Disaggregating Labor Payments in the GTAP 8 Data Base

Terrie Walmsley and Caitlyn Carrico

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Prior to the release of version 4, the GTAP Data Base included three primary factors: agricultural land, capital and labor. In the GTAP 4 Data Base, labor was disaggregated labor into two categories: professional (skilled) and production and farm laborers (unskilled). Subsequent GTAP releases have used the same methodology, updating countries and sectors as required. In 2010, Weingarden and Tsigas (2010) developed a process for imputing wages by occupation and industry using the 2008 ILO Yearbook and a constrained optimization model. The purpose of this paper is to summarize the work undertaken by Weingarden and Tsigas (2010) and outline how this work has been used to update and expand the level of disaggregation of labor in the GTAP 8.1 Data Base to five labor categories. It is expected that these five new labor categories will be formally integrated into the GTAP Data Base in version 9. Finally, the paper also examines how incorporating the new labor data can enhance analysis of labor markets, by demonstrating the macro and labor impacts of a number of illustrative simulations.

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1 Introduction

Prior to the release of version 4, the GTAP Data Base included three primary factors: agricultural land, capital and labor. In the first three versions, labor was provided as a single category, without distinction by worker classification. In the GTAP 4 Data Base (McDougall, Elbehri, and Truong, 1998), Liu, van Leeuwen, Vo, Tyers, and Hertel (1998a and b) disaggregated labor into two categories: professional (skilled) and production and farm laborers (unskilled). They computed shares of payments to labor for 7 countries using data from national sources. For countries with less reliable labor data, GDP and educational attainment were used as explanatory variables in a non-transformed linear model to estimate the shares of payments to labor for skilled workers. Subsequent GTAP versions 5-8, followed the same methodology, expanding coverage to newly included countries when necessary (Narayanan, Aguiar and McDougall, 2012).

Lui et al. (1998a and b) had previously explored using globally available labor data from the International Labor Organization (ILO) to compute the payments to labor shares for GTAP version 4. However, they noted two major drawbacks of the ILO data: first, industries are very broadly defined; and second, there is no dataset reporting wages by both occupation and industry. In 2009, it was decided that the labor splits in the GTAP Data Base were grossly out of date and efforts began to re-examine the availability of labor data. This resulted in a comparison being made of the ILO data with country data for China and the USA (Mirza, Narayanan and van Leewuen, 2010).

Then in 2010, Weingarden and Tsigas (2010) developed a process for imputing wages by occupation and industry using a constrained optimization model that addressed the second issue. As inputs for their optimization, Weingarden and Tsigas (2010) used wage data reported by industry in the *ILO Yearbook* (2008) along with wage data reported by occupation in the *ILO October Inquiry* and processed by Oostendorp (2005). Additional data was also collected from

national sources for India and China. The compiled dataset contained both number of workers and imputed wages for 5 occupations and for 95 and 48 countries respectively.

The purpose of this paper is to summarize the work undertaken by Weingarden and Tsigas (2010) and then outline how this work was expanded across all countries and all 57 GTAP commodities for incorporation into the GTAP Data Base (Narayanan, Aguiar and McDougall, 2012). Finally, some simulations are used to illustrate how the inclusion of the additional labor categories can enhance analysis of the labor market.

Following the introduction, section 2 describes the initial data sources obtained from Weingarden and Tsigas (2012) and provides some summary figures of this data; section 3 outlines the process used to incorporate this data into the GTAP database; section 4 then uses a model and database augmented with the additional labor to show how such additional data can improve analysis. In section 5, the paper is concluded and future directions noted.

2 Data Sources

The labor force data compiled by Weingarden and Tsigas (2010) consists of the number of workers by occupation and industry for 95 countries and imputed wages for 48 countries. The imputed wages are reported across 21 individual and aggregate sectors of the International Standard Industrial Classification, Revision 3 (ISIC-Rev.3) and across 5 individual and aggregate occupational categories of the International Standard Classification of Occupations (ISCO-88), Tables 1 and 2 respectively. The number of workers is also reported by ISIC-Rev.3 and ISCO-88. However, the number of workers for the 47 countries, without corresponding imputed wages, is distinctly categorized according to seven groups: six separate groups consisting of ISCO-88 Major Groups 1 through 6, and the seventh group comprised of an aggregation of ISCO-88 Major Groups

7 through 9. Additionally, while number of workers was reported for ISIC-Rev.3 sectors Q, QX, and X[1], no wage data was available for these sectors.

Table 1. Twenty Individual and Aggregate Sectors of ISIC-Rev.3

ISIC-Rev.3	**Description**
A	Agriculture, hunting and forestry
AB	Combination of sectors
B	Fishing
C	Mining and quarrying
D	Manufacturing
E	Electricity, gas and water supply
F	Construction
G	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods
GH	Combination of sectors
H	Hotels and restaurants
I	Transport, storage and communications
J	Financial intermediation
JK	Combination of sectors
K	Real estate, renting and business activities
L	Public administration and defence; compulsory social security
LMNOP	Combination of sectors
M	Education
N	Health and social work
O	Other community, social and personal service activities
P	Private households with employed persons

In the original 2008 *ILO Yearbook* dataset, wages are reported in the local currency of each country; however, wage rates are not standard. Wages may be reported per hour, per day, per week, or per month. Oostendorp's (2005) dataset of wages by occupation reports hourly wages in local currency. In order to standardize wage units, Weingarden and Tsigas (2010) converted wages in

[1] Sectors Q and X are defined as Extra-Territorial Organizations and Bodies and Not classifiable by economic activity, respectively, with QX defined as the combination of the two sectors.

the 2008 *ILO Yearbook* to hourly wages with the assumption of individuals working 40 hours per week and 4.3 weeks per month; wages remained reported in local currency.

Table 2. Five Individual and Aggregate Categories of ISCO-88

ISCO-88 Major Group	Abbreviated Name used in GTAP	Short name used in Paper	Description
1,2	off_mgr_pros	Officials and Mangers	legislators, senior officials and managers (Major Groups 1), and professionals (Major Group 2)
3	tech_aspros	Technicians	technicians and associate professionals
4	Clerks	Clerks	Clerks
5	service_shop	Service/Shop workers	service workers and shop and market sales workers
6,7,8,9	ag_othlowsk	Agricultural and Unskilled	skilled agricultural and fishery workers (Major Group 6), craft and related trade workers (Major Group 7), plant and machine operators and assemblers (Major Group 8), and elementary occupations (Major Group 9)

For each country within the 2008 *ILO Yearbook*, Weingarden and Tsigas (2010) used data from the most recent year between 1990 and 2008 for which data was complete. Because wages from Oostendorp's (2005) dataset were used to estimate the wage distribution across occupations, they did not need to adjust Oostendorp's (2005) dataset to the selected year from the 2008 *ILO Yearbook*. They did ensure that there was no incidence of extreme inflation for any of the 48 countries during the selected years.

Employment is reported in thousand individuals of the economically active population, as defined by the ILO. The ILO compiles its datasets from national sources which differ not only in the definition of actively employed workers but also in data compilation. Although individuals employed may not be clearly identified as full time workers, this is the best estimate of the employed workforce for these countries over the course of the given year.

3 Data Processing and Compilation

Once the data was received from Weingarden and Tsigas (2010) additional data cleaning was performed to standardize occupational categories, industry sectors, and country codes. For the 47 countries with only employment statistics available, the number of workers was summed into the 5 aggregate occupational categories used for wage imputation, Table 2. Additionally, sectors Q, QX, and X were dropped from the dataset. Long country names were used to match the 2-digit country codes within the Weingarden and Tsigas (2010) dataset to the standard 3-digit ISO country codes.

3.1 Description of Data

The following is a list of the basic data and sets available:

- ***IND_ILO*** – This set contains the 20 individual ISIC-Rev.3 industries and aggregates of ISIC-Rev.3 industries listed in table 1, plus GTAP's capital goods sector.
- ***CTRY*** – This set contains all 95 countries (standard 3-digit ISO country code used).
- ***OCCU*** – This set contains 5 individual and aggregate ISCO-88 occupational categories listed in table 2.
- ***EMPL*** – This data contains employment by occupation (OCCU) in the 21 individual ISIC-Rev.3 industries (IND_ILO, Table 1) and aggregates of ISIC-Rev.3 industries for 95 countries (CTRY).
- ***WAGE*** – This data contains wages by occupation (OCCU) in each of the 21 individual ISIC-Rev.3 industries (IND_ILO) and 48 countries (subset of the 95 countries for which employment was available (CTRY)).

3.2 Statistical Summary

This section provides an overview of the statistics within the compiled dataset. First we present a series of rankings of labor ratios and wage ratios by country. Then we consider the concentration of labor in different sectors in comparison with per capita GDP across countries.

Below we consider the ratio of the weighted mean wage by occupation to the total weighted mean wage within each country. We consider the top five and the bottom five countries. A high ratio

(greater than 1) suggests that the wage within the occupation exceeds the average wage for the country, whereas a low ratio (less than 1) suggests that the wage within the occupation is less than the average wage for the country.

