Global trade in services, jobs, and incomes

Bohn, Timon

DOI:
10.33612/diss.104863895

Chapter 4

Who's afraid of Virginia WU? The labor composition and labor gains of trade

ABSTRACT

There are various ways to indicate the importance of international trade. In this paper, we use the 'labor footprint' concept to gain new insights into the implications of trade for employment. We focus on the US, but also provide information on 39 other, mostly developed, countries for the period 1995-2008. We show that US consumption increasingly depends on foreign workers. At the same time, US labor has benefited from new jobs generated by the world economy, especially in the services sector. Next we compare labor footprints with labor endowments to evaluate the capacity of countries to be self-sufficient in terms of labor in a hypothetical situation of autarky and perfect labor mobility. This counterfactual exercise reveals that most countries in our study are able to produce all output for consumption themselves. However, once the assumption that labor is perfectly mobile across skill levels and that all unemployed workers accept a job when offered one is relaxed, most countries can no longer be self-sufficient. That is, these countries would not be able to sustain their current consumption pattern.

This chapter is based on Bohn et al. (2019).

4.1 Introduction

The famous play “Who’s afraid of Virginia Woolf” by Edward Albee is about a married couple that take refuge in illusion and addresses the question “who’s afraid of living life without false illusions?”. This paper is about the fear of foreign workers, or a proverbial Chinese Virginia Wu, taking away domestic jobs, which for some countries turns out to be a false illusion. In this paper we investigate the issue whether foreign workers are a threat to domestic workers by using an empirical model that has become possible with the availability of global input-output tables: global labor footprints.

A country’s global labor footprint measures the global amount of labor that is embodied in the final products that this country consumes. The idea behind labor footprints is simple. Trade enables countries to use foreign labor, as embodied in imported goods and services. Not only the foreign labor that is embodied *directly* in the import of a – final or intermediate − product should be accounted for, but also the foreign labor that goes into the inputs that go into the production of this particular product. And the labor that goes into the inputs that go into the inputs, and so forth. This is the labor that is *indirectly* embodied. The international fragmentation of production processes has increased in importance (Baldwin, 2006), which had two consequences. First, the contribution to the footprint of labor that is indirectly embodied has probably increased. Second, calculating labor footprints is difficult because international fragmentation has led to longer global supply chains. However, using global input-output tables allows us to include all indirectly embodied labor. We can thus trace global supply chains and calculate the labor footprint more precisely than is possible without these data.

As Rodrik (2017) indicates, the analysis is also related to the often observed worries that foreign workers take away domestic jobs. The perceived threat to domestic jobs has increased, now that production processes and value chains have become global (Hummels et al., 2001). These developments have been associated with well-publicized outsourcing and offshoring concerns in advanced economies. Many policymakers fear the consequences of the increased international trade for ‘local jobs’. The negative effects of offshoring of US jobs to low income countries was a major topic in the 2016 US presidential election. After the election in 2016, the US has initiated a renegotiation of NAFTA, withdrew from the Trans-Pacific Partnership (TPP), and put the negotiations on the Transatlantic Trade and Investment Partnership (TTIP) on hold. Also the import penetration from China has revived the question ‘are the gains of trade positive for the US?’. Recent studies document possible negative effects of Chinese import exposure on the US labor market (Acemoglu et al., 2016; Autor et al., 2014; Ebenstein et al., 2012; Pierce and Schott, 2016). Autor et al. (2013), for instance, find that Chinese supply shocks accounted for 44% of total decline in US manufacturing jobs between 1990 and 2007. Import exposure also led to higher unemployment, lower wages in non-manufacturing sectors, and sizable transfer payments.

The labor footprint concept provides an alternative way of looking at the trade effects of import competition. The analysis covers 14 consecutive years from 1995 to 2008 and we focus mostly on the labor footprint of the US. We define the labor footprint as the number of workers, worldwide, required to produce the entire bundle of final products (goods and services) consumed in a certain country (e.g., the US) and year. This method allows us to calculate how much labor (of different skill-types and different origins) are currently at work. We measure the number of domestic workers that go into US consumption and the number of workers that are imported. On the flip side, we consider the number of US workers that are exported, i.e., are embodied in foreign consumption of final products. We compare this situation with the amount and type of workers required in autarky and take labor endowments into account (using unemployment data).

The analysis then answers the question whether ‘lost’ jobs would have been saved in case there was no trade with the condition that the country would still sustain its current level of consumption. This approach is (partially) linked to the gains-of-trade literature (see Dixit and Norman, 1980, or Feenstra, 2016, for comprehensive surveys of the concept). The standard gains-of-trade analyses show that countries are better off with trade than without. Our analysis should not be interpreted as a complete picture of the gains of trade because we focus only on one component: labor. Labor gains of trade occur if the consumption of a country would need more workers under autarky than current employment. In other words, the currently employed workers would only allow a reduced consumption under autarky. The reduction reflects the labor gains of trade.

We provide three measures related to what we call the labor benefits of trade. Firstly, we define the worker surplus as the labor endowments minus the footprint. A negative surplus indicates that a country “consumes” more workers than it actually endows. This has become possible through trade, so that a negative worker surplus (as a share of the labor force) is seen as a benefit from trade. We introduce worker productivity differences across countries in order to assess the self-sufficiency prospects of the US and other countries more properly (under a strong ceteris paribus assumption). Secondly, we calculate the footprint in autarky and the corresponding worker surplus. A negative surplus indicates that a country has a labor force that is not large enough to sustain its current consumption level and pattern in autarky. Also this can be viewed as a benefit of trade for the current, actual situation (because absence of trade would hamper consumption). Thirdly, we define the labor gains of trade as the footprint in autarky minus the number of employed workers, as a share of the employed workers. For example, an outcome of 0.1 indicates that the same consumption bundle would require 10% more workers in autarky than in the actual situation. The same number of workers can thus reach in autarky (10/11=) 91% of the consumption that workers in the actual situation can.

Our findings indicate that nearly half of all workers embodied in US consumption were foreign workers in 2008. The share of foreign workers in the US labor footprint grew 7.8 percentage points between 1995 and 2008. This may seem like a heavy dependence of domestic consumption on foreign labor. However, labor productivity differences have to be taken into account. Whereas the 'raw' share of Chinese workers in the 2008 US labor footprint was 14.2%, it was 1.5% after adjusting for efficiency differences between US and foreign workers. At the same time, nearly one million new jobs in services were created in the US to serve foreign demand – mitigating the negative effect of import competition.

Our main finding is that domestic US workers could have produced the entire US consumption bundle (which applies to every year in the period 1995-2008) in a situation of autarky. This, however, only holds if we assume: (i) perfect substitutability between domestic workers of different skill-types; and (ii) all unemployed workers are able and willing to accept a job if offered. If imperfect substitutability is allowed, the US would have showed a shortage of low-skilled workers in most years. Medium- and high-skilled workers would have needed to be re-allocated to low-skilled tasks. This implies that the US could not have been self-sufficient in autarky under realistic assumptions. We also find positive labor gains of trade for the US throughout the time period. The US consumed between 1.3% and 4.2% more in the actual trade structure between 1995 and 2008 than what would be possible in autarky with the same number of workers - even before accounting for imperfect labor mobility.

We use the US as an illustration, but the analysis covers 40 different countries. The paper is organised as follows. First, we provide the context and literature in Section 4.2, then we present the methodology in Section 4.3 and the data sources in Section 4.4. Subsequently, we discuss the results in Sections 4.5 and 4.6, and finalize our analysis with a conclusion in Section 4.7.

4.2 Literature

Footprint indicators are becoming increasingly popular in research, policy- and decision-making (Gomez-Paredes et al., 2015). They have been used in a diverse context including for the analysis of issues related to ecology, energy, water usage, land, biodiversity, wages and inequality. The concept captures both direct and indirect repercussions along production and distribution chains (Cucek et al., 2012). Not only the direct impact of a particular final product is calculated, but also the indirect impact of supplying (foreign) intermediate products and supplying the intermediates for producing the intermediates *et cetera*. Footprints are computed by using input-output analysis (Gomez-Paredes et al., 2015; Arto et al., 2014; Wiedmann et al., 2006). The labor footprint builds on this concept and can be used to track the global flows of labor that ends up in the consumption of final products (i.e., final demand) of a particular country.

4.2.1 The labor footprint

The labor footprint is constructed by linking employment accounts to trade flows using international input-output tables. It accounts for all workers, in whatever country, engaged in producing the final consumption bundle of country *R*, e.g., the US. All labor footprints together yield the global use of labor. Our empirical analysis can be split into two parts.

First, we use labor footprints to calculate the different types and origins of labor embodied in final consumption. We measure the exports of domestic labor (i.e., domestic labor embodied in foreign final demand) and the imports of foreign labor (i.e., foreign labor embodied in domestic final demand). We consider whether the imports of labor (reflecting the dependency of a country on foreign workers) increased between 1995 and 2008. Second, we compare the structure of the labor footprint in actual trade to the corresponding labor footprint in autarky. We check whether labor endowments were sufficient to sustain actually observed consumption levels, using various assumptions. We include both temporal and country-level comparisons.

We consider a country to gain from trade in terms of labor if its overall levels of consumption in the actual trade structure could not be obtained in a situation of autarky (with the same number of employed workers). Hence, autarky then implies residents must sacrifice part of their current consumption. The magnitude of the labor gains of trade in our measurements is given by the extra labor a country would need in a counterfactual situation of autarky to sustain the same consumption levels as in the actual situation (including the actual trade structure). To compare the labor gains of trade across time in the US, the number of workers the US would be in surplus of (or be short of) in autarky is taken as a percentage of the actually employed workers.

4.2.2 Factor content of trade

This paper fits into the recent discussion on trade in factor services, which is an approach that has been used for counterfactual analysis and to measure the gains from trade (Costinot and Rodriquez-Clare, 2018). The approach is based on the framework proposed by Adao et al. (2017). Trade in factor services includes all factors such as labor, capital, land, and so on that are embodied in the production of goods and services that are traded. Our analysis focusses on a specific element of trade in factor services: labor.[70]

The calculations for the labor footprints are also related to the extensive literature on the factor content of trade. Studies on this topic have long provided a method to compute the factors embodied in trade. Just like the labor footprint concept, also the factor content of trade analyses are based on input-output (IO) models.[71] This literature goes back to the Hecksher-Ohlin (HO) prediction, extended by Vanek (1968), which hypothesizes that countries export (import) their relatively abundant (scarce) factors. Numerous studies attempted to empirically confirm the Heckscher-Ohlin-Vanek theorem (HOV) but their models performed poorly when confronted with the data. The most famous example is the 'Leontief paradox' (1953). Subsequent studies extended HOV by relaxing certain assumptions to allow for technology differences, intermediate trade, and alternative assumptions on the preferences across countries.

One of the challenges in extensions to HOV was to account for cross-country productivity differences, which is an issue highly relevant to our study. Leontief (1953) and other early work had insufficient data on the production techniques of foreign trading partners and resorted to US technology to estimate labor and capital embodied in imports from abroad. A widely cited study by Trefler (1993) introduced factor-augmenting productivity differences across countries into the HOV model. He imputed international productivity differences to make the HOV theorem perfectly fit the data on trade and endowments, then determined they strongly correlated to cross-country variation in factor prices. However, there were two limitations in his study. First, Trefler (1993) used the US IO-matrix to measure the factor content of trade globally for all countries. Reliance on technology coefficients of a highly developed and capital-abundant country to serve as a reference is problematic as it leads to a (downward) bias in the

[70] The analysis is limited to labor because our focus is on the labor footprint; hence the counterfactual analysis can be considered a partial analysis of the gains of trade.
[71] For an overview, see Foster and Stehrer (2010).

factor content of exports by countries with less efficient technologies (Davis and Weinstein, 2001). That is, most countries would need less of each factor to produce their exported output using the US technology matrix than what they employ in reality. Second, Trefler (1993) did not account for trade in intermediate products, which became important with the global integration of production and the ongoing international fragmentation.

