The Employment Footprints of Nations

Uncovering Master-Servant Relationships

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Keywords:

employment and wages footprints
industrial ecology
input-output tables
international trade
social science
supply chains

Supporting information is available on the *JIE* Web site

Summary

In this study, we present an analysis of the average wages paid for producing direct and indirect imports of nations using employment and income footprints. An employment footprint includes a country's domestic employment and that occurring along the supply chains of, and hence embodied in, its imported goods and services. Our results allow us to group the world's nations into "masters" that enjoy a lifestyle supported by workers in other countries and "servants" that support the lifestyle of master countries. We show that, in 2010, employment footprints of countries differed substantially from their own workforce footprints. Hong Kong, Singapore, the United Arab Emirates, and Switzerland occupy the top-ranking positions of master countries, whereas many African and Asian countries are servants. Our findings show that the commodities that are "servant intensive," such as electronics, agricultural products, and chemicals, tend to have complex supply chains often originating in third-world countries. The quantification of these master-servant relationships and the exposing of implicated supply chains could be of benefit to those concerned with their corporate social responsibility and committed to fairer trading or those developing policy around fair globalization.

Introduction

"*The real price of every thing, what every thing really costs to the man who wants to acquire it, is the toil and trouble of acquiring it. What every thing is really worth to the man who has acquired it . . . is the toil and trouble which it can save to himself, and which it can impose upon other people*." (Smith 1904, book 1, chapter 5, p. 2).

To Adam Smith, possession of commodities implies the acquisition of someone else's labor, someone else's "toil and trouble" in producing those commodities. This, in itself, need not be a problem—in an equal society, workers may exchange their toil and trouble on equal terms. However, being in a position to "impose" on others implies unequal terms and the existence of someone who is "imposed upon."

Almost 250 years after Adam Smith inquired into the nature and cause of the wealth of nations (Smith 1904, first published in 1776), there are, today, millions of people who could be said to be imposed upon—workers in an unequal society with little means to change their working conditions—modern-day servants to their masters.[1] Often, this is hidden from view in complex supply chains that make it difficult to trace who is acquiring what from whom. However, from time to time, supply-chain issues erupt in the press, for example, the case of the hundreds of textile workers killed in a building collapse in Bangladesh in April 2013 (Young 2013). These predominantly female workers sew clothes for global brands and mostly Western consumers. They are among the lowest paid in the entire industry and often work in dangerous conditions. No wonder the pervading and usually unexamined Hobbesian social contract[2] that binds us

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DOI: 10.1111/jiec.12104

Editor managing review: Shinichiro Nakamura

Volume 18, Number 1

into the kind of political and economic systems to which we tacitly agree is being challenged on grounds not only of gender, but also of racial inequality that "makes possible and justifies some people, in virtue of their alleged superiority, exploiting the peoples, lands, and resources of other races" (Friend 2004).

Industries rely on people to produce their goods, yet the social dimensions of innovation and efficiency, in themselves cornerstones of industrial ecology, are little understood (McBain [forthcoming]). By extending previous studies, such as those dealing with carbon, biodiversity, water, and ecological footprints, to include social responsibility—in this case, we construct employment and wages footprint accounts—we are bringing to businesses new ways of understanding "impacts, performance management, system design and innovation" (Lenzen 2013, 1; McBain [forthcoming, 2]). The field of social footprinting provides quantitative, consistent, and rigorous methods for calculation of the third pillar of the triple bottom line (TBL). As a part of the TBL, the rationale for reporting on such indicators (employment and wages) quite naturally falls within the corporate/national social responsibility ambit.

Using a new multiregional input-output (MRIO) database (Lenzen et al. 2013, 2012b), our study allows us to group the world's nations into what we are calling "master" countries that enjoy a lifestyle supported by others and "servant" countries that support the lifestyle of masters. To this end, we calculate *global employment footprints*—these include a country's domestic employment and that recruited along the supply chains of, and hence embodied in, its imported goods and services. Employment footprints can be compared with the domestic workforce to reveal either how many workers a population needs, in addition to its own workforce, to satisfy its consumption through imports or how many workers in a domestic workforce work for the sake of producing exports, in addition to satisfying its own consumption. The former are net importers of employment, whereas the latter are net exporters. Continuing our metaphor, the population of the former countries occupies the role of masters for whom foreign servants work, whereas the population of the latter are servants to the masters. In addition, we determine the *wages footprints* of nations, which, again, include a country's domestic wages and those paid along the supply chains of, and hence embodied in, its imported goods and services. In combination with the employment footprint, we determine the average wages of the servants of master countries. This work allows us to divide the world into master nations and servant nations—in Adam Smith's terms, the imposers and the imposed upon.

To our knowledge, such an analysis has never been undertaken before. Our analysis, for the first time, quantifies global master-servant relationships in unprecedented country, commodity, and supply-chain detail. We pinpoint country pairs, and even individual supply chains, that map the global routes along which major "international servant services" are being procured. This is only possible because we have used an input-output (I/O) footprint calculation, which is capable of capturing the complete footprint.

We make two important qualifications. First, we do not mean to say that people in servant countries are servile. For example, many Bangladeshis report a life satisfaction on a par with countries such as Portugal and Spain (Jackson 2012), even though we find that people of Bangladesh who work for export industries have much lower wages than those that work within Bangladesh for their own country. Jackson (2012) also found the same to be true of the Philippines, even though it rates sixth in the percentage of people who work for exports rather than for their own country (i.e., support the lifestyle of others). In Sri Lanka, too, the people who work for exports have lower wages than those who work for their own country, yet the United nations (UN 2009) reports that Sri Lanka's social policies of inclusion aimed at developing social capital have, despite low gross national product, managed to raise standards of living and maintain within-country equality.

Second, though our work points out inequalities in global employment and wages, it does not, in any way, seek to comment on, or imply knowledge of, "imposition" felt by workers and attributed to their employment. For some workers, a low-wage job in an export industry in a servant country may be a way out of poverty not imposed from outside, but a part of the worker's life plan. Likewise, we do not imply judgement on master nations who are providing jobs in servant countries under the political and economic systems—the social contract—of our time.

Our article is organized in the following way. In the next section, we provide a context for our work within the fair trade movement and corporate social responsibility (CSR). The section after this provides data sources and methodology, whereas the subsequent section covers results, and the final section is the discussion and conclusion.

