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.
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 (1)                   | 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 (1)                   | 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 (1)                   | 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 (1)                   | 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]   |

(1) 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]

\[
\begin{pmatrix}
Z^{11} & Z^{12} & Z^{13} & \ldots & Z^{1n} \\
Z^{21} & Z^{22} & Z^{23} & \ldots & Z^{2n} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
Z^{n1} & Z^{n2} & Z^{n3} & \ldots & Z^{nn}
\end{pmatrix}
\begin{pmatrix}
y^{11} \\
y^{21} \\
\vdots \\
y^{n1}
\end{pmatrix}
= 
\begin{pmatrix}
Z^{x1} & Z^{x2} & Z^{x3} & \ldots & Z^{xn} \\
F_1 \\
F_2 \\
\vdots \\
F_n
\end{pmatrix}
\begin{pmatrix}
y^{11} \\
y^{21} \\
\vdots \\
y^{n1}
\end{pmatrix}
\]

(1)

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” “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-yeq) in bad labor, and in relative values (DALY or p-yeq in bad labor per 1000 p-yeq 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-yeq in bad labor per million euros of GDP); bad labor intensity of consumption (DALY or p-yeq in bad labor per million euros expenditure); bad labor per capita (DALY or p-yeq 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-yeq in bad labor per 1000 p-yeq 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 subsides.
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.

| Total employment | Footprint (1000 p-yeq) | North America | Europe OECD | Non-OECD Europe | Middle East | Latin America | Asia and the Pacific | Africa |
|------------------|------------------------|---------------|-------------|------------------|-------------|----------------|----------------------|--------|
|                  | 340,597                | 442,142       | 140,138     | 64,629           | 193,651     | 1,643,781      | 261,241              |
| Domestic share of footprint | 59% | 49% | 73% | 68% | 92% | 97% | 96% |
| Imports share of footprint | 41% | 51% | 27% | 32% | 8% | 3% | 4% |
| Exports footprint | 10,732 | 23,263 | 22,692 | 15,243 | 36,583 | 283,298 | 99,223 |
| Exports share of production | 5% | 10% | 18% | 26% | 17% | 15% | 28% |

| Vulnerable employment | Footprint (1000 p-yeq) | North America | Europe OECD | Non-OECD Europe | Middle East | Latin America | Asia and the Pacific | Africa |
|-----------------------|------------------------|---------------|-------------|------------------|-------------|----------------|----------------------|--------|
|                      | 77,436                 | 135,302       | 27,759      | 24,443           | 64,262      | 539,060        | 149,147              |
| Domestic share of footprint | 33% | 28% | 49% | 66% | 93% | 97% | 98% |
| Imports share of footprint | 67% | 72% | 51% | 34% | 7% | 3% | 2% |
| Exports footprint | 1367 | 3821 | 3047 | 5955 | 16,010 | 99,916 | 66,816 |
| Exports share of production | 5% | 9% | 18% | 27% | 21% | 16% | 31% |

| Low-skilled labor | Footprint (1000 p-yeq) | North America | Europe OECD | Non-OECD Europe | Middle East | Latin America | Asia and the Pacific | Africa |
|-------------------|------------------------|---------------|-------------|------------------|-------------|----------------|----------------------|--------|
|                    | 69,642                 | 104,618       | 25,589      | 9858             | 36,885      | 768,777        | 75,923               |
| Domestic share of footprint | 32% | 22% | 45% | 48% | 89% | 99% | 97% |
| Imports share of footprint | 68% | 78% | 55% | 52% | 11% | 1% | 3% |
| Exports footprint | 1,136 | 2,166 | 2,450 | 1,493 | 4,058 | 118,907 | 32,602 |
| Exports share of production | 5% | 9% | 18% | 24% | 11% | 14% | 31% |

| Occupational health | Footprint (1000 DALYs) | North America | Europe OECD | Non-OECD Europe | Middle East | Latin America | Asia and the Pacific | Africa |
|---------------------|------------------------|---------------|-------------|------------------|-------------|----------------|----------------------|--------|
|                     | 2138                   | 3616          | 1540        | 697              | 1590        | 15,444         | 3814                 |
| Domestic share of footprint | 36% | 29% | 76% | 78% | 91% | 97% | 98% |
| Imports share of footprint | 64% | 71% | 24% | 22% | 9% | 3% | 2% |
| Exports footprint | 34 | 96 | 286 | 235 | 374 | 2,458 | 1,707 |
| Exports share of production | 5% | 9% | 18% | 24% | 11% | 14% | 31% |