Subsequent studies have addressed the shortcomings, both through improved methodologies and better data. Davis and Weinstein (2001) used the OECD database to introduce the use of intermediates into the theoretical HOV model and to take into account productivity differences. Reimer (2006) extended the approach of Davis and Weinstein (2001) by using a world IO-matrix to measure the factor content of trade when production technologies differ across countries and intermediate inputs are traded. A more recent contribution that employs international IO tables is Trefler and Zhu (2010). They used the global GTAP database and a method consistent with Vanek's factor content predictions to determine a high correlation between relative factor endowments and the factor content of trade. Stehrer et al. (2012) found similar results using WIOD data. However, some authors (Fisher and Marshall, 2015; Zhang 2015) have criticized the approach of Trefler and Zhu (2010) as being "logically correct but economically misleading" due to double-counting of re-exported intermediates in complex trade structures.

4.2.3 Our approach

Our approach draws upon the insights of the factor content literature to account for both intermediate goods trade and differing production techniques across countries. To do so we use an IO-method and the same global database as in Stehrer et al. (2012) and H. Zhang (2015). However, our study differs from the factor content research in three respects. First, our focus is on labor footprints, not on testing the validity of the HOV model. Second, in order to avoid the double-counting of labor inputs in trade, we draw upon the 'trade in value-added' concept (Johnson, 2014). This means we trace the domestic factors embodied in domestic production that is directly or indirectly contained in the final consumption of partner countries (even in the absence of direct bilateral trade between them). This demand based perspective distinguishes our method from related studies such as Groshen et al. (2005) and Stehrer and Stöllinger (2014), both of whom used IO tables to compare the number of jobs embodied in exports with the hypothetical number of jobs required to produce imports.[72] Third, rather than focussing on the factor content of trade (which is –by definition– zero if there is no trade between two countries), we are interested in the trade in factors (i.e., how much factor content is embodied in the entire consumption bundle of another country). In this respect, we draw upon the footprints approach and want to know *all* the origins (including 'home') of the factors embodied in final consumption. We describe the data we use after the methodology section.

4.3 Methodology

The analysis is global and we work with a world IO table (also known as a Global Multiregional Input-Output table, see Tukker and Dietzenbacher, 2013, for an overview). For the ease of exposition but without loss of generality, suppose that the world consists of only three countries (*R*, *S*, and *T*). In this case, the world IO table looks as follows.[73]

Table 4.1. The world input-output table

	Intermediate use in:			Final use in:			Total output
	R	*S*	*T*	*R*	*S*	*T*	
Product flows from							
country *R*	$\mathbf{Z}^{RR}$	$\mathbf{Z}^{RS}$	$\mathbf{Z}^{RT}$	$\mathbf{f}^{RR}$	$\mathbf{f}^{RS}$	$\mathbf{f}^{RT}$	$\mathbf{x}^{R}$
country *S*	$\mathbf{Z}^{SR}$	$\mathbf{Z}^{SS}$	$\mathbf{Z}^{ST}$	$\mathbf{f}^{SR}$	$\mathbf{f}^{SS}$	$\mathbf{f}^{ST}$	$\mathbf{x}^{S}$
country *T*	$\mathbf{Z}^{TR}$	$\mathbf{Z}^{TS}$	$\mathbf{Z}^{TT}$	$\mathbf{f}^{TR}$	$\mathbf{f}^{TS}$	$\mathbf{f}^{TT}$	$\mathbf{x}^{T}$
Value added	$(\mathbf{v}^{R})'$	$(\mathbf{v}^{S})'$	$(\mathbf{v}^{T})'$				
Total inputs	$(\mathbf{x}^{R})'$	$(\mathbf{x}^{S})'$	$(\mathbf{x}^{T})'$				
Labor inputs	$(\mathbf{l}^{R})'$	$(\mathbf{l}^{S})'$	$(\mathbf{l}^{T})'$				

Assuming *n* industries in each country, $\mathbf{Z}^{RS}$ is the $n \times n$ matrix with intermediate deliveries and its element z_{ij}^{RS} gives the delivery of goods and services (expressed in million US$) that industry *i* in country *R* sells to industry *j* in country *S*. The element f_i^{RS} of the vector $\mathbf{f}^{RS}$ gives the delivery of goods and services from industry *i* in country *R* for household consumption and other domestic final demand purposes (including private investments, government consumption and investments, and changes in stocks) in country *S*. These are the exports from *R* to *S* in industry i. For simplicity, we use the term consumption in this paper to refer to the total of all final demand categories. The element x_i^R of the vector $\mathbf{x}^R$ gives the total output (or value of

[72] See also Steher (2012) who compares the demand-based measure of value added flows ('trade in value added') with the supply-based approach ('value added in trade') and applies them using the WIOD.
[73] This follows standard IO methodology (see Miller and Blair, 2009). Bold-faced lower-case letters are used to indicate vectors, bold-faced capital letters indicate matrices, italic lower-case letters indicate scalars (including elements of a vector or matrix). Subscripts indicate industries and superscripts indicate countries. Vectors are columns by definition, row vectors are obtained by transposition, denoted by a prime (e.g., $\mathbf{x}'$). Diagonal matrices are denoted by a circumflex (e.g., $\hat{\mathbf{x}}$).

production) by industry i in country R. In country S, the element v_j^S of the (row) vector $(\mathbf{v}^S)'$ gives the value added (including wages and salaries, employers' contributions, capital depreciation, indirect taxes, price-decreasing subsidies, and operating surplus or other income) generated in industry j in country S. Additionally, the element l_j^S of the (row) vector $(\mathbf{l}^S)'$ gives the input of labor in industry j in country S. Labor is measured in thousands of workers (not corrected for productivity differences). Note that there are no separate column vectors with exports nor separate row vectors with imports included in Table 4.1. This is because there are no other countries in this world than R, S and T.

The labor footprint gives the amount of work worldwide that is necessary for the final demands of a country (say R). Define

$$\mathbf{A} = \begin{bmatrix} \mathbf{A}^{RR} & \mathbf{A}^{RS} & \mathbf{A}^{RT} \\ \mathbf{A}^{SR} & \mathbf{A}^{SS} & \mathbf{A}^{ST} \\ \mathbf{A}^{TR} & \mathbf{A}^{TS} & \mathbf{A}^{TT} \end{bmatrix}, \boldsymbol{\omega} = \begin{pmatrix} \boldsymbol{\omega}^R \\ \boldsymbol{\omega}^S \\ \boldsymbol{\omega}^T \end{pmatrix}$$

where $\mathbf{A}^{RS} = \mathbf{Z}^{RS}(\hat{\mathbf{x}}^S)^{-1}$ is the $n \times n$ matrix of input coefficients $a_{ij}^{RS} = z_{ij}^{RS}/x_j^S$, and $\boldsymbol{\omega}^R = \mathbf{l}^R(\hat{\mathbf{x}}^R)^{-1}$ is the vector of labor inputs per US\$ of output, i.e., $\omega_j^R = l_j^R/x_j^R$. The vector with (in this case three) labor footprints is then given by

$$\begin{aligned} &(\varphi^R \quad \varphi^S \quad \varphi^T) \\ &= \quad ((\boldsymbol{\omega}^R)' \quad (\boldsymbol{\omega}^S)' \quad (\boldsymbol{\omega}^T)') \begin{bmatrix} \mathbf{M}^{RR} & \mathbf{M}^{RS} & \mathbf{M}^{RT} \\ \mathbf{M}^{SR} & \mathbf{M}^{SS} & \mathbf{M}^{ST} \\ \mathbf{M}^{TR} & \mathbf{M}^{TS} & \mathbf{M}^{TT} \end{bmatrix} \begin{bmatrix} \mathbf{f}^{RR} & \mathbf{f}^{RS} & \mathbf{f}^{RT} \\ \mathbf{f}^{SR} & \mathbf{f}^{SS} & \mathbf{f}^{ST} \\ \mathbf{f}^{TR} & \mathbf{f}^{TS} & \mathbf{f}^{TT} \end{bmatrix} \end{aligned} \tag{4.1}$$

where $\mathbf{M}$ is the multiplier matrix $(\mathbf{I} - \mathbf{A})^{-1}$, known as the Leontief inverse (or total requirements matrix). Element m_{ij}^{RS} of the matrix $\mathbf{M}^{RS}$ indicates how much output from industry i in country R is directly and indirectly required per unit of final demand for the products produced by industry j in country S. φ^R gives the labor footprint for country R, which gives the amount of labor worldwide that is necessary to sustain the consumption pattern of country R. Note that

$$\varphi^R = (\boldsymbol{\omega}^R)' \sum_{J=R,S,T} \mathbf{M}^{RJ}\mathbf{f}^{JR} + (\boldsymbol{\omega}^S)' \sum_{J=R,S,T} \mathbf{M}^{SJ}\mathbf{f}^{JR} + (\boldsymbol{\omega}^T)' \textstyle\sum_{J=R,S,T} \mathbf{M}^{TJ}\mathbf{f}^{JR} \tag{4.2}$$

The first term on the right-hand side gives the labor in country R that is embodied in the entire consumption bundle of country R. The second and third term give the labor in countries S and T, again, embodied in the consumption by R. The latter two terms give the imports of labor.

The question is whether the labor footprint φ^R in country R is larger (or smaller) than the actual labor force in this country. If larger, country R can be said to consume more labor than it actually has (given the current trade structure). The actual labor force is given by the number of workers employed in country R (i.e., $(\mathbf{l}^S)'\mathbf{e}$, with $\mathbf{e}$ the summation vector consisting of ones) and unemployment in workers. Unemployed workers are workers not currently engaged in productive activities but actively searching for a job. The difference between the labor footprint and the number of employees (excluding unemployed workers) is equivalent to the imports of labor minus the exports of labor. (In a follow-up analysis, we also take worker productivity into account. Differences in production technologies across countries are then assumed to be perfectly reflected by differences in factor costs.)

The next step is to assume that country R acts under autarky, i.e., without any trade relations. In that case, the labor footprint equals

$$(\boldsymbol{\omega}^R)'(\mathbf{I} - \bar{\mathbf{A}}^R)^{-1}\bar{\mathbf{f}}^R \tag{4.3}$$

where $\bar{\mathbf{A}}^R = \sum_{J=R,S,T} \mathbf{A}^{JR}$ is the matrix with technical input coefficients. For instance, it gives how many dollars of steel are necessary for one dollar of car production, irrespective of the origin of the steel. In a situation of autarky, a country has to produce everything itself, including the inputs that go into the production (and the inputs that go into the inputs, etcetera). Similarly, $\bar{\mathbf{f}}^R = \sum_{J=R,S,T} \mathbf{f}^{JR}$ gives the consumption in country R under the assumption that all goods and services are now produced at home. Note that in autarky all the labor involved in producing for other countries in the current trade structure is released. It is now available for domestic production, including production to substitute for 'lost' imports.

