	4	1.193	3	0.471	5	0.572
	2001	2.287	1	1.161	3	0.815	4	1.232	2	0.285	5	0.657
	2004	2.969	1	1.232	3	0.830	4	1.314	2	0.193	5	0.920

Table A2. Factor rankings, OECD countries (*cont.*)

		Land	Rank	Unskilled labour	Rank	Skilled labour	Rank	Capital	Rank	Natural resources	Rank	Std Dev.
Luxem-bourg	1997	0.526	4	1.025	2	1.148	1	0.878	3	0.050	5	0.397
	2001	0.481	4	1.144	2	1.357	1	0.951	3	0.050	5	0.472
	2004	0.594	4	0.758	3	0.918	2	1.213	1	0.031	5	0.393
Mexico	1997	2.381	1	0.623	4	0.397	5	1.458	3	2.336	2	0.830
	2001	1.438	3	0.664	4	0.480	5	1.526	2	1.849	1	0.527
	2004	1.592	1	0.477	4	0.444	5	0.803	2	0.735	3	0.415
Nether-lands	**1997**	**0.302**	**5**	**0.895**	**3**	**1.011**	**1**	**0.937**	**2**	**0.588**	**4**	**0.265**
	2001	0.288	5	0.647	3	0.779	2	0.972	1	0.625	4	0.224
	2004	0.387	4	0.617	3	0.768	2	1.054	1	0.344	5	0.261
New Zealand	1997	0.546	5	0.965	2	0.839	4	0.979	1	0.946	3	0.162
	2001	0.918	4	1.093	2	0.909	5	1.124	1	1.071	3	0.091
	2004	0.849	4	1.131	2	0.907	3	1.228	1	0.632	5	0.211
Poland	1997	1.762	1	0.895	4	0.635	5	0.980	3	1.501	2	0.414
	2001	1.658	1	0.831	4	0.562	5	1.048	3	1.068	2	0.362
	2004	1.048	2	0.692	3	0.542	5	1.128	1	0.666	4	0.230
Portugal	1997	1.442	1	1.016	3	1.315	2	0.659	4	0.342	5	0.408
	2001	0.657	4	1.069	2	1.409	1	0.710	3	0.338	5	0.368
	2004	0.706	4	0.861	3	0.974	2	1.024	1	0.264	5	0.274
Russia	1997	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000
	2001	1.333	2	1.091	3	0.651	5	0.869	4	9.346	1	3.352
	2004	1.600	2	0.821	4	0.579	5	1.211	3	6.026	1	2.019
Slovak Republic	1997	..	..	..	..	..	..	..	..	..	..	..
	2001	1.056	2	0.715	3	0.526	4	1.465	1	0.440	5	0.377
	2004	1.266	2	0.673	3	0.495	4	1.349	1	0.232	5	0.436
Slovenia	1997	..	..	..	..	..	..	..	..	..	..	..
	2001	0.529	4	1.143	1	0.899	3	0.901	2	0.395	5	0.273
	2004	0.964	3	1.079	1	0.752	4	1.004	2	0.223	5	0.310
Spain	1997	1.153	1	0.897	4	0.942	3	1.100	2	0.423	5	0.258
	2001	0.622	4	0.826	3	0.884	2	1.163	1	0.440	5	0.245
	2004	0.680	4	0.976	2	0.971	3	1.162	1	0.166	5	0.348
Sweden	1997	0.436	4	0.967	2	1.254	1	0.627	3	0.256	5	0.361
	2001	0.292	4	0.847	2	1.080	1	0.680	3	0.277	5	0.313
	2004	0.351	4	0.672	3	0.843	1	0.823	2	0.162	5	0.270
Switzerland	1997	0.704	4	1.030	2	1.215	1	0.814	3	0.072	5	0.390
	2001	0.637	4	0.909	2	1.071	1	0.840	3	0.089	5	0.340
	2004	0.433	4	1.073	2	1.121	1	0.933	3	0.024	5	0.424
Turkey	1997	1.146	2	0.830	3	0.534	5	1.479	1	0.679	4	0.340
	2001	1.124	1	1.098	2	0.660	4	1.021	3	0.631	5	0.216
	2004	1.373	1	1.024	3	0.635	4	1.297	2	0.370	5	0.385
United Kingdom	1997	0.511	5	1.017	2	1.176	1	0.820	3	0.565	4	0.255
	2001	0.227	5	0.992	2	1.163	1	0.809	3	0.545	4	0.331
	2004	0.197	5	0.952	2	1.078	1	0.813	3	0.447	4	0.327
United States	1997	0.457	4	1.063	2	1.263	1	0.924	3	0.407	5	0.337
	2001	0.431	4	1.106	2	1.292	1	0.946	3	0.340	5	0.375
	2004	0.347	4	1.185	2	1.382	1	0.697	3	0.343	5	0.427