Context

Notwithstanding the above-described qualifications, our work does deal with inequality, and even raising this as a topic worthy of study implies concern about the disparity between what we have called master countries and servant countries. In this, we are not alone. Our work sits against a background of growing concern about the destabilizing effect of global inequality. The World Economic Forum rated "economic imbalances and social inequality" as the major risk to reversing the gains of globalization in its Global Risks 2012 report.[3] The UN sees inequality as a threat to social, political, and economic stability around the world (UN 2010). These concerns are echoed by organizations such as Oxfam in its response to what it sees as the inadequacies of the UN's post-2015 development goals in not recognizing the "growing consensus that high levels of inequality are both morally repugnant and damaging for growth and stability.[4]"

Many in the business world are mindful of their social responsibility and keen to assist servant nations. Business for Millennium Development[5] calls for recognition of the business case

for helping poor countries—those at the base of the pyramid—to develop. Also, Business Call to Action[6] discusses "pro-poor business strategies" to help businesses meet their inclusive business goals. The World Business Council for Sustainable Development (WBCSD 2010) is committed to supporting the development of good governance, which, they say, includes fairness and overcoming the divides between developing and developed countries. It calls on governments, business, and civil society to join forces to support developing countries.

Civil society is supported in its purchasing choices by the fair trade movement. For example, Made in a Free World[7] asks, "How many slaves are working for you?", and suggests we ask manufacturers the origin of their materials. Organizations such as this put pressure on businesses to disclose their supply chains and accept and report on their social responsibility. Our work helps to bring transparency to CSR and is of use to such bodies as the International Social and Environmental Accreditation and Labeling Alliance,[8] providing member organizations such as Fairtrade International with detailed information that can be used to promote and support ethical consumption. This detailed information extends the scope of the fair trade label, something that the UN Environment Program (UNEP) recognizes a need for because, it says, the label currently "ignores huge sections of the life cycle" (UNEP 2009, 8). The complete life cycle is the foundation of our work. It is through the employment and wages footprints that we can show clearly, for example, that more than 27% of the Bangladesh workforce is engaged in producing clothing for export to countries, such as the United States, Britain, and Germany, at an average wage of approximately one quarter that of people working to satisfy its domestic consumption. Whereas it is not surprising that servant countries' average wages are lower than master countries' wages, understanding the within-country wage differential for export commodities can provide a powerful tool for promotion of fair trade. Retailers and brands are sensitive to reputation damage, and consumers are willing to pay a premium for items produced in decent working conditions (Heintz 2006). Our work can be used by first-world consumers of a range of products and services to pressure global chains to improve pay and conditions in the interests of a fairer world. The supply-chain detail revealed by our work can also be used to indicate to organizations themselves where they should be concentrating their CSR time and dollars for the greatest good.

As well as supporting companies in their pursuit of CSR and the work of fair trade nongovernmental organizations, employment and wages footprints are relevant to the work of the World Federation of Trade Unions (WFTU). In its constitution, the WFTU committed to "obtain and guarantee living and working conditions for all workers which would allow them the widest possible benefits from the fruits of their labour, in order to obtain for them and their families the time and the means to live in conditions appropriate to our epoch" (WFTU 2011, 7). Our work supports this commitment, providing a tool to help uncover inequalities in the global workplace. In doing so, we are part of a global movement working toward a fairer world.

Methodology and Data Sources

In this work, we employ MRIO analysis to enumerate the employment and income footprints of nations. In essence, these footprints describe full-time equivalent person-years of employment and the dollars of income and salaries required directly (within a country) and indirectly (embodied in imports from other countries) for satisfying the consumption of a given population. The international literature already features a number of global footprint studies using MRIO analysis, for example, on carbon emissions (Peters 2010; Hertwich and Peters 2009), water (Feng et al. 2011), materials (Wiedmann et al. 2013), net primary production (Haberl et al. 2007), and biodiversity (Lenzen et al. 2012b).

Basic Input-Output Theory

The first attempt to calculate labor and capital in a supply chain of products for the U.S. economy was by Leontief in 1953. Since its conception by Leontief (1966), I/O analysis has been used intensively to investigate the repercussions caused by economic activity in one part of an economy and felt in other parts. In 1989, Duchin provided a historical perspective on the work of I/O economists on labor (and the built capital) embedded in trade flows. Within I/O analysis, the demand-pull model has been particularly popular, because it reflects the demand-driven character of modern economies and because its monetary components can easily be extended with information on physical quantities, such as resources and pollutants. The strength of I/O analysis lies in its ability to capture flow-on effects that ripple across complex supply-chain networks, starting from locations where populations consume goods and services, through locations where those goods are manufactured and services supported, to locations where pollutants are emitted and resources extracted, and ultimately to satisfy the initial consumption. To this end, a set of I/O matrices are required: one $N \times N$ intermediate transactions matrix $\mathbf{T}$ with elements T_{ij} that represent monetary amounts of intermediate demand from supplying economic sectors[9] $i = 1, \ldots, N$ into using sectors $j = 1, \ldots, N$; one $K \times N$ value-added matrix $\mathbf{v}$ with elements v_{kj} that represent monetary amounts of primary input from value-added categories[10] $k = 1, \ldots, K$ into using sectors $j = 1, \ldots, N$; and one $N \times M$ final demand matrix $\mathbf{y}$ with elements y_{jm} that represent monetary amounts of final demand from supplying economic sectors $i = 1, \ldots, N$ into final demand categories[11] $m = 1, \ldots, M$.

Defining total output $\mathbf{x} = \mathbf{T}\mathbf{1}^N + \mathbf{y}\mathbf{1}^M$, where $\mathbf{1}^N = \{1,1,\ldots,1\}$, etc., are suitable summation operators, and setting $\mathbf{T}\mathbf{1}^N = \mathbf{A}\mathbf{x}$, we find the fundamental I/O identity $\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{y}\mathbf{1}^M \Leftrightarrow \mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\,\mathbf{y}\mathbf{1}^M = \mathbf{L}\,\mathbf{y}\mathbf{1}^M$, where $\mathbf{I}$ is an $N \times N$ identity matrix, $\mathbf{A}$ is the input coefficients matrix, and $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$ is the famous Leontief inverse. The input coefficient matrix $\mathbf{A}$ is essentially a map of the interconnected structure of an economy, containing detailed information on the production recipes of industries. Whereas $\mathbf{A}$ describes the direct links between industries, $\mathbf{L}$ captures all direct and indirect links and is thus used to determine the total output $\mathbf{x}$ that

is ultimately (directly and indirectly) needed to satisfy a final demand bundle $\mathbf{y1}^M$.

Extended Input-Output Analysis

As early as the 1960s and 1970s, I/O analysis was used for solving environmental and social problems (Leontief and Ford 1970; Leontief and Duchin 1986). In the same vein, we employ I/O analysis to shed light on global flows of embodied labor and embodied income payments. To enable this, we couple our I/O system $\{\mathbf{T}, \mathbf{v}, \mathbf{y}\}$ with data in the shape of two $1 \times N$ satellite accounts $\mathbf{Q}_{emp}$ and $\mathbf{Q}_{inc}$ with elements Q_{1j} describing amounts of employment recruited and income paid by economic sectors $j = 1, \ldots, N$. Setting $Q = \mathbf{Q1}^N = \mathbf{qx}$, where Q represents the economy-wide total of the satellite account $\mathbf{Q}$, we can extend the fundamental I/O relationship derived above to $\mathbf{qx} = \mathbf{qL}$ $\mathbf{y1}^M = \mathbf{m}$ $\mathbf{y1}^M$. The vector $\mathbf{q}$ holds so-called employment and income intensities that describe the amount of the employment recruited and income paid per one unit of total output. In contrast, the multiplier $\mathbf{m}$ describes the amounts of employment and income ultimately (directly and indirectly) required to satisfy one unit of final demand. In addition to the so-called direct effects covered by $\mathbf{q}$, the multiplier $\mathbf{m}$ includes all indirect flow-on effects rippling throughout the complex supply-chain network of the entire economy, as described by the Leontief inverse $\mathbf{L}$.