4.4 Data sources

Our primary data source is the 2013 version of the World-Input-Output Database (WIOD). This database contains a time-series of World Input-Output Tables (WIOTs) for the period 1995-2011.[74] There are 40 countries and 35 industries included, covering more than 85% of world GDP, in addition to the 'Rest of World'.[75] The WIOTs were compiled by harmonizing national supply-use tables (or national input-output tables) and combining them with detailed

[74] Although a new version of the WIOD was released in 2016 (with a time-period from 2000-2014, and which includes three more countries), we use the 2013 release because the socio-economic accounts accompanying the 2016 release did not update employment data by skill levels, which is crucial for our analysis.
[75] A list of all countries is provided in Table 4.A1 of the appendix. The 35 industries are based on the NACE revision 1, which corresponds to ISIC revision 3.

international trade data. This provides a single and consistent source of global trade linkages involving intermediate and final trade flows between all industries and countries.[76] The WIOD's socio-economic accounts (SEAs) give additional information on employment and wage shares of three skill categories of workers. Note that employment is defined as 'all persons engaged', which includes paid employees, the self-employed, part-time, and informal workers (the latter has been estimated). This disaggregated employment and factor payment data are available for every industry and country.[77] All data have been harmonized to ensure international comparability and compatibility with the WIOTs. Differences in labor productivity across countries will be proxied in our study by the factor cost data at the industry and skill level.

To estimate the labor force (or domestic labor endowment), we need data on unemployed workers, which are then added to the number of employees engaged. For unemployment data, we use the International Labor Organization (ILO) database. In most cases unemployment data was based on Labor Force Surveys (LFSs). Whenever the ILO provided multiple data sources for unemployment, the LFS was preferred over official national sources because LFSs use a consistent methodology across countries. The ILO also provides unemployment data as unemployment ratios, which we use later as a robustness check. In this way we were able to obtain data for nearly all countries and years in the WIOD database.

Although the data covers the years 1995-2011, our analysis focusses on the period until 2008 for two reasons. First, labor and capital compensation data are not available for non-EU countries in 2010 and 2011. This precludes productivity comparisons between EU and non-EU countries based on using factor costs as a proxy of worker productivity. Second, 2009 and 2010 were the years most influenced by the financial crisis and thus may taint our results because of the general contraction of trade. This could imply that the worker composition of the consumption bundle became less diversified, with a higher share of domestic workers compared to previous years.

Employment data in numbers of workers also reflect labor participation rates, which are to some extent culturally determined and may differ across countries. For this reason we considered using hours worked (instead of workers) as our unit of measurement. This

[76] The WIOD is available for free at www.wiod.org. For more details on its construction, see Dietzenbacher et al. (2013) and Timmer et al. (2015).

[77] Industry-level employment for the 'Rest of World' aggregate (making up 15% of world GDP but more in employment terms) is not included in the publicly released SEAs; however, confidential estimations, including a breakdown by skill-level, were gratefully provided by Gaaitzen de Vries. He was involved in the development of the WIOD satellite accounts. For more details on the construction of the satellite accounts, see Erumban et al. (2012).

information is also provided by the SEAs, but data in hours are incomplete because only the EU, US, Japan, and other advanced countries (with the exception of China) have reliable data on this variable. The SEA creators derived data on hours worked for all other countries contained in the WIOD directly from employment data in numbers of workers (which does thus provide the same information). In addition, data on hours worked in the 'Rest of World' is not provided by the SEAs and would be difficult to estimate. Therefore, we use workers – initially without any cross-country productivity adjustment – as our baseline unit of measurement.

4.5 Results: US case study

We begin our analysis with a case study of the United States. This includes determining the composition of the US labor footprint (i.e., answering the question "who contributes how much labor to the US consumption bundle?") and evaluating the self-sufficiency of US labor in autarky, followed by robustness and sensitivity checks. In Section 4.6, we move beyond the US and analyze the situation of 39 more countries by comparing each country's labor footprint with its labor endowment. In each case we also examine the labor gains of trade.

4.5.1 US labor footprint

We first employ the labor footprint concept to compute the number of workers directly and indirectly embodied in the consumption bundle of the United States (in 1995 and 2008). The calculation is similar to what is done in equation (4.2) for a world with three countries. The first term on the right-hand side gives the domestic workers embodied in the consumption bundle of country R (i.e., in this case US workers embodied in US consumption), the second and third terms give the embodied foreign workers (from S and T).

Table 4.2 displays the worker composition of the US labor footprint. The table shows the number (and share) of domestic (i.e., US) workers embodied in US consumption and the numbers (and shares) of 'imported workers'. In 1995, approximately 203 million workers were worldwide engaged, directly and indirectly, to produce the goods and services consumed in the US in that year. 124 million (61.1%) of them were domestic US workers and almost 79 million (38.9%) were foreign workers. Of all workers in the US labor footprint, only 9 million workers (4.5%) were from advanced nations (EU-27 and other advanced nations), while the remaining nearly 70 million foreign workers (34.3%) were from all other countries (including mostly developing and emerging countries).[78] China alone provided more than 25 million workers or 12.6% of all the labor required to produce the US consumption bundle.

In 2008, the year just preceding the economic crisis, 264 million workers were embodied in US consumption (+61 million workers). The share of workers originating from developing countries (i.e., China, Other emerging, and 'Rest of World') rose. The total share of foreign workers increased by 7.8 percentage points, but the share of workers from emerging and developing countries increased by 8.4 percentage points. This implies that the share of workers from all advanced countries decreased by 8.4 percentage points (7.8 percentage points in the US itself, 0.6 percentage points in the EU-27 and Other advanced countries). While the number of domestic US workers increased in absolute terms, from 124 to 140 million, the share of US workers in all embodied workers decreased to 53.3% in 2008. This is indicative of large and increasing net labor imports.[79] The share of US workers increased a few percentage points during the financial crisis (2009-2011; not shown here). World trade contracted and the trend towards greater US dependence on foreign labor temporarily reversed.

Table 4.2. US labor footprint, by region

A. Workers embodied in US consumption (in thousands of workers)

	1995	2008	Change
US workers (1)	124106	140874	16768
All foreign workers (2)	78931	123472	44541
EU-27 workers	4066	5004	938
Other advanced	5157	5428	271
China	25562	37607	12046
Other emerging	15638	22283	6644
Rest of World	28508	53150	24642
Footprint (3) = (1) + (2)	203037	264346	61309

B. Workers embodied in US consumption (as percentage of all embodied workers)

	1995	2008	Change
US workers (1)	61.1	53.3	-7.8
All foreign workers (2)	38.9	46.7	7.8
EU-27 workers	2.0	1.9	-0.1
Other advanced	2.5	2.1	-0.5
China	12.6	14.2	1.6
Other emerging	7.7	8.4	0.7
Rest of World	14.0	20.1	6.1
Total	100	100	0

[78] Other advanced countries include Australia, Canada, Japan, Korea, and Taiwan; Other emerging countries (i.e., other than China) include Brazil, India, Indonesia, Mexico, Russia, and Turkey; the 'Rest of World' aggregate combines all other countries in the world not included in any of the other categories, such that the labor footprint covers all countries.

[79] As shown in Table 4.3, net imports were greatest in manufacturing and 'other' categories.

There are two observations. First, the workers involved in producing for US consumption diversified over the period because reliance on domestic workers declined (in relative terms). This is consistent with the increasing international specialization patterns in trade in that period. Although the US 'lost' jobs overseas, it 'gained' jobs because more US workers were involved in producing foreign consumption (not captured in Table 4.2). What matters in this respect is the net trade of workers. In addition, foreign workers, while large in number, may be less productive than domestic US workers. We return to this issue in the counterfactual exercises, in Section 4.5.2. The second observation is that the share of Chinese workers did not increase substantially in the period of observation.

The current debate on US job losses is focused on lost jobs in manufacturing. Table 4.3 therefore splits the workers according to the industry group (manufacturing, services, other) they are working in. It gives the US manufacturing workers embodied in the US consumption bundle, the imports of manufacturing workers (i.e., foreign manufacturing workers embodied in US consumption), and the export of manufacturing workers (i.e., US manufacturing workers embodied in foreign consumption).

The number of US manufacturing jobs in US consumption shrank by 4 million between 1995 and 2008. This large reduction in US manufacturing jobs was only marginally compensated by new US manufacturing jobs in foreign consumption. At the same time, 15 million manufacturing jobs were created overseas to directly or indirectly serve US consumption. The number of services jobs in US consumption increased by almost 33 million. Nearly 20 million of them were newly created US jobs and 13 million were newly offshored services jobs.

Focusing on the number of US workers embodied in foreign consumption bundles, the results show that in 2008 nearly 11 million US workers were involved in this – more than 6 million of which in services. The changes in these numbers over time indicate that nearly 1 million new services jobs were induced by exporting related activities between 1995 and 2008. These 1 million new jobs could contribute to (partially) replace domestic jobs that may have been lost to globalization and import competition. Thus, the perspective of lost jobs in manufacturing is – in the debate – incomplete because in a GVC context these can (and are) offset by gains in other sectors. The data strongly suggest that this is propelled by a transition from manufacturing to services jobs. This supports a study by Timmer et al. (2013), which found that advanced nations were increasing their competitiveness by transitioning to (high-skilled) services activities. Note that the numbers do not yet reveal anything about the skill-type (quality) of jobs gained or lost by US and foreign workers. We discuss skill-distributions next to check the activities in which advanced nations specialize within production networks.

Table 4.4 splits all workers embodied in the US consumption bundle into two groups: domestic workers and foreign workers. For each of the workers we distinguish three skill levels. They are defined by educational attainment categories using skill-shares provided in the SEAs (medium and high-skilled workers typically correspond to workers having at least a secondary education, e.g., High School and vocational training). In 1995, 89% of US workers involved in US consumption were either medium or high skilled, compared to only 29% of the foreign workers. The numbers 2008 were 91% and 37%, respectively. Among all workers embodied in US consumption, domestic US workers were highly educated relative to their foreign peers. Highly skilled workers typically have better salaries, and in Ricardian theory cross-country income differences are expected to reflect differences in labor productivity. This suggests that there may be significant productivity discrepancies between domestic and foreign workers. These discrepancies may, when properly accounted for, influence the capacity of US labor to be self-sufficient in autarky. We use this insight to take a deeper look at the impact of productivity in Section 4.5.2.

Table 4.3. Who works for whom? (in thousands of workers)

		1995	2008	Change
Manufacturing	US workers for US consumption	14873	10674	-4200
	Import of foreign workers	26307	41405	15098
	Export of US workers	3744	3852	107
Services	US workers for US consumption	98919	118405	19485
	Import of foreign workers	15351	28770	13420
	Export of US workers	5364	6305	942
Other	US workers for US consumption	10313	11795	1482
	Import of foreign workers	37273	53297	16024
	Export of US workers	766	712	-53
Total	US workers for US consumption	124106	140874	16768
	Import of foreign workers	78931	123472	44541
	Export of US workers	9873	10869	996

Table 4.4. US domestic and foreign workers in US consumption by skill-level (as percent of all domestic and foreign employment, respectively, embodied in US consumption)

	1995	2008	Change
Domestic workers			
Low-skilled (1)	10.9	9.0	-1.9
Medium-skilled (2)	64.0	60.1	-3.9
High-skilled (3)	25.1	30.9	5.8
Total	100	100	
Foreign workers			
Low-skilled (1)	70.6	62.8	-7.8
Medium-skilled (2)	25.0	29.5	4.5
High-skilled (3)	4.5	7.7	3.3
Total	100	100	

4.5.2 Counterfactual exercises

Next we compare the labor that is necessary to sustain the US consumption bundle with the US labor endowments (or labor force). Table 4.5 displays the US labor endowment and the total number of workers embodied in US consumption (i.e., the US labor footprint). The difference (endowment minus footprint) gives the worker surplus and equals the difference between US exports of labor (US workers embodied in foreign consumption) plus all unemployed US workers in the labor force on the one hand and US imports of labor (foreign workers embodied in US consumption) on the other hand. For 1995, for example, we find: endowment (141383) minus footprint (203037) equals –61654 for the worker surplus. This is the same as exports of US labor (9873, in Table 4.3) plus unemployment (7404) minus imports of labor (78931, also in Table 4.3).

