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Article

## The “Bad Labor” Footprint: Quantifying the Social Impacts of Globalization

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**Abstract:** The extent to what bad labor conditions across the globe are associated with international trade is unknown. Here, we quantify the bad labor conditions associated with consumption in seven world regions, the “bad labor” footprint. In particular, we analyze how much occupational health damage, vulnerable employment, gender inequality, share of unskilled workers, child labor, and forced labor is associated with the production of internationally traded goods. Our results show that (i) as expected, there is a net flow of bad labor conditions from developing to developed regions; (ii) the production of exported goods in lower income regions contributes to more than half of the bad labor footprints caused by the wealthy lifestyles of affluent regions; (iii) exports from Asia constitute the largest global trade flow measured in the amount bad labor, while exports from Africa carry the largest burden of bad labor conditions per unit value traded and per unit of total labor required; and (IV) the trade of food products stands out in both volume and intensity of bad labor conditions.

**Keywords:** social footprint; international trade; social impacts of consumption; labor conditions; supply chain; consumption-based accounting; multiregional input-output model

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## 1. Introduction

Bad labor conditions exist around the world, but just how much of this bad labor is driven by the globalization of production chains? The rapid increase in the volume of international trade and the spread of manufacturing stages across the globe has dispersed environmental, social, and economic impacts. It is becoming increasingly harder to trace the origins of consumed products. Attention is often drawn to bad labor conditions when high-profile incidents events occur, as in the case of the death of over one thousand workers caused by the Bangladeshi Rana Plaza garment factory collapse in April 2013, in hundreds of deaths and human rights violations during construction works related to the 2022 FIFA World Cup in Qatar [1–3], or in recent slavery conditions uncovered at sugarcane plantations in Brazil [4]. Consumers and retailers alike have expressed the desire for humane working conditions in the supply chains of products [5–8]. Companies have been gradually adopting proactive measures, with examples such as the Fairphone initiative [9] and the recent announcement by Intel on the use of conflict-free minerals [10]. Recently, regulations aim to promote supply chain sustainability, such as the California Transparency in Supply Chains Act of 2010 and the (unsuccessful) Transparency in UK Company Supply Chains (Eradication of Slavery) Bill 2012–2013. Media reports and NGO campaigns suggest that consumers, retailers and brand-owners in Europe and North America are not unaffected by-standers but beneficiaries of bad labor conditions, indicating a moral responsibility to counter them [11]. Many case studies demonstrate that bad labor conditions, such as child labor, forced labor, and poor working conditions and pay, are associated with the production of internationally traded goods [12–17]. However, just how important are the global supply chains of traded products to the problem of poor labor conditions? Which consumers and which product groups are most relevant in tracking the “embodied” poor labor conditions from source to destination? In this paper, we quantify the extent to which bad labor conditions are related to internationally traded products using a new model of global production and consumption.

Institutions such as the International Labor Organization (ILO), The United Nations Statistics Division (UNStats), the World Bank, and the OECD Statistics Division (OECD Stats) provide useful statistics and indicators to assess social and labor conditions around the globe. Available labor statistics show the global distribution of work conditions from the point of view of where it occurs, both regionally and in which economic sectors [18–20]. Until now, however, it has not been quantified how much of these undesirable “bad” labor conditions is associated with the globalization of production chains.

Many studies conclude that trade openness and foreign investments increase income, reduce inequalities, and thus have positive effects in labor conditions in domestic production, such as the reduction of child labor [21–26]. At the same time, however, the globalization of production chains and the growing cross-country inequalities [27] demand a combination of local, regional and global policies to eradicate extreme poverty and inequality and to provide good work conditions and access to the market for everyone [28,29]. Policies focusing on banning or boycotting goods produced with bad labor practices can

have the opposite effect as desired, as it increases the wage gap between good and poor work practices, as it generates less income to poor households. The increased wage gap penalizes poor households by leading not to the reduction, but maintenance or even increase of poor work to achieve subsistence levels [21,23], and reduces the market prices of goods produced with bad labor relative to certified products made in good labor conditions [30]. At the same time, economic growth is not enough to reduce bad labor conditions [31]. Local and regional policies aiming to reduce wage distortions, increase human capital, and provide universal access to education lead to long-run economic development and decrease in bad labor conditions [21]. Child labor, for example, derives mostly from poor households whose short-term benefits from income generated by the children exceed the benefits of sending the children to be educated. For the poorest households, increases in income generated by local and regional economic development may push the household above its subsistence threshold, allowing it to reduce or eliminate its dependence on child labor income [22].

Traditional trade theory, based on factor endowments, suggests that countries with high labor availability specialize in the production and exports of labor-intensive goods [32,33]. The spread of production stages among several countries and regions implies, however, that countries do not necessarily specialize in production of determined goods, but mostly in particular stages of the production process for which the country has the lowest opportunity cost [34,35]. This would suggest that labor-intensive stages of production, especially those that demand less skilled and less specialized labor, would progressively migrate from regions with higher labor costs to labor-abundant regions. Recently published labor footprints show that the majority of physical labor required to produce traded goods, either in the direct production or in the upstream supply chain of those goods, follows a clear path from developing to developed countries while wages flow between developed nations [36]. Less developed economies are net exporters of labor embodied in products and high-income countries are net importers [37]. With high flows of low-paid labor from developing countries associated with the production of goods supplied to affluent nations, the investigation of labor conditions associated with those products becomes critical.

Recent efforts have mapped bad labor conditions associated with production in different regions. Examples of these efforts include the Social Hotspots Database [5], the List of Goods Produced with Child Labor or Forced Labor [38], the Global Slavery Index [39], and the Slavery Footprint [40]. Although previous studies provided valuable insights to some bad labor indicators associated with different products and specific manufacturing stages, identifying impacts related to all stages of production spread in different industries and regions is only possible by using a global multi-regional input-output (MRIO) analysis. MRIO is a comprehensive method for calculating footprints based on the consumption of final products. It traces all correlations between industries in different sectors and regions, and estimates total output from intermediate industries contributing to the upstream supply chain for each product consumed [41].

Consumption-based studies through MRIOs are being increasingly used for analyzing the displacement of environmental pressures and resource requirements. The task of integrating social indicators to that analysis is still a challenge, mostly due to the availability and level of regional and sectorial aggregation of social indicators. Here, we attempted to move one step closer to overcome those obstacles in this study by quantifying on a global scale the bad labor associated to production and the paths and flows of goods and services from the place of origin to the final consumer. We expect that growing international trade, multinationals presence, and offshoring and outsourcing in search for lower production costs mean that

the distance between social externalities in production in poor regions to support prosperous lifestyles get smaller.

We quantified six bad labor conditions: occupational health damage, vulnerable employment, gender inequality, predominance of unskilled and low-skilled labor in workforce, child labor, and forced labor. We aimed to quantify: (i) the contribution of inter-continental trade to bad labor footprints in the seven world regions assessed; (ii) the sectorial contributions to bad labor footprints; and (iii) the bad labor intensities of imports, exports, and domestic production for each of the regions.

## 2. Methods

This section presents the methods used in the study. First, it defines the bad labor indicators used and describes the model. More detailed method and data structure descriptions and sources are available in the online Supplementary Material (S1).

We calculated indicators for undesirable work conditions associated with consumption, the *Bad Labor Footprint*, as presented and detailed in Table 1. We used a consumption-based approach to calculate footprints and a fully-integrated MRIO model. Different measures of bad labor intensities were compared to provide relative impact of consumed products. We do not prioritize or weight the bad labor measures; we present independent results for the different footprints.

### 2.1. Bad Labor Measures

This section presents a brief description of each of the bad labor measures and associated indicators assessed in this study. A detailed description of how each of them was calculated and allocated in the model can be found in the online Supplementary Material (S1).

#### 2.1.1. Occupational Health Damage

Estimates place over 300,000 worker deaths and 3.5 years of healthy life lost globally for every 1000 workers as a result of occupational injuries every year [42]. These estimates do not include disabilities resulting injuries. If diseases resulting from occupational exposure to asthmagens, carcinogens, noise, and ergonomic stressors are also taken into account, death counts can reach up to 850,000 and healthy life lost can rise to over 8 years per 1000 workers [43]. The indicator used to evaluate occupational health damage is disability-adjusted life years (DALY), which measures the gap between the current situation and an ideal one in which everyone lives to the standard life expectancy in perfect health [44,45]. It comprises the time lived with disabilities and the time lost due to premature mortality.

**Table 1.** Summary of labor and bad labor indicators used in the study.

Measure	Indicators	Unit	Definition	Spatial Detail of Original Data	Temporal Detail	Source
Total labor	Total labor	Persons-year equivalent (p-yeq)	Total employment required for the production of goods and services	EXIOBASE <sup>(1)</sup>	2007	[19,46]
Occupational health damage	Incidence of burden of disease for cancer of the trachea, bronchus and lung; leukemia; chronic obstructive pulmonary disease; asthma; noise-induced hearing loss; low back pain; and injuries	Disability-Adjusted Life Years (DALY)	Measures the gap between the current situation and an ideal situation in which everyone lives up to the standard life expectancy in perfect health. It combines the time lived with disabilities and the time lost due to premature mortality	Africa, Middle East, North America OECD, Latin America and the Caribbean, Europe OECD, Europe Other, Asia and the Pacific	2000	[43,47,48]
Vulnerable employment	Persons in total labor without employee status	Persons-year equivalent (p-yeq); Share of total labor (%)	Workers without proper coverage of labor regulations and guarantees. It comprises unpaid contributing family workers and own-account workers.	EXIOBASE <sup>(1)</sup>	2007	[19,46]
Gender inequality	Women in workforce, as a share of total labor	Share of total labor (%)	Share of women in the labor market	EXIOBASE <sup>(1)</sup>	2007	[19]
Incidence of unskilled and low-skilled workers	Low-skilled labor, in absolute values and as a share of total labor	Persons-year equivalent (p-yeq); Share of total labor (%)	Employment in elementary occupations [49] and/or employees with educational attainment levels until (and including) primary education [50]	EXIOBASE <sup>(1)</sup>	2007	[19]
Child labor	Children in child labor and in hazardous child labor	Persons-year equivalent (p-yeq)	Work done by children who are younger than the designated minimum working age and children in hazardous labor, that is, in worst forms of labor due to moral, health, and safety risks. Can include children in forced labor.	Asia and the Pacific, Latin America and the Caribbean, Sub-Saharan Africa, Other regions	2004 to 2008	[18]
Forced labor	Workers in forced labor	Persons-year equivalent (p-yeq)	All work or service which is not performed voluntarily, including debt bondage. Can include children in forced labor.	Asia and the Pacific, Latin America and the Caribbean, Africa, Middle East, Central and South-Eastern Europe (non-EU) and CIS, Developed economies and the EU	2002 to 2011	[51]

<sup>(1)</sup> 43 countries, consisting of all countries in the Europe Union (EU-27) plus 16 countries (Norway, Switzerland, United States, Canada, Australia, Japan, South Korea, Taiwan, Turkey, Russia, Mexico, Brazil, South Africa, China, Indonesia, and India); plus five Rest of the World (RoW) regions (Africa, Middle East, Asia and the Pacific, Latin America and the Caribbean, and Other Europe).