Source: Author's calculations based on GTAP database versions 5, 6 and 7.1.

Table A3. Factor rankings, selected emerging economies

		Land	Rank	Unskilled labour	Rank	Skilled labour	Rank	Capital	Rank	Natural resources	Rank	Std Dev.
Argentina	1997	2.559	1	1.074	3	0.631	5	1.149	2	0.807	4	0.683
	2001	1.239	1	0.928	2	0.708	5	0.817	4	0.885	3	0.178
	2004	2.412	1	1.019	3	0.694	5	0.915	4	1.779	2	0.639
Bangladesh	1997	4.907	1	1.125	3	0.541	5	0.986	4	2.244	2	1.576
	2001	5.926	1	1.348	3	0.645	5	1.025	4	2.535	2	1.922
	2004	6.934	1	1.380	3	0.624	5	1.163	4	2.058	2	2.298
Brazil	1997	1.105	2	0.946	3	0.766	4	1.125	1	0.516	5	0.228
	2001	0.695	5	0.885	2	0.841	3	0.953	1	0.741	4	0.094
	2004	0.965	2	0.898	4	0.768	5	1.034	1	0.933	3	0.088
China	1997	4.538	1	1.427	3	0.557	5	1.009	4	3.115	2	1.483
	2001	5.320	1	1.705	3	0.679	5	1.089	4	2.947	2	1.672
	2004	4.555	1	1.371	4	0.672	5	2.341	3	3.171	2	1.363
India	1997	9.398	1	0.913	4	0.321	5	1.122	3	1.408	2	3.402
	2001	10.063	1	1.169	3	0.604	5	1.094	4	1.435	2	3.605
	2004	10.688	1	1.199	3	0.569	5	1.194	4	1.324	2	3.856
Indonesia	1997	7.438	1	1.164	4	0.378	5	1.363	3	4.800	2	2.678
	2001	5.799	2	0.809	4	0.375	5	1.368	3	6.158	1	2.534
	2004	7.059	1	1.101	4	0.418	5	1.371	3	4.109	2	2.468
Malaysia	1997	5.034	2	1.035	4	0.572	5	1.796	3	5.550	1	2.080
	2001	1.240	3	1.309	2	0.664	5	1.154	4	4.631	1	1.434
	2004	1.309	2	1.243	3	0.599	5	1.211	4	4.833	1	1.519
South Africa	1997	..	..	..	..	..	..	..	..	..	..	..
	2001	0.502	5	1.166	2	0.876	3	0.849	4	2.601	1	0.732
	2004	0.425	5	0.973	3	0.828	4	1.180	1	0.998	2	0.254
Thailand	1997	3.115	1	0.404	4	0.235	5	2.233	2	1.161	3	1.099
	2001	4.317	1	0.690	4	0.434	5	1.459	3	1.499	2	1.383
	2004	4.752	1	0.682	4	0.421	5	1.591	2	1.314	3	1.558
Vietnam	1997	4.727	1	0.967	4	0.466	5	1.194	3	4.139	2	1.768
	2001	6.324	1	1.183	4	0.466	5	1.317	3	4.359	2	2.240
	2004	8.165	1	1.314	3	0.634	5	1.039	4	6.031	2	3.072

Source: Author's calculations based on GTAP database versions 5, 6 and 7.1.