The footprints for 1995 and 2008 are the same as the ones in the previous section, but now we consider additional years. In 1995, there was a discrepancy between endowment and footprint of 62 million workers. In other words, there was a negative worker surplus, which was –43.6% of the US labor force. This labor deficit grew to –80.8% by 2006, meaning that US consumers became even more dependent on imports of labor over time. Clearly, the US consumed more labor than it had available and could not be self-sufficient in terms of labor if workers have the same productivity across countries. Thus, there were positive benefits from trade in both cases (of 43.6% and 80.8%, respectively). However, given our insights from standard trade theory and the literature, the assumption that all workers have the same productivity across countries is an overly simplistic assumption because there are productivity differences.

In the first scenario we consider the case of autarky. We assume the US produces everything it consumes using its own technology and labor. This includes the production of the current imports and all foreign indirect inputs into the US production process. On the other hand, all US workers that were previously embodied in foreign consumption bundles are freed up now. We use equation (4.3) for the calculations. The US labor footprint in this case shows that almost 136 million US workers would be required in 1995, which is about 6 million less than the US labor endowment of that year. The results imply that if the US used all of its workers in an optimal way, including unemployed workers, the US would have a slight 4.0% labor surplus (as a share of its labor force). In other words, unemployment would have fallen to 4.0% and the US could have sustained the same consumption levels it actually achieved that year. This worker surplus declined to 0.5% in 2006. This means that in a situation of autarky, the US would only manage to be self-sufficient if at least 90% of all unemployed workers would accept a job.[80] This would assume little to no frictional unemployment.

In the second scenario we return to the actual trade structure and take a closer look at the foreign workers embodied in US consumption and account for productivity differences. The socio-economic accounts in the WIOD database allow us to calculate the wage rates by dividing the labor payments and the number of workers. We have done this for all 35 industries in 41 countries (including the 'Rest of World') and for three skill types. Using these wage rates we 'translate' the imports of foreign workers into so-called US-efficient workers. To illustrate how this works, suppose that we find that US consumption requires 360 high-skilled local workers in the Indian automobile industry. Suppose also that the wage rate of high-skilled workers in the US automobile industry is twice the corresponding wage rate in India. Then, the amount of money that is paid for the 360 Indian high-skilled workers would have paid for only 180 US workers. We thus assume that the output produced by two high-skilled Indian workers in the automobile industry (using Indian technology) can be replaced by output produced by one US worker (using US technology). Dividing the number of high-skilled Indian workers in the automobile industry by two gives the number of US-efficient workers. This procedure is repeated for the foreign workers of all skill types, industries and countries. It is expected to work well if labor payments perfectly reflect differences in labor productivity.[81]

[80] The worker surplus reduces to 729 thousand workers, which is 10.4% of the number of unemployed workers. Hence, 89.6% of the currently unemployed workers would have to accept a job offer.

[81] As an alternative, we also used overall average wages (i.e., not distinguishing between high-, medium-, and low-skilled workers) to proxy productivity. The results using this more aggregated data did not differ much from the results in Table 4.5 (which are more precise).

In Table 4.5 we see that the US had a labor surplus of 3.5% in 1995 (declining to 0.3% in 2006) when using US-efficient workers. The imports of 78931 thousand workers (Table 4.3) is equivalent to only 12273 US-efficient workers. This implies that US workers are found to be on average 6.4 times as productive as foreign workers. The import of US-efficient workers was only a little larger than the export of US workers, implying that trade was fairly balanced (when compared to the unadjusted numbers of workers).

As percentage of the US labor endowment, the US import of workers in 2008 was 10.5% when measured in US-efficient workers instead of 46.7% in unadjusted workers. The share of Chinese workers in 2008 was only 1.5% when measured in US-efficient workers, rather than 14.2% in case the numbers had not been adjusted for efficiency or productivity differences. In absolute numbers, the import of Chinese workers in 2008 was equivalent to 2.3 million US workers whereas the export of US workers to China was 0.8 million workers. US-China trade created 548 thousand *new* US jobs (i.e., the increase in US exports) between 1995 and 2008. The number of jobs created in China was equivalent to 1656 thousand new US-efficient workers. Hence, while trade with China may have cost net US jobs, the numbers are not as impressive as conventional studies like Autor et al. (2013) suggest.

Table 4.5. Labor footprints and endowments (top part, in thousands of workers), the worker surpluses (as percentage of the labor force, middle part), and the labor gains of trade (bottom part)

	1995	2000	2005	2006	2007	2008
(1) Employed workers	133979	147717	148903	151319	152567	151743
(2) Unemployed workers	7404	5692	7591	7001	7078	8924
(3) Labor endowment *(employed + unemployed)*	141383	153409	156494	158320	159645	160667
(4) US labor footprint *(using the actual trade structure)*	203037	256722	282337	286191	274698	264346
(5) US labor footprint under autarky	135753	152547	155188	157591	158066	157151
(6) US labor footprint *(after efficiency adjustments)*	136379	152236	155944	157909	158268	157528
Worker surpluses (as share of (3))						
(7) Actual trade structure (no adjustments)	-43.6	-67.3	-80.4	-80.8	-72.1	-64.5
(8) Autarky	4.0	0.6	0.8	0.5	1.0	2.2
(9) Actual trade structure *(incl. efficiency adjustments)*	3.5	0.8	0.4	0.3	0.9	2.0
(10) Labor gains of trade	1.3	3.3	4.2	4.1	3.6	3.6

Notes: (3) = (1) + (2); (7) = 100×[(3) - (4)]/(3); (8) = 100×[(3) - (5)]/(3); (9) = 100×[(3) - (6)]/(3); (10) = 100×[(5) - (1)]/(1).

The last row in Table 4.5 gives the labor gains of trade which are defined as the footprint in autarky minus the number of employed workers, as a share of the employed workers. The 1995 consumption bundle requires in the actual situation with the current trade structure 134 million US workers. Some of these workers are exported and traded for foreign workers. Through this trade in embodied workers, the US is able to consume its 1995 bundle. In autarky, however, the same bundle would require 136 million workers. The current 134 million employed workers would generate a consumption bundle is only 98.7% (≈ 134/136). The labor gains of trade then state that the current bundle is 1.3% larger than the bundle that would be possible in autarky. The labor gains of trade were even larger in later years – as high as 4.2% in 2005, meaning the same consumption bundle would require 4.2% more workers in autarky than in the actual situation.

4.6 Extensions

The key finding of our counterfactual exercises is that the labor force (or labor endowment) in the US is large enough to enable the country to achieve the same consumption levels in autarky as in the current situation with trade. This result rests on a strong ceteris paribus clause and two key assumptions however. First, any unemployed worker is assumed to be available for the labor market and, second, there is perfect substitutability of workers across industries and skill-types. In particular the assumption that a high-skilled worker can be replaced by a low-skilled worker is implausible. This section will assume no substitutability across skill-types, which implies that we redo the counterfactual exercises for each skill level. A second extension in this section is to consider the results for the other countries in the WIOD database.

4.6.1 Sectoral substitutability and worker endowments

The assumption of perfect worker substitutability between industry and skill-types is unlikely to be satisfied in the short-term. Restructuring takes time and efforts (e.g., retraining or re-educating workers), which will have consequences. If workers have different aptitudes (comparative advantages) for jobs of different skill levels and are not easily retrained, then moving them around is not possible or will seriously reduce productivity. Transitioning between skill-specific tasks requires a lot of time and is costly so it is plausible to expect less than full substitutability, at least in the short term (e.g., Borjas et al., 2008).

Instead of assuming perfect worker substitutability between industries *and* skill levels (in autarky), we now posit that in the short-term workers are mobile only between industries, but not between skills. This implies that – for each skill-type – we have labor endowments and that we calculate how many US workers are necessary under autarky for the US consumption bundle. The labor endowment is obtained by summing the employed and unemployed workers in each industry for each skill-type. The unemployed workers have been estimated by allocating the total amount of unemployed workers in an industry proportionally to skill categories. This implies that for each industry we assume identical unemployment rates across skill-types.

Table 4.5 in the previous section showed that the worker surplus was 862 thousand workers in 2000 (i.e., row (3) minus row (5)). So, if a large part (i.e., 84.9%) of the 5692 thousand unemployed workers would have been willing and able to accept a job, the US could have sustained its consumption. The question, however, is whether this also holds if workers cannot (or will not) switch to a job with another skill-level. Table 4.6 shows that in 2000 the US would have lacked 169 thousand low-skilled workers if it had produced its own consumption under autarky. This shortage rose to 233 thousand workers by 2006. At the same time, the US would have had a surplus of medium- and high-skilled workers throughout the period (fluctuating but generally decreasing over time). For instance, there would have been a surplus of 568 thousand medium-skilled workers and 394 thousand high-skilled workers in 2006. As the US generally had a surplus in highly skilled workers and a deficit in low-skilled workers, there was a skills-mismatch in terms of workers available and required. Because the low-skilled worker deficit was small compared to the surpluses of medium- and high-skilled workers in all years, the more highly qualified workers could have been able to compensate the low-skilled worker shortage (if redeployed to low-skilled tasks) - even when factoring in a small productivity loss.

Table 4.6. United States - employment, endowments, and labor footprints by skill-level (in thousands of workers)

	1995	2000	2005	2006	2007	2008
Low-skilled workers						
employed (1)	14636	15265	15083	15234	14655	13723
unemployed (2)	809	588	769	705	680	807
US labor footprint under autarky (3)	15085	16022	15989	16172	15482	14521
surplus of workers (4)	360	-169	-137	-233	-147	9
Medium-skilled workers						
employed (1)	85757	92163	90683	91401	92014	91232
unemployed (2)	4739	3551	4623	4229	4269	5365
US labor footprint under autarky (3)	86733	95093	94370	95062	95233	94408
surplus of workers (4)	3763	621	936	568	1050	2189
High-skilled workers						
employed (1)	33587	40289	43137	44685	45898	46789
unemployed (2)	1856	1552	2199	2067	2129	2752
US labor footprint under autarky (3)	33935	41432	44828	46358	47350	48223
surplus of workers (4)	1508	409	508	394	677	1318

Notes: (4) = (1) + (2) – (3).

The second assumption that we have made and that is not realistic is that all unemployed workers are willing and able to accept a job if so required. This is overly optimistic because there will always be at least some frictional unemployment. The numbers in row (1) of Table

4.5 show that 152 million workers (of all skill-types) were employed in the US in 2008, but it follows from row (5) that 157 million workers would have been required to be self-sufficient in autarky. This implies that more than 5 million (of the 9 million, see row (2)) unemployed workers would have needed to take up a job. That would be no problem under the assumptions that we have made. If, however, we assume a natural unemployment rate of 5% as most economists do, only 1 million workers would be able to accept a job.[82] Consequently, there would have been a true shortage of 4 million workers in 2008, implying that the US would not have been able to produce its consumption bundle.

The data shows that for all years between 1995 and 2008, the number of US workers required in autarky was always larger than the number of employed workers. The difference (between currently employed workers and required workers under autarky, i.e., row (5) minus row (1) in Table 4.5), however, was also always smaller than the number of unemployed workers. We have already seen that this is not true for low-skilled jobs if they cannot be carried out by medium- or high-skilled workers. For medium- and high-skilled jobs we see that the number of workers required in autarky almost matched the number of actually employed workers.[83] The gross worker deficit of medium- and high-skilled workers in autarky would never have been more than four million and two million, respectively, in any year. The deficits were always smaller than the number of unemployed workers. However, there was a significant shortage of low-skilled workers employed relative to the low-skilled workers required under autarky. In other words, the US would not have been able to perform enough low-skill functions as required to sustain the consumption bundle. So, in the absence of substitutability between skill-types, a reversion to autarky would be impossible.