### 2.1.2. Vulnerable Employment

Persons in vulnerable working conditions are those with large economic risks associated with their jobs. They are less likely to have formal employment arrangements, and are more susceptible to economic cycles and environmental disasters. Workers considered to be in vulnerable conditions are those classified as own-account workers and contributing family workers, that is, with no formal employment bonds [52]. Vulnerable employment affects approximately half of the total employment pool. In developed economies, vulnerable employment accounts for around 10% of total workers, while in regions like South Asia and Sub-Saharan Africa they comprise nearly three quarters of total workforce [20]. Vulnerable employment can indicate a number of other work-related conditions, such as: informal employment, workers not covered by social security and by formal labor regulation and representation, workers without contribution to and benefits from pension schemes, workers with no possibility of paid leave due to sickness or invalidity, workers without or with limited rights to parental leave, and workers with no stability and security of work.

### 2.1.3. Gender Inequality

Women empowerment and access to education and the labor market is still a goal for several developing regions. Globally, only 48% of working age women were employed in 2007, in contrast to 73% of men. In some regions, however, this difference is even higher, as in the case of South Asia (33% of women and 79% of men), North Africa (19% of women and 67% of men) and the Middle East (15% of women and 67% of men) [20]. We measure gender inequality by quantifying the share of women in the workforce relative to total employment.

### 2.1.4. Incidence of Unskilled and Low-Skilled Workers

Unskilled and low-skilled workers (henceforth called low-skilled workers) are those who perform elementary occupations [49] and those who have a level of education attainment up to lower secondary education [50]. A high share of low-skilled workers implies low diversity of the economy and lower economic productivity, as well as lower human capital and lower value added in production. It often indicates sub-optimal use of human resources. Although employment in low-skilled labor is not necessarily a bad labor condition in of itself, the predominance of low-skilled workers in the production of exported goods can indicate other aspects of poor working conditions, such as working poverty, low wages, income inequality, limited education attainment of adult population, and widespread poverty. The indicators used to measure the prevalence of low-skilled workers are number of low-skilled workers and the share of these in total labor force.

### 2.1.5. Child Labor

Child labor refers to work performed by children who are younger than the designated minimum working age, which is usually 13 to 15 years old, and all children under 18 who are involved in the worst forms of child labor, namely modern-day slavery, sexual exploitation, illicit activities, and hazardous work. Over 215 million children were estimated victims of child labor worldwide in 2008, most of which worked in agriculture [18]. Only one in every five working children is in paid employment, and the overwhelming majority (around two thirds) are unpaid family workers. Over half of the children involved in child labor

perform hazardous activities, that is, activities that may affect the child's safety, health, and moral development. Such activities include work with heavy equipment, work that involves exposure to toxic substances, and work that does not allow the possibility of returning home each day. Although all forms of child labor are undesired, children in hazardous work are treated as a proxy for children in the worst labor conditions. Hazardous child labor can include children in forced labor. We quantify both children in child labor and children in hazardous child labor.

#### 2.1.6. Forced Labor

The ILO [51] estimates that 20.9 million people are victims of forced labor globally. Force labor includes all form of work made by coercion, debt bondage, or withholding of documentation or pay, and all human trafficking for both labor and sexual exploitation. Forced labor in economic activities, associated to supply chains for manufactured products consumed worldwide, cover around 68% of total modern-day slavery, or about 14.2 million workers. Most forced labor is concentrated in non-technological, traditional work that feeds in local economies, especially in agriculture, brick-making, mining and quarrying, textile manufacture, domestic service, forest clearing, and charcoal-making [53]. Not all of forced labor is performed by adults; around one quarter of all forced labor is estimated to be executed by children.

#### 2.2. Multi-Regional Input-Output Model

Input-output (IO) analysis is an economic approach, constructed from observed data from a particular year and region and which considers flows of products between economic sectors and to final consumption. Social and environmental impacts can be calculated with this framework by using a socially and environmentally extended input-output table that attributes requirements and impacts to each industry or product.

The social burdens in the global supply chains were calculated through a multi-regional input-output (MRIO) model, EXIOBASE (version 2) [54,55]. The model represents the world economy for 2007, and comprises 163 industries and 200 products traded within and between 43 countries (all countries in the Europe Union plus Norway, Switzerland, United States, Canada, Australia, Japan, South Korea, Taiwan, Turkey, Russia, Mexico, Brazil, South Africa, China, Indonesia, and India) and 5 broad "rest of the world" regions (Africa, Asia and the Pacific, Latin America and the Caribbean, Middle East, and Rest of Europe). All sectors are listed in table S1.6 in the Supplementary Material (S1). MRIOs comprise not only each region's IO table, but also traces the origin and destiny of traded products between different regions.

The MRIO model comprises three sections:

- (1) the inter-industry model ( $Z$ ), which shows the flows of products between industries;
- (2) the final demand matrix ( $Y$ ), which contains direct expenditures to both domestic and imported products from households and governments and to capital formation; and
- (3) a matrix ( $F$ ) comprised of factors of production associated with each economic sector. Factors of production are requirements, such as labor, and burdens, such as pollution, expressed per unit of output from each industry.



The model is represented in a simplified manner below in Equation (1), where each region is denoted by a number (1, 2, 3, ..., n) and each matrix element is represented by a letter (Z, y, F). For detailed literature on input-output algebra and a description of extended input-output methods, we recommend the reading of Peters and Hertwich [56] and Miller and Blair [57]

$$\begin{pmatrix} \mathbf{Z}^{11} & \mathbf{Z}^{12} & \mathbf{Z}^{13} & \dots & \mathbf{Z}^{1n} \\ \mathbf{Z}^{21} & \mathbf{Z}^{22} & \mathbf{Z}^{23} & \dots & \mathbf{Z}^{2n} \\ \mathbf{Z}^{31} & \mathbf{Z}^{32} & \mathbf{Z}^{33} & \dots & \mathbf{Z}^{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \mathbf{Z}^{n1} & \mathbf{Z}^{n2} & \mathbf{Z}^{n3} & \dots & \mathbf{Z}^{nn} \end{pmatrix} \begin{pmatrix} \mathbf{y}^{11} & \mathbf{y}^{12} & \mathbf{y}^{13} & \dots & \mathbf{y}^{1n} \\ \mathbf{y}^{21} & \mathbf{y}^{22} & \mathbf{y}^{23} & \dots & \mathbf{y}^{2n} \\ \mathbf{y}^{31} & \mathbf{y}^{32} & \mathbf{y}^{33} & \dots & \mathbf{y}^{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \mathbf{y}^{n1} & \mathbf{y}^{n2} & \mathbf{y}^{n3} & \dots & \mathbf{y}^{nn} \end{pmatrix} \quad (1)$$

$$(\mathbf{F}^1 \quad \mathbf{F}^2 \quad \mathbf{F}^3 \quad \dots \quad \mathbf{F}^n)$$

With this model, we can trace manufacturing stages happening in different industries and regions represented in the Z matrices, and final products traded between countries in the y matrices. Production and consumption of domestic products are found on the diagonal, represented by  $Z^{xx}$  and  $y^{xx}$ , and traded goods between different regions are found in off-diagonal elements, represented by  $Z^{xn}$  and  $y^{xn}$  (from region  $x$  to region  $n$ ). The  $F^x$  matrix characterizes the direct impacts associated to each industry, which allow us to estimate social impacts associated to each manufacturing stage in each region.

### 2.3. Data and Allocation

Data on bad labor indicators are specified in Table 1. Economic and trade data, as well as total labor data, are from the EXIOBASE model. Labor data are derived from national labor force and industrial surveys [19,46]. Data on occupational burden of diseases was obtained from Concha-Barrientos *et al.* [47], the European Commission [48], and Nelson *et al.* [43]. Vulnerable employment and work divided by skill level and gender originate from ILO LABORSTA database [19], and child and forced labor were obtained through ILO reports [18,51]. Population and gross domestic product (GDP) per purchasing power parity (PPP) data are retrieved from The World Bank Database [58]. The model represents a picture of international economy and labor conditions in 2007.

Although labor statistics such as the number of employees in each economic sector are usually well covered by labor force and industry surveys, the quality of these jobs is usually based on estimates, and therefore carry a great deal of uncertainty. That is mostly true for statistics on some of the worst labor conditions, such as child and forced labor. Statistics on these forms of work are scarce; their illegal nature makes it difficult to collect statistically representative data—over 90% of slavery in Europe is estimated to go undetected [59]. Additional factors include statistical survey design [60], and insufficient effort from government agencies to collect and make available these data [38].

The allocation of bad labor conditions into EXIOBASE sectorial and regional classification was performed based on employment share [37]. We assumed that, within a region, the rate of bad labor per total labor in each broad sector was similar. Broad sector, here, is considered aggregated sector classification from the original data. Furthermore, due to the lack of information, we do not distinguish between goods produced for domestic consumption and those produced for export within a sector. Even though previous studies have pointed at the existence of better conditions in exporter-oriented companies than those oriented to the domestic market (e.g., Alvarez and Lopez [61]), we do not have sufficient information to distribute the bad labor across products sold in the domestic and international market. This

is a limitation of this study, and provides a basis for further research as more data become available. Child and forced labor were allocated according to the share of low-skilled labor, under the assumption that these positions are more likely to concentrate these worst forms of labor. More details on allocation can be found in Section S1.1.2 of the Supplementary Material (S1).