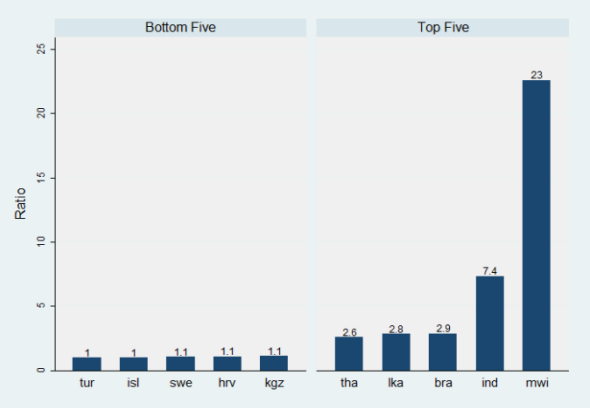
In Figure 1, Panel A we observe that legislators, senior officials and managers (Major Groups 1), and professionals (Major Group 2) earn between two to three times as much as the average worker in Thailand, Sri Lanka, and Brazil whereas they earn over seven times as much as the average worker in India. They earn twenty-three times the average in Malawi. In Turkey, Iceland, Sweden, Croatia, and Kyrgyzstan, earnings are the same as or only slightly more than the national average. In Panel B we observe the that technicians and associate professionals (Major Group 3) earn between two and three times the average worker in Thailand, the Philippines, Nicaragua and India, whereas they earn over eight times as much as the average worker in Malawi. They earn around roughly between two-thirds and three-quarters as much as the average worker in Venezuela and the Netherlands. They earn eighty percent as much as the average worker in Russia and just less than the national average in Moldova and Estonia.

In Panel C we observe that clerks (Major Group 4) earn between one and a half times to twice as much as the average worker in Peru, Venezuela, and China, whereas they earn over three times as much as the average worker in Malawi and India. They earn around roughly between two-thirds and three-quarters as much as the average worker in Moldova, Singapore, Luxembourg, and Mexico. They earn less than one half of the national average in Russia. In Panel D we observe that service workers and shop and market sales workers (Major Group 5) earn the same as or only slightly more than the average worker in Russia, Kyrgyzstan, Thailand, and Turkey, whereas they earn over five times as much as the average worker in Malawi. They earn around half as much as the average worker in Singapore, the Philippines, Brazil, and Bulgaria. They earn less than one third of the national average in the United States.

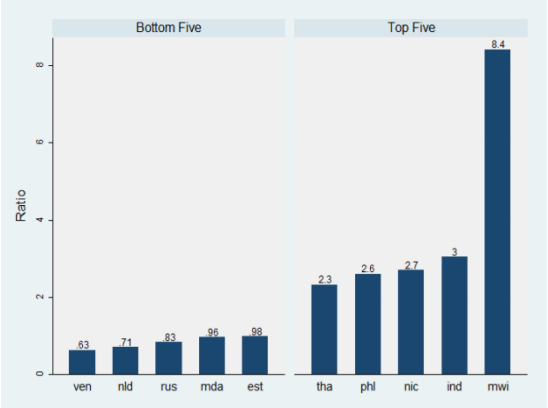
Disaggregation Labor Payments

Figure 1. Ratio of Weighted Mean Wages within Occupation Group to Total Weighted Mean Wages by Country

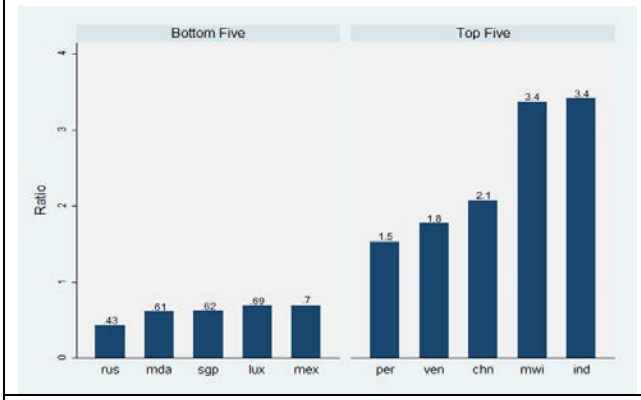
Panel A. Group 1&2 Occupations (legislators, senior officials and managers and professionals)



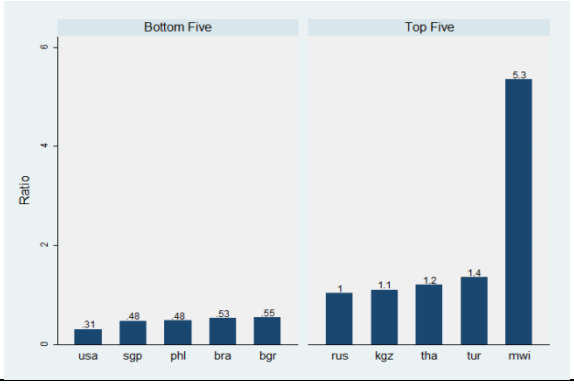
Panel B Group 3 Occupations (technicians and associate professionals)



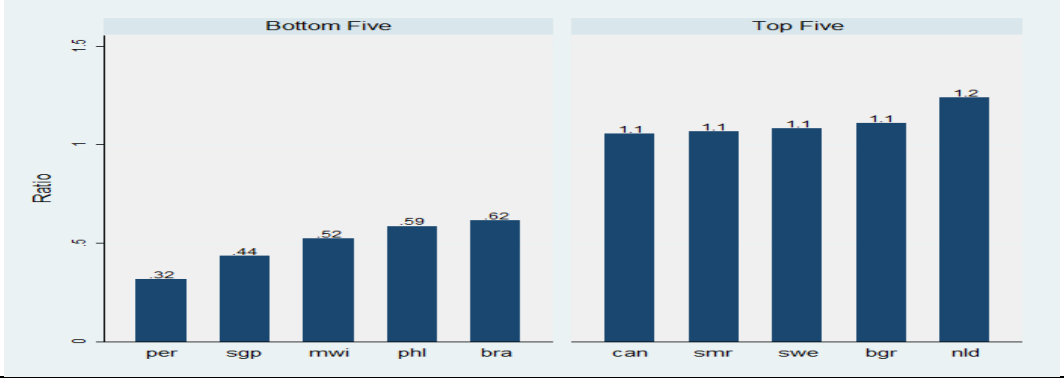
Panel C. Group 4 Occupations (Clerks)



Panel D. Group 5 Occupations (service and shop workers)



Panel E. Group 6,7,8&9 Occupations (agricultural, craft, trade, machine operators and elementary occupations)



Disaggregation Labor Payments

In Panel E we observe that skilled agricultural and fishery workers (Major Group 6), craft and related trade workers (Major Group 7), plant and machine operators and assemblers (Major Group 8), and elementary occupations (Major Group 9) earn just slightly more than the average worker in Canada, San Marino, Sweden, Bulgaria and the Netherlands. They earn between one-half and two-thirds as much as the average worker in Malawi, the Philippines, and Brazil. They earn forty-four percent as much as the average worker in Singapore and less than one third the average wage in Peru.

The following section (Figure 2) ranks the top five and bottom five countries by the ratio of labor in each occupation relative to the total workforce. Naturally, a high ratio indicates that jobs within the given occupation employ a high proportion of the total workforce whereas a low ratio suggests that jobs within the given occupation employ a very low proportion of the total workforce.

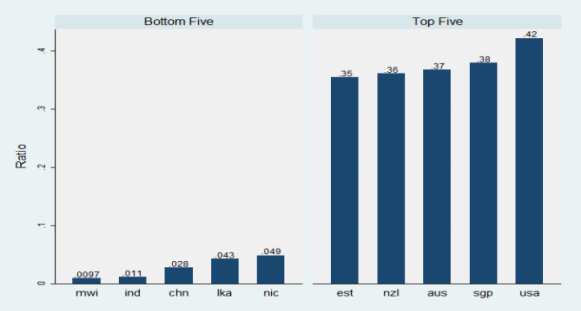
In Panel A we observe that roughly thirty to forty percent of workers are employed as legislators, senior officials and managers (Major Group 1), and professionals (Major Group 2) in Estonia, New Zealand, Australia, Singapore, and the United States. However, less than five percent of the actively employed work in this sector in the Nicaragua, Sri Lanka, China, India, and Malawi. In Panel B we observe that roughly a quarter of the labor force is employed as technicians and associate professionals (Major Group 3) for Germany, Luxembourg, Slovakia, Austria, and the Czech Republic. Employment in these occupations is less than four percent for Thailand, China, and Sri Lanka, and less than one percent for Malawi and India.

In Panel C we observe that one third of the labor force is employed as clerks (Major Group 4) in San Marino whereas just less than one fifth of the labor force is employed as clerks in Cyrpus, Korea, Singapore, and Venezuela. In Barbados, Kyrgyzstan, China, Nicaragua, and India between two and three percent of workers are employed as clerks. In Panel D we observe that nearly half of the labor force in Bolivia consists of service workers and shop and market sales workers (Major Group 5), whereas roughly one third of the labor force is employed in the occupational group in Korea, San Marino, Peru, and Brazil. Between seven and ten percent of the workforce in Japan and India is employed in this occupational grouping whereas less than five percent of workers in Thailand, Turkey and Malawi are employed in this occupation.