| Child labor | Footprint (1000 p-yeq) | North America | Europe OECD | Non-OECD Europe | Middle East | Latin America | Asia and the Pacific | Africa |
|-------------|------------------------|---------------|-------------|------------------|-------------|----------------|----------------------|--------|
|             | 13,149                 | 26,524        | 8,025       | 3,037            | 9,632       | 96,437         | 43,016                |
| Domestic share of footprint | 28% | 27% | 66% | 67% | 91% | 96% | 99% |
| Imports share of footprint | 72% | 73% | 34% | 33% | 9% | 4% | 1% |
| Exports footprint | 238 | 585 | 922 | 902 | 4,375 | 13,098 | 17,807 |
| Exports share of production | 6% | 8% | 15% | 31% | 33% | 12% | 29% |

| Hazardous child labor | Footprint (1000 p-yeq) | North America | Europe OECD | Non-OECD Europe | Middle East | Latin America | Asia and the Pacific | Africa |
|-----------------------|------------------------|---------------|-------------|------------------|-------------|----------------|----------------------|--------|
|                       | 8276                   | 16,807        | 5966        | 2270             | 6352        | 41,788         | 25,589                |
| Domestic share of footprint | 38% | 36% | 75% | 76% | 92% | 94% | 99% |
| Imports share of footprint | 62% | 64% | 25% | 24% | 8% | 6% | 1% |
| Exports footprint | 201 | 494 | 779 | 761 | 2,923 | 5,553 | 10,601 |
| Exports share of production | 6% | 8% | 15% | 31% | 33% | 12% | 29% |

| Forced labor | Footprint (1000 p-yeq) | North America | Europe OECD | Non-OECD Europe | Middle East | Latin America | Asia and the Pacific | Africa |
|--------------|------------------------|---------------|-------------|------------------|-------------|----------------|----------------------|--------|
|              | 901                    | 1822          | 897         | 332              | 728         | 6822           | 1678                  |
| Domestic share of footprint | 34% | 38% | 81% | 80% | 92% | 97% | 98% |
| Imports share of footprint | 66% | 62% | 19% | 20% | 8% | 3% | 2% |
| Exports footprint | 20 | 52 | 126 | 112 | 353 | 938 | 688 |
| Exports share of production | 6% | 7% | 15% | 30% | 34% | 12% | 29% |
Figure 1. Gross flows of labor embodied in traded goods, in million persons-year equivalent \(^1\).

\(^1\) 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) ¹.