4.6.2 Sensitivity analysis

In this section we modify the way unemployment data are obtained and cross-country productivities are measured. So far, we have used ILO unemployment estimates in persons. Now we draw upon unemployment rates, which are also readily available from the ILO. We derive unemployed workers by combining the rates with data on the number of employed workers provided by the WIOD's satellite accounts.[84] Note that employment data from the

[82] That is, (160,667 thousand)*0.05 = 8 million persons remain unemployed under autarky, where 160,667 thousand is from (3) in Table 4.5. This indicates only 1 million of the 9 million currently unemployed workers are employed under autarky, leaving a 5 – 1 = 4 million worker shortage under autarky in 2008.

[83] That is, (3) – (1) in Table 4.6.

[84] Specifically, let e = employed workers, u = unemployed workers, L = labor force = e + u, and α = unemployment ratio = u/L. Then $u = \alpha(e+u)$, which yields $u = [\alpha/(1-\alpha)]e$.

satellite accounts is not identical to the ILO employment data due to the former being harmonized with the world IOTs. Hence the new estimates for unemployment in persons and resulting labor endowments differ somewhat from the original estimates. For example, for 2008, we now find 9.3 million unemployed workers in the US instead of 8.9 million (see Table 4.5). The alternative estimate is less than 5% higher than the original number. The modification only slightly increases resulting labor endowment levels and does not meaningfully affect the results. The 2008 case for the US is indicative for other countries and years, suggesting that the results are robust to this alternative measure of unemployment.

Next, we use an alternative estimation for the productivity of the 'Rest of World' (ROW) for the scenario based on the actual trade structure with efficiency adjustments (i.e., used to produce rows (6) and (9) in Table 4.5). It is important to check for robustness because the US labor footprints showed large shares of embodied ROW workers (before any efficiency adjustments). This indicates the role of ROW in this respect. The productivity was measured by the per-person wage-rate. In the analysis so far, the wage rates in ROW were obtained in the same way they were obtained for the other countries: by dividing the labor payments in ROW by the number of workers (for low-, medium-, and high-skilled workers, respectively). Then these wage rates were used to 'translate' the imports of foreign workers from ROW into US-efficient workers. However, employment figures for ROW were obtained confidentially from the WIOD creators and are based on estimation techniques. This data was not part of the officially released satellite accounts. As so many countries and workers are reflected in the aggregated number of ROW workers, the employment data for ROW could be expected to be more approximated than for the individual countries included in the WIOD.

Now we take the unweighted average per-person labor payment of the 7 largest emerging countries included in WIOD (Brazil, China, India, Indonesia, Mexico, Russia, and Turkey) to proxy ROW productivity (that is, the per-person labor payments in each country are summed up and divided by 7) and use this to replace the productivity of ROW workers in the original specification. The discrepancy between the original worker surplus shares for the US (i.e., row (9) in Table 4.5) and the modified surplus shares based on adjustments to ROW worker productivity was less than 1.5 percentage points in all years before 2005. For example, The US worker surplus in the original specification was 6.4 million workers in 1995 (or 3.5% of the labor force) compared to 5.6 million workers using the alternative proxy for ROW's productivity in the same year (2.9% of the labor force).

The situation is slightly different in later years. Table 4.5 reported a surplus (endowment in row (3) minus footprint after efficiency adjustments in row (6)) of 3.1 million workers (or

2.0% of the labor force) in 2008. Using the alternative proxy for ROW productivity, however, would have yielded a *shortage* of 1.6 million workers (-1.0% of the labor force) in 2008. This larger discrepancy in more recent years is because the new estimates for the wage rate in ROW are based on the wage rates in emerging countries. These have grown more rapidly than the original estimates of ROW's wage rates. Because the wage rate is used to proxy productivity, the productivity gaps between ROW workers using emerging country wage rates and US workers narrowed. This caused the US labor surplus to decline and even change into a shortage. Similar findings were observed for other years and other advanced countries. We feel that the original ROW estimates seem more suitable than the alternative. This is because ROW includes many developing countries that are not yet emerging countries. Their productivity (i.e., wage rate) did not increase as much and as fast as the wage rate of the largest emerging countries. We feel that the alternative overestimates the wage rate in ROW. The alternative should therefore be viewed as a 'worst case scenario' (for the US).

4.6.3 Comparative perspective of the other countries in WIOD

Now we expand the analysis to track the hypothetical self-sufficiency prospects and labor gains of trade of all 40 countries in the WIOD database. We calculate a country's ability to sustain its consumption bundle in autarky using only domestic workers. This follows the same method as before for the US, using equation (4.3) leading to the results in row (5) in Table 4.5.[85] As in Section 4.5.2, we assume (*i*) perfect worker substitutability between skill-types and industries (based on effective use of each country's production technology), and (*ii*) that unemployed workers are able and willing to accept at any time a job if offered one. The exercise examines which countries are most dependent on foreign workers to sustain consumption levels and how this dependence changes over time in the period 1995-2008. This also puts the case of the US into a broader context.

Table 4.7 displays all 40 countries, 34 of which had complete data (with unemployment data available in 1995 and 2008). The surplus is displayed in the same way as in row (8) in Table 4.5 for the US. That is, the labor endowment (currently employed plus unemployed workers) minus the number of workers required under autarky, expressed as a percentage of the labor endowment. Serious sacrifices would be necessary in cases where a country's labor

[85] The counterfactual method employed in this section hypothetically modifies the underlying trade structure. The second counterfactual exercise in Section 4.5 corrected for efficiency differences of workers across countries and estimated efficiency equivalent workers based on labor payments. Results based on the application of this second counterfactual method to the 40 WIOD countries are similar to the results with the first method for the same country and are available upon request.

endowment is less than the number of workers required in autarky (i.e., a shortage). For instance, Bulgaria had an estimated surplus of 16.1% in 1995, meaning that its domestic labor endowment would have easily been sufficient to produce everything itself without trade that year. However, Bulgaria would have had a deficit of 6.1% in 2008, implying that autarky would necessarily entail reduced consumption, even in the most ideal circumstances (i.e., perfect substitutability and all unemployed workers can and will accept the jobs they are offered).

The results reveal two notable insights. First, nearly all countries in our analysis could have been self-sufficient in terms of producing everything for themselves using only their own domestic labor. In the year 1995, 32 of 35 countries had an excess in labor endowments (all except Estonia, Greece and Portugal); in 2008 still 28 out of 39 countries would have had a labor surplus. Second, a clear majority of countries became less able to be self-sufficient over time (25 of 34).

Table 4.7. Self-sufficiency measured by the labor 'surplus' or 'deficit' in hypothetical autarky

Country	Suplus 1995	Surplus 2008	Change (08-95)	Country	Surplus 1995	Surplus 2008	Change (08-95)
Bulgaria	16.1	-6.1	-22.2	Netherlands	12.0	10.0	-2.0
Lithuania	13.1	-2.8	-16.0	USA	4.0	2.2	-1.8
Spain	19.3	4.9	-14.4	Sweden	15.4	13.7	-1.8
Finland	22.7	9.2	-13.6	India	11.5	10.4	-1.1
Ireland	21.4	8.2	-13.1	Korea	5.0	5.0	0.0
Romania	6.0	-5.7	-11.8	Japan	3.8	4.0	0.3
Greece	-4.5	-15.7	-11.1	Hungary	6.5	7.7	1.2
Poland	17.7	6.6	-11.1	China	6.7	10.4	3.7
Mexico	7.8	0.0	-7.8	Indonesia	6.5	10.8	4.2
Italy	14.3	7.0	-7.3	Germany	9.5	14.6	5.1
France	13.3	6.0	-7.3	Austria	1.4	8.0	6.6
Canada	11.6	4.4	-7.2	Taiwan	6.8	16.2	9.4
Slovenia	4.7	-1.5	-6.2	Luxembourg	6.7	17.4	10.7
Denmark	12.3	6.5	-5.7	Estonia	-9.7	3.6	13.3
Belgium	15.9	10.2	-5.7	Brazil	6.5	n/a	n/a
Slovakia	13.4	8.3	-5.0	Australia	n/a	1.8	n/a
Great Britain	8.9	4.3	-4.6	Cyprus	n/a	-23.4	n/a
Turkey	9.0	4.6	-4.4	Czech Republic	n/a	10.3	n/a
Portugal	0.0	-4.2	-4.2	Latvia	n/a	-4.3	n/a
Russia	0.8	-2.6	-3.4	Malta	n/a	-1.8	n/a

Notes: The first two columns give the labor endowment (i.e., employed plus unemployed workers) minus the workers required to sustain the consumption bundle in autarky, expressed as percentage of the labor endowment. If the result is positive we have a 'surplus', if negative a 'deficit'. The third column gives the percentage point changes between 1995 and 2008. The countries are ranked by largest decrease (in percentage points) over time.

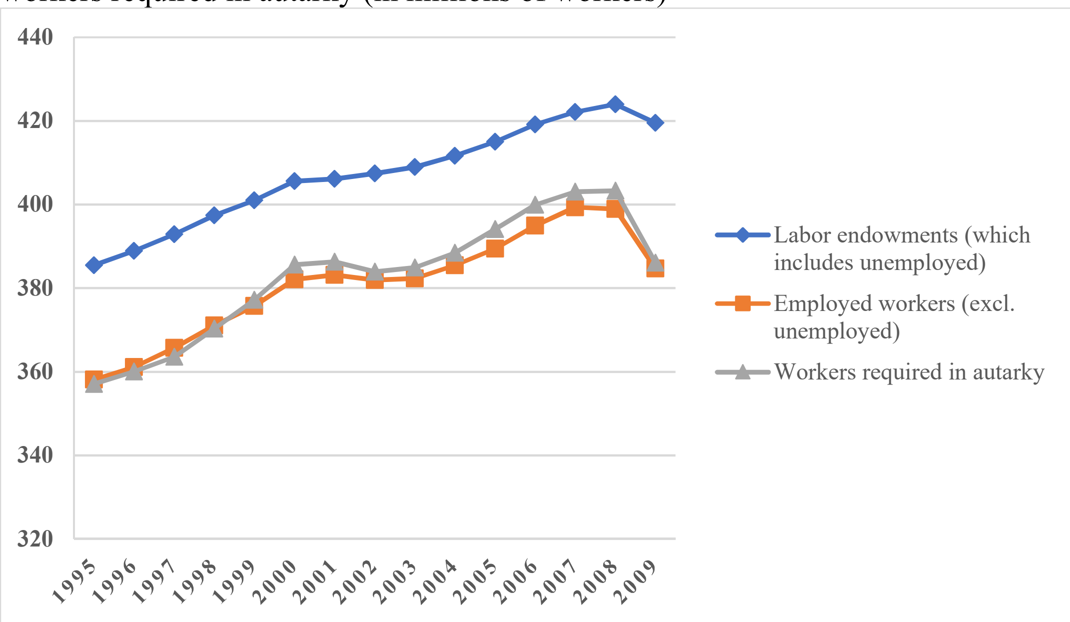
The number of countries still in position to be self-sufficient in 2008 may appear surprising. The next-best case scenario assumes that unemployed workers cannot immediately accept a job and that the number of unemployed workers cannot fall. In that scenario, only 24 of 35 countries had sufficient labor in 1995 and 18 of 39 in 2008 (which also means that unemployment had increased in these countries). Under realistic circumstances, the share of hypothetically self-sufficient countries would probably be lower. This is because worker substitutability between sectors and industries is not perfect, the unemployment is underreported in certain countries, and innumerable other factors are not fully captured (such as efficiency losses related to the lack of import competition). In addition, small open economies simply do not have certain industries. In autarky, they thus could not possibly produce the same diversity of inputs and products as they currently consume. This is an important caveat and makes this exercise appear more reasonable for large and independent countries like the US than for small and trade-dependent countries.