The employment and income accounts $\mathbf{Q}_{emp}$ and $\mathbf{Q}_{inc}$ used in this work were constructed at a detail of 187 countries, (see table S1 in the supporting information available on the Journal's website) with a combined 15,909 sectors, in order to complement a matching MRIO framework $(\mathbf{T}, \mathbf{v}, \mathbf{y})$ of the world economy (Lenzen et al. 2012a, 2013).[12] Whereas the income satellite account is based on a multitude of data sources (see Lenzen et al. 2012a), the employment satellite account is based on data published by the International Labor Organization (ILO 2012). Given these data sources, the term $\mathbf{m}' \# \mathbf{y1}^M$ (where the prime (') denotes vector transposition and the # symbol denotes element-wise multiplication) contains the employment and wages footprints of nations, broken down into contributions from the populations of 187 countries jointly consuming the output of 15,909 economic sectors.

Results

Below, we present our results in order of increasing detail, starting with an overview of global flows, followed by country ranking of employment footprints, ranking of wage differences, and, finally, on country pairs and detailed traded commodities and supply chains.

Global Flows of Labor and Wages

Our results show that global employment and global wages footprints look markedly different. Our map of the world's demand for goods and services high in embodied labor shows a very different picture from that of embodied wages (figure 1). On the one hand, we have the world's top embodied labor flows pouring out from China and India and, to a lesser extent, from Russia, Indonesia, and Mexico, predominantly to serve the consumption appetite of developed economies. On the other hand, we can see that most of the wages embodied in exported goods and services flow between developed countries, such as between the United States and Japan, and between the United States and Europe. We suggest that these different trading patterns lead to different roles on the world stage—those of master countries and servant countries.

The full-time equivalent work of more than 200 million laborers is embodied in exports from China and India alone. These laborers are working to satisfy the consumption demands of the rest of the world, especially the demands of developed countries (figure 1; table S2 in the supporting information on the Web). The United States is the world's largest recipient of embodied labor and wages (figure 1; table S2 in the supporting information on the Web); however, it is by no means the highest recipient per head of population. Although figure 1 provides an overview of what we have termed the world's master and servant countries, below we analyze the global flows in more detail and tease out just who all of these servants are working for and who is earning the wages. For example, Japan (average domestic wages, US$54,000) imports T-shirts that are manufactured in China (average domestic wages, US$2,700), which, in turn, relies on cotton yarn from India (average domestic wages, US$1,100), and the latter rely on yarn of staple fabrics from Nepal (average domestic wages, US$600).

By recognizing the flows of embodied labor (or employment footprint) and the workforce of the demand countries, we can calculate the amount of labor needed for every country to satisfy its consumers' demands.

Master-Servant Ratios

What is also clear from our analysis is that the employment footprint of countries differs substantially from their own domestic workforce (figure 2). Countries occupy the top ten ranks given in figure 2 if their employment footprint is much larger than their own workforce. The opposite holds for the bottom-ranked countries; their employment footprint is much smaller than their workforce. Once again, these results allow us to group the world's nations into masters and servants. Some top-ranking countries shown in figure 2 do not appear in figure 1, solely because these countries are small. This does not detract, however, from their roles as masters and servants. Full results are listed in table 1.

The richest Asian countries, Hong Kong, Singapore, and United Arab Emirates (UAE), occupy some of the top-ranking master country positions (figure 2). This means, for example, that to satisfy its consumption, each Hong Kong resident needs seven servants from the rest of the world in addition to its own workforce, five are needed for each Singaporean, and four for each person in the UAE. These countries rely on foreign labor

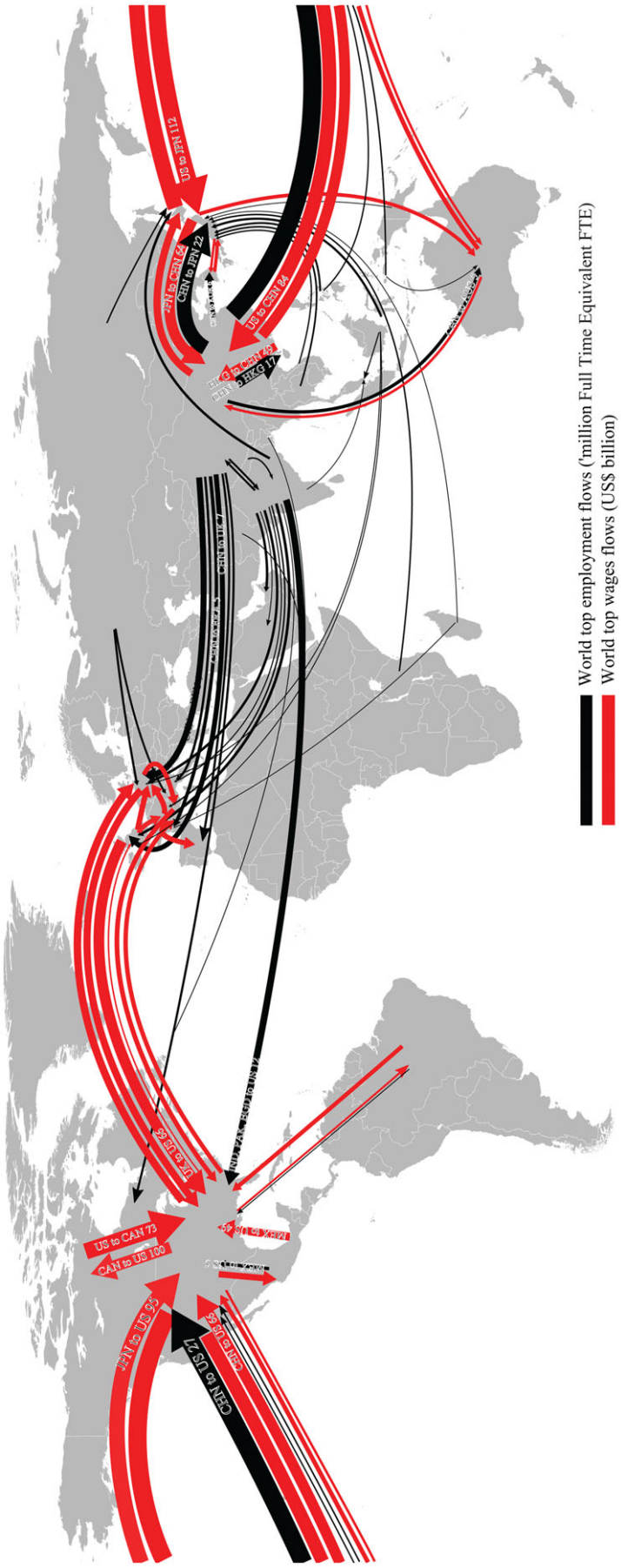

Figure 1 Flow map of the world's top embodied labor and wages in 2010 (additional information regarding the data is in table S2 in the supporting information on the Web).