Table A4. Wage regression estimates
Initial GDP per capita

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	% Growth Wage (02-84)	% Growth Wage (02-84)	% Growth Wage (02-84)	% Growth Wage (01-84)	% Growth Wage (01-84)	% Growth Wage (01-84)	% Growth Wage (00-84)	% Growth Wage (00-84)	% Growth Wage (00-84)
Log of GDP per capita 1984	1.527***	1.164***	0.758**	-0.236*	-0.115	-0.495***	-0.370***	0.0174	-0.612***
	(0.124)	(0.335)	(0.314)	(0.125)	(0.808)	(0.165)	(0.109)	(0.279)	(0.127)
Constant	-13.76***	-10.61***	-6.149*	3.871***	2.114	6.349***	4.903***	0.712	7.241***
	(1.201)	(3.274)	(3.108)	(1.207)	(8.065)	(1.580)	(1.064)	(2.784)	(1.225)
Observations	299	299	299	363	363	363	475	475	475
Number of clusters		8	122		8	152		11	155
R-squared overall	0.099	0.0994	0.0994	0.009	0.00904	0.00904	0.025	0.0252	0.0252
Robust standard errors in parentheses									

*** p<0.01, ** p<0.05, * p<0.1

OLS in (1), (4), and (7); OLS with Random Effects in (2), (5), and (8); OLS with country fixed effects in (3), (6), and (9)

Clusters are by country in (2), (5), and (8) and by occupation in (3), (6), and (9)

Source: Author's calculations.

Table A5. Wage regression estimates

Initial GDP per capita and openness

	(1) % Growth Wage (02-84)	(2) % Growth Wage (02-84)	(3) % Growth Wage (02-84)	(4) % Growth Wage (01-84)	(5) % Growth Wage (01-84)	(6) % Growth Wage (01-84)	(7) % Growth Wage (00-84)	(8) % Growth Wage (00-84)	(9) % Growth Wage (00-84)
Log of GDP per capita 1984	1.501***	1.292***	0.741**	-0.283**	-0.184	-0.445**	-0.506***	-0.0506	-0.674***
	(0.150)	(0.322)	(0.306)	(0.137)	(0.728)	(0.180)	(0.102)	(0.244)	(0.123)
Log Openness	0.0304	-0.182	0.0224	0.117	0.156	-0.136	0.558***	0.232	0.403***
	(0.114)	(0.178)	(0.117)	(0.194)	(0.413)	(0.247)	(0.0973)	(0.303)	(0.103)
Constant	-13.61***	-11.25***	-6.061**	3.905***	2.244	6.352***	4.295***	0.587	6.448***
	(1.279)	(3.263)	(3.036)	(1.195)	(7.639)	(1.581)	(1.064)	(2.650)	(1.303)
Observations	299	299	299	363	363	363	475	475	475
Number of clusters		8	122		8	152		11	155
R-squared overall	0.099	0.0937	0.0994	0.010	0.00857	0.00793	0.060	0.0327	0.0521

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

OLS in (1), (4), and (7); OLS with Random Effects in (2), (5), and (8); OLS with country fixed effects in (3), (6), and (9)

Clusters are by country in (2), (5), and (8) and by occupation in (3), (6), and (9)

Source: Author's calculations.

Table A6. Wage regression estimates with GTAP sectors

Initial GDP per capita and openness

	(1) % Growth Wage (02-84)	(2) % Growth Wage (02-84)	(3) % Growth Wage (02-84)	(4) % Growth Wage (01-84)	(5) % Growth Wage (01-84)	(6) % Growth Wage (01-84)
Log of GDP per capita 1984	1.118***	1.089***	-0.420***	-0.410**	-0.525***	-0.616***
	(0.319)	(0.286)	(0.143)	(0.159)	(0.116)	(0.100)
Log Openness		0.0352		-0.0258		0.480***
		(0.135)		(0.420)		(0.171)
Constant	-9.710***	-9.550***	5.628***	5.625***	6.396***	5.631***
	(3.162)	(2.925)	(1.370)	(1.352)	(1.121)	(1.336)
Observations	299	299	363	363	475	475
Number of GTAP sectors	26	26	27	27	27	27
R-squared	0.041	0.041	0.025	0.025	0.047	0.071
R-squared overall	0.0994	0.0994	0.00904	0.00882	0.0252	0.0569

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Ordinary Panel estimator with sector fixed effects in all regressions

Clusters are by GTAP sectors in all regressions

Source: Author's calculations.