Original data for child and forced labor presented high sectorial and regional aggregation (three sectors economy and 4 and 6 regions respectively). Therefore, results were re-aggregated in seven regions and eight consumption categories in order to avoid a false representation of the resolution of the analysis. The aggregated regions for analysis are (1) Africa; (2) Asia and the Pacific; (3) Europe OECD; (4) Latin America and the Caribbean; (5) Middle East; (6) non-OECD Europe; and (7) North America. The aggregated consumption categories represent groups of products and services purchased by final consumers, and they are (1) food; (2) clothing; (3) shelter; (4) construction; (5) manufactured products; (6) mobility; (7) services; and (8) trade; consumption category aggregation is detailed in Table S1.6 in the Supplementary Material (S1). Each consumption category refers to a basket of products and services purchased by final consumers.

We calculated the bad labor footprints through a consumer perspective. It analyzes *what drives* the bad labor footprint, and allocates all bad labor associated to the upstream supply chain to the final consumed products. With this methodology, the bad labor footprint associated to manufactured products, for example, accounts for all bad labor conditions associated to not only the manufacture of these products, but also to the remaining industries providing intermediate goods and services to the production of those goods. In analyzing what drives the footprints, we also keep track of where the bad labor actually occurs—allowing the traceability of, for example, the labor impacts of agriculture in Asia, through processing in international supply chains to the ultimate goods purchased by consumers.

We account for the bad labor flows for trade occurring both inside a region and between different regions. Goods and services produced and consumed within a country or traded between countries within the same region (for example, from France to Italy) are considered intra-region (“domestic”) trade. Alternatively, traded products between countries in different regions are included in inter-region flows (“imports” and “exports”). The footprints are calculated over a region’s consumption, that is, domestic and imported products to final demand. All footprints were calculated for the full MRIO model, at sector- and region-level detail.

Footprints were calculated both in absolute DALY or persons-year equivalents (p-y<sub>eq</sub>) in bad labor, and in relative values (DALY or p-y<sub>eq</sub> in bad labor per 1000 p-y<sub>eq</sub> in total labor footprint). Different measures of intensity were calculated based on the bad labor footprint and compared. Intensity is presented relative to four different measures: bad labor intensity of the economy (DALY or p-y<sub>eq</sub> in bad labor per million euros of GDP); bad labor intensity of consumption (DALY or p-y<sub>eq</sub> in bad labor per million euros expenditure); bad labor per capita (DALY or p-y<sub>eq</sub> in bad labor per 1000 persons in total population); and bad labor intensity of total labor footprint, or bad labor intensity of the labor footprint (DALY or p-y<sub>eq</sub> in bad labor per 1000 p-y<sub>eq</sub> in total labor). Person-year equivalent represents the amount of work that would be made by a person during a year. Gross Domestic Product refers to domestic economy of the entire region, not of individual countries. It was calculated by summing the value added of the production for each country in the region, including taxes and excluding subsidies.

### 3. Results

#### 3.1. Consumption in Affluent Countries Drives Bad Labor Transfer

We find a clear distinction between the structure of bad labor footprints for developed and developing regions. This is mainly due to the fact that developing countries export large amounts of primary products with low value added and high labor intensity, while developed countries export goods and services with high value added and lower labor intensity [62,63]. Most of the total labor and the bad labor, in absolute numbers, occur in developing countries, and most of it is associated with the production of goods and services traded within a region. Nevertheless, the consumption of imported products originating from developing countries carry significant amount of bad labor conditions associated to their production. This is especially true for food products. The consumption of these imported products can increase the bad labor footprints of developed economies by up to 150%.

Table 2 shows footprints for each bad labor indicator in absolute values and split into the domestic and imported shares. It also displays the bad labor footprint of exports from the region, and how much products destined for export contribute to total bad labor occurring in the region. In the case of exports, the share is not based on the footprint of consumption, but to the total bad labor that takes place in the production in the region. Total bad labor of production would correspond to domestic plus exports, while footprints of consumption accounts for domestic plus imports. Regions are presented from highest to lowest GDP per PPP per capita. In OECD Europe and in North America, the contribution of imports and overseas production to bad labor footprints is up to 62%–78%, which is significantly more than the share of imports in the total labor footprint (41%–51%). This difference suggests that imports are relatively more bad-labor intensive, in persons in bad labor per persons in total labor, than domestic production in those regions. At the same time, in the developing regions of Latin America, Asia Pacific, and Africa, imports account for little or virtually no impact on their bad labor footprints (1%–11%), but exports can correspond to a significant amount of bad labor in those regions (up to 31%).

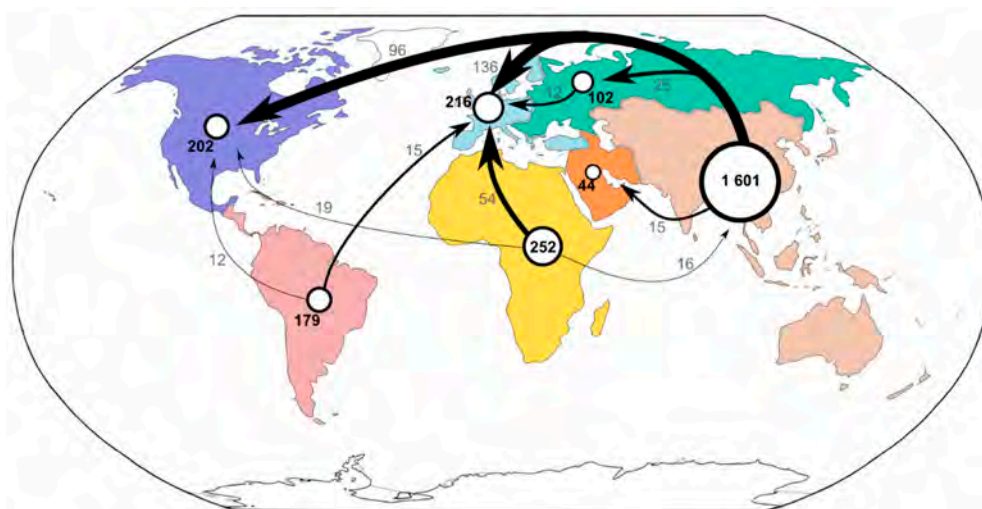
Approximately 16% of total labor was associated to the production of goods consumed in other regions. Similarly, bad labor conditions associated with global supply chains corresponded to 15%–20% of total bad labor happening globally (15% for low-skilled labor, 17% for forced labor, 18% for occupational health damage, 19% for child labor, 19% for vulnerable employment, and 20% for hazardous child labor). Women represented 38% of total labor associated to products traded between regions. We highlight that those share represent globalization of production and consumption between the seven regions used here, and not between individual countries.

Figure 1 illustrates the main flows of labor embodied in traded products within regions (circles) and between regions (arrows). All flows represented account for at least 2% of total labor/bad labor in inter-regional trade. In absolute values, flows of bad labor associated with foreign consumption follow the same path as total labor. Figure A1, in the Appendix, shows all major flows of bad labor associated with inter-regional trade. Imports to OECD Europe account for 46% of total labor and 50%–51% of all bad labor conditions associated with inter-regional trade. With a similar GDP and around 80% of the population of Europe OECD, North America accounts for 28% of total labor and 24%–29% of bad labor conditions associated to trade across regions.

**Table 2.** Labor and bad labor footprints of each region and footprints of trade.

		North America	Europe OECD	Non- OECD Europe	Middle East	Latin America	Asia and the Pacific	Africa
Total employment	<b>Footprint</b> (1000 p-yeq)	<b>340,597</b>	<b>442,142</b>	<b>140,138</b>	<b>64,629</b>	<b>193,651</b>	<b>1,643,781</b>	<b>261,241</b>
	<i>Domestic share of footprint</i>	59%	49%	73%	68%	92%	97%	96%
	<i>Imports share of footprint</i>	41%	51%	27%	32%	8%	3%	4%
	Exports footprint	10,732	23,263	22,692	15,243	36,583	283,298	99,223
	<i>Exports share of production</i>	5%	10%	18%	26%	17%	15%	28%
Vulnerable employment	<b>Footprint</b> (1000 p-yeq)	<b>77,436</b>	<b>135,302</b>	<b>27,759</b>	<b>24,443</b>	<b>64,262</b>	<b>539,060</b>	<b>149,147</b>
	<i>Domestic share of footprint</i>	33%	28%	49%	66%	93%	97%	98%
	<i>Imports share of footprint</i>	67%	72%	51%	34%	7%	3%	2%
	Exports footprint	1367	3821	3047	5955	16,010	99,916	66,816
	<i>Exports share of production</i>	5%	9%	18%	27%	21%	16%	31%
Low-skilled labor	<b>Footprint</b> (1,000 p-yeq)	<b>69,642</b>	<b>104,618</b>	<b>25,589</b>	<b>9858</b>	<b>36,885</b>	<b>768,777</b>	<b>75,923</b>
	<i>Domestic share of footprint</i>	32%	22%	45%	48%	89%	99%	97%
	<i>Imports share of footprint</i>	68%	78%	55%	52%	11%	1%	3%
	Exports footprint	1,136	2,166	2,450	1,493	4,058	118,907	32,602
	<i>Exports share of production</i>	5%	9%	18%	24%	11%	14%	31%
Occupational health	<b>Footprint</b> (1000 DALYs)	<b>2138</b>	<b>3616</b>	<b>1540</b>	<b>697</b>	<b>1590</b>	<b>15,444</b>	<b>3814</b>
	<i>Domestic share of footprint</i>	36%	29%	76%	78%	91%	97%	98%
	<i>Imports share of footprint</i>	64%	71%	24%	22%	9%	3%	2%
	Exports footprint	34	96	286	235	374	2,458	1,707
	<i>Exports share of production</i>	4%	8%	20%	30%	21%	14%	31%
Child labor	<b>Footprint</b> (1000 p-yeq)	<b>13,149</b>	<b>26,524</b>	<b>8,025</b>	<b>3,037</b>	<b>9,632</b>	<b>96,437</b>	<b>43,016</b>
	<i>Domestic share of footprint</i>	28%	27%	66%	67%	91%	96%	99%
	<i>Imports share of footprint</i>	72%	73%	34%	33%	9%	4%	1%
	Exports footprint	238	585	922	902	4,375	13,098	17,807
	<i>Exports share of production</i>	6%	8%	15%	31%	33%	12%	29%
Hazardous child labor	<b>Footprint</b> (1000 p-yeq)	<b>8276</b>	<b>16,807</b>	<b>5966</b>	<b>2270</b>	<b>6352</b>	<b>41,788</b>	<b>25,589</b>
	<i>Domestic share of footprint</i>	38%	36%	75%	76%	92%	94%	99%
	<i>Imports share of footprint</i>	62%	64%	25%	24%	8%	6%	1%
	Exports footprint	201	494	779	761	2,923	5,553	10,601
	<i>Exports share of production</i>	6%	8%	15%	31%	33%	12%	29%
Forced labor	<b>Footprint</b> (1000 p-yeq)	<b>901</b>	<b>1822</b>	<b>897</b>	<b>332</b>	<b>728</b>	<b>6822</b>	<b>1678</b>
	<i>Domestic share of footprint</i>	34%	38%	81%	80%	92%	97%	98%
	<i>Imports share of footprint</i>	66%	62%	19%	20%	8%	3%	2%
	Exports footprint	20	52	126	112	353	938	688
	<i>Exports share of production</i>	6%	7%	15%	30%	34%	12%	29%

**Figure 1.** Gross flows of labor embodied in traded goods, in million persons-year equivalent <sup>1</sup>.



<sup>1</sup> The sizes of the circles indicate domestic trade and thickness of the arrows indicate the volume of labor embodied in the flows between regions.