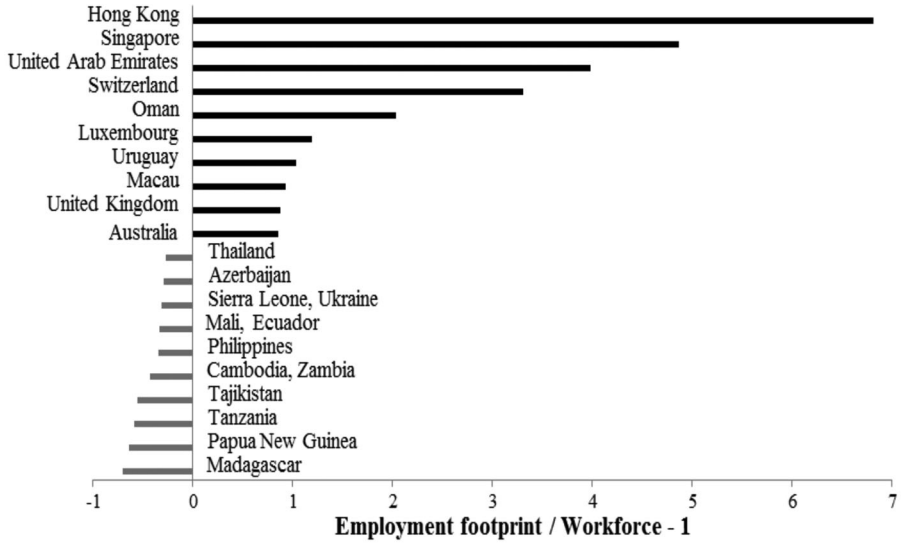

Figure 2 Ratio of employment footprint to the workforce.

for several reasons; for example, a high gross domestic product (GDP) per capita, compared with surrounding countries, or an increasingly aging population in the domestic workforce. In the case of Hong Kong and also Macau, there is a natural affinity to trade with China, where the labor is cheap, because of ethnic and administrative ties. Notice that Japan and Korea are not found in the top-ranking countries. This is because, unlike Hong Kong, Singapore, and Macau, they each have a large domestic workforce. In addition to the rich Asian city states, some of the Arab states of the Persian Gulf that also have a small workforce are found among the top ten master countries. The same is true for some of the small European countries and for Uruguay. Uruguay probably occupies this position because it has a small workforce and a good per capita income, compared to surrounding countries such as Brazil. This means that residents have money to spend, and therefore rely, on imports to satisfy their consumption. Countries with a high domestic workforce classed among the top master countries are the United Kingdom and Australia.

Most African countries are servants. Heading the list is Madagascar, which, to satisfy its own consumption, needs only 30% of its workforce, whereas 70% of the workforce toils for the sake of producing exports (figure 2; table S3 in the supporting information on the Web). This is not a simple ratio between two different databases (employment footprint and country workforce), but the employment footprint is the outcome of I/O calculations capturing effects from a complex supply-chain network spanning the entire world.

Global Wage Differentials

If we consider the wages of labor in depth, we can begin to understand why there are servants and masters (figure 3). Ranking of countries according to the ratio $r = w/(Qinc/Qemp)$ of domestic wages w and wages Qinc/Qemp of foreign employment footprint Qemp. Countries occupy the top ranks shown in figure 3 if their domestic wages are higher than the average of wages that are paid in exchange for the employment embodied in their imports (see table 1 for more details). This can be either because their imports come from low-wage countries or their own country's wages are very high (e.g., Japan, which occupies a rank similar to that of Switzerland, but for different reasons; see table 1 for supporting data). The opposite pattern holds for the bottom-ranked countries. Their footprint wages, which includes all wages embodied in imports, is much larger than their domestic wages. That means either their imports come from high-wage countries (e.g., in the case of China) or their own country's wages are very low (e.g., in the case of Tanzania; see table 2).

Production of some commodities needs labor and income in a country to produce raw materials and the same in another country to manufacture the commodity and then people in a demand country to consume those products. For example, French people (average domestic wage, US$58,000) smoke cigars that are manufactured in Poland (average domestic wage, US$10,000), which, in turn, relies on raw material that is produced in Tanzania (average domestic wage, US$170). In turn, Tanzania imports computers that are produced in China and designed in the United States. However, the volume of goods and the amount of labor embodied in those imported goods is not equivalent to the amount of exported labor and volume of exported goods. In 2010, approximately 500,000 laborers in Tanzania worked to support U.S. consumption (earned $215 million), whereas approximately 3,000 laborers in the United States worked for Tanzania (earned $50 million). As an example of longer chains, U.S. citizens (average domestic wage, $58,000) wear clothes that are manufactured in China (average domestic wage, US$2,700), woven from yarn in Pakistan (average domestic wage, US$1,460) made with raw cotton from Tajikistan (average domestic wage, US$450). The manufacture

Table 1 Main master countries: Ranked list and details for top countries as in figures 2 and 3