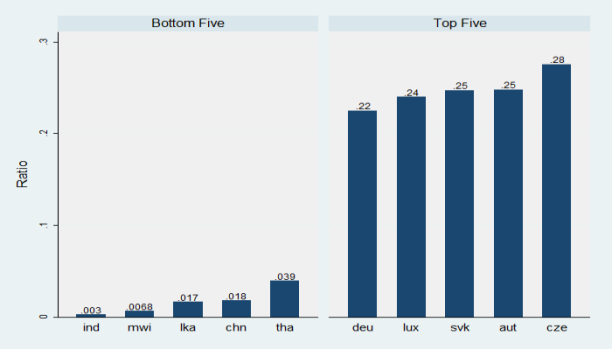
Disaggregation Labor Payments

Figure 2. Ratio of Labor within Group to Total Labor by Country

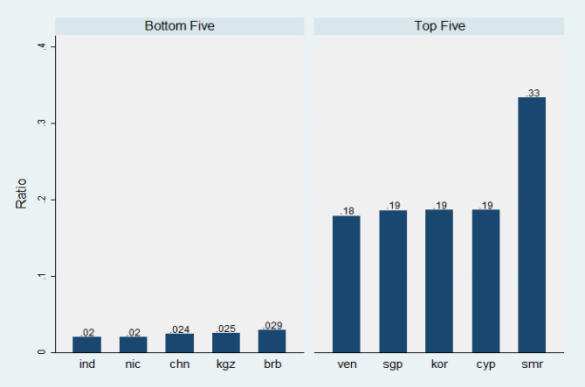
Panel A. Group 1&2 Occupations (legislators, senior officials and managers and professionals)



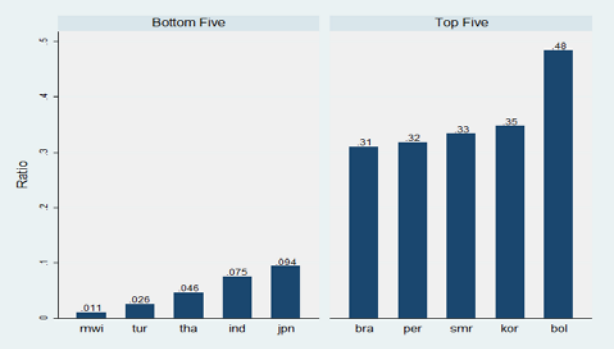
Panel B. Group 3 Occupations (technicians and associate professionals)



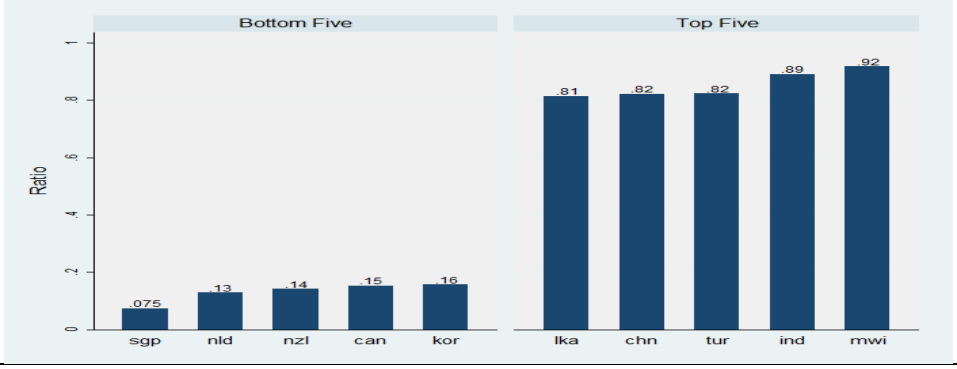
Panel C. Group 4 Occupations (Clerks)



Panel D. Group 5 Occupations (service and shop workers)



Panel E. Group 6,7,8&9 Occupations (agricultural, craft, trade, machine operators and elementary occupations)



Disaggregation Labor Payments

In Panel E we observe that about ninety percent of the labor force in India and Malawi is employed as skilled agricultural and fishery workers (Major Group 6), craft and related trade workers (Major Group 7), plant and machine operators and assemblers (Major Group 8), and elementary occupations (Major Group 9). Just over eighty percent of workers are employed in this occupational grouping in Turkey, China, and Sri Lanka. Roughly fifteen percent of the labor force works in this occupational grouping in Korea, Canada, New Zealand, and the Netherlands. Singapore has the lowest proportion of workers employed in this occupational category, at less than eight percent.

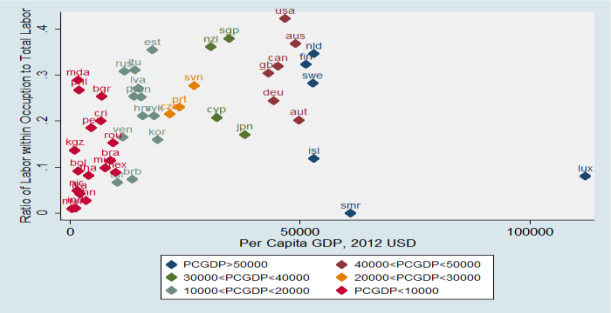
In comparing Figures 1 and 2 it is clear that skilled workers (Officials and Managers, and Technicians) tend to have higher wages than unskilled in all countries. Moreover we find that those labor types where supply is particularly low (Figure 2) in a country also tend to have very high wages (Figure 1). Those developing countries with severely inadequate supplies of Officials and Managers, Technicians, Clerks, and Service and Shop workers and those developed countries with inadequate supplies of Agricultural and Unskilled workers also have the highest wages for those labor categories. The reverse, however, is not necessarily true. Countries with large supplies of workers, particularly the very skilled managers and technicians, do not necessarily have the lowest relative wages for those labor categories.

Now we will consider the ratio of labor employed in each sector relative to the per capita GDP of each country, as shown in Figure 3. We obtain 2008 per capita GDP in current (2012) USD for all countries in our compiled dataset from the World Bank's World Development Indicators (2010). The expectation would be that countries with higher per capita GDP would tend to employ a greater proportion of the labor force in occupations that require more skilled work or more education, such as Technicians, whereas countries with lower per capita GDP would tend to employ a greater proportion of the labor force in occupations that require less skilled work and less education, such as Agricultural and Unskilled workers. For ease of visual analysis, countries have been grouped according to per capita GDP by intervals of 10,000 current USD.

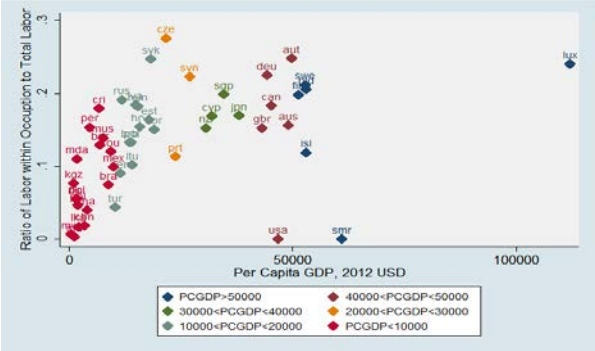
Disaggregation Labor Payments

Figure 3. Ratio of Labor within Group Occupations to Total Labor by Per Capita GDP

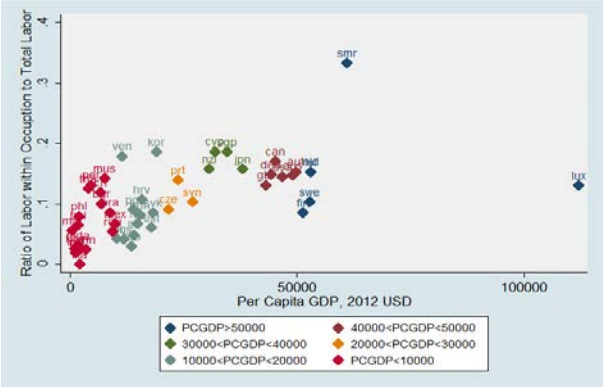
Panel A. Group 1&2 Occupations (legislators, senior officials and managers and professionals)



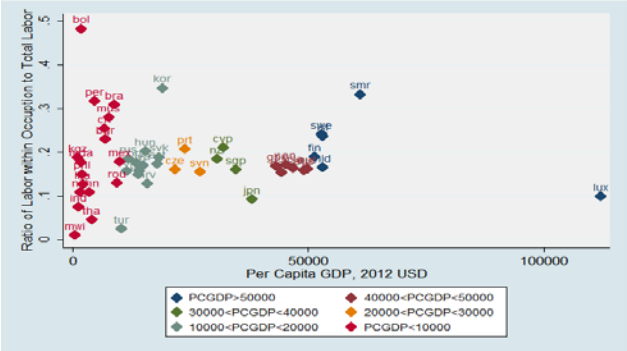
Panel B. Group 3 Occupations (technicians and associate professionals)