¹ Units: DALYs per 1000 p-y_eq for occupational health damage; share of total employment for vulnerable employment, gender inequality, and low-skilled labor; and p-y_eq in child or forced work per 1000 p-y_eq 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 (1)                      | 0.2          | 0.3        | 1.0             | 0.8         | 0.9           | 1.7          | 5.6    |
| per GDE (2)                      | 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-yeq                   | 6.3          | 8.2        | 11.0            | 10.8        | 8.2           | 9.4          | 14.6   |
| Vulnerable employment (p-yeq)    |              |            |                 |             |               |              |        |
| per GDP (1)                      | 7            | 11         | 19              | 27          | 37            | 60           | 220    |
| per GDE (2)                      | 6            | 11         | 19              | 30          | 37            | 61           | 225    |
| per 1000 inhabitants             | 173          | 250        | 106             | 89          | 139           | 143          | 171    |
| per 1000 p-yeq                   | 227          | 306        | 198             | 378         | 332           | 328          | 571    |
| Women in workforce (p-yeq)       |              |            |                 |             |               |              |        |
| per GDP (1)                      | 12           | 15         | 42              | 19          | 47            | 68           | 148    |
| per GDE (2)                      | 12           | 14         | 42              | 21          | 47            | 70           | 151    |
| per 1000 inhabitants             | 319          | 331        | 234             | 62          | 177           | 162          | 115    |
| per 1000 p-yeq                   | 419          | 406        | 438             | 265         | 423           | 371          | 383    |
| Low-skilled workers (p-yeq)      |              |            |                 |             |               |              |        |
| per GDP (1)                      | 6            | 8          | 17              | 11          | 21            | 85           | 112    |
| per GDE (2)                      | 6            | 9          | 18              | 12          | 21            | 88           | 114    |
| per 1000 inhabitants             | 156          | 193        | 98              | 36          | 80            | 204          | 87     |
| per 1000 p-yeq                   | 205          | 237        | 183             | 153         | 191           | 468          | 291    |
| Child labor (p-yeq)              |              |            |                 |             |               |              |        |
| per GDP (1)                      | 1            | 2          | 5               | 3           | 6             | 11           | 64     |
| per GDE (2)                      | 1            | 2          | 6               | 4           | 6             | 11           | 65     |
| per 1000 inhabitants             | 30           | 49         | 31              | 11          | 21            | 26           | 49     |
| per 1000 p-yeq                   | 39           | 60         | 57              | 47          | 50            | 59           | 165    |
| Hazardous child labor (p-yeq)    |              |            |                 |             |               |              |        |
| per GDP (1)                      | 1            | 1          | 4               | 3           | 4             | 5            | 38     |
| per GDE (2)                      | 1            | 1          | 4               | 3           | 4             | 5            | 39     |
| per 1000 inhabitants             | 19           | 31         | 23              | 8           | 14            | 11           | 29     |
| per 1000 p-yeq                   | 24           | 38         | 43              | 35          | 33            | 25           | 98     |
Table 3. Cont.

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

(1) GDP = Gross Domestic Product, in million euros; (2) 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-yeq 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-yeq 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 1.

1 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-yeq). 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 ¹.

| Vulnerable employment (*) | Low-skilled labor (⁷) | 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 | 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 | ME Food 752 AP Cons 581 EU Cons 129 OE Cons 26 OE Food 178 OE Food 132 ME Food 16 | LA Food 636 AP Cloth 539 AP Cons 135 Af Cons 20 LA Food 173 Af Food 114 LA Food 14 | EU Food 625 AF 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.

| Reg | Cat | Vulnerable employment (*) | Low-skilled labor (*) | Gender inequality (*) | Occupational health (**) | Child labor (*) | Hazardous child labor (*) | Forced labor (*) |
|-----|-----|---------------------------|-----------------------|-----------------------|--------------------------|----------------|---------------------------|----------------|
| 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 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 Food 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 Shelt 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.

| Reg | Cat | V  | Reg | Cat | V  | Reg | Cat | V  | Reg | Cat | V  | Reg | Cat | V  |
|-----|-----|----|-----|-----|----|-----|-----|----|-----|-----|----|-----|-----|----|
| 52  | OE  | Cons | 89  | OE  | Serv | 115 | EU  | Serv | 523 | AP  | Trade | 3.4 | OE  | Cons | 15 | OE  | Serv | 11 | LA  | Cons | 1.4 |
| 53  | NA  | Man  | 88  | LA  | Cloth | 100 | NA  | Serv | 527 | EU  | Serv | 3.2 | ME  | Serv | 14 | OE  | Mob  | 11 | EU  | Trade | 1.4 |
| 54  | EU  | Man  | 86  | NA  | Serv | 93  | OE  | Trade | 532 | EU  | Trade | 2.8 | OE  | Serv | 14 | AP  | Serv | 10 | NA  | Trade | 1.2 |
| 55  | OE  | Serv | 75  | Af  | Cons | 85  | OE  | Serv | 578 | NA  | Serv | 2.7 | NA  | Serv | 13 | NA  | Serv | 9  | EU  | Serv | 1.1 |
| 56  | OE  | Man  | 69  | LA  | Food | 84  | LA  | Shelt | 644 | NA  | Trade | 2.3 | Af  | Cons | 11 | Af  | Cons | 9  | NA  | Serv | 0.8 |

1 Values (V) in the following units: (*) = p-y eq in bad labor per 1000 p-y eq in total employment; (**) = DALYs per 1000 p-y eq 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.

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