Country	*Main master countries and their imports (import origin,% of total labor footprint, and main imported commodity)*	*Employment footprint (millions full -time equivalent [FTE])*	*Total workforce (millions full -time equivalent [FTE])*	*Average wage of foreign footprint (000s US$)*	*Domestic wages (000s US$)*
Hong Kong	CHN 68 tel, ele, com; PHL 5 ele, com, gold; THA 5 ele, com, gold, diamonds; IND 4 diamonds, jew, cotton yarn	25.4	3.5	4.9	24.8
Singapore	CHN 27 ele, com, tel; IDN 17 pog, gold; IND 12 po, jew, cruise; MYS 5 ele, po, offi	9.5	1.9	8.5	57.6
United Arab Emirates	IND 47 diamonds, jew, po; CHN com, tel, trans; TNZ fish, leg, tea	7.5	1.8	5.2	89.1
Switzerland	RUS 20 cop, plat, prec; CHN 15 com, tel, clo; IND 7 oxy, clo; IDN 4 fer, clo, chem	15.2	4.3	8.8	71.7
Oman	IND 45 po, inwire, et; CHN 14 pipes, tel, cruise; TNZ 4 clo, rice	0.6	0.3	6.5	48.1
Luxembourg	CHN 20 ele, clo, diamonds; DEU 9 med, cars, fer; IND 9 diamonds, po, med, clo; RUS 7 diamonds, po, coal	0.5	0.3	18.2	67.5
Uruguay	CHN 21 com, clo, cars; BRA cars, tracks, po, accars; RUS 10 min, acids; IND 7 et, antibiotics	1.6	1.5	7.1	12.8
Macau	CHN 78 ee, po, clo	0.4	0.3	5.1	25.1
United Kingdom	CHN 26 com, trans, tel, clo; IND 15 clo, med, po; USA 4 gold, jets, med	28.6	29.4	11.9	40.3
Japan	CHN 41 com, mp, clo, ele; IDN 6 pg, gold, po, coal; IND 6 po, fer, diamonds; PHL 4 ele, ban	53.0	63.9	6.5	53.6
Australia	CHN 44 com, clo, tel; IDN po, gold; VNM 8 po, coconuts, crustaceans; THA 4 trucks, gold	11.1	10.8	8.3	59.7
United States	CHN 37 com, tel, mp, clo; IND, 13 diamonds, clo, med; MEX mp, cars, accars, po; IDN 3 clo, rub, po	72.9	145.4	9.0	58.0
Qatar	CHN 29 com, clo, trans; IND 19 trans, iron, clo; IDN 4 wod, mp, cars	0.6	0.8	6.2	38.2
France	CHN 25 com, trans, clo; IND 11 po, clo, med; MGD 6 crustaceans, clo, vegetables, fruits; ESP 5 cars, accars, trucks, med	20.9	26.0	11.0	57.7
Norway	CHN 31 com, trans, clo; IND 9 clo, lamps; IDN 4 clo, seats, fruits	2.4	2.5	13.7	59.4
Germany	CHN 28 com, ele, clo, cruise; IND 12 clo, med, ele, trans; RUS 10 cop, po, coal	32.1	38.7	9.7	42.3
Netherlands	CHN 28 com, tel, ele, clo; IND 11 po, tel, ele, clo; IDN 6 palm oil, rub, coal, clo; TNZ 4 tob, plants	7.6	8.4	10.8	45.1

Note: BRA = Brazil; CHN = China; DEU = Germany; ESP = Spain; IDN = Indonesia; IND = India; MEX = Mexico; MGD = Madagascar; MYS = Malaysia; PHL = Philippine; RUS = Russia; THA = Thailand; TNZ = Tanzania; USA = United States; VNM = Vietnam; Accars = part and accessories of cars and motor vehicles; Acids = salts of oxometallic or petoxometallic acids; Ban = banana and plantains;. chem = chemical and allied products; Clo = clothes and textile products; Com = computers; cop = copper; ele = electronics (such as diodes and electronic integrated circuits); ee = electrical energy; et = electrical transformers; fer = ferrous products; Inwire = insulated wire; jew = jewelery; jets = turbojets; leg = dried legumes; med = medicaments; mp = monitors and projectors; offi = parts and accessories for office machines; pg = petroleum gases; plants = live plants with roots; po = petroleum oil; pog = petroleum oil and gas; prec = precious metal ore; rub = natural rubber; tel = telephone; trans = transmission apparatus for radio and TV.

of a car in Germany may need the following: copper from Chile (average domestic wages, US$12,330) and Zambia (average domestic wage, US$1,600); natural rubber or tires from Indonesia (average domestic wage, US$2,200); iron and aluminium from Brazil (average domestic wage, US$10,170); other vehicle parts from China (average domestic wage, US$2,700); petroleum products from Russia (average domestic wage, US$6,830); and so on. Not surprisingly, the manufactured car will be used mostly in developed countries. Each country makes use of yet a poorer one to deliver the imports needed to produce their exports.

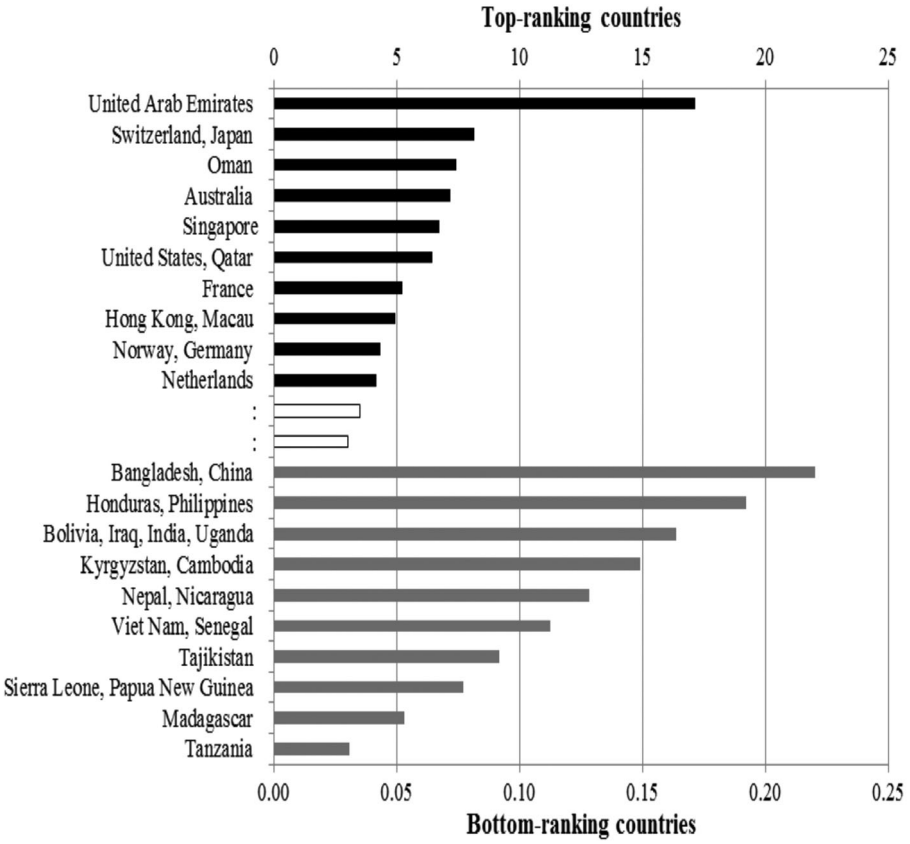

Figure 3 Ratio of domestic wages to the wages of foreign employment footprint (blank bars in the middle of this figure represent the remaining countries that were explored in this work).

These wage differentials reveal that there are master (United States and France) and servant (Tanzania and Tajikistan) countries and also intermediary countries that are neither masters nor servants (China and Poland). These supply chains represent only three examples from the entire global network that we have examined in this work.

Commodities Traded between Masters and Servants

The main imports of developed master countries are electronics and clothes, raw materials and natural resources, and manufactured parts that are used as an intermediate input into making other products (table 1). An example for the latter category is motor vehicle parts from Mexico exported for input into car production in the United States. Master countries such as Germany (average domestic wage, US$42,300) and the Netherlands (average domestic wage, US$45,100) rely on low wages elsewhere (e.g., electronic integrated circuits and diodes from China [average domestic wage, US$2,700] and copper wire from Russia [average domestic wage, US$6,800) to reduce their own input bills in producing final products, such as cars and electronics. Similarly, producing a Japanese electronic device (e.g., a telephone) may require labor from: China (average domestic wage, US$2,700) to manufacture an electronic integrated circuit, such as a transistor, from the Philippines (average domestic wage, US$1,700) to produce diodes, and, possibly, labor from Indonesia (average domestic wage, US$2,200) to produce coal and petroleum gas. It will of course need labor from Japan (average domestic wage, US$53,600) to manufacture the device.