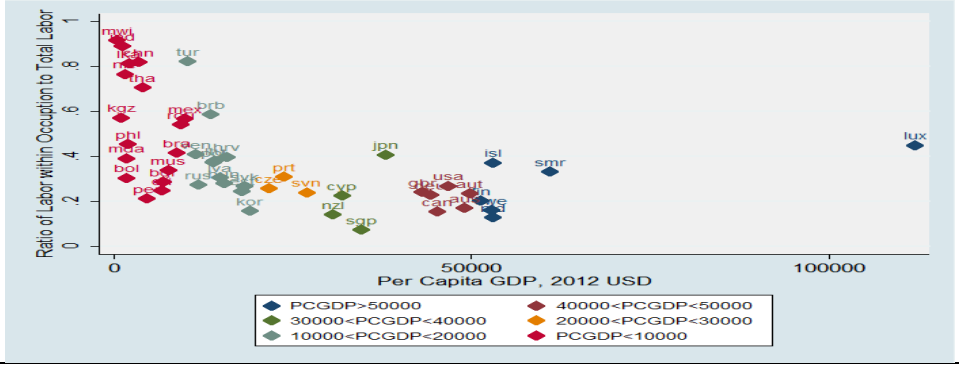
Panel C. Group 4 Occupations (Clerks)



Panel D. Group 5 Occupations (service and shop workers)



Panel E. Group 6,7,8&9 Occupations (agricultural, craft, trade, machine operators and elementary occupations)



Disaggregation Labor Payments

In Panel A, we observe that within groupings of per capita GDP, there is an apparent wide distribution of the ratio of labor in the occupational group legislators, senior officials and managers (Major Groups 1), and professionals (Major Group 2) relative to each country's total labor. Nonetheless there seems to be a general pattern that countries with higher per capita GDPs employ a higher proportion of these workers. The concentration of employment in this category may be affected by various other factors, such as country size or government structure. For the ratio of labor employed as technicians and associate professionals (Major Group 3) relative to the total labor within each country, there is a more apparent pattern of employment, as seen in Panel B. Here, we can clearly observe that countries with lower per capita GDPs tend to employ less within this profession than those of higher per capita GDP. Again in Panel C, for the ratio of workers employed as clerks (Major Group 4) to the total actively employed population per country, there is an apparent pattern such that countries with higher per capita GDP employ more clerks whereas countries with lower per capita GDP employ less clerks. With the exception of San Marino, the concentration of clerks within countries is less than twenty percent. In Panel D, the ratio of service workers and shop and market sales workers (Major Group 5) in comparison with total labor employed by country appears widely distributed within the lower end groupings of per capita GDP, particularly in the range less than 10,000 USD. This may be because of the varied nature of service jobs. For example, some service jobs would cater to wealthier nations and would not be present within less wealthy countries. However, other service professions cater to non-domestic clientele, e.g. tourist professions or call-center jobs.

Finally, in Panel E we see higher concentrations of labor employed as skilled agricultural and fishery workers (Major Group 6), craft and related trade workers (Major Group 7), plant and machine operators and assemblers (Major Group 8), and elementary occupations (Major Group 9) within countries with less than 20,000 USD per capita GDP. Countries with greater than 20,000 USD per capita GDP appear to have a concentration of employment within these occupations of around twenty to thirty percent.

Overall, these comparisons with per capita GDP demonstrate anticipated patterns. We observe that workers in Major Groups 1 through 4, requiring higher skillsets and more education, are employed in equal and often greater concentrations within countries with higher per capita GDPs compared with countries with lower per capita GDPs. Likewise, workers employed in Major Groups 6

through 9 tend to be employed in higher concentrations in countries with lower per capita GDPs than countries with higher per capita GDP. The concentration of employment in Major Group 5, service workers and shop and market sales workers, does not follow such an apparent pattern; this may be due to the nature of service jobs.

4 Incorporating the additional Labor splits into the GTAP Data Base

These data, provided by Weingarden and Tsigas (2010), were then used to disaggregate the value of labor services in the GTAP I-O tables. In this section, the procedure used is outlined and then some summary figures are provided.

4.1 Procedure

To do this missing values needed to be filled. It was decided that data on both wages and employment would be disaggregated and/or filled separately so that employment and wage data, as well as values could be retained. Figures 4 and 5 are used to describe the procedure used during this process.

Converting Wages into US dollars

Before proceeding to the explanation of how the data was filled, the first step was to ensure that the wages were in US dollars. As mentioned above wages were initially recorded in local currency. The wages were first converted into US dollars using the ratio of GDP in US dollars to GDP in local currency obtained from the IMF (in the year the wage was collected).

Filling across Sectors

Figure 4 shows the relationship between the original 21 ILO sectors (Column I, Figure 4) for which data are available and the GTAP sectors (Column IV). Some countries provide more aggregated data than others, so the 21 sectors includes a complete list of all possible sectoral combinations supplied. For example some countries might provide data for sectors A and B separately, while others for A and B combined. As a consequence our initial list of sectors includes sectors A, B and AB. The first step (Figure 5) is then to disaggregate the combined sectors (e.g., AB). To do this the 21 sectors are mapped to 16 unique disaggregated ILO sectors (Column II, Figure 4).

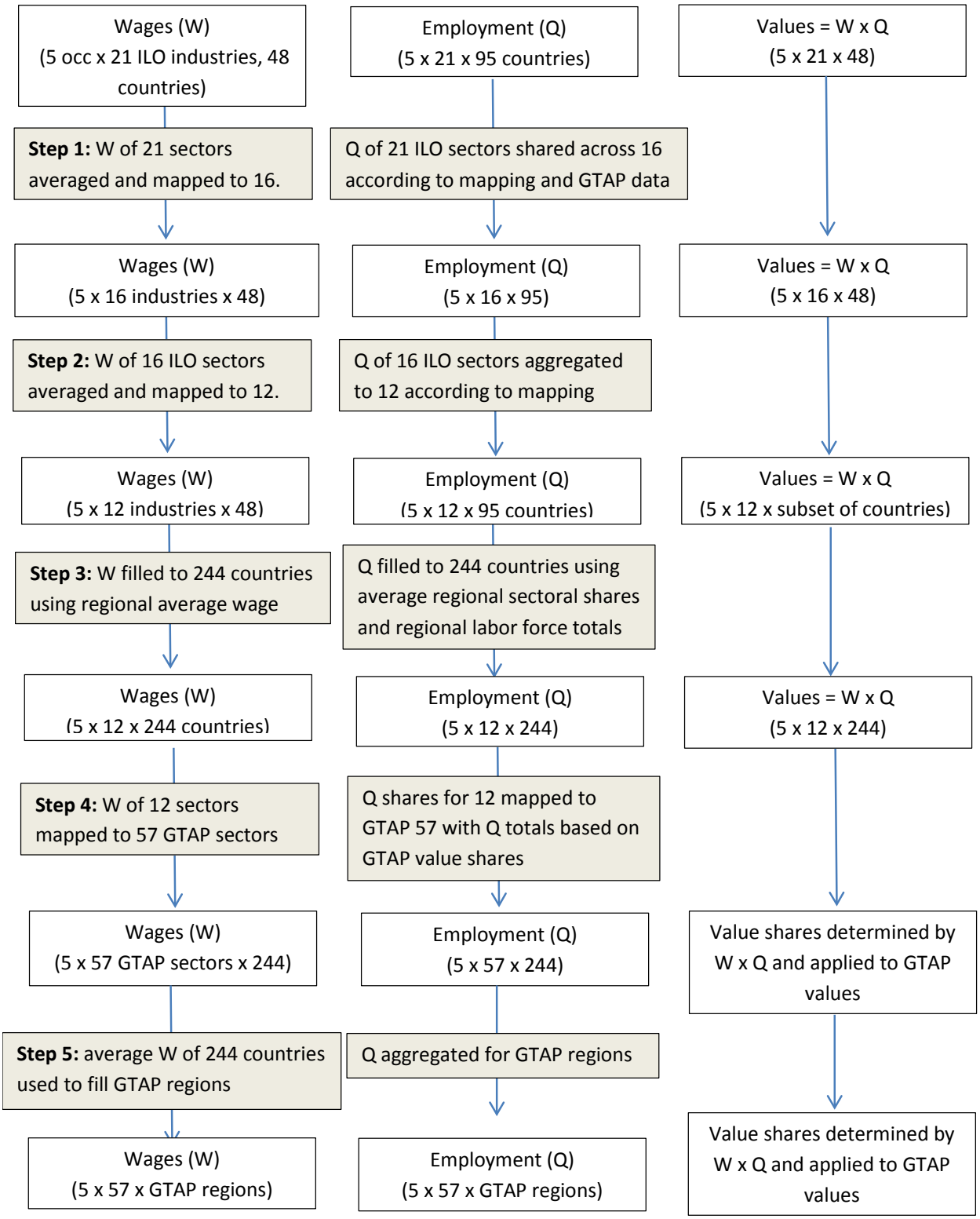
Disaggregation Labor Payments

Figure 4. Relationship between ILO sectors and GTAP sectors

I			II	III	IV
21 ILO sectors (Table 1)			**16 ILO sectors**	**12 ILO sectors**	**GTAP sectors**
AB	A		A	A	1-13
	B		B	B	14
C			C	C	15-18
D			D	D	19-42
E			E	E	43-45
F			F	F	46
GH	G		G	GH	47
	H		H		
I			I	I	48-51
JK	J		J	J	52-53
	K		K	K	54
LMNOP	L		L	LMNO	56-57 and cgds
	MN	M	M		
		N	N		
	O		O		
	P		P	P	55

Disaggregation Labor Payments

Figure 5. Procedure used to process the skilled values, employment and wage data



Disaggregation Labor Payments

The second step is to move between the 16 unique sectors to the 57 GTAP sectors. Unfortunately the 16 unique ILO sectors do not map perfectly to an aggregation of the 57 GTAP sectors and so some of the 16 sectors must first be aggregated into 12 (Column III, Figure 4 and step 2, Figure 5). The 12 sectors are then allocated across the 57 in GTAP (Column IV, Figure 4 and step 4, Figure 5).