Most bad labor conditions are associated with intra-regional trade. Regarding inter-regional trade, the majority of bad labor associated with exchanges flows from the Asia Pacific and Africa regions to developed regions; flows from Asia Pacific to Europe OECD and North America correspond to almost half of all labor embodied in inter-regional trade. These trades are also responsible for over 60% of low-skilled labor, 41% of vulnerable employment, 39% of DALYs, 34% of forced labor, 29% of child labor, and only 22% of hazardous child labor. Flows from Africa to these same developed regions, however, account for only 11% of total labor embodied in inter-regional trade, but almost 20% of all DALYs and vulnerable employment and over one quarter of all child and hazardous child labor. These flows are significantly different from the flows of value added in inter-regional trade. For the latter, exports from Europe OECD and North America sum 45%, while exports from Asia and the Pacific correspond to 28%.

### 3.2. The Contribution of Consumption to Bad Labor Footprints

Figure 2 presents the contribution of each consumption category to the global bad labor footprints. It shows the *drivers* for the footprints, that is, all the impacts associated to the upstream supply chains of the consumption of products in each category. The consumption categories are organized according to their contribution to total labor footprint in the world. Bars in dark color represent categories that contribute to more than 10% of total labor and bad labor footprints.

Globally, the consumption of services is the main driver for employment, corresponding to around one third of workers worldwide, but is not responsible for most of the bad labor conditions. Food consumption drives 40% of all vulnerable labor in the world, and over half of all employment driven by food production are in a vulnerable situation. It also induces around 40% of low-skilled workers, and over 40% of child and forced labor. The construction drives one fifth of all DALYs, and it has the lowest proportion of female workers; only 26% of all workers in activities related to construction are women.

**Figure 2.** Contribution of each consumption category to total and to bad labor footprints in the world.

Industries related to each consumption category are displayed in Table S1.6 in the Appendix, and figures for the contribution of each consumption category to total and to bad labor footprints in each region are found in the results section of the Supplementary Material (S1).

Bad labor footprints are concentrated in different consumption categories, depending on the region. There are some similarities. Services drive the highest share of total labor footprint in all regions except for Asia Pacific and Africa. Occupational health damages result mainly by the consumption of services, food products, construction services, and manufactured products.

Food consumption represent higher share of the bad labor footprint in most of the regions. It is especially high for child and forced labor. In the developed economies of North America and OECD Europe, food products represent the second highest contribution to total labor (17% and 18%, respectively), but are largest source of bad labor conditions. Europe OECD not only has a higher bad labor footprint

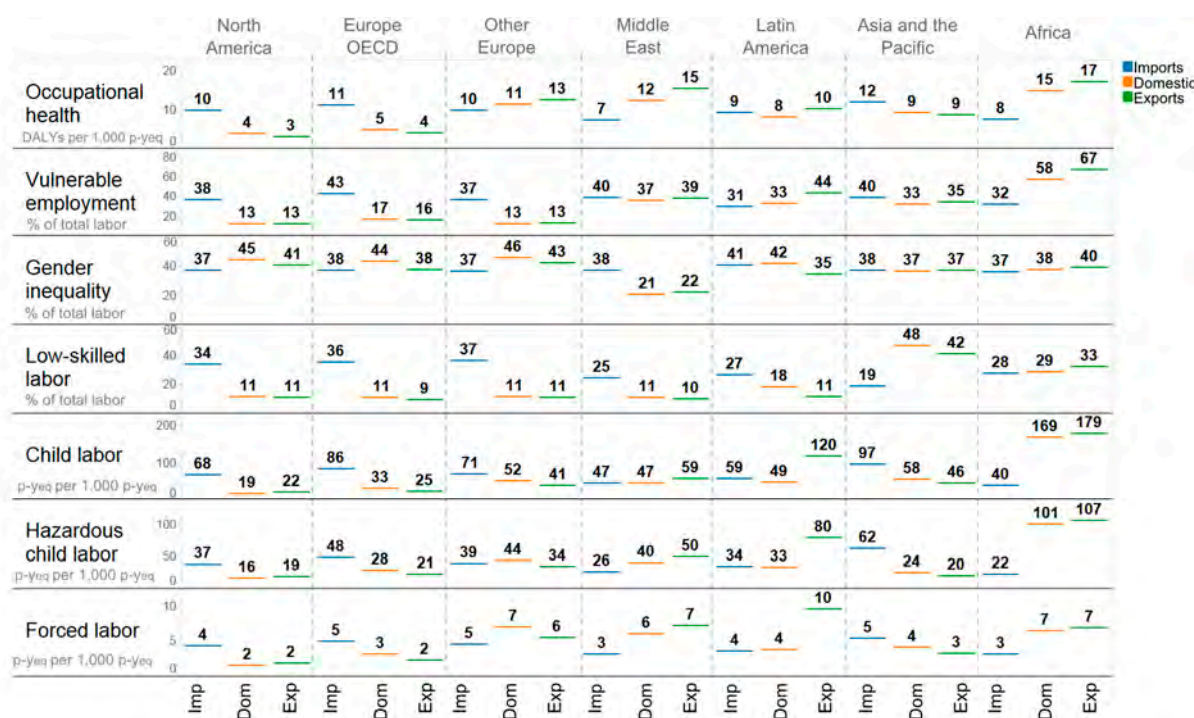
than North America, but also higher contribution from food products in general due to its higher imports from Asia and Africa, regions that have the majority of their bad labor conditions in food production. Absolute footprints for each sector are available in the Table S1.2.1 in the online Supplementary Material (S1), ranked in decreasing footprint.

A complete spreadsheet detailing the flows between the seven studied regions categorized by production sector is available in the online Supplementary Material (S2). Although the sectorial classification is the same as for the consumption categories, the spreadsheet shows where the production occurs, and not the consumption as a driver for the footprints.

### 3.3. Bad Labor Intensities

Figure 3 offers a breakdown of share of bad labor conditions per unit labor footprint. These are presented for imported products (left bar, in blue), goods produced and traded domestically (middle bar, in orange), and exported products (bar to the right, in green). The share of bad labor is usually highest for domestic production and exports in developing regions, while it is always highest for imports into Europe OECD and North America. It appears that products exported from Latin America to other regions have a significantly higher share of vulnerable employment and persons in child and forced labor than products produced and traded domestically. In contrast, African products have similar intensities for both domestically-traded and exported products.

**Figure 3.** Bad labor intensity of total labor footprint for imports (left; blue), intra-regional trade (middle; orange), and exports (right; green) <sup>1</sup>.



<sup>1</sup> Units: DALYs per 1000 p-yeq for occupational health damage; share of total employment for vulnerable employment, gender inequality, and low-skilled labor; and p-yeq in child or forced work per 1000 p-yeq for child labor, hazardous child labor, and forced labor.



One could measure bad labor intensity from an economic, lifestyle, or probability perspective. To cover different perspectives, four measures of intensities were calculated and compared and are presented in Table 3. The first two measures cover an economic perspective, using bad labor per GDP and bad labor per expenditure (GDE, gross domestic expenditure) as indicators. The former measures the bad labor footprint of each region per unit of production, that is, value added to the economy, and considers the economic output of the region as the main target of policies and analysis. The latter evaluates the bad labor footprint per million euros of consumption of final products by households, governments, and for capital formation. This approach considers final consumption to be the ultimate goal of production systems. The third measure is bad labor per capita. This measure considers bad labor footprints per total population of the consuming region, and considers how many people benefit from lifestyles supported by the labor and bad labor associated with their consumed products. The fourth measure is the share of bad labor in total labor footprints, and measures how bad a certain flow or footprint is; higher intensities indicate higher probability that the purchase of products from a certain consumption category has been produced under bad labor conditions.

**Table 3.** Labor and bad labor intensities of each region, based on different measures.

		North America	Europe OECD	Non-OECD Europe	Middle East	Latin America	Asia Pacific	Africa
Occupational health damage (DALYs)	per GDP <sup>(1)</sup>	0.2	0.3	1.0	0.8	0.9	1.7	5.6
	per GDE <sup>(2)</sup>	0.2	0.3	1.1	0.9	0.9	1.8	5.7
	per 1000 inhabitants	4.8	6.7	5.9	2.5	3.4	4.1	4.4
	per 1000 p-y <sub>eq</sub>	6.3	8.2	11.0	10.8	8.2	9.4	14.6
Vulnerable employment (p-y <sub>eq</sub> )	per GDP <sup>(1)</sup>	7	11	19	27	37	60	220
	per GDE <sup>(2)</sup>	6	11	19	30	37	61	225
	per 1000 inhabitants	173	250	106	89	139	143	171
	per 1000 p-y <sub>eq</sub>	227	306	198	378	332	328	571
Women in workforce (p-y <sub>eq</sub> )	per GDP <sup>(1)</sup>	12	15	42	19	47	68	148
	per GDE <sup>(2)</sup>	12	14	42	21	47	70	151
	per 1000 inhabitants	319	331	234	62	177	162	115
	per 1000 p-y <sub>eq</sub>	419	406	438	265	423	371	383
Low-skilled workers (p-y <sub>eq</sub> )	per GDP <sup>(1)</sup>	6	8	17	11	21	85	112
	per GDE <sup>(2)</sup>	6	9	18	12	21	88	114
	per 1000 inhabitants	156	193	98	36	80	204	87
	per 1000 p-y <sub>eq</sub>	205	237	183	153	191	468	291
Child labor (p-y <sub>eq</sub> )	per GDP <sup>(1)</sup>	1	2	5	3	6	11	64
	per GDE <sup>(2)</sup>	1	2	6	4	6	11	65
	per 1000 inhabitants	30	49	31	11	21	26	49
	per 1000 p-y <sub>eq</sub>	39	60	57	47	50	59	165
Hazardous child labor (p-y <sub>eq</sub> )	per GDP <sup>(1)</sup>	1	1	4	3	4	5	38
	per GDE <sup>(2)</sup>	1	1	4	3	4	5	39
	per 1000 inhabitants	19	31	23	8	14	11	29
	per 1000 p-y <sub>eq</sub>	24	38	43	35	33	25	98



Table 3. Cont.