Investigating the main labor flows in imports of developing countries (table 2) shows that virtually no embodied employment flows from master to servant countries (with the exception of minor flows from Australia to Papua New Guinea and from South Africa to Zambia). China, India, Vietnam, the Philippines, and Thailand (with a high employment footprint and average domestic wages spanning US$1,000 to US$2,700) import chiefly raw materials and intermediate goods. For example, China imports raw materials (iron and copper from India and coal and rubber from Indonesia and Vietnam) and intermediate products (cotton yarn from India and electronic integrated circuits from the Philippines). Some African countries without a strong manufacturing base import labor embodied in telecommunication devices, clothes and fabrics, and pharmaceutical products, mainly from China and India. Interestingly, these countries also import labor embodied in intermediate goods, such as tractors and water tanks, which are ultimately used to produce food. Some of this imported labor will not benefit the local population if the agricultural products are destines for exportation.

Table 2 Main servant countries: Ranked list and details for bottom countries as in figures 2 and 3

Country	*Main servant countries and their imports (import origin,% of total labor footprint, and main imported commodity)*	*Employment footprint (millions full -time equivalent [FTE])*	*Total workforce (millions full -time equivalent [FTE])*	*Average wage of foreign footprint (000s US$)*	*Domestic wages (000s US$)*
China	IND 14 iron, cop, cotton yarn; IDN 10 coal, palm oil, rub; VNM 7 coal, offi, cotton yarn, rub; THA 5 com, ele, rub, offi	21.2	771.5	13.1	2.7
Bangladesh	IND 48 wf, cotton raw; CHN 32 wf, tel	1.2	47.3	3.7	0.8
Honduras	CHN 17 tel, motorcycles, wf; GTM 15 med, clo; USA 13 po, cotton yarn; SLV 12 clo, med, packing of goods	0.3	2.8	12.3	2.4
Bolivia	CHN 34 clo, fur; BRA 18 po, rub; CHL 4 cars, accars, clo, trucks; ARG 4 wheat, med	0.2	4.6	9.2	1.5
Iraq	CHN 40 tel, cars, clo; IND 22 leg; IRN 6 cars, cement, apples, tomatoes	1.2	7.7	4.6	0.8
India	CHN 28 trans, tel, minerals; NPL 21 wf, iron, fruit juices; IDN 5 coal, palm oil, rub	10.6	477.6	6.3	1.1
Uganda	IND 34 med, trans; TNZ 23 rice, sug, po; CHN 17 trans, tel, clo	0.4	9.3	4.1	0.7
Kazakhstan	RUS 45 po; CHN 17 clo; UKR 7 med, electrical transformers; IND 4 accars	1.0	7.9	6.8	6.0
Nepal	CHN 41 tel, trans, clo; IND 23 motorcycles, iron, med	0.3	9.9	4.3	0.6
Nicaragua	CHN 13 trans, com, clo; GTM 13 med, iron, clo; SLV 9 packing of goods, med; USA 7 med, po	0.3	2.1	9.2	1.2
Vietnam	CHN 35 tel, trans, com, clo; THA 8 po, sugar raw, accars; JPN 7 ele, printers, iron; KHM 6 rub, cars; PHL 5 accars, cop, minerals	2.5	42.3	8.7	1.0
Senegal	CHN 32 ships, clo, tel; IND 13 cides; MLI 7 cotton, bovines, sheep; THA 6 fish, com	0.3	3.2	7.0	0.8
Tanzania	IND 37 po; CHN 23 tel, clo, trucks; UGA 5 palm oil, com, sunflowers seeds	0.3	18.4	5.7	0.2
Papua New Guinea	CHN 34 trans, clo, iron; IDN 12 pipes, soap, batteries; AUS 8 po, machi, trucks	0.3	2.3	10.1	0.8
Madagascar	CHN 56 wf, med, water tanks; IND 11 tractors, wf	0.2	9.9	6.2	0.3
Mali	CHN 41 tel, motorcycles, tea; RUS 7 chem, iron	0.1	2.4	5.9	1.4
Ecuador	CHN 25 clo, tires, tel; COL 19 trucks, po, clo, med; BRA 7 airc, trans, chem; USA 6 po, com, cars	0.5	4.0	10.9	2.6
Philippines	CHN 24 ele, tel, offi, clo; VNM 15 rice; IDN 12 coal, offi, cars; IND 10 med, motorcycles, tires	1.8	33.9	8.7	1.7
Cambodia	CHN 43 wf, tel; THA 15 drill; VNM 14 po, tel, wf	1.5	17.6	12.3	5.3
Zambia	ZAF 25 cars, iron, tractors; TNZ 24 minerals, iron, clo; CHN 15 machi, X-ray apparatus, clo	0.2	3.4	6.7	1.6
Tajikistan	RUS 20 po,wod, med, iron; CHN 17 clo, accars, tel; AZE 8 sugar raw	0.1	2.5	4.9	0.4
Thailand	CHN 30 offi, com, clo; BGD 13 inwire, iron, clo; IND 13 diamonds, med, accars; MMR 7 pg	5.4	37.8	7.8	2.1
Azerbaijan	CHN 28 machine tools for working metal by forging, eb; RUS cars, wood, cocoa, med; UKR 17 pipes, cars, inwire	0.2	4.1	6.6	2.2
Sierra Leone	CHN 28 tel, cruise, fishing vessels; RUS 15 yachts, machi	0.04	1.9	4.7	0.4
Ukraine	CHN 25 com, clo, trans; RUS 21 pog, coal; IND 9 med	1.4	21.0	7.0	2.4

Note: ARG = Argentina; AUS = Australia; AZE = Azerbaijan; BGD = Bangladesh; BRA = Brazil; CHL = Chile; CHN = China; COL = Colombia; GTM = Guatemala; IDN = Indonesia; IND = India; IRN = Iran; JPN = Japan; KHM = Cambodia; MLI = Mali; MMR = Myanmar; NPL = Nepal; PHL = Philippines; RUS = Russia; SLV = El Salvador; THA = Thailand; TNZ = Tanzania; UGA = Uganda; USA = United States; UKR = Ukraine; VNM = Vietnam; ZAF = South Africa; accars = part and accessories of cars and motor vehicles; airc = aircraft; chem = chemical and allied products; cides = insecticides, rodenticides, fungicides, herbicides; clo = clothes and textile products; com = computers; cop = copper; drill = floating or submersible drilling platforms; eb = electrical boards and panels for protecting electrical circuits; ele = electronics (such as diodes and electronic integrated circuits); fur = furniture; inwire = insulated wire; machi = machinery for working earth; med = medicaments; offi = parts and accessories for office machines; pg = petroleum gases; po = petroleum oil; pog = petroleum oil and gas; rub = natural rubber and plastic products; tel = telephone; trans = transmission apparatus; wf = woven fabrics.