Filling across Countries/Regions

In addition to filling in missing sectors, we also need to fill in missing countries. Our approach in the GTAP Data Base is always to fill data to a standard country list of 244 countries. If we were interested only in wages and quantity or value shares this would not be problematic, because labor shares can easily be applied to other countries. However our aim is to also retain the quantity detail across 244 countries and across sectors: this requires information on the size of the sector and the total quantity of labor in the country. We use the GTAP Data Base, expanded to 244 countries[2], to provide us with the sectoral weights and include total labor force data from the *2008 ILO Yearbook* to provide the total quantity of labor. Step 4 in Figure 5 is therefore to fill in wage and quantity data for all 244 countries using regional averages and total quantities. The final wages and quantities are then averaged and aggregated respectively to get data for the GTAP regions, relevant to the particular aggregation (134 in v8.1). The wages and quantities are multiplied together to obtain the value and these value shares are then applied to the total value of labor obtained from the GTAP Data Base.

Obtaining consistency with GTAP data Base

At each step the wages ($W^{\mathrm{ILO}}_{(\mathrm{l,j,r})}$) and quantities ($Q^{\mathrm{ILO}}_{(\mathrm{l,j,r})}$) are multiplied together to give Values ($V^{\mathrm{ILO}}_{(\mathrm{l,j,r})}$), wherever $W^{\mathrm{ILO}}_{(\mathrm{l,j,r})}$ and $Q^{\mathrm{ILO}}_{(\mathrm{l,j,r})}$ are both available. The final value $V^{\mathrm{ILO}}_{(\mathrm{l,j,r})}$ does not necessarily add up to the value obtained from the IO tables and used in the GTAP Data Base ($V^{\mathrm{IOT}}_{(\mathrm{LAB,j,r})}$). So

[2] We assume a simple expansion where a GTAP rest of region is split into countries using GDP shares. So all countries in the same GTAP region have the same IO structure; this is necessary as we do not have IO tables for all 244 countries.

the wages and quantities are consistent with the ILO data and across regions and sectors but they are not consistent with the GTAP Data Base.

$$V^{IOT}_{(\mathrm{LAB,j,r})} \neq \sum_{i \in ILO} W^{\mathrm{ILO}}_{(\mathrm{l,j,r})} \cdot Q^{\mathrm{ILO}}_{(\mathrm{l,j,r})}$$

One of the reasons for this is the units: wages are hourly wages, while the quantities are millions of people. Multiplying these together gives the hourly wage bill by labor type, rather than the annual wage bill.

Moreover, the GTAP total come from the IO tables ($V^{\mathrm{IOT}}_{(\mathrm{LAB,j,r})}$), while the labor data is processed from various sources (Weingarden and Tsigas, 2010) – for convenience we label this the ILO data since this is the main source. In order to resolve this inconsistency we assume that the GTAP total value of labor from the IO tables is correct, but use the ILO data to obtain the shares by labor type. This means that:

$$V^{\mathrm{GTAP}}_{(\mathrm{l,j,r})} = V^{\mathrm{IOT}}_{(\mathrm{LAB,j,r})} \cdot \left[\frac{W^{\mathrm{ILO}}_{(\mathrm{l,j,r})} \cdot Q^{\mathrm{ILO}}_{(\mathrm{l,j,r})}}{\sum_{i \in ILO} W^{\mathrm{ILO}}_{(\mathrm{l,j,r})} \cdot Q^{\mathrm{ILO}}_{(\mathrm{l,j,r})}} \right]$$

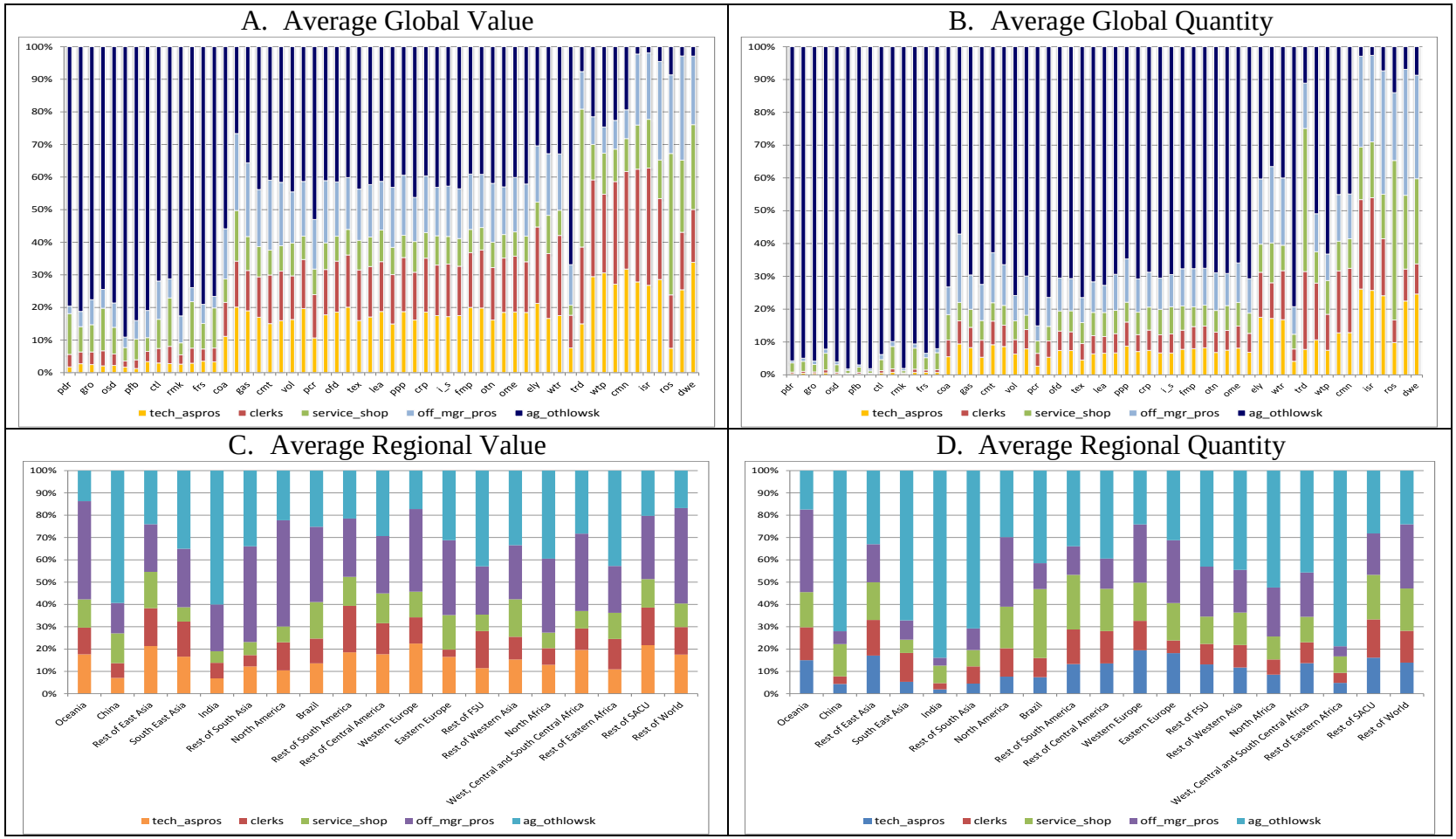
This determines the values to be used in GTAP, then we must choose whether to believe the ILO quantities and wages let the other be determined from the value.

4.2 Statistical summary

Figure 6 (A and C) show the global value shares by sector and the regional labor shares respectively. The global shares across sectors show that agriculture has higher shares of agricultural and less skilled workers, while more skilled workers have low shares. These shares reverse as we examine the manufacturing sector and even more so as we look at other sectors. Since data was only obtained for 12 aggregated sectors the value shares within a country are uniform across sectors mapped to the same sector (e.g., Paddy rice (pdr) and wheat (wht) both map to ILO sector A (Figure 4) and therefore have the same shares. The differences globally are the result of differences in the relative sizes of the sectors across countries.