		North America	Europe OECD	Non-OECD Europe	Middle East	Latin America	Asia Pacific	Africa
Forced labor (p-y <sub>eq</sub> )	per GDP <sup>(1)</sup>	0.1	0.1	0.6	0.4	0.4	0.8	2.5
	per GDE <sup>(2)</sup>	0.1	0.1	0.6	0.4	0.4	0.8	2.5
	per 1000 inhabitants	2.0	3.4	3.4	1.2	1.6	1.8	1.9
	per 1000 p-y <sub>eq</sub>	2.6	4.1	6.4	5.1	3.8	4.2	6.4
Total labor (p-y <sub>eq</sub> )	per GDP <sup>(1)</sup>	29	36	95	71	111	183	386
	per GDE <sup>(2)</sup>	28	37	36	80	112	187	394
	per 1000 inhabitants	761	815	535	235	420	435	300
	per 1000 p-y <sub>eq</sub>	-	-	-	-	-	-	-

<sup>(1)</sup> GDP = Gross Domestic Product, in million euros; <sup>(2)</sup> GDE = Gross Domestic Expenditure, in million euros.

Bad labor intensities measured based on economic production and consumption are particularly high for Africa, due to its high labor footprint and low GDP and GDE. OECD Europe and North America have among the highest footprints per capita. Both OECD Europe and North America present the highest total labor footprint per capita, with 815 and 761 p-y<sub>eq</sub> required to produce goods and services consumed for each 10,000 inhabitants in those regions, respectively. The Middle East was the only region identified with a bad labor footprint for gender inequality. This region employs only 62 women per 1000 inhabitants, or 265 women per 1000 p-y<sub>eq</sub> in total labor.

Africa also has the highest share of bad labor in total labor footprints, except for low-skilled labor, where Asia Pacific leads with almost half of its workers performing low-skill production activities. The shares of bad labor in total labor for each region and production sector are ranked from higher to lower in Table A1, in the Appendix.

Higher shares of bad labor in total labor footprints are found in food products, except for gender inequality and occupational health, where construction activities have the worst conditions.

#### 4. Discussion

This section is divided into two parts. First, we discuss the main findings of the study, followed by a discussion of the identified limitations and uncertainties in the model and suggest ways to reduce these uncertainties in future work.

##### 4.1. The Social Footprints of Trade

The fact that most bad labor conditions are in developing countries is intimately connected to both poor living and labor conditions in these regions and to the high population and low labor productivity. As previously shown for employment footprints [36,37], transfers of bad labor across regions also appear to be linked to affluence. However, while 15% of bad labor conditions are mainly driven by consumption in rich countries in North America and OECD Europe, around 85% take place in the production of goods traded within a region.

Different measures of bad labor intensities can provide divergent results. Bad labor intensities from the production perspective are significantly lower for developed regions in comparison to developing ones.

However, this difference can be significantly reduced (or even reversed) when the bad labor intensity is measured with reference to the consuming population.

By looking at the share of bad labor in the total labor footprints of traded goods, we confirm that developed countries have similar or better labor conditions in export-dominated industries than that of domestic-oriented ones, mainly due to the exports of high value-added products. Our results show that imports to those regions, however, are associated with nearly four times worse labor conditions per unit of labor than that of domestic production. In contrast, export-dominated industries in developing regions tend to present similar or worse labor conditions than those of domestic production. This appears to be related to the fact that developing regions are specialized in the exports of primary products and manufacturing stages that are intensive in low-skilled labor [37], where most bad labor conditions are concentrated. We can conclude that not only is the share of bad labor higher in developing economies than in developed ones, but also that a significant proportion of industries associated with bad labor conditions occurs in developing countries. Labor availability and labor costs play an important role in the globalization of supply chains, and developing regions are abundant in low-skilled labor [37]. Low-skilled labor is not considered a bad labor condition in itself, but a dominant share of low-skilled workers in trade flows are considered as sub-optimal working conditions in the economy as a whole. That calls for an articulation between local and regional development policies and global supply chain sustainability policies to guarantee fair working conditions throughout production processes worldwide.

Food production occupies around one third of global employment and suffers from worse labor conditions than other economic sectors. That is likely connected to the fact that agriculture and fishing are ultimately an activity of last resort. This sector not only includes those who farm, hunt and fish as an occupation, but also subsistence farmers, especially in areas with high incidence of poor rural households. That is true for not only developing economies, but also for developed countries. Subsistence agriculture and informal markets constitute a potential uncertainty to our study and is discussed in Section 4.2.

Simply reducing the consumption of goods produced in developing regions with a high incidence of bad labor conditions could lead to positive impacts on the developed economies' footprints. Nevertheless, it could lead to more negative impacts in poor households and reduce the positive impacts of employment and income generation in these developed regions. With over 80% of the bad labor impacts linked to intra-regional trade, local and regional policies for poverty alleviation will have a higher impact on bad labor mitigation than global supply chain policies.

#### *4.2. Limitations and Further Research*

Four main sources of uncertainty can be identified in the modeling performed here. Further research in these areas is recommended to increase robustness of results. The first two relate to (1) data availability and consequently to the uncertainties introduced through (2) disaggregation and allocation. These uncertainties are exceptionally higher for forced and child (and hazardous child) labor due to higher levels of uncertainties inherent in the source data and because the source data are more aggregated at both sectorial and regional levels. Uncertainties in the quantification of child and forced labor in different regions due to the illegal and hidden nature of these workers are well discussed in the reports consulted [18,51]. Due to the imprecision of these estimates and their association with human trafficking between countries and regions, they are aggregated into large regions and broad economic sectors. The

disaggregation and allocation of this data to the MRIO regions and sectors were made under considerable assumptions, based on low-skilled labor in each sector, and might increase the correlation between labor embodied in trade and bad labor embodied in trade. The results were re-aggregated in broad regions and consumption categories to avoid giving the misleading illusion of precision.

We present the trade-related impacts for the seven global regions, while there are clearly additional trade-related impacts within each of the world regions (for example, between Mexico and the United States, considered intra-regional in the current study). Accounting for trade at the national level will significantly increase the proportion of labor and bad labor footprints associated with internationally traded products. We modeled total labor, vulnerable employment, and low-skilled labor in international trade at the level of detail of the MRIO (43 countries + 5 “rest of the world” regions). In this new assessment, 22% of total labor, 25% of total vulnerable employment, and 19% of total low-skilled labor were associated to internationally traded products and services, against 16%, 19% and 15% found in the inter-regional trade. The aggregation of labor-abundant developing countries in the “rest of the world” regions, however, also present an incomplete picture of labor associated with products traded between the countries in those regions.

The two latter sources of uncertainties are those inherent to the input-output framework. MRIO uses “product groups” to ensure tractability of all goods and services in the economy. This has the effect that labor impacts are associated to the average of the product group, while different types of products within the same product group generally embody different impacts, and are sold to different consumers. This represents an inherent imprecision to the model, for which the contribution has not yet been quantified in terms of the effects on impacts embodied in trade [64–68]. Furthermore, labor (and land, capital, energy, and other factors of production) can differ significantly both: (a) regionally within a single country; and (b) between small and medium domestically-oriented and large-scale exported-oriented production inside a same sector. Exemplifying the case of agriculture production in Brazil (data for 2006), small and medium family-owned properties correspond to almost 85% of all farms, three thirds of total employment in agriculture, but only 38% of agricultural GDP and one quarter of all land occupied for agriculture. Those small and medium properties accounted for only 19% of all agricultural exports in the same year [69]. This example reveals that exported agricultural products from Brazil are more capital intensive and less labor-intensive than agriculture destined for domestic consumption.

This observation can also be linked to the fourth identified uncertainty, which is the inability to separate formal and informal economy in the current MRIO model. While small and medium familiar agricultural properties concentrate most of the labor force in the agricultural sector, not all of their production will necessarily be traded in the formal market. In Eastern African countries, for example, smallholder farming accounts for around 75% of total agriculture production and over 75% of total employment in agriculture, the majority of these being subsistence farmers [70]. In South Africa, around 5 million workers are estimated to be involved in subsistence activities [71]. Subsistence farming is generally outside of the formal economy, and thus out of the MRIO boundaries. Generally, neither economic nor physical production/consumption of subsistence farming is included in the input-output system. However, persons for whom subsistence farming is the main work activity are included in labor force surveys as persons employed in agriculture. Global poverty dramatically affects agricultural households, and three out of every four poor people live in agriculture-dependent households [72]. The lack of information on the share of subsistence farmers in total employment results in a great challenge to separate these from

the formal economy in the IO system. Just like in subsistence farming, a large part of children involved in production are unpaid family workers that could be involved in informal subsistence activities and in housework activities that do not contribute economically to the household [73,74]. Since labor statistics cover both the formal and the informal economy, total labor and bad labor associated with commercial trade are potentially overestimated.

## 5. Conclusions

In this study, we provide a new perspective on how to account for social impacts of globalization. While most of the existing assessments only consider activities directly related to the production of goods, MRIO analysis quantifies the full supply chain of goods and services. These include all steps from material and energy extraction, manufacture of intermediate products, and the direct production of the final goods.

Globalization raises the question of to what extent the bad labor conditions worldwide are linked to different products consumed overseas. We confirm that the transfer of bad labor occurs mainly from developing to developed countries. Imports correspond to 62% to 78% of rich regions' bad labor footprints. Imports to regions with low GDP per capita do not contribute to their bad labor footprints. Up to 30% of the bad labor conditions in these countries, however, are related to the production of exported products.