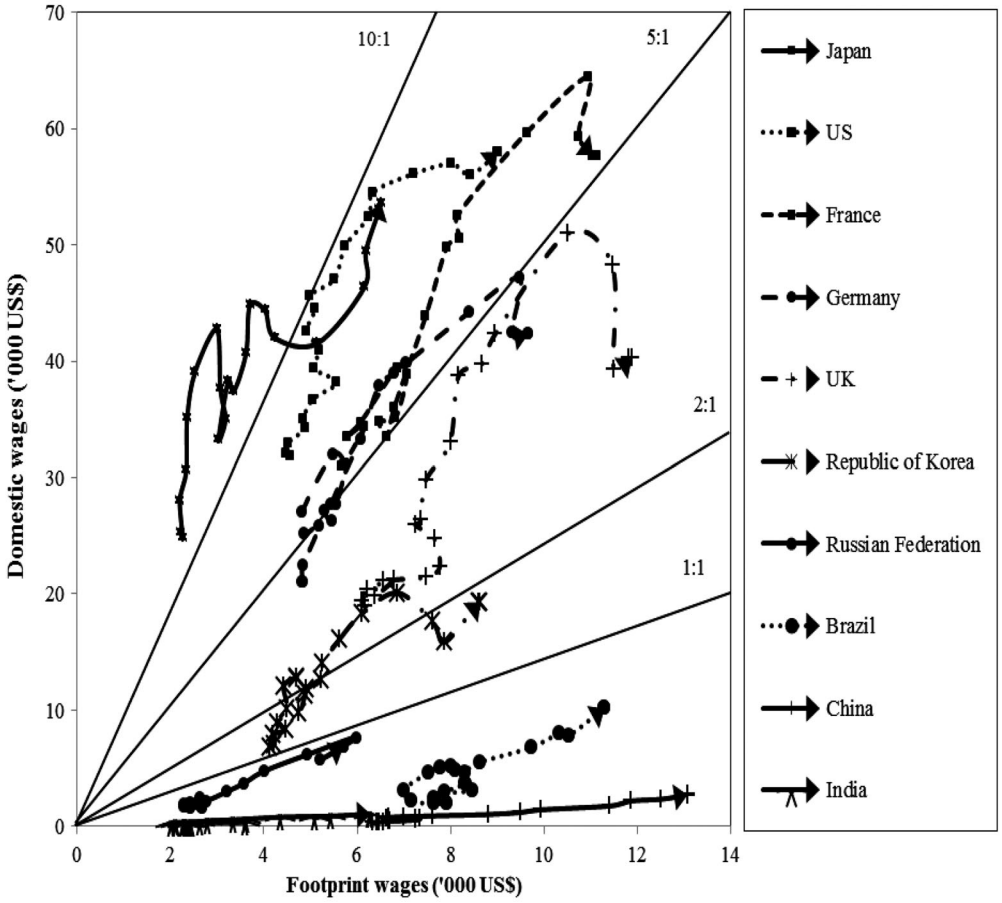

Figure 4 Example of time series of footprint wages against domestic wages spanning 1990–2010 for the top countries in terms of population and income (each year is represented by a dot point and 2010 is represented by the arrowhead).

Time Series of Domestic and Footprint Wages

Having quantified these master-servant relationships, we now show that little has changed over time. Considering the past two decades and the most powerful countries (figure 4) in terms of wage and labor share, Japan (among developed countries) has the lowest wage footprint and China (among developing countries) has the highest. High GDP per capita in Japan, compared with surrounding low-wage countries, probably facilitates a reliance on foreign labor, whereas the position of China as a big manufacturing country of most commodities is maintained by ongoing demand from developed countries. France, Germany, and the United Kingdom show a decrease in their domestic wages after the global financial crisis and recession and more reliance on cheap labor embodied in imports (figure 4). The decreasing wages footprint after the recession may be a result of rising commodity prices after 2008 (in the case of the United Kingdom) (Tang 2008). The Asian Financial Crisis (1997–2002) influenced Japan's domestic wages more than other developed countries (figure 4). During that time, Japan's domestic wages were more than tenfold its footprint (figure 4). The United Kingdom saw a considerable increase in its domestic wages from two- to about fivefold of its footprint, especially before the Global Financial Crisis as a result of its growth in the past two decades (Family Spending 2011).

Conclusion

Although our results do not reveal anything about the mechanisms that may lead to such wage differentials as those discussed above, it is the first study that establishes wages differentials across supply chains and thus reveals indirect differentials. It reveals exploitation through complex pathways affecting millions of people worldwide. This is not trivial, because it affects more than just a handful of sectors of the economy, organizations, or countries. It has far-reaching ethical implications that, once known of and understood, we cannot disregard. They must be addressed across all sectors of the economy in the same way as we now tackle, for example, responsible jewelery,[13] fair trade coffee,[14] and child-labor–free carpets.[15]

Knowing that inequality exists is a good reason to consider other supply chains with high master-slave ratios or wage differentials. Our work shines daylight on unequal wages and compels us to examine whether, from a developed-country point of view, it is ethical to consume products from poor, developing countries without attempting to address the issue of working

conditions or whether we should join our voices with the Fair Trade Advocacy Office in their Fair Trade Beyond 2015 Campaign calling for the creation of a "just, equitable and sustainable world."

In its constitution, the WFTU committed to "obtain and guarantee living and working conditions for all workers which would allow them the widest possible benefits from the fruits of their labour, in order to obtain for them and their families the time and the means to live in conditions appropriate to our epoch" (WFTU 2011). Our work supports this commitment, providing a tool to help uncover inequalities in the global workplace. In doing so, we hope that the imposed upon may be better able to achieve a fair return for their toil and trouble and obtain "the time and the means to live in conditions appropriate to our epoch" (WFTU 2011).

Building on our work, we envision that future work will include research based on wages adjusted for purchasing power parity.