Disaggregation Labor Payments

Figure 6. Average value and quantity shares of 5 labor types in total labor



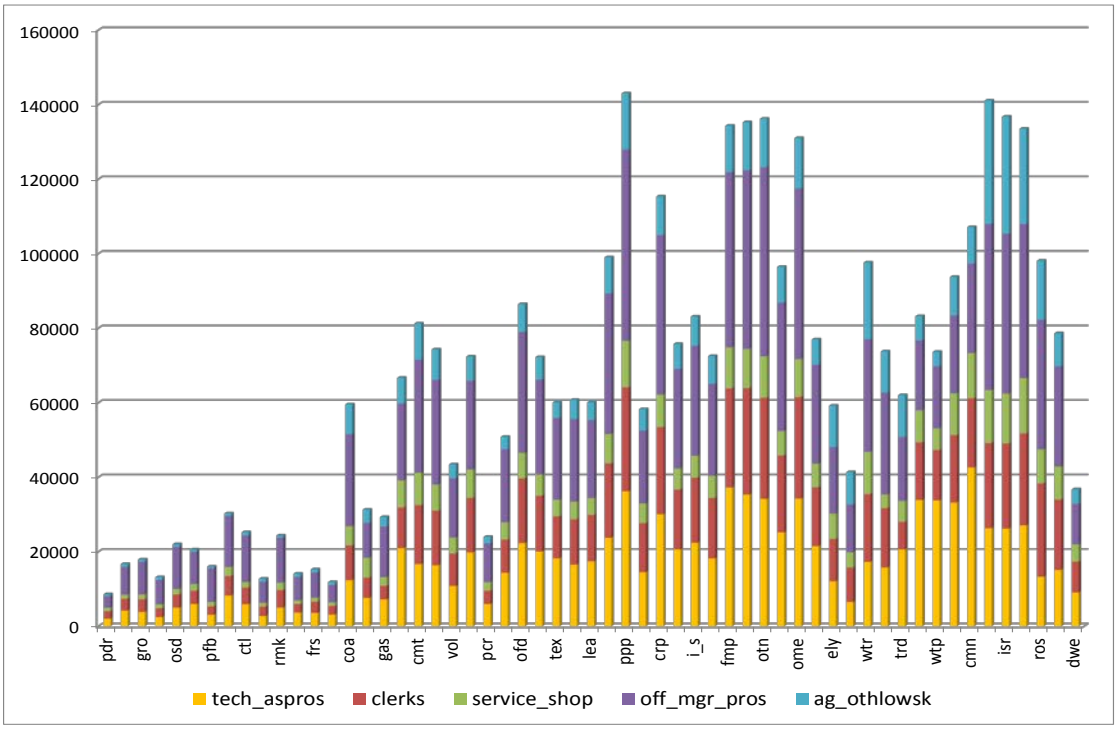
Disaggregation Labor Payments

When we look at the shares across regions in Figure C, we also find that developing countries have higher shares of agricultural and less skilled workers, while more developed economies exhibit the reverse tendencies.

Figure 6B and D show the quantity shares. The quantity shares are weighted towards agricultural workers and less skilled since the wages of these workers tend to be lower than the other more skilled workers. This is also seen in the regional shares.

Figure 7 show the average wages by sector. In general wages of all skill types are lower in agriculture and food processing than in manufactures and services.

Figure 7. Average global wage of 5 labor types by sector



5 Modelling and Analysis

In this section we examine the impact of adding the additional labor splits into the GTAP 8.1 Data Base (GTAP 8.1L Data Base). Three scenarios are examined to demonstrate how the additional

labor types can alter the results and improve analysis. The results of these experiments are compared with the GTAP 8.1 Data Base with two labor categories.

1. The main simulation is the removal of all tariff barriers globally. This is undertaken under two alternative closures: a) assuming full employment (standard GTAP closure); and b) assuming unemployment of unskilled labor. In the GTAP 8.1L Data Base, unskilled labor is assumed to include Agricultural and Unskilled workers; Service and Shop workers and Clerks.

Following this we also show the results for two growth scenarios:

2. A baseline scenario where real GDP, capital and skilled and unskilled labor forecasts are introduced into the model to move the economy forward from 2007 to 2030.
3. Growth in regional income using a PE closure similar to that undertaken in Walmsley, Hertel and Hummels (forthcoming).

The scenarios are not meant to examine the impact of any particular policy scenario currently being considered, they are merely chosen to demonstrate how the inclusion of additional labor categories can enhance analysis or change the results from the GTAP model. The GTAP Data Base was aggregated into 16 regions and 14 sectors for the purpose of this exercise. The list of sectors and regions is provided in Table A1 in the Appendix.

Trade Liberalization

Table 3 shows the impact on Real GDP of the removal of all tariffs globally. As can be seen from the results, the inclusion of additional labor detail has minimal impact on the real GDP (at least to the third decimal place) under the standard GTAP closure. This is a little surprising given the differences in "unskilled" labor shares between the two datasets; however the total labor share in value added remains unchanged between the two versions and in this standard closure all labor is perfectly mobile across sectors. Hence, all labor can reallocate to those sectors that require the additional labor, and, while there are some differences in real wages (Table 4) that lead to a reallocation of labor (see Figure 8 for India for example), these differences are small and do not lead to significant changes in average marginal product of labor (as a whole) between the two datasets.

Disaggregation Labor Payments

When restrictions on that mobility are imposed or unemployment is allowed for some of the labor categories, the macro results differ considerably as these assumptions on the different types of labor alter the relative marginal product of skilled verses unskilled labor even further, as well as the relative quantity of unskilled and skilled labor (see impact on employment in Table 4). This combined with the differences between the shares of "unskilled" (as defined across the two different datasets) in labor causes larger differences in labor's quantity and marginal product that subsequently impact Real GDP.

Table 3. Impact of Trade liberalization on Real GDP (% changes)

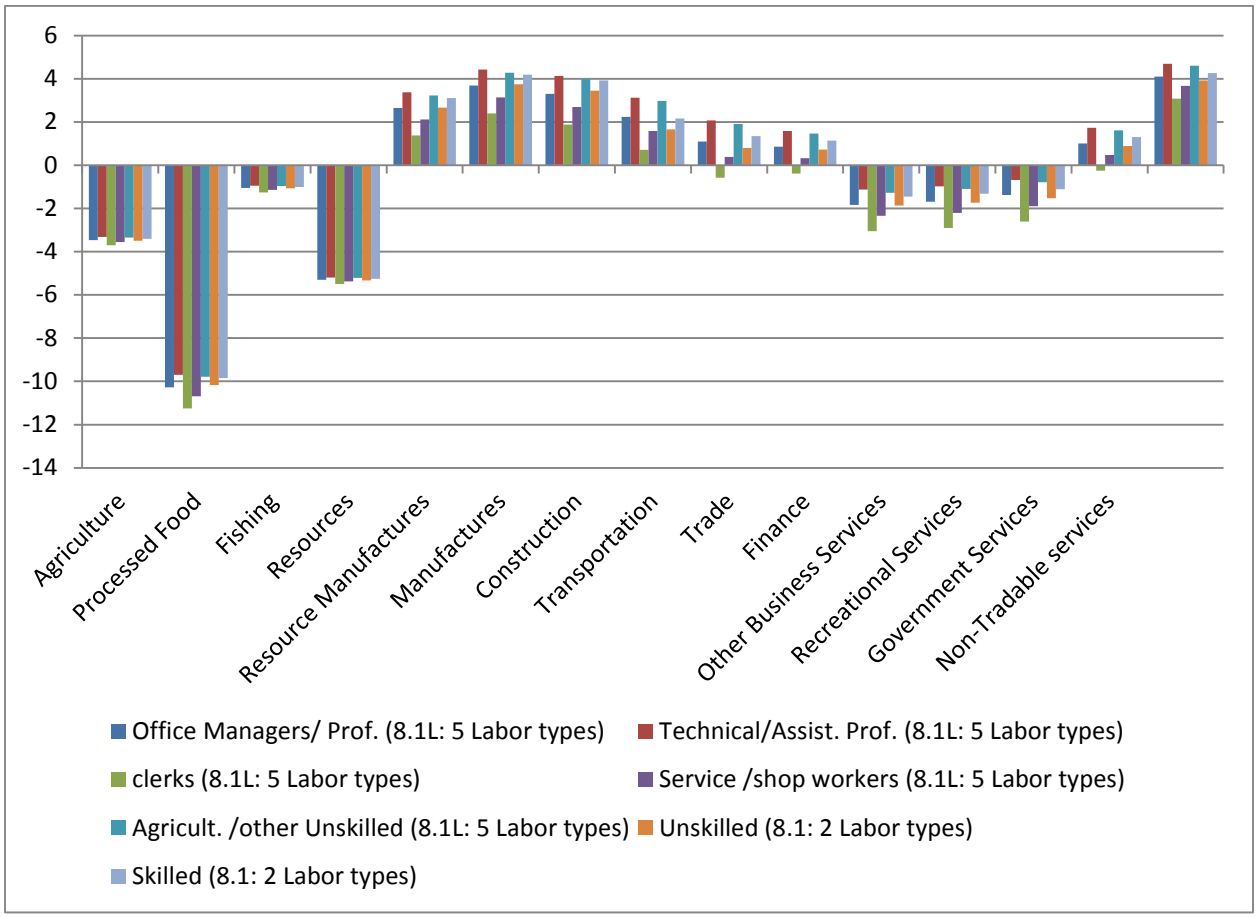
	Share of unskilled in VA		Share of unskilled in Labor		Full Employment		With Unemployment	
	8.1 (2 labor)	8.1L (5 labor)	8.1 (2 labor)	8.1L (5 labor)	8.1 (2 labor)	8.1L (5 labor)	8.1 (2 labor)	8.1L (5 labor)
China	0.38	0.37	0.76	0.73	0.50	0.50	1.33	1.29
Japan	0.33	0.25	0.62	0.48	0.08	0.08	0.70	0.52
USA	0.37	0.27	0.56	0.40	0.01	0.01	0.00	0.00
India	0.37	0.28	0.74	0.57	1.49	1.49	3.91	3.17
Brazil	0.37	0.26	0.66	0.47	0.09	0.08	0.41	0.46
Russia	0.20	0.14	0.68	0.48	0.46	0.46	0.95	0.79
Oceania	0.34	0.23	0.59	0.39	0.10	0.10	0.56	0.34
East Asia	0.33	0.28	0.65	0.56	0.27	0.27	2.15	1.84
S.E. Asia	0.30	0.24	0.74	0.58	0.18	0.18	1.16	0.96
South Asia	0.36	0.25	0.73	0.51	0.35	0.35	2.85	1.96
North America	0.28	0.20	0.64	0.46	0.08	0.08	0.21	0.16
Latin America	0.32	0.24	0.68	0.51	0.13	0.13	0.68	0.52
EU 25	0.26	0.18	0.58	0.41	0.04	0.04	0.14	0.09
Middle East and North Africa	0.30	0.23	0.71	0.54	0.42	0.42	1.85	1.39
Sub-Saharan Africa	0.34	0.25	0.75	0.56	0.32	0.32	1.56	1.10
Rest of World	0.23	0.18	0.65	0.52	0.10	0.10	0.69	0.53