The labor gains of trade were also calculated for the WIOD countries (see Table 4.A2 of the Appendix for full results). As could be expected with the trend towards declining worker surpluses in the counterfactual autarky situation over time in most countries, the labor gains of trade increased in 27 of the 40 countries between 1995 and 2008. The labor gains of trade rose in nearly all countries that became less self-sufficient in the period, and countries that were not able to be self-sufficient in autarky (as shown in Table 4.7) enjoyed the highest overall labor gains of trade.

Figure 4.1 gives the labor endowment, the number of employed workers, and the number of workers that would be required under autarky. The numbers are for the 'Triad', i.e., the first 15 members of the EU, Japan, and the United States and are given for the years from 1995 to 2009. Our motivation to highlight these countries is two-fold. First, they are commonly perceived to be the countries that are at greatest risk of job loss through outsourcing arrangements and import competition. Second, their unemployment estimates are readily available for every year in all countries and their employment data in general are probably more reliable than that of emerging and developing countries (which tend to have major urban/rural divides). Note that although the results of the 17 countries have been aggregated it is still assumed that each separate country operates alone in autarky and does not trade with any country – whether inside or outside of the group. The total Triad labor endowment (including all employed and unemployed workers, and marked by the blue line in Figure 4.1) clearly exceeded the number of workers cumulatively required in the Triad countries to maintain their combined consumption bundle in any of the years (the grey line). However, comparing the employed workers (the orange line) with the number of workers required under autarky shows an almost perfectly parallel movement. The Triad countries were thus able to sustain their current consumption levels with the currently employed workers.

Finally, it is worth noting the sudden change in 2009 (Figure 4.1). This paper's analysis does not cover the crisis years, primarily because these years were a clear aberration from the norm. There was a general collapse of trade, higher levels of unemployment, and declining labor endowments. Little change occurred in 2009 in the relative abilities of countries to sustain consumption levels in autarky with the currently employed workers (as the orange and grey lines dipped in tandem). But when unemployment (which has seriously risen in 2009) is included as part of the labor endowment, we observe an increase in the labor surplus in 2009 (blue minus grey lines).

Figure 4.1. The Triad (European Union-15, Japan, and United States) – labor endowments (which includes unemployed), employed workers (excluding unemployed), and domestic workers required in autarky (in millions of workers)



Notes: The EU-15 (members prior to May 1, 2004) consists of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

4.7 Conclusions and Evaluation

In this paper, we began by describing a way of computing labor footprints based on standard input-output methodology. The aim was twofold: first, to explore how much labor of different types is embodied in the labor footprint of the US, and second, to provide an alternative perspective on the labor benefits of trade and the popular debate over lost jobs due to globalization. Labor footprints are defined as the total number of workers (domestic and foreign) directly or indirectly involved in producing all final goods and services consumed in a country. While the labor footprint concept is not novel by itself, this is to our knowledge the first time it has been combined with employment data to systematically evaluate the (hypothetical) self-sufficiency of domestic labor. These insights help shed new light into the employment implications of trade – including the dependence of countries on foreign labor and the threat of foreign workers for domestic jobs. The analysis was focused on the US but covered 40 countries and 14 consecutive years.

In the US case study, we showed that the share of foreign workers in the US labor footprint grew steadily over time. The trend was largely driven by workers induced in emerging and developing countries. This does not necessarily imply a net US job loss because new jobs were created in export-related activities. We find that many new jobs were gained especially in the services industries. Furthermore, most of the foreign workers were shown to be low-skilled. We considered two counterfactual exercises and determined that US labor would have been able to produce enough to sustain the domestic consumption bundle all by itself (i.e., in autarky) in most years between 1995 and 2008. Despite the worker surplus possible in autarky, there were still positive labor gains of trade for the US when these labor gains are defined as the footprint in autarky minus the number of employed workers as a share of the employed workers. Employed workers achieved a consumption bundle that was 1.3% larger in 1995 and 3.6% larger in 2008 in the actual situation than the consumption bundle that would be possible in autarky.

The second counterfactual exercise was based on the idea that wage rate differences between countries reflected differences in productivity. US workers and US production technology are more efficient than the foreign workers ending up in US consumption (in the current trade structure). Correcting for the differences in productivity levels showed that the enormous amounts of imports of foreign workers would be equivalent to much less US workers. The US labor footprint (in US-efficient workers) was thus fairly close to the autarkic US labor requirements. These results were upheld using different sources for unemployment data and, to a lesser extent, a different proxy for the productivity of the 'Rest of World' workers.

However, if we drop the assumption of perfect substitutability between sectors and skill-levels it becomes clear that US labor cannot be self-sufficient (which would also increase the labor gains of trade). In fact, the US would face an acute shortage of low-skilled workers in autarky, and the US was no longer able to be self-sufficient in any year.

Dropping additional assumptions in the analysis would almost certainly further emphasize that US labor cannot be self-sufficient (in terms of maintaining consumption levels). For instance, price effects are important. If the US did not import from China and Mexico, many consumer goods would have been much more expensive for US consumers. They would buy less and US employment would be lower. In other words, consumption is not exogenous to trade as implied in our analysis; employment and imports can also be positively correlated. Second, in a world with internationally fragmented production processes, US export competitiveness is also determined by finding the cheapest, most reliable, and most flexible suppliers of intermediate inputs, which are often not located in the US itself. Therefore, factor prices (and hence input coefficients) will differ in autarky due to the switch from foreign to possibly less efficient domestic suppliers of intermediate inputs. Domestic inputs may not be perfect substitutes of foreign inputs even if differences in the production technologies between countries are accounted for.[86] Of course, these caveats are even more applicable to smaller countries with higher dependencies on trade and foreign suppliers – in an extreme case when they lack certain industries or factor endowments entirely. Related to this point, consumption bundles in autarky may be less diverse in most if not all countries even if it were possible to produce the required industry-level output levels.[87] This implies less product varieties available to consumers.

We did not incorporate additional constraining factors in the analysis - such as the possible endogeneity of consumption to trade - for two reasons. First and foremost, our goal was not to simulate autarky. This would not be possible with our input-output approach; a different type of analysis would have been required and this would go beyond the scope of our paper. Further

[86] For instance, foreign suppliers may be able to produce more cheaply due to economies of scale or country-specific idiosyncrasies e.g., cultural factors, which are not accounted for by production technology. In addition, it has been shown that exporting firms are more productive and pay higher wages than non-exporters (Bernard et al. 2007). In autarky, all firms would be non-exporters. World IOTs are not currently detailed enough to distinguish between exporters and non-exporters, precluding any consideration of this in our analysis.

[87] We cannot test this because of database limitations. Labor payments, employment figures, and footprint contributions are aggregated to the industry level (35 industries in the case of WIOD) and it is not possible to differentiate between product varieties within these industries.

refinements and/or alternative approaches are avenues for future research, for instance through use of computable general equilibrium models. Second, the inability of the US to be self-sufficient after dropping the assumption of perfect labor market mobility for workers of different skill-levels already confirms the hypothesis. Additional evidence would hence corroborate but not overturn the main conclusions. The finding that the US cannot maintain the same consumption levels in autarky using only domestic workers already sends an important policy message: protectionism has clear drawbacks and some of the rhetoric in the public sphere from politicians and the popular press is misleading. At the same time, it should be noted that efficiency losses related to protectionism (due primarily to lack of competition and disincentives for innovation and optimal resource allocation) do still matter and would reinforce the findings (i.e., there would be even bigger sacrifices necessary in autarky).

Lastly, we return to the specific case of the perceived threat of China for US jobs. We highlighted this issue at the start as it was one of the motivating factors for the paper. Despite widespread fears of a growing China rapidly taking away US jobs, we found that the share of Chinese workers embodied in the US labor footprint increased by only 1.6 percentage points between 1995 and 2008 (from 12.6% of the labor force to 14.2%). Just shy of half of this increase involved manufacturing jobs, which potentially reflects import competition in that sector. While the overall share of 14.2% in 2008 is not insignificant, this number too may exaggerate the impact. To demonstrate this, we convert all Chinese workers reflected in the labor footprint to US efficiency equivalents. Our analysis based on wage differences (at industry- and skill-levels) between US and foreign workers as a proxy of productivity differences showed that the efficiency-adjusted share of Chinese workers in the US labor footprint amounted to only 1.5% in 2008!

Thus, while the evidence does suggest that some US jobs involved in producing for US consumption have been outsourced to China, we do not find that China had a particularly large negative impact on US jobs (and the same holds true for other developing countries). This is underscored by looking at the reverse perspective. US trade with China was responsible for the largest US job gains in terms of export-related activities between 1995 and 2008 (548,000 new jobs), providing nearly 800,000 US jobs overall in 2008. Therefore, it is equally important to consider how US labor has integrated in the world economy and the jobs that have been gained due to globalization. The threat of China is therefore exaggerated and the US has relatively little to fear.

Appendix Chapter 4

Table 4.A1

Names and abbreviations of all countries included in the World Input-Output Database

AUT = Australia	ITA = Italy
AUT = Austria	JPN = Japan
BEL = Belgium	KOR = South Korea
BGR = Bulgaria	LTU = Lithuania
BRA = Brazil	LUX = Luxembourg
CAN = Canada	LVA = Latvia
CHN = China	MEX = Mexico
CYP = Cyprus	MLT = Malta
CZE = Czech Republic	NLD = The Netherlands
DEU = Germany	POL = Poland
DNK = Denmark	PRT = Portugal
ESP = Spain	ROU = Romania
EST = Estonia	RUS = Russia
FIN = Finland	SVK = Slovak Republic
FRA = France	SVN = Slovenia
GBR = Great Britain	SWE = Sweden
GRC = Greece	TUR = Turkey
HUN = Hungary	TWN = Taiwan
IDN = Indonesia	USA = United States
IND = India	ROW = Rest of World
IRL = Ireland	

Table 4.A2

Labor gains (LG) of trade
(Percentage of employed workers)

Country	LG of trade 1995	LG of trade, 2008	Change (08-95)	Country	LG of trade 1995	LG of trade, 2008	Change (08-95)
Bulgaria	-2.7	11.7	14.4	Slovakia	0.0	2.0	2.1
Latvia	0.6	12.6	11.9	Great Britain	-0.8	1.0	1.8
Greece	14.2	24.7	10.6	Lithuania	7.2	8.7	1.5
Turkey	-1.9	7.1	9.0	Korea	-3.1	-1.9	1.2
Ireland	-10.8	-2.1	8.8	Russia	8.0	8.9	0.8
Romania	3.5	12.2	8.7	Japan	-0.7	0.0	0.7
Poland	-5.0	0.5	5.5	India	-2.9	-2.8	0.1
Portugal	7.4	12.6	5.2	Sweden	-7.3	-7.8	-0.5
Spain	2.5	7.1	4.6	Indonesia	-2.3	-3.2	-0.9
Mexico	-1.2	3.2	4.4	Netherlands	-5.5	-7.5	-1.9
Canada	-2.6	1.7	4.2	China	-5.6	-8.7	-3.1
Cyprus	23.8	28.0	4.2	Brazil	-1.2	-4.5	-3.3
Finland	-7.2	-3.0	4.2	Hungary	3.2	-0.3	-3.5
Belgium	-7.4	-3.5	3.9	Germany	-1.8	-8.0	-6.2
Slovenia	2.3	6.2	3.8	Austria	3.1	-4.3	-7.4
France	-2.1	1.4	3.5	Taiwan	-5.2	-12.6	-7.4
Italy	-4.0	-0.9	3.1	Czech Republic	3.3	-6.4	-9.7
Denmark	-5.5	-3.2	2.3	Luxembourg	-4.6	-15.0	-10.4
USA	1.3	3.6	2.2	Malta	19.4	8.1	-11.3
Australia	0.3	2.5	2.1	Estonia	21.5	1.9	-19.5

Notes: The labor gains of trade are defined as the footprint in autarky minus the number of employed workers, expressed as percentage of employed workers. The last columns give the percentage point changes between 1995 and 2008. The countries are ranked by largest increase (in percentage points) in their gains of trade over time.