While the production of services provides the largest share of employment globally, the largest share of bad labor in the world occurs in food production. Whilst the largest flows of bad labor occur within and from the Asia and the Pacific region, the most intensive impact of bad labor per unit value of the traded product generally occurs in Africa, mainly in food production. In all regions, construction activities present a higher density for gender inequality and occupational health, shown by a lower share of women and a higher volume of DALYs per 1000 workers, respectively. The bad labor intensities of imports, exports, and domestic trade also present a distinct profile in each region. The export-oriented production in affluent economies present better labor conditions than those for domestic consumption, and significantly better conditions than those from imported products. In less developed regions, in contrast, both domestic and export-oriented productions are more bad labor intensive.

In this article, we showed that (i) as expected, there is a net flow of bad labor conditions embodied in products traded from developing to developed regions; (ii) bad labor footprints caused by wealthy lifestyles of rich regions are primarily, but not solely, due to the import of goods from lower income regions; and (iii) whilst the largest quantities of "bad labor" occur in rapidly developing regions, the intensity of bad labor intensities embodied in goods is still often highest in the poorest regions. In terms of type of traded goods, the group of food products stands out in both volume and intensity of embodied bad labor. As our society develops further, the reduction in inequalities and labor related impacts are going to be integral in achieving social sustainability. Clearly, there is a global responsibility across both producers and consumers in realizing this goal.

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## Author Contributions

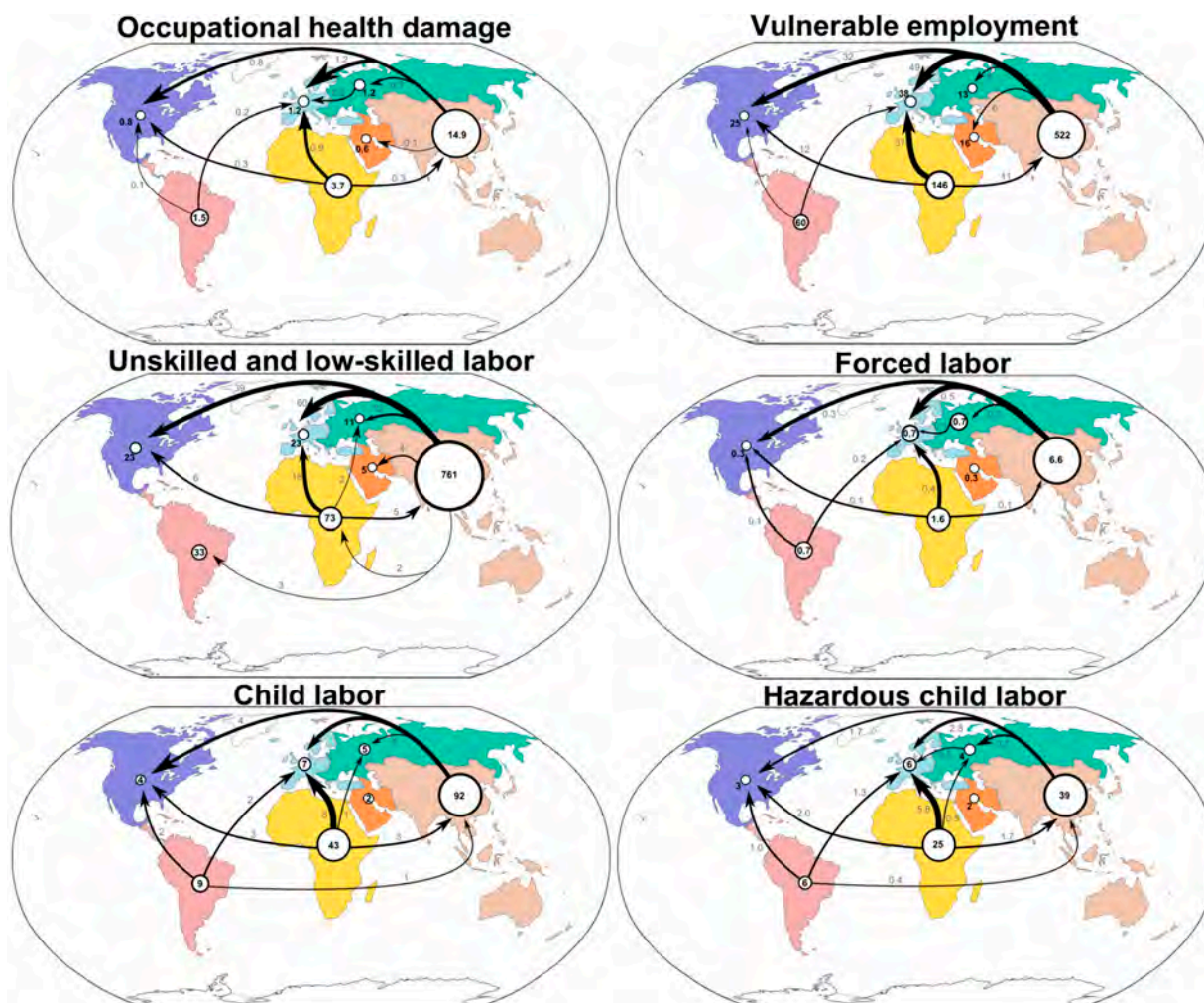
Richard Wood, Edgar Hertwich and Mark Huijbregts conceived and designed the study. Richard Wood and Moana Simas structured the project. Moana Simas and Laura Golsteijn collected and processed the data and wrote the article. Richard Wood supervised the research. All authors contributed to preparing and approving the manuscript.

## Supplementary Materials

Supplementary materials can be accessed at: <http://www.mdpi.com/2071-1050/6/11/7514/s1>.

## Appendix

**Figure A1.** Gross flows of bad labor embodied in traded goods <sup>1</sup>.



<sup>1</sup> Size of the circles indicates domestic trade (big circles mean high volume) and thickness of the arrows indicate the volume of bad labor embodied in the flows between regions. Flows are identified for the following indicators: Occupational health damage (in million DALYs), vulnerable employment, unskilled and low-skilled labor, forced labor, child labor, and hazardous child labor (all in million p-y<sub>eq</sub>). Data used for elaboration of this map is found in Table S1.2.2 in the Supplementary Material.

**Table A1.** Bad labor intensity of total labor footprints for each sector and region <sup>1</sup>.

	Vulnerable employment (*)			Low-skilled labor (*)			Gender inequality (*)			Occupational health (**)			Child labor (*)			Hazardous child labor (*)			Forced labor (*)		
	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V
1	Af	Food	819	AP	Food	691	NA	Cons	123	AP	Cons	30	Af	Food	192	ME	Food	133	OE	Food	17
2	ME	Food	752	AP	Cons	581	EU	Cons	129	OE	Cons	26	OE	Food	178	OE	Food	132	ME	Food	16
3	LA	Food	636	AP	Cloth	539	AP	Cons	135	Af	Cons	20	LA	Food	173	Af	Food	114	LA	Food	14
4	EU	Food	625	AP	Man	504	Af	Cons	196	Af	Cons	20	ME	Food	172	LA	Food	114	OE	Shelt	11
5	NA	Food	580	LA	Shelt	491	ME	Serv	218	EU	Cons	20	EU	Food	146	EU	Food	93	EU	Food	10
6	OE	Food	531	AP	Shelt	482	LA	Cons	218	Af	Food	18	Af	Shelt	144	Af	Shelt	85	NA	Food	8.2
7	AP	Food	459	OE	Cloth	403	OE	Cons	245	NA	Cons	18	Af	Trade	141	Af	Trade	84	Af	Food	7.5
8	AP	Trade	395	EU	Food	400	ME	Man	249	LA	Cons	17	Af	Serv	139	Af	Serv	83	AP	Food	6.5
9	Af	Cloth	376	NA	Cloth	397	ME	Mob	250	ME	Food	16	Af	Mob	134	Af	Mob	80	LA	Shelt	5.9
10	Af	Shelt	371	Af	Food	395	AP	Mob	259	Af	Mob	16	Af	Cloth	134	Af	Cloth	79	Af	Shelt	5.7
11	ME	Trade	362	NA	Food	365	NA	Mob	267	Af	Shelt	14	Af	Man	132	Af	Man	79	Af	Trade	5.5
12	AP	Cloth	354	NA	Shelt	364	EU	Mob	270	Af	Man	14	Af	Cons	118	OE	Shelt	76	Af	Cloth	5.4
13	LA	Cons	348	EU	Cloth	363	ME	Trade	284	ME	Mob	13	NA	Food	114	Af	Cons	70	Af	Serv	5.4
14	LA	Trade	347	OE	Food	327	ME	Cloth	293	OE	Shelt	13	OE	Shelt	95	NA	Food	69	Af	Mob	5.3
15	AP	Shelt	337	EU	Shelt	322	EU	Cloth	308	OE	Mob	13	AP	Food	93	LA	Shelt	54	Af	Man	5.2
16	Af	Trade	337	NA	Man	314	AP	Cloth	313	ME	Man	13	EU	Shelt	82	EU	Shelt	52	EU	Shelt	5.1
17	Af	Mob	328	AP	Mob	296	LA	Food	313	EU	Shelt	13	LA	Shelt	82	NA	Shelt	44	AP	Cons	5.0
18	Af	Serv	318	ME	Cloth	293	Af	Mob	319	OE	Food	13	NA	Shelt	71	AP	Food	40	NA	Shelt	4.9
19	ME	Shelt	317	Af	Cloth	269	OE	Mob	334	OE	Man	13	AP	Cons	69	AP	Cons	29	Af	Cons	4.6
20	LA	Mob	300	EU	Man	261	NA	Food	341	Af	Cloth	12	AP	Shelt	63	AP	Shelt	28	AP	Shelt	4.4
21	EU	Cloth	297	NA	Cons	252	EU	Man	343	EU	Food	12	ME	Shelt	41	ME	Shelt	26	ME	Shelt	3.7
22	ME	Mob	291	AP	Trade	234	Af	Serv	345	LA	Food	12	AP	Mob	37	NA	Cons	23	ME	Cloth	3.0
23	ME	Serv	290	Af	Shelt	232	Af	Trade	350	NA	Food	11	AP	Cloth	34	LA	Man	19	OE	Cons	3.0
24	EU	Shelt	283	ME	Food	221	NA	Cloth	350	LA	Mob	11	EU	Cloth	33	ME	Cloth	18	OE	Serv	2.9
25	AP	Mob	279	LA	Mob	206	ME	Shelt	350	NA	Shelt	11	AP	Man	31	EU	Cloth	17	AP	Mob	2.6
26	LA	Serv	263	LA	Trade	195	ME	Food	355	AP	Shelt	11	AP	Trade	31	LA	Cloth	16	ME	Serv	2.6

Table A1. Cont.