Disaggregation Labor Payments

Table 4. Impact of Trade Liberalization on Real Wages or Employment (% changes)

	Full Employment, impact on Real Wages							Unemployment, impact on Employment			
	8.1 (2 Labor Types)		8.1L (5 Labor Types)					8.1 (2 Labor Types)	8.1L (5 Labor Types)		
	Skilled	Unskilled	Office Managers / Prof.	Technical /Assist. Prof.	clerks	Service /shop workers	Agricult. /other Unskilled	Unskilled	clerks	Service /shop workers	Agricult. /other Unskilled
China	1.56	1.55	1.56	1.51	1.54	1.53	1.56	2.20	2.58	2.46	2.01
Japan	1.09	1.00	1.06	1.03	1.01	1.01	1.03	1.80	1.78	1.85	1.44
USA	0.04	0.04	0.06	0.06	0.07	0.07	-0.04	-0.01	0.04	0.04	-0.12
India	4.47	4.81	4.75	4.15	5.79	5.19	4.26	6.65	8.48	9.27	4.35
Brazil	0.31	0.47	-0.08	0.12	0.15	0.32	2.06	0.84	0.64	0.84	2.50
Russia	1.35	1.37	1.39	1.41	1.71	1.70	1.17	1.80	2.51	2.90	1.26
Oceania	0.38	0.72	0.55	0.54	0.40	0.54	0.95	1.25	0.71	0.95	1.12
East Asia	2.88	3.10	2.89	2.88	3.13	2.48	3.83	5.45	5.46	4.77	5.55
S.E. Asia	1.65	2.38	1.71	1.62	2.00	1.51	3.04	3.36	3.52	2.59	3.40
South Asia	4.22	4.93	4.75	3.79	4.53	4.33	5.34	7.11	7.89	7.38	5.86
North America	0.19	0.28	0.20	0.27	0.29	0.16	0.32	0.39	0.42	0.27	0.33
Latin America	0.78	1.04	0.79	0.87	0.90	0.86	1.39	1.68	1.54	1.45	1.67
EU 25	0.22	0.21	0.22	0.26	0.30	0.23	0.08	0.30	0.41	0.32	0.07
Middle East and North Africa	3.52	3.29	3.45	3.62	3.48	3.37	3.12	4.91	5.73	5.36	3.73
Sub-Saharan Africa	1.98	2.05	1.88	1.79	1.94	1.76	2.43	3.36	3.62	3.46	2.43
Rest of World	1.27	1.31	1.29	1.32	1.47	1.29	1.22	2.07	2.36	2.18	1.52

Figure 8. Reallocation of Labor across Industries by India as a result of Trade Liberalization (Full Employment) (% changes)



The impact on real wages (Table 4 with full employment) due to the trade liberalization is not significantly different across the alternative labor types; however, there are some differences reflecting where production and hence labor reallocates as a result of the trade liberalization. For instance, consider change in labor demand across industries in India; see Figure 8. Production in India's manufacturing, construction and transportation industries rises while agriculture and food processing falls, causing an economy-wide increase in demand for Clerks, and Service and Shop workers, as opposed to Agricultural and Unskilled workers. This is even more obvious when unemployment is assumed as the supply of Clerks, and Service and Shop workers rises by more than double the percentage change in Agricultural and Unskilled workers. The reverse is true for

Brazil, where agriculture rises and Agricultural and Unskilled workers gain significantly more than Clerks, and Service and Shop workers. When all of these unskilled workers were combined into one single unskilled worker category, these differences between unskilled workers could not be explored.

Similarly, we may also consider the advantage of having skilled labor disaggregated. The higher demand for Officials and Managers, as opposed to Technicians, in India, reflected by the relative percent change increase in real wages in response to the trade liberalization, is a result of the higher share of this labor in manufacturing, construction and services. In Brazil, however, Technicians are a more important input than Officials and Managers into construction, the main source of demand for skilled workers. So we see an increase in Technicians' real wages whereas Officials and Managers experience a real wage decline.

Growth

In this section we examine how the separation of labor into 5 categories impacts each of our growth scenarios, respectively.

In the first scenario, we exogenize GDP and endogenize technological change. Then using a simple baseline scenario for the comparative static GTAP model that is commonly used to update the database to a new base year, we implement forecasts of Real GDP, capital, skilled and unskilled labor to move the economy from 2007 to 2030 (Table 5). From this, we can observe technological change in the economy and how this change subsequently effects production and hence the labor market, as seen by workers' real wages.

In the GTAP 8.1L database where we have 5 labor categories, we apply the unskilled forecasts to agricultural and other unskilled workers, service and shop workers and clerks. The skilled worker forecasts are applied to the other two categories: office managers and professionals and technical and assistant professionals. This is done because, firstly, forecasts of labor growth at the detailed level are not available, and secondly, imposing differential growth rates would have confounded the differences in the results.

The resulting changes in technological change (Table 5) show that the inclusion of 5 labor categories has indeed affected the results. In general, less productivity growth is required to

achieve the GDP target (Figure 5) in the GTAP 8.1L Data Base. This is due to the fact that skilled workers are forecast to grow at a much greater rate than unskilled (Table 5) and as seen in Table 3, the share of unskilled workers (Clerks, Service and Shop workers, and Agricultural and Unskilled workers) is much lower in the new GTAP 8.1L Data Base with 5 labor categories.

Disaggregation Labor Payments

Table 5. Impact of Baseline Growth Scenario on Technological Change (Cumulative % changes 2007-2030)

	Technological Change		**Exogenous Forecasts 2007-2030**			
	8.1 (2 labor)	8.1L (5 labor)	Real GDP	Capital	Unskilled	Skilled
China	335.14	331.61	495.5	85.2	-3.55	81.82
Japan	35.96	27.84	23.22	3.9	-44.95	38.54
USA	160.68	157.41	53.47	-89.65	10.25	23.85
India	232.64	226.03	356.3	44.1	35.68	70.8
Brazil	284.96	276.01	103.46	-86.05	21.02	50.93
Russia	213.33	197.4	74.54	-62.78	-36.71	35.86
Oceania	116.53	117.75	64.31	-68.96	30.5	25.34
East Asia	75.62	70.26	96.54	15.49	-15.41	62.18
S.E. Asia	113.37	109.42	169.33	21.15	27.91	73.48
South Asia	179.43	175.34	288.4	29.68	54.84	78.27
North America	267.82	263.96	74.82	-84.98	23.4	35.31
Latin America	278.75	273.81	109.47	-81.26	37.32	59.04
EU 25	235.16	211.45	33.44	-90.3	-27.15	42.59
Middle East and North Africa	438.6	434.11	191.48	-76.93	46.26	67.33
Sub-Saharan Africa	412.05	411.85	234.5	-79.93	82.92	102.34
Rest of World	340.41	326.95	84.94	-83.25	-4.89	49.22