Notes

1. Note that we use the terms master and servant in a metaphorical sense. Although the terms connote eighteenth- and nineteenth-century power relationships between employers and employees enshrined in various Master and Servant Acts of Parliament (e.g., Tasmania, 1857; Australia, 1902; Hawaii, 1850; UK, 1867), which made it illegal for the worker to break a contract no matter how exploitative the conditions, we include in our category of servant not only coerced labor, but also all labor that enshrines between-country inequality whether or not that work is freely entered into by the worker. We use the terms to draw attention to the issue of global inequality.
2. Social contract theory, developed by Hobbes in the first half of the seventeenth century, is regarded by some as the basis of CSR. The notion of the social contract has more recently been developed by Rawls (1971) in his *Theory of Justice*. However, the underlying ideas of "rational man" and "self-interest" prevail and can be found behind much of today's debate around definitions of CSR (UNEP 2009).
3. www.weforum.org/reports/global-risks-2012-seventh-edition.
4. www.oxfam.org/en/pressroom/pressrelease/2013-05-30/global-leaders-shirk-responsibility-tackle-global-inequality-crisis.
5. http://creatingsharedvalue.b4md.com.au/about/co-creating-wealth-2012/.
6. www.businesscalltoaction.org/news-highlights/2011/11/encouraging-expanding-and-scaling-inclusive-business-models-event-report/.
7. http://madeinafreeworld.com/.
8. www.isealalliance.org/.
9. Industries or products, for example, agriculture, forestry, fishing, mining, manufacturing, utilities, trade, transport, or services.
10. Wages and salaries, gross operating surplus, and net taxes on production.
11. Household consumption, government final consumption, gross fixed capital expenditure, and changes in inventories.
12. For further information on MRIO frameworks and MRIO analysis, please consult Leontief and Strout (1963), Miller and Blair (2010), Tukker and Dietzenbacher (2013), and Murray and Lenzen (2013).
13. www.responsiblejewellery.com/.
14. www.oxfam.org.au/explore/trade/fairtrade-coffee-campaign/.
15. www.goodweave.org/home.php.

References

Family Spending. 2011. Edition released: 30 November 2010. UK Office for National Statistics.

Feng, K., A. K. Chapagain, S. Suh, S. Pfister, and K. Hubacek. 2011. Comparison of bottom-up and top-down approaches to calculating the water footprints of nations. *Economic Systems Research* 23(4): 371–385.

Friend, C. 2004. *Social contract theory*. www.iep.utm.edu/soc-cont/. Accessed 1 June 2013.

Haberl, H., K.-H. Erb, F. Krausmann, V. Gaube, A. Bondeau, C. Plutzar, S. Gingrich, W. Lucht, and M. Fischer-Kowalski. 2007. Quantifying and mapping the human appropriation of net primary production in earth's terrestrial ecosystems. *Proceedings of the National Academy of Sciences of the United States of America* 104(31): 12942–12947.

Hertwich, E. G. and G. P. Peters. 2009. Carbon footprint of nations: A global, trade-linked analysis. *Environmental Science & Technology* 43(16): 6414–6420.

Heintz, J. 2006. Low-wage manufacturing and global commodity chains: A model in the unequal exchange tradition. *Cambridge Journal of Economics* 30(4): 507–520.

ILO (International Labor Organization). 2012. *LABORSTA—Main statistics (annual): Employment general level, by economic activity, by occupation, by status in employment*. Geneva: International Labor Organization. http://laborsta.ilo.org. Accessed 1 April 2013.

Jackson, T. 2012. *Prosperity without growth? Economics for a finite planet*. London: Taylor and Francis Ltd.

Lenzen, M. 2013. An outlook into a possible future of footprint research. *Journal of Industrial Ecology* DOI: 10.1111/jiec.12080.

Lenzen, M., K. Kanemoto, D. Moran, and A. Geschke. 2012a. Mapping the structure of the world economy. *Environmental Science & Technology* 46(15): 8374–8381. http://dx.doi.org/8310.1021/es300171x. Accessed 1 July 2013.

Lenzen, M., D. Moran, K. Kanemoto, and A. Geschke. 2013. Building Eora: A global multi-region input-output database at high country and sector resolution. *Economic Systems Research* 25(1): 20–49.

Lenzen, M., D. Moran, K. Kanemoto, B. Foran, L. Lobefaro, and A. Geschke. 2012b. International trade drives biodiversity threats in developing nations. *Nature* 486(7401): 109–112.

Leontief, W. 1966. *Input-output economics*. New York: Oxford University Press.

Leontief, W. and D. Ford. 1970. Environmental repercussions and the economic structure: An input-output approach. *Review of Economics and Statistics* 52(3): 262–271.

Leontief, W. and F. Duchin. 1986. *The future impact of automation on workers*. Oxford, UK: Oxford University Press.

Leontief, W. W. and A. A. Strout. 1963. Multiregional input-output analysis. In *Structural interdependence and economic development*, edited by T. Barna. London: Macmillan.

McBain, D. forthcoming. Comment on the Role of Social Footprinting in Industrial Ecology. *Journal of Industrial Ecology*.

Miller, R. E. and P. D. Blair. 2010. *Input-output analysis: Foundations and extensions*. Englewood Cliffs, NJ, USA: Prentice-Hall.

Murray, J. and M. Lenzen, eds. 2013. *The practitioner's guide to multi-regional input-output analysis*. Champaign, IL, USA: Common Ground.

Peters, G. P. 2010. Carbon footprints and embodied carbon at multiple scales. *Current Opinion in Environmental Sustainability* 2(4): 245–250.

Smith, A. 1904. *An inquiry into the nature and causes of the wealth of nations* (first published 1776, 5th ed., Vol. 1), edited by E. Cannan. London: Methuen & Co., Ltd.

Tang, M. K. 2008. *Twin global shocks dent United Kingdom outlook*. www.imf.org/external/pubs/ft/survey/so/2008/CAR081108A.htm. (European department, Imf.org). Accessed 1 March 2013.

Tukker, A. and E. Dietzenbacher. 2013. Global multiregional input-output frameworks: An introduction and outlook. *Economic Systems Research* 25(1): 1–19.

UN (United Nations). 2010. *The inequality predicament: Report on the world social situation, 2005*. Department of Economic and Social Affairs; Social Policy and Development Division. New York: United Nations.

UN (United Nations). 2009. *Rethinking poverty—Report on the world social situation 2010*. Department of Economic and Social Affairs. New York: United Nations.

UNEP (United Nations Environment Program). 2009. *Guidelines for social life cycle assessment of products*. Druk in de weer, Belgium: United Nations Environment Program.

Wiedmann, T., H. Schandl, M. Lenzen, D. Moran, S. Suh, J. West, and K. Kanemoto. 2013. The material footprint of nations—Reassessing resource productivity. *Proceedings of the National Academy of Sciences of the United States of America* 110(36): 1–6.

WBCSD (World Business Council for Sustainable Development). 2010. *Business and development: Challenges and opportunities in a rapidly changing world*. Geneva: World Business Council for Sustainable Development.

WFTU (World Federation of Trade Unions). 2011. *Constitution of the World Federation of Trade Unions*. Athens: World Federation of Trade Unions.

Young, E. 2013. *Bangladesh textile workers' deaths 'avoidable'*. www.bbc.co.uk/news/business-22296645. Accessed 3 June 2013.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

Supporting Information S1: This supporting information provides a table showing countries listed in the main article and the number of industries and products (sectors) of each (table S1), a table showing the world's top flows of employment and income in 2010 supporting figure 1 of the main article (table S2), and a table that breaks down the employment footprint and workforce levels shown in figure 2 of the main article (table S3).