	Vulnerable employment (*)			Low-skilled labor (*)			Gender inequality (*)			Occupational health (**)			Child labor (*)			Hazardous child labor (*)			Forced labor (*)		
	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V
27	ME	Cloth	260	Af	Trade	195	LA	Mob	356	AP	Man	10	NA	Cons	30	LA	Mob	16	OE	Trade	2.6
28	Af	Cons	259	LA	Serv	194	NA	Man	357	ME	Cloth	10	NA	Cloth	30	AP	Mob	16	OE	Mob	2.6
29	EU	Trade	258	Af	Mob	190	LA	Man	363	ME	Shelt	10	ME	Cloth	30	NA	Cloth	16	AP	Cloth	2.5
30	NA	Cloth	248	AP	Serv	184	OE	Man	364	AP	Food	9.9	LA	Man	29	NA	Man	16	ME	Trade	2.5
31	LA	Cloth	245	OE	Shelt	184	LA	Cloth	365	AP	Mob	9.8	OE	Cloth	29	OE	Cloth	15	ME	Man	2.5
32	NA	Shelt	241	ME	Shelt	183	AP	Trade	370	OE	Cloth	9.7	NA	Man	27	LA	Serv	15	OE	Cloth	2.4
33	Af	Cons	235	Af	Serv	181	Af	Cons	372	LA	Shelt	9.2	EU	Man	26	EU	Man	15	NA	Cloth	2.4
34	Af	Man	224	LA	Cons	166	EU	Food	377	LA	Man	9.1	EU	Mob	26	LA	Trade	15	ME	Mob	2.3
35	LA	Man	218	ME	Trade	164	AP	Man	381	AP	Cloth	9.1	LA	Cloth	25	EU	Mob	15	AP	Man	2.3
36	NA	Trade	212	EU	Mob	160	AP	Shelt	381	Af	Serv	9.0	LA	Mob	24	AP	Cloth	14	EU	Cloth	2.3
37	EU	Cons	209	OE	Man	154	OE	Food	382	EU	Mob	8.8	AP	Serv	23	EU	Cons	14	AP	Trade	2.2
38	AP	Serv	203	ME	Man	152	Af	Cloth	388	EU	Man	8.5	NA	Mob	23	ME	Trade	14	OE	Man	2.0
39	NA	Cons	198	NA	Mob	152	Af	Man	389	ME	Serv	8.2	ME	Trade	23	AP	Man	14	Af	Cons	2.0
40	EU	Mob	193	Af	Man	150	AP	Food	400	EU	Cloth	8.2	LA	Serv	22	LA	Cons	14	NA	Man	1.9
41	ME	Man	189	Af	Cons	145	OE	Shelt	400	NA	Man	8.0	LA	Trade	22	AP	Trade	13	NA	Cons	1.9
42	LA	Shelt	180	NA	Trade	144	OE	Cloth	402	NA	Cloth	7.9	EU	Trade	21	NA	Trade	13	LA	Man	1.8
43	OE	Trade	180	EU	Cons	139	Af	Food	409	NA	Mob	7.8	EU	Cons	21	NA	Mob	13	LA	Mob	1.7
44	OE	Shelt	177	ME	Mob	136	AP	Serv	417	LA	Cloth	7.3	LA	Cons	20	OE	Man	13	EU	Mob	1.7
45	NA	Mob	168	OE	Cons	125	EU	Shelt	428	Af	Trade	6.4	NA	Trade	19	EU	Trade	13	LA	Trade	1.7
46	EU	Serv	143	ME	Serv	123	EU	Trade	432	OE	Serv	6.1	ME	Man	18	OE	Cons	12	AP	Serv	1.7
47	AP	Cons	131	EU	Serv	122	LA	Trade	432	LA	Serv	5.9	OE	Man	17	ME	Man	12	EU	Man	1.6
48	NA	Serv	113	OE	Mob	121	NA	Shelt	433	ME	Trade	4.9	ME	Mob	17	EU	Serv	11	LA	Cloth	1.6
49	OE	Mob	113	LA	Man	119	Af	Shelt	438	AP	Serv	4.5	EU	Serv	16	ME	Mob	11	LA	Serv	1.6
50	OE	Cloth	102	OE	Trade	118	NA	Trade	439	OE	Trade	4.3	OE	Trade	16	ME	Serv	11	EU	Cons	1.5
51	AP	Man	98	EU	Trade	117	LA	Serv	487	LA	Trade	4.2	OE	Mob	15	OE	Trade	11	NA	Mob	1.4

Table A1. Cont.

	Vulnerable employment (*)			Low-skilled labor (*)			Gender inequality (*)			Occupational health (**)			Child labor (*)			Hazardous child labor (*)			Forced labor (*)		
	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V	Reg	Cat	V
<b>52</b>	OE	Cons	<b>89</b>	OE	Serv	<b>115</b>	EU	Serv	<b>523</b>	AP	Trade	<b>3.4</b>	OE	Cons	<b>15</b>	OE	Serv	<b>11</b>	LA	Cons	<b>1.4</b>
<b>53</b>	NA	Man	<b>88</b>	LA	Cloth	<b>100</b>	NA	Serv	<b>527</b>	EU	Serv	<b>3.2</b>	ME	Serv	<b>14</b>	OE	Mob	<b>11</b>	EU	Trade	<b>1.4</b>
<b>54</b>	EU	Man	<b>86</b>	NA	Serv	<b>93</b>	OE	Trade	<b>532</b>	EU	Trade	<b>2.8</b>	OE	Serv	<b>14</b>	AP	Serv	<b>10</b>	NA	Trade	<b>1.2</b>
<b>55</b>	OE	Serv	<b>75</b>	Af	Cons	<b>85</b>	OE	Serv	<b>578</b>	NA	Serv	<b>2.7</b>	NA	Serv	<b>13</b>	NA	Serv	<b>9</b>	EU	Serv	<b>1.1</b>
<b>56</b>	OE	Man	<b>69</b>	LA	Food	<b>84</b>	LA	Shelt	<b>644</b>	NA	Trade	<b>2.3</b>	Af	Cons	<b>11</b>	Af	Cons	<b>9</b>	NA	Serv	<b>0.8</b>

<sup>1</sup> Values (V) in the following units: (\*) = p-y<sub>eq</sub> in bad labor per 1000 p-y<sub>eq</sub> in total employment; (\*\*) = DALYs per 1000 p-y<sub>eq</sub> in total employment. Regions (Reg): Af = Africa; AP = Asia and the Pacific; EU = Europe OECD; LA = Latin America and the Caribbean; ME = Middle East; NA = North America; OE = Other Europe. Categories (Cat): Cloth = Clothing; Cons = Construction; Man = Manufactured products; Mob = Mobility; Serv = Services; Shelt = Shelter.



## Conflicts of Interest

The authors declare no conflict of interest.

## References

1. BBC. Bangladesh factory collapse toll passes 1000. *BBC News*, 10 May 2013.
2. BBC. Qatar migrant workers “treated like animals”—Amnesty. *BBC News*, 17 November 2013.
3. BBC. Indian worker death rate in Qatar “normal.” *BBC News*, 19 February 2014.
4. McGrath, S. Fuelling global production networks with slave labour? Migrant sugar cane workers in the Brazilian ethanol GPN. *Geoforum* **2013**, *44*, 32–43.
5. Benoit-Norris, C.; Cavan, D.A.; Norris, G. Identifying Social Impacts in Product Supply Chains: Overview and Application of the Social Hotspot Database. *Sustainability* **2012**, *4*, 1946–1965.
6. Kolk, A.; van Tulder, R. Ethics in international business: Multinational approaches to child labor. *J. World Bus.* **2004**, *39*, 49–60.
7. Raynolds, L.T. Mainstreaming Fair Trade Coffee: From Partnership to Traceability. *World Dev.* **2009**, *37*, 1083–1093.
8. Smith, S.; Barrientos, S. Fair trade and ethical trade: Are there moves towards convergence? *Sustain. Dev.* **2005**, *13*, 190–198.
9. Fairphone. *Social Assessment Program—December 2013*; Fairphone: Amsterdam, The Netherlands, 2013. Available online: <http://www.fairphone.com/> (accessed on 7 January 2014).
10. BBC. Intel vows to stop using “conflict minerals” in new chips. *BBC News*, 7 January 2014.
11. O’Rourke, D. The science of sustainable supply chains. *Science* **2014**, *344*, 1124–1127.
12. Baland, J.M.; Duprez, C. Are labels effective against child labor? *J. Public Econ.* **2009**, *93*, 1125–1130.
13. Busse, M. Do Labor Standards Affect Comparative Advantage in Developing Countries? *World Dev.* **2002**, *30*, 1921–1932.
14. Chakrabarty, S.; Grote, U. Child Labor in Carpet Weaving: Impact of Social Labeling in India and Nepal. *World Dev.* **2009**, *37*, 1683–1693.
15. Fung, A. *Can We Put an End to Sweatshops?* New Democracy Forum Series; Beacon Press: Boston, MA, USA, 2001.
16. Phillips, N.; Sakamoto, L. Global Production Networks, Chronic Poverty and “Slave Labour” in Brazil. *Stud. Comp. Int. Dev.* **2012**, *47*, 287–315.
17. Polaski, S. Combining global and local forces: The case of labor rights in Cambodia. *World Dev.* **2006**, *34*, 919–932.
18. ILO. *Accelerating Action against Child Labour: Global Report Under the Follow-Up to the ILO Declaration on Fundamental Principles and Rights at Work: Report of the Director-General*; International Labour Organization: Geneva, Switzerland, 2010.
19. ILO LABORSTA—Database on Labour Statistics. Available online: <http://laborsta.ilo.org/> (accessed on 7 January 2013).
20. ILO. *Global Employment Trends 2014: Risk of a Jobless Recovery?* International Labor Organization: Geneva, Switzerland, 2014.