Disaggregation Labor Payments

Table 6. Impact of Growth

	A. Impact on Real Wages (% changes) Due to Baseline Growth 2007 to 2030							B. Impact of Supply (% change) Due to Own Real Income Growth						
	8.1 (2 Labor Types)		8.1L (5 Labor Types)					8.1 (2 Labor Types)		8.1L (5 Labor Types)				
	Skilled	Unskill	Office Managers /Prof.	Technical /Assist. Prof.	clerks	Service /shop workers	Agricult. /other Unskilled	Skilled	Unskill	Office Managers / Prof.	Technical /Assist. Prof.	clerks	Service /shop workers	Agricult. /other Unskilled
China	192	394	179	184	376	373	399	7.76	6	7.9	7.79	6.51	6.9	5.5
Japan	26	141	12	13	138	141	182	8.2	8.17	8.72	8.18	8.35	9.31	7.09
USA	10	18	8	11	22	18	13	9.05	8.89	9.17	9.2	9.15	9.02	8.22
India	176	188	168	208	202	205	131	9.02	7.91	9.09	8.42	8.16	9.16	7.17
Brazil	25	44	18	23	68	33	36	9.54	8.58	8.84	9.32	9.39	9.54	7.59
Russia	35	149	21	22	127	238	102	8.94	7.21	8.26	9.29	8.06	8.99	6.18
Oceania	24	16	23	26	22	19	-1	8.54	7.85	8.3	8.1	8.27	8.83	7.2
East Asia	35	122	31	31	115	117	128	6.93	5.88	7.02	6.27	5.56	7.44	4.83
S.E. Asia	59	97	57	57	106	101	85	6.86	5.55	6.54	6.2	6.77	7.63	4.76
South Asia	108	117	104	114	122	128	94	9.32	8.27	8.77	9.8	8.71	9.32	7.54
North America	30	42	34	35	51	46	23	8.61	7.45	8.47	8.22	7.87	8.85	6.4
Latin America	41	60	42	52	77	64	32	9.1	7.69	8.47	8.52	8.53	8.87	6.79
EU 25	5	70	2	3	75	63	55	8.95	8.49	8.91	8.68	8.6	9.4	7.97
Middle East and North Africa	69	81	85	81	124	103	41	8.26	6.5	7.55	7.56	7.43	7.98	5.99
Sub-Saharan Africa	90	75	95	95	123	101	21	9.11	7.45	8.39	8.88	8.4	8.54	6.6
Rest of World	43	95	43	47	116	110	62	8.05	6.94	7.85	7.77	7.41	8.47	5.78

Disaggregation Labor Payments

The changes in real wages across occupations (Table 6 panel A) is also remarkably different between the two datasets, particularly between the two types of skilled categories, Managers and Technicians. These results can be traced back to the ratio of managers to technical workers in those sectors that are growing the most. For instance in the USA, the availability of managers in all sectors is excessively high, such that growth places increasing pressure on the more scarce technical workers, hence causing increasing pressure on the wages of technical workers. In India, there are many managers in selected sectors, but in those that grow (e.g., other business services) the ratio of managers to technical workers is low and more managers are required, raising their wages.

In the final simulation, we use a partial equilibrium closure to set up a fixed price multiplier model and increase each country's income by 10%.[3] As income increases, consumption rises and demand for both domestic and imported commodities increases. Rising demand for domestic commodities increases production and may increase imports and exports, depending on industry specific demand response. Now, allowing endowments to adjust endogenously, these downstream changes initiated by the income increase will have a "multiplied" effect on the economy as increased production increases demand for factor endowments which in turn means increased factor income. This reinitiates the multiplier effect.

Now this framework can measure the self-sufficiency or degree of autarky of an economy. For example, when producers or consumers import goods, rather than buy domestically, the income shock is "leaked" to other countries which now benefit from the originating country's income growth. Had these agents purchased domestically, then the benefit would have remained internal or domestic.

Leakages directly affect the labor market as increases in income increase consumption, and any consumption of domestic goods will increase the demand for labor in order to support growth in

[3] Details of the simulation closure can be found in Walmsley, Hertel and Hummels (forthcoming).

domestic production. In response, employment will rise, again increasing economy-wide income and consumption. However, if the initial shock to income results in increased imports over domestic goods, then the demand for labor decreases and employment falls.

Given a fixed wage, in this scenario we consider the response of the labor force to the income growth. Those workers, primarily technical and managers (Table 6, panel B), that gain the most as a result of the income shock are those that are most important in the production of domestic goods and in particular those who work in the services sectors (Figure 6, panel A and B). Services are rarely imported and hence leakages through imports are lower; agriculture, on the other hand, is tradable and leakages through imports are larger. Those that lose (Table 6, panel B) are those workers that are used most intensely in the highly tradable sectors, e.g., agricultural and other unskilled workers who work in agriculture and manufactures (Figure 6, panel A and B).

6 Conclusions and Future Directions

The purpose of this paper was twofold: first, we summarize how additional ILO labor data processed by Weingarden and Tsigas (2010) could be incorporated into the GTAP Data Base; second, several simulations were undertaken to illustrate how the additional labor data could enhance analysis of the labor market impacts of various policy shocks. In general, we find that while the inclusion of additional labor data does not always alter the macroeconomic impact of a policy simulation, the additional analysis obtained from having greater detail regarding the labor categories can be very helpful in illustrating how a policy affects different elements of the population. The exploration of these differences is likely to significantly improve the usefulness of CGE models for policy analysis.

Despite the large amount of filling required to make this dataset compatible with GTAP, we believe that the new labor shares and quantities represents an improvement in the GTAP Data Base. We hope that this will lead to further improvements in the underlying data that can be incorporated into the database in future.

There are several ways in which this dataset could be improved. As discussed above, Weingarten and Tsigas (2010) generated imputed wages by sector and occupation using Oostendorp's (2005)

dataset available through 2003. At the time, this was the most up to date data available, however in May 2012, Oostendorp (2012) released an updated dataset containing data available through 2012. In the future, we could consider adapting the methods of Weingarden and Tsigas (2010), using this new dataset.

7 References

2008 ILO Yearbook: International Labor Organization, (2008). "Yearbook of Labour Statistics - Time series – 2008". <http://www.ilo.org/global/publications/ilo-bookstore/order-online/periodicals/WCMS_090411/lang--en/index.htm>

ILO October Inquiry: International Labor organization, (2008). "Occupational wages and hours of work and retail food prices. Statistics from the ILO October Inquiry 2009". < http://www.ilo.org/global/publications/ilo-bookstore/order-online/books/WCMS_115945/lang--en/index.htm>

Liu, J.; van Leeuwen, N.; Vo, T. T.; Tyers, R.; and T. Hertel, (1998a). "Disaggregating Labor Payments by Skill Level in GTAP". *GTAP Technical Papers*, 10, Center for Global Trade Analysis, West Lafayette, IN.

Liu, J.; van Leeuwen, N.; Vo, T. T.; Tyers, R.; and T. Hertel, (1998b). "Chapter 18: Disaggregating labour payments by skill level". *Global Trade Assistance and Protection: The GTAP 4 Data Base*, Center for Global Trade Analysis, West Lafayette, IN

McDougall, R.A., A. Elbehri, and T.P. Truong (1998). *Global Trade Assistance and Protection: The GTAP 3 Data Base*, Center for Global Trade Analysis, Purdue University

Mirza, Tasneem, Badri Narayanan and Nico van Leewuen (2010). "Trade with China and the Impact on Relative Wages in Industrial Economies". Presented at the 13th Annual Conference on Global Economic Analysis, Penang, Malaysia.

Narayanan, G., B., A. Aguiar and R. McDougall, Eds. (2012). *Global Trade, Assistance, and Production: The GTAP 8 Data Base*, Center for Global Trade Analysis, Purdue University

Oostendorp, Remco H., (2005). "The Standardized ILO October Inquiry 1983-2003". Report to the ILO. < http://www.nber.org/oww/Technical_document_1983-2003_standardizationv3.pdf>

Oostendorp, Remco H., (2012). "The Occupational Wages around the World (OWW) Database: Update for 1983-2008". *NBER*. < http://data.nber.org/oww/>

Weingarden, A., and M. Tsigas. (2010). “Labor Statistics for the GTAP Database”. Presented at the 13th Annual Conference on Global Economic Analysis, Penang, Malaysia.

World Development Indicators, (2010). The World Bank. Updated: 21 Dec.

Walmsley, T. L., T. W. Hertel and D. Hummels (2013). “Developing a GTAP-Based Multi-Region, Input-Output Framework for Supply Chain Analysis”, paper presented at the 16th Annual Conference in Global Economic Analysis, Shanghai, China, June 12-14.

8 Appendix

Table A1. List of Sectors and Regions

	Sectors		Regions
1	Agriculture	**1**	China
2	Processed Food	**2**	Japan
3	Fishing	**3**	USA
4	Resources	**4**	India
5	Resource Manufactures	**5**	Brazil
6	Manufactures	**6**	Russia
7	Construction	**7**	Oceania
8	Transportation	**8**	East Asia (excluding China and Japan)
9	Trade	**9**	S.E. Asia
10	Finance	**10**	South Asia (excluding India)
11	Other Business Services	**11**	North America (excluding the USA)
12	Recreational Services	**12**	Latin America (excluding Brazil)
13	Government Services	**13**	EU 25
14	Non-Tradable services	**14**	Middle East and North Africa
		15	Sub-Saharan Africa
		16	Rest of World (Excluding Russia)