Table 4.A3

Unemployment by country
(in thousands of persons)

	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
AUS	n/a	n/a	n/a	n/a	592	n/a	524	508	478	474
AUT	167	181	154	187	188	223	223	212	200	172
BEL	391	290	266	301	337	329	390	383	353	333
BGR	565	556	686	619	458	406	334	306	240	200
BRA	4198	n/a	7644	7724	8453	8083	8747	8024	7853	n/a
CAN	1394	1082	1162	1269	1283	1232	1169	1106	1077	1112
CHN	7900	19070	10870	12120	11750	10260	14730	13370	12100	14820
CYP	n/a	15	13	11	14	15	19	17	15	15
CZE	n/a	449	407	357	384	419	410	372	277	230
DEU	3179	3123	3078	3362	3894	4261	4571	4245	3601	3136
DNK	196	127	118	122	154	151	140	114	111	101
ESP	3664	2469	1856	2103	2216	2248	1934	1841	1846	2596
EST	68	90	88	66	76	69	54	41	32	38
FIN	413	297	276	280	281	275	220	204	183	172
FRA	2941	2631	2231	2276	2308	2488	2432	2432	2223	2064
GBR	2475	1606	1357	1470	1416	1363	1434	1642	1623	1753
GRC	381	519	493	474	454	507	493	448	418	388
HUN	417	267	232	230	241	241	302	318	312	326
IDN	3918	8005	9132	9531	10251	11899	10932	10011	9395	8963
IND	36742	41343	41996	41173	41390	40457	39348	41465	39974	39112
IRL	172	75	66	78	84	86	89	94	105	146
ITA	2639	2545	2268	2206	2146	1913	1877	1654	1481	1664
JPN	2100	3220	3390	3570	3510	3130	2950	2770	2570	2640
KOR	419	979	897	752	818	860	888	827	783	770
LTU	347	269	278	212	218	171	130	88	64	88
LUX	5	4	3	5	7	10	9	10	9	11
LVA	n/a	156	150	153	131	127	108	78	68	88
MEX	2379	989	981	1137	1188	1528	1470	1367	1495	1584
MLT	n/a	10	11	11	12	12	11	11	11	10
NLD	523	220	175	214	303	395	402	336	278	243
POL	2279	2830	3208	3432	3281	3225	3045	2344	1619	1211
PRT	336	199	203	243	333	342	414	421	441	418
ROU	968	816	758	862	700	776	704	728	641	576
RUS	6710	7699	6423	5700	5959	5676	5264	5311	4588	4793
SVK	324	491	509	486	448	491	430	355	296	256
SVN	68	66	55	58	62	60	66	61	50	46
SWE	396	239	215	227	256	309	351	337	298	305
TUR	1610	1498	1969	2466	2493	2498	2520	2329	2361	2605
TWN	165	291	452	515	503	454	429	410	417	450
USA	7404	5692	6801	8378	8774	8149	7591	7001	7078	8924

Source: International Labor Organization (ILOSTAT 2015), http://www.ilo.org/ilostat/

Table 4.A4

Labor endowments (or labor force) by country

(all workers gainfully employed, including informal workers, plus unemployed workers; in thousands of persons)

	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
AUS	n/a	n/a	n/a	n/a	10111	n/a	10552	10797	11036	11336
AUT	3884	4112	4113	4146	4159	4209	4255	4302	4361	4472
BEL	4258	4399	4431	4460	4498	4528	4648	4692	4731	4783
BGR	4083	3795	3900	3842	3775	3810	3830	3918	3967	3959
BRA	77744	n/a	87189	90353	92488	96335	99653	101271	102567	n/a
CAN	14987	16130	16361	16837	17185	17398	17574	17783	18124	18598
CHN	688550	739920	741120	749520	756070	762260	772980	777370	782000	789620
CYP	n/a	330	335	339	355	369	386	389	400	406
CZE	n/a	5389	5369	5348	5307	5359	5402	5460	5500	5579
DEU	40780	42267	42394	42458	42620	43141	43406	43320	43325	43586
DNK	2748	2840	2861	2868	2868	2848	2867	2897	2972	3009
ESP	17233	18880	18786	19441	20094	20757	21201	21863	22475	23172
EST	701	663	666	651	670	664	661	687	687	698
FIN	2466	2590	2600	2626	2628	2632	2609	2638	2669	2713
FRA	25635	26963	26995	27195	27259	27465	27547	27794	27952	28009
GBR	30388	31223	31281	31576	31824	32066	32524	33040	33225	33426
GRC	4512	4774	4754	4831	4862	5021	5044	5149	5201	5335
HUN	4442	4518	4464	4453	4468	4407	4458	4500	4481	4395
IDN	91189	101326	102569	103186	104574	106595	106396	107891	112744	114716
IND	417529	458226	474372	465379	490413	498357	509125	513233	500204	502491
IRL	1457	1772	1814	1857	1899	1957	2051	2142	2228	2322
ITA	24480	25475	25662	26000	26295	26169	26273	26528	26669	26942
JPN	68958	68473	68150	67318	67047	66807	66867	66967	67008	65685
KOR	20817	22115	22454	22904	22935	23394	23718	23960	24201	24331
LTU	1827	1668	1624	1607	1644	1596	1591	1575	1593	1619
LUX	220	268	282	293	300	309	317	329	342	381
LVA	n/a	1097	1103	1134	1131	1140	1140	1157	1186	1209
MEX	35507	40214	41085	42095	42844	44561	45171	46636	47575	51278
MLT	n/a	155	160	162	163	160	162	165	170	174
NLD	7678	8336	8457	8538	8586	8606	8654	8728	8884	8981
POL	17014	17847	17403	17199	16887	16998	17120	16874	16793	16994
PRT	4867	5229	5324	5395	5455	5459	5514	5621	5639	5636
ROU	10471	11587	11416	10436	10269	10187	9972	10059	10006	9942
RUS	81774	81425	81150	80628	81755	81950	82167	82687	82940	83481
SVK	2431	2516	2545	2525	2508	2547	2519	2488	2473	2518
SVN	986	971	964	981	981	983	986	995	1012	1040
SWE	4525	4539	4607	4620	4624	4647	4700	4759	4822	4847
TUR	22196	23078	23493	23820	23640	24230	24476	23421	23099	23799
TWN	9533	9888	9835	9969	10077	10238	10372	10523	10709	10854
USA	141383	153409	153619	153777	153963	155014	156494	158320	159645	160667

Source: International Labor Organization (ILOSTAT 2015) for unemployment; WIOD satellite accounts for employment data.

Table 4.A5

Current trade structure: labor footprints by country
(in thousands of persons; includes total number of domestic and foreign workers without efficiency adjustments)

	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
AUS	13906	15264	15058	16214	17262	19433	20421	20253	21700	21569
AUT	6580	6538	6576	6431	6850	7044	7123	7211	7308	7435
BEL	7413	8243	8254	8555	9525	9919	10112	10281	10310	10706
BGR	2950	2569	2619	2588	2729	2851	3055	3134	3307	3465
BRA	72860	76858	75177	75724	76502	78858	82877	86771	90269	93913
CAN	19327	22301	23154	23536	25308	25647	27596	29464	29682	29942
CHN	577903	628115	641626	639211	633498	630546	621570	617768	623743	645381
CYP	484	558	597	604	636	632	623	650	683	817
CZE	4782	4719	4879	5142	5231	5311	5297	5436	5625	5953
DEU	64686	65492	64364	62285	66056	66720	65647	66446	68160	68303
DNK	4552	4442	4531	4640	4815	5198	5263	5480	5573	5634
ESP	19750	24780	25861	26760	28799	31349	32972	34676	36302	34968
EST	504	624	662	767	837	818	779	867	906	858
FIN	3383	3533	3494	3545	3883	3998	4156	4329	4469	4847
FRA	34637	37810	39030	39747	41748	43114	43693	43460	44698	45432
GBR	40623	48614	49451	50584	51681	58127	59722	60579	60484	57059
GRC	5544	6484	6530	6917	7195	7402	7325	7642	8105	8858
HUN	3792	4155	4204	4394	4616	4580	4501	4400	4396	4318
IDN	80054	80145	80382	83397	83998	84093	83981	88434	93841	96146
IND	351789	376220	392496	381642	407842	411106	423897	420806	412902	416739
IRL	1719	2497	2581	2923	3087	3268	3360	3867	4031	4047
ITA	31936	35118	36505	37731	39794	40455	40479	41814	41670	41838
JPN	114618	106906	105275	101527	102555	104903	106047	103881	98147	96090
KOR	27423	30135	30113	32400	33029	33406	33579	34447	35138	33417
LTU	1305	1464	1436	1503	1607	1585	1644	1697	1798	1879
LUX	387	480	469	488	540	606	639	810	639	585
LVA	826	889	931	970	1014	1080	1088	1203	1323	1287
MEX	30053	38056	40044	41356	41855	43684	44911	46870	47559	50906
MLT	216	240	237	234	247	226	234	280	280	252
NLD	18039	19957	20370	21044	21095	20042	19874	19235	18652	19465
POL	13491	15133	14280	13947	13590	13932	14435	15126	16202	17615
PRT	5732	6489	6700	6654	6647	6860	6752	6751	6898	7094
ROU	8355	9303	9441	8219	8504	8502	8761	9155	9653	9613
RUS	72837	63009	67193	68805	71773	75021	78651	79782	88152	91550
SVK	1976	1929	2030	2059	2118	2383	2522	2631	2860	3026
SVN	1056	1103	1098	1152	1238	1205	1204	1226	1327	1573
SWE	6185	6856	6652	6993	7341	7526	7513	7678	8068	8108
TUR	21188	23342	21274	21907	22990	24379	25302	25011	25659	32489
TWN	11900	13023	12245	12451	12292	13047	13042	12759	12231	12468
USA	203037	256722	257448	260723	263466	272848	282337	286191	274698	264346

Source: Author's calculations based on the World Input-Output Database (WIOD)

Table 4.A6

Current trade structure: labor endowment minus labor footprint
(without efficiency adjustments; surplus or deficit expressed as percent share of given country's labor force)