21. Contreras, S. Child labor participation, human capital accumulation, and economic development. *J. Macroecon.* **2008**, *30*, 499–512.
22. Davies, R.B.; Voy, A. The effect of FDI on child labor. *J. Dev. Econ.* **2009**, *88*, 59–66.
23. Neumayer, E.; de Soysa, I. Trade Openness, Foreign Direct Investment and Child Labor. *World Dev.* **2005**, *33*, 43–63.
24. Ranjan, P. An economic analysis of child labor. *Econ. Lett.* **1999**, *64*, 99–105.
25. Ranjan, P. Credit constraints and the phenomenon of child labor. *J. Dev. Econ.* **2001**, *64*, 81–102.
26. Thorbecke, E.; Nissanke, M. Introduction: The impact of globalization on the world's poor. *World Dev.* **2006**, *34*, 1333–1337.
27. Wade, R.H. Is Globalization Reducing Poverty and Inequality? *World Dev.* **2004**, *32*, 567–589.
28. Basu, K. Globalization, poverty, and inequality: What is the relationship? What can be done? *World Dev.* **2006**, *34*, 1361–1373.
29. Ravallion, M. Looking beyond averages in the trade and poverty debate. *World Dev.* **2006**, *34*, 1374–1392.
30. Basu, K.; Zarghamee, H. Is product boycott a good idea for controlling child labor? A theoretical investigation. *J. Dev. Econ.* **2009**, *88*, 217–220.
31. Swaminathan, M. Economic growth and the persistence of child labor: Evidence from an Indian city. *World Dev.* **1998**, *26*, 1513–1528.
32. Fisher, E.O. Introduction to Heckscher–Ohlin theory: A modern approach. *Int. Rev. Econ. Financ.* **2011**, *20*, 129–130.
33. Ruffin, R.J. A note on the Heckscher–Ohlin theorem. *J. Int. Econ.* **1977**, *7*, 403–405.
34. Nishioka, S. R&D, trade in intermediate inputs, and the comparative advantage of advanced countries. *J. Jpn. Int. Econ.* **2013**, *30*, 96–110.
35. Reimer, J.J. The domestic content of imports and the foreign content of exports. *Int. Rev. Econ. Finance* **2011**, *20*, 173–184.
36. Alsamawi, A.; Murray, J.; Lenzen, M. The Employment Footprints of Nations: Uncovering Master-Servant Relationships. *J. Ind. Ecol.* **2014**, *18*, 59–70.
37. Simas, M.; Wood, R.; Hertwich, E. Labor Embodied in Trade: The Role of Labor and Energy Productivity and Implications for Greenhouse Gas Emissions. *J. Ind. Ecol.* **2014**, in press.
38. U.S. DOL. *List of Goods Produced by Child Labor or Forced Labor 2012—Report Required by the Trafficking Victims Protection Reauthorization Act of 2005*; U.S. Department of Labor: Washington, DC, USA, 2012.
39. Bales, K.; David, F.; Datta, M.; Grono, N. *The Global Slavery Index 2013*; The Walk Free Foundation: Perth, Australia, 2013.
40. Made in a Free World the Slavery Footprint. Available online: <http://slaveryfootprint.org/> (accessed on 7 March 2014).
41. Tukker, A.; Dietzenbacher, E. Global multiregional input–output frameworks: An introduction and outlook. *Econ. Syst. Res.* **2013**, *25*, 1–19.
42. Concha-Barrientos, M.; Nelson, D.I.; Fingerhut, M.; Driscoll, T.; Leigh, J. The global burden due to occupational injury. *Am. J. Ind. Med.* **2005**, *48*, 470–481.

43. Nelson, D.I.; Concha-Barrientos, M.; Driscoll, T.; Steenland, K.; Fingerhut, M.; Punnett, L.; Prüss-Ustün, A.; Leigh, J.; Corvalan, C. The global burden of selected occupational diseases and injury risks: Methodology and summary. *Am. J. Ind. Med.* **2005**, *48*, 400–418.
44. Lopez, A.D.; Mathers, C.D.; Ezzati, M.; Jamison, D.T.; Murray, C.J. Global and regional burden of disease and risk factors, 2001: Systematic analysis of population health data. *Lancet* **2006**, *367*, 1747–1757.
45. Murray, C.J.; Lopez, A.D. *The Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020*; Global Burden of Disease and Injury Series; Harvard University Press: Cambridge, MA, USA, 1996.
46. OECD. *STAN Indicators Database Rev. 3, 2011*; Organisation for Co-operation and Development, 2011. Available online: [http://www.oecd-ilibrary.org/industry-and-services/data/stan-oecd-structural-analysis-statistics/stan-indicators\\_data-00561-en](http://www.oecd-ilibrary.org/industry-and-services/data/stan-oecd-structural-analysis-statistics/stan-indicators_data-00561-en) (accessed on 7 January 2013).
47. Concha-Barrientos, M.; Nelson, D.I.; Driscoll, T.; Steenland, K.; Punnett, L.; Fingerhut, M.; Prüss-Ustün, A.; Leigh, J.; Tak, S.; Corvalan, C. Selected occupational risk factors. In *Comparative Quantification of Health Risks: Global and Regional Burden of Disease Attributable to Selected Major Risk Factors*; World Health Organization: Geneva, Switzerland, 2004.
48. European Commission. *Work and Health in the EU: A Statistical Portrait, Data 1994–2002*; Theme 3—Population and Social Conditions, 2003 ed.; Office for Official Publications of the European Communities: Luxembourg, Luxembourg 2004.
49. ILO. *International Standard Classification of Occupations: ISCO-08*; ILO: Geneva, Switzerland, 2012.
50. UNESCO. *International Standard classification of Education ISCED 2011*; UNESCO Institute for Statistics: Montreal, PQ, Canada, 2012.
51. ILO. *ILO Global Estimate of Forced Labour: Results and Methodology*; International Labour Office: Geneva, Switzerland, 2012.
52. ILO. *Guide to the Millennium Development Goals Employment Indicators*, 2nd ed.; International Labour Office, Employment Sector: Geneva, Switzerland, 2013.
53. Bales, K.; Trodd, Z. *Addressing Contemporary Forms of Slavery in EU External Policy*; European Parliament—Directorate-General for External Policies of the Union: Brussels, Belgium, 2013.
54. Tukker, A.; de Koning, A.; Wood, R.; Hawkins, T.; Lutter, S.; Acosta, J.; Rueda Cantuche, J.M.; Bouwmeester, M.; Oosterhaven, J.; Drosdowski, T.; *et al.* Exiopol—Development and illustrative analyses of a detailed global MR EE SUT/IOT. *Econ. Syst. Res.* **2013**, *25*, 50–70.
55. Tukker, A.; Bulavskaya, T.; Giljum, S.; de Koning, A.; Lutter, S.; Simas, M.; Stadler, K.; Wood, R. *The Global Resource Footprint of Nations: Carbon, Water, Land and Materials Embodied in Trade and Final Consumption Calculated with EXIOBASE 2.1*; The Netherlands Organisation for Applied Scientific Research; Leiden University; Vienna University of Economics and Business; Norwegian University of Science and Technology: Leiden, The Netherlands; Delft/Vienna, Austria; Trondheim, Norway, 2014.
56. Peters, G.; Hertwich, E. *Production Factors and Pollution Embodied in Trade: Theoretical Development*; Industrial Ecology Programme, Norwegian University of Science and Technology (NTNU): Trondheim, Norway, 2004.

57. Miller, R.E.; Blair, P.D. *Input-Output Analysis: Foundations and Extensions*, 2nd ed.; Cambridge University Press: Cambridge, UK & New York, NY, USA, 2009.
58. The World Bank World Development Indicators. Available online: <http://data.worldbank.org/> (accessed on 20 July 2014).
59. Datta, M.N.; Bales, K. Slavery in Europe: Part 1, Estimating the Dark Figure. *Hum. Rights Q.* **2013**, *35*, 817–829.
60. Dillon, A.; Bardasi, E.; Beegle, K.; Serneels, P. Explaining variation in child labor statistics. *J. Dev. Econ.* **2012**, *98*, 136–147.
61. Alvarez, R.; Lopez, R.A. Exporting and performance: Evidence from Chilean plants. *Can. J. Econ. Can. Econ.* **2005**, *38*, 1384–1400.
62. Lai, H.; Zhu, S.C. Technology, endowments, and the factor content of bilateral trade. *J. Int. Econ.* **2007**, *71*, 389–409.
63. Timmer, M.P.; Los, B.; Stehrer, R.; de Vries, G.J. Fragmentation, incomes and jobs: An analysis of European competitiveness. *Econ. Policy* **2013**, *28*, 613–661.
64. Andrew, R.; Peters, G.P.; Lennox, J. Approximation and regional aggregation in multi-regional input–output analysis for national carbon footprint accounting. *Econ. Syst. Res.* **2009**, *21*, 311–335.
65. Bouwmeester, M.C.; Oosterhaven, J. Specification and Aggregation Errors in Environmentally Extended Input–Output Models. *Environ. Resour. Econ.* **2013**, *56*, 307–335.
66. Stadler, K.; Steen-Olsen, K.; Wood, R. The “Rest of the World”—Estimating the economic structure of missing regions in global MRIO tables. *Econ. Syst. Res.* **2014**, *26*, 303–326.
67. Su, B.; Ang, B.W. Input-output analysis of CO<sub>2</sub> emissions embodied in trade: The effects of spatial aggregation. *Ecol. Econ.* **2010**, *70*, 10–18.
68. Xu, Y.; Dietzenbacher, E. *Does the Rest of the World Matter? A Sensitivity Analysis with the WIOD Tables (Sensitivity of Model Results with Respect to Data Availability)*. In Proceedings of the 19th International Input-Output Conference, Alexandria, VI, USA, 13 June–7 July 2011.
69. IBGE. Censo Agropecuário 2006 [Agricultural Census 2006]; Instituto Brasileiro de Geografia e Estatística [Brazilian Institute of Geography and Statistics]: Brasilia, 2007. Available online: <http://www.ibge.gov.br/> (accessed on 4 June 2014).
70. Salami, A.; Kamara, A.B.; Brixiova, Z. *Smallholder Agriculture in East Africa: Trends, Constraints and Opportunities*; African Development Bank: Tunis, Tunisia, 2010.
71. Statistics South Africa. *Quarterly Labour Force Survey, Quarter 4, 2013*; Statistics South Africa: Pretoria, South Africa, 2014.
72. Bussolo, M.; de Hoyos, R.; Medvedev, D. Free Trade in Agriculture and Global Poverty. *World Econ.* **2011**, *34*, 2019–2043.
73. Edmonds, E.V.; Pavcnik, N. Child Labor in the Global Economy. *J. Econ. Perspect.* **2005**, *19*, 199–220.
74. Webbink, E.; Smits, J.; de Jong, E. Hidden Child Labor: Determinants of Housework and Family Business Work of Children in 16 Developing Countries. *World Dev.* **2012**, *40*, 631–642.