	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
AUS	n/a	n/a	n/a	n/a	-70.7	n/a	-93.5	-87.6	-96.6	-90.3
AUT	-69.4	-59.0	-59.9	-55.1	-64.7	-67.3	-67.4	-67.6	-67.6	-66.3
BEL	-74.1	-87.4	-86.3	-91.8	-111.8	-119.0	-117.5	-119.1	-117.9	-123.8
BGR	27.8	32.3	32.9	32.6	27.7	25.2	20.2	20.0	16.6	12.5
BRA	6.3	n/a	13.8	16.2	17.3	18.1	16.8	14.3	12.0	n/a
CAN	-29.0	-38.3	-41.5	-39.8	-47.3	-47.4	-57.0	-65.7	-63.8	-61.0
CHN	16.1	15.1	13.4	14.7	16.2	17.3	19.6	20.5	20.2	18.3
CYP	n/a	-69.0	-78.3	-78.1	-79.2	-71.4	-61.6	-66.8	-70.7	-101.4
CZE	n/a	12.4	9.1	3.9	1.4	0.9	1.9	0.4	-2.3	-6.7
DEU	-58.6	-54.9	-51.8	-46.7	-55.0	-54.7	-51.2	-53.4	-57.3	-56.7
DNK	-65.6	-56.4	-58.4	-61.8	-67.9	-82.5	-83.6	-89.2	-87.5	-87.2
ESP	-14.6	-31.2	-37.7	-37.6	-43.3	-51.0	-55.5	-58.6	-61.5	-50.9
EST	28.2	5.9	0.6	-17.9	-25.0	-23.2	-17.8	-26.3	-31.9	-22.9
FIN	-37.2	-36.4	-34.4	-35.0	-47.7	-51.9	-59.3	-64.1	-67.4	-78.6
FRA	-35.1	-40.2	-44.6	-46.2	-53.2	-57.0	-58.6	-56.4	-59.9	-62.2
GBR	-33.7	-55.7	-58.1	-60.2	-62.4	-81.3	-83.6	-83.4	-82.0	-70.7
GRC	-22.9	-35.8	-37.4	-43.2	-48.0	-47.4	-45.2	-48.4	-55.8	-66.1
HUN	14.6	8.0	5.8	1.3	-3.3	-3.9	-1.0	2.2	1.9	1.7
IDN	12.2	20.9	21.6	19.2	19.7	21.1	21.1	18.0	16.8	16.2
IND	15.7	17.9	17.3	18.0	16.8	17.5	16.7	18.0	17.5	17.1
IRL	-18.0	-40.9	-42.3	-57.4	-62.6	-67.0	-63.8	-80.5	-80.9	-74.3
ITA	-30.5	-37.9	-42.3	-45.1	-51.3	-54.6	-54.1	-57.6	-56.3	-55.3
JPN	-66.2	-56.1	-54.5	-50.8	-53.0	-57.0	-58.6	-55.1	-46.5	-46.3
KOR	-31.7	-36.3	-34.1	-41.5	-44.0	-42.8	-41.6	-43.8	-45.2	-37.3
LTU	28.6	12.2	11.6	6.5	2.2	0.7	-3.3	-7.8	-12.8	-16.1
LUX	-75.7	-79.0	-66.5	-66.9	-80.0	-95.9	-101.6	-146.4	-87.1	-53.3
LVA	0.0	19.0	15.5	14.5	10.3	5.2	4.6	-4.0	-11.6	-6.4
MEX	15.4	5.4	2.5	1.8	2.3	2.0	0.6	-0.5	0.0	0.7
MLT	n/a	-54.8	-48.2	-43.8	-52.0	-40.7	-44.6	-69.4	-64.7	-44.9
NLD	-134.9	-139.4	-140.9	-146.5	-145.7	-132.9	-129.7	-120.4	-109.9	-116.7
POL	20.7	15.2	17.9	18.9	19.5	18.0	15.7	10.4	3.5	-3.7
PRT	-17.8	-24.1	-25.8	-23.3	-21.9	-25.7	-22.4	-20.1	-22.3	-25.9
ROU	20.2	19.7	17.3	21.2	17.2	16.5	12.1	9.0	3.5	3.3
RUS	10.9	22.6	17.2	14.7	12.2	8.5	4.3	3.5	-6.3	-9.7
SVK	18.7	23.3	20.2	18.4	15.6	6.4	-0.1	-5.8	-15.7	-20.2
SVN	-7.1	-13.6	-13.9	-17.5	-26.1	-22.7	-22.1	-23.2	-31.1	-51.3
SWE	-36.7	-51.0	-44.4	-51.3	-58.8	-62.0	-59.9	-61.3	-67.3	-67.3
TUR	4.5	-1.1	9.4	8.0	2.8	-0.6	-3.4	-6.8	-11.1	-36.5
TWN	-24.8	-31.7	-24.5	-24.9	-22.0	-27.4	-25.7	-21.2	-14.2	-14.9
USA	-43.6	-67.3	-67.6	-69.5	-71.1	-76.0	-80.4	-80.8	-72.1	-64.5

Source / notes: Author's calculations based on the World Input-Output Database (WIOD). Difference between actual number of employees available and labor footprint: [(Export of Labor + Unemployed Workers) - (Imports of labor)] / [Workforce]

Table 4.A7

Autarky trade structure: labor footprints by country
(in thousands of persons)

	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
AUS	8316	9098	9247	9622	9774	10115	10396	10656	11041	11128
AUT	3832	3902	3928	3846	3890	3887	3912	3923	3975	4115
BEL	3583	3862	3889	3813	3843	3894	4008	4041	4115	4296
BGR	3425	3242	3279	3220	3363	3489	3696	3819	4056	4201
BRA	72671	77434	76466	77227	77694	80221	83308	86553	89246	91884
CAN	13246	14216	14420	14917	15429	15616	16077	16496	17005	17781
CHN	642630	681524	692438	691857	697421	701775	692826	689246	691088	707370
CYP	367	398	400	408	423	432	438	453	480	501
CZE	5317	5018	5030	5007	4942	4831	4743	4845	4891	5004
DEU	36914	38308	37916	36805	36680	36443	36396	36487	36611	37221
DNK	2411	2558	2568	2594	2549	2590	2635	2717	2813	2813
ESP	13914	17331	17770	18088	18705	19632	20639	21589	22302	22046
EST	769	599	605	625	628	639	638	696	708	673
FIN	1905	2113	2132	2146	2203	2221	2303	2343	2388	2465
FRA	22223	24037	24421	24499	24652	24834	25175	25501	25984	26320
GBR	27697	29763	30193	30512	30712	31134	31659	31904	32073	31989
GRC	4716	5114	5181	5280	5323	5379	5421	5655	5896	6170
HUN	4155	4502	4365	4334	4418	4331	4289	4269	4159	4057
IDN	85239	88172	89054	89655	89492	90390	90550	93343	99111	102363
IND	369640	394497	411906	401109	429735	438786	454481	453916	444607	450308
IRL	1146	1627	1648	1691	1685	1743	1866	1961	2055	2132
ITA	20975	22504	22871	23343	23781	23871	24145	24758	24958	25046
JPN	66357	64385	64384	63014	62645	62625	63201	63646	63723	63035
KOR	19769	19905	20498	21335	21166	21191	21694	22238	22513	23106
LTU	1587	1465	1388	1457	1479	1517	1542	1587	1645	1664
LUX	206	272	283	288	283	285	292	287	290	315
LVA	1547	1547	1547	1547	1547	1547	1547	1547	1547	1547
MEX	32740	39899	40773	41598	42386	43900	44466	46055	46972	51284
MLT	166	169	170	165	167	170	163	175	178	177
NLD	6758	7605	7759	7750	7744	7600	7554	7750	7905	8086
POL	14004	15509	14228	13766	13445	13514	13567	14184	15063	15866
PRT	4868	5666	5767	5699	5592	5661	5697	5731	5737	5875
ROU	9838	11094	11202	9922	10215	10087	10054	10258	10551	10512
RUS	81097	70560	74401	76782	77952	78193	79977	80339	84512	85666
SVK	2106	2054	2195	2157	2062	2081	2129	2172	2150	2309
SVN	940	948	933	926	943	960	953	964	1009	1056
SWE	3827	3986	4071	4076	4048	3966	3993	4048	4159	4185
TUR	20194	21859	20753	21279	21272	22071	22402	21753	21490	22703
TWN	8883	9006	8525	8461	8580	8994	9039	8988	9010	9097
USA	135753	152547	151549	150449	150543	152676	155188	157591	158066	157151

Source: Author’s calculations based on the World Input-Output Database (WIOD)

Table 4.A8

Autarky trade structure: labor endowment minus labor footprint
(surplus or deficit expressed as percent share of given country's workforce)

	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
AUS	n/a	n/a	n/a	n/a	3.3	n/a	1.5	1.3	0.0	1.8
AUT	1.4	5.1	4.5	7.2	6.5	7.7	8.1	8.8	8.8	8.0
BEL	15.9	12.2	12.2	14.5	14.6	14.0	13.8	13.9	13.0	10.2
BGR	16.1	14.6	15.9	16.2	10.9	8.4	3.5	2.5	-2.2	-6.1
BRA	6.5	n/a	12.3	14.5	16.0	16.7	16.4	14.5	13.0	n/a
CAN	11.6	11.9	11.9	11.4	10.2	10.2	8.5	7.2	6.2	4.4
CHN	6.7	7.9	6.6	7.7	7.8	7.9	10.4	11.3	11.6	10.4
CYP	n/a	-20.5	-19.4	-20.4	-19.2	-17.2	-13.4	-16.2	-19.9	-23.4
CZE	n/a	6.9	6.3	6.4	6.9	9.8	12.2	11.3	11.1	10.3
DEU	9.5	9.4	10.6	13.3	13.9	15.5	16.1	15.8	15.5	14.6
DNK	12.3	9.9	10.2	9.6	11.1	9.1	8.1	6.2	5.3	6.5
ESP	19.3	8.2	5.4	7.0	6.9	5.4	2.7	1.3	0.8	4.9
EST	-9.7	9.6	9.1	4.0	6.3	3.7	3.5	-1.3	-3.1	3.6
FIN	22.7	18.4	18.0	18.3	16.2	15.6	11.7	11.2	10.6	9.2
FRA	13.3	10.9	9.5	9.9	9.6	9.6	8.6	8.2	7.0	6.0
GBR	8.9	4.7	3.5	3.4	3.5	2.9	2.7	3.4	3.5	4.3
GRC	-4.5	-7.1	-9.0	-9.3	-9.5	-7.1	-7.5	-9.8	-13.4	-15.7
HUN	6.5	0.3	2.2	2.7	1.1	1.7	3.8	5.1	7.2	7.7
IDN	6.5	13.0	13.2	13.1	14.4	15.2	14.9	13.5	12.1	10.8
IND	11.5	13.9	13.2	13.8	12.4	12.0	10.7	11.6	11.1	10.4
IRL	21.4	8.2	9.2	8.9	11.3	10.9	9.0	8.4	7.8	8.2
ITA	14.3	11.7	10.9	10.2	9.6	8.8	8.1	6.7	6.4	7.0
JPN	3.8	6.0	5.5	6.4	6.6	6.3	5.5	5.0	4.9	4.0
KOR	5.0	10.0	8.7	6.9	7.7	9.4	8.5	7.2	7.0	5.0
LTU	13.1	12.2	14.5	9.3	10.0	5.0	3.1	-0.7	-3.2	-2.8
LUX	6.7	-1.6	-0.6	1.5	5.6	7.8	7.9	12.5	15.1	17.4
LVA	n/a	9.3	6.5	3.0	-1.8	-9.7	-17.3	-16.2	-14.2	-4.3
MEX	7.8	0.8	0.8	1.2	1.1	1.5	1.6	1.2	1.3	0.0
MLT	n/a	-9.0	-6.6	-1.3	-2.6	-6.1	-0.4	-6.1	-4.9	-1.8
NLD	12.0	8.8	8.3	9.2	9.8	11.7	12.7	11.2	11.0	10.0
POL	17.7	13.1	18.2	20.0	20.4	20.5	20.8	15.9	10.3	6.6
PRT	0.0	-8.4	-8.3	-5.6	-2.5	-3.7	-3.3	-2.0	-1.7	-4.2
ROU	6.0	4.3	1.9	4.9	0.5	1.0	-0.8	-2.0	-5.4	-5.7
RUS	0.8	13.3	8.3	4.8	4.7	4.6	2.7	2.8	-1.9	-2.6
SVK	13.4	18.3	13.8	14.5	17.8	18.3	15.5	12.7	13.0	8.3
SVN	4.7	2.4	3.2	5.6	3.9	2.3	3.4	3.1	0.3	-1.5
SWE	15.4	12.2	11.6	11.8	12.5	14.7	15.0	14.9	13.8	13.7
TUR	9.0	5.3	11.7	10.7	10.0	8.9	8.5	7.1	7.0	4.6
TWN	6.8	8.9	13.3	15.1	14.9	12.2	12.9	14.6	15.9	16.2
USA	4.0	0.6	1.3	2.2	2.2	1.5	0.8	0.5	1.0	2.2

Source: Author's calculations based on the World Input-Output Database (WIOD).