Social life cycle assessment of t-shirt supply chains using willingness to pay

Tatsuya Hirokawa¹ · Tomohiko Ihara¹

Received: 14 January 2021 / Accepted: 6 July 2022 © The Author(s) 2022

Abstract
Managing social risks in the supply chain is an important issue that directly affects business performance. However, the existing literature does not provide sufficient quantitative assessment of labor problems for corporate decision-making. This study fills this research gap by conducting a social life cycle assessment (S-LCA) of the T-shirt supply chain from a consumer perspective to quantify labor issues in monetary terms. The framework consists of two approaches: (1) calculation of willingness to pay (WTP) to solve labor problems and (2) inventory analysis. To calculate the WTP, questionnaires were distributed to 203 respondents. The WTP ranged from 344 JPY (labor rights) to 596 JPY (child labor). The WTP was used as an indicator of integration of labor problems. In inventory analysis, working hours were used to quantify the impact on workers. The results showed that working hours were long in the textile and wearing apparel stages. In conclusion, T-shirts manufactured in Vietnam were identified as the least worker-friendly T-shirts sold in Japan, with a social cost of 2,835 JPY. In supply chain stages, child labor was identified as a major problem in India at the textile stage and in Vietnam, at the wearing apparel stage. This study quantifies labor risks through a cost–benefit analysis, thereby contributing to the development of supply chain strategies for companies.

Keywords Supply chain · Social life cycle assessment · Willingness to pay · Labor · T-shirt · Ethical consumption

Introduction
Various labor problems are prevalent worldwide. One such major labor problem currently attracting attention is the concern about forced labor in the Xinjiang Region, China. Many companies are now considering whether to use cotton produced in this region (Lehr 2020). In this regard, attention to labor problems in the supply chain

¹ The University of Tokyo, Tokyo, Japan
has been growing rapidly. However, labor problems in supply chains are nothing new. Child labor in the cobalt supply chain of the Democratic Republic of Congo has been widely researched and is still a serious problem (Calvao et al. 2021; Faber et al. 2017; Sovacool 2021). Furthermore, labor problems are serious social issues not only in developing countries but also in developed countries. In Japan, overtime work is a serious issue, and several studies have examined its impact on physical and mental health (Kuwahara et al. 2018; Tomono et al. 2021).

Social life cycle assessment (S-LCA) is a methodology for assessing the social impact of a product over its value chain. It has been developed especially since the first official guideline was published by the United Nations Environment Programme (UNEP) in 2009. The second version of the guideline published in 2020 suggests that S-LCA can be used typically for three objectives (United Nations Environment Programme (UNEP) 2020). The first objective is to identify the main social hotspots. Umair et al. (2015) studied the social impact in the waste phase of ICT and electronic equipment in Pakistan. They identified negative effects on the worker’s health and the local community as well as positive impacts on local economy. Lenzo et al. (2017) studied the textile sector in Italy and identified occupational injuries and deaths in Italy and child labor in Mongolia as social hotspots. The second objective of S-LCA is to quantify and qualify the social performance of products. Manik et al. (2013) studied the palm oil industry in Indonesia by evaluating the impacts on workers, local community, society, and value chain actors, and integrated these impacts into five categories. Dong and Ng (2015) conducted a case study of building construction sites in Hong Kong, and evaluated the impacts on workers, local communities, and society, and integrated these impacts into a single score in the range of -5 to 5. The third objective of S-LCA is to compare the social performance and social impacts of product systems. van der Velden and Vogtlaender (2017) estimated the social costs of T-shirt production on a monetary basis and compared these costs across different supply chains. Tsalidis et al. (2020) compared the social impact of brine treatment systems in four countries and visualized the endpoint social indicators by medium-risk hours.

Although past S-LCA research has examined these three objectives, they lack the quantification of impacts for corporate use. Manik et al. (2013) and Dong and Ng (2015) conducted an integrated assessment using a Likert scale. Tsalidis et al. (2020) visualized labor problems by medium risk hours. These studies successfully quantified the labor problems, but not the cost to improve the labor problems or the benefits that can be gained from doing so. Van der Velden and Vogtlaender (2017) calculated social costs in monetary terms by computing the cost to achieve sustainable labor practices. Although the authors summarized the results in monetary terms, their approach has two disadvantages owing to its control cost approach. First, it would be difficult to calculate the social cost of labor problems whose countermeasures are difficult to evaluate. The authors used disability adjusted life years (DALY) to evaluate child labor based on medical costs; however, it would not be a reasonable assessment of indecent labor practices. Second, the approach would only show the possible cost needed to improve the supply chain, but not the benefit the company can gain. Companies are concerned about whether they can attract consumers by improving the social impacts of the supply chain (Henisz et al. 2019). Quantification
in monetary terms from the consumer’s perspective enables companies to conduct a cost–benefit analysis. In the field of environmental impact assessment, there is already LIME 3, which proposes a monetary weighting factor that reflects the values of the public (Itsubo et al. 2015; Murakami et al. 2017).

The objective of this study is to develop a methodology to quantify labor problems in supply chains in monetary terms from the consumer’s perspective. We used a two-step methodology. First, we calculated consumers’ willingness-to-pay (WTP) for eight labor problems. The WTP approach has been used in LCA studies to quantify non-market values such as environmental and social impacts (Murakami et al. 2017; Wang et al. 2018). Weighting the eight labor problems by WTP enables the quantification of the total impact on workers. Second, we conducted an inventory analysis to integrate multiple stages of the supply chain. The impact of each stage in the supply chain was summed using the working hours, following previous studies (Benoit-Norris et al. 2012; Tsalidis et al. 2020).

Methods

Outline of the method

The S-LCA is an assessment method, primarily of the unit of a product. Here, the chosen product was a 100% cotton T-shirt. We selected this product since its supply chain is simple and there are previous studies with which we can compare our results (Anh, et al. 2020; Ellis et al. 2012). The methodological flow of this study can be classified into five steps as shown in Fig. 1: classification of labor problems, calculation of WTP for each labor problem, distribution of WTP to each stage of the supply chain, quantification of social cost from labor problems in each stage of the supply chain, and integration of the stages.

In step 1, the labor problems were classified into eight categories.

![Fig. 1 Methodological flow](image-url)
In step 2, the WTP for solving each labor problem was calculated based on the surveys’ results. WTP is a type of methodology used in research that measures the value people find in certain characteristics of a product. WTP is expressed in monetary units, and therefore, can be advantageously used for marketing. Furthermore, it is quantitative. Therefore, one can draw comparisons between different labor problems and the distribution of WTP to different stages. A larger WTP would mean that consumers are willing to solve those problems because they think that the problems are more serious or urgent. The distribution of WTP would be possible by working hours assuming that the longer workers are on duty, the greater the negative effects on them.

In step 3, the WTP was distributed to every stage based on working hours. If workers dedicate substantial time in the wearable apparel stage compared to the transportation stage, then the calculated WTP implies that the value of solving labor problems in the wearable apparel stage is greater than in the transportation stage. This is reasonable because the effects on workers are larger for workers who work for a longer time, if the severity of the impact is the same.

In step 4, the indicators evaluated in the social hotspots database (SHDB) were used to quantify the social cost (Benoit-Norris 2018). This database quantifies the seriousness of each labor problem. Some indicators are quantitative; for instance, the percentage of children involved in economic activity. Others are qualitative; for example, the level of seriousness in forced labor.

Finally, all stages in the supply chain were summarized. Some T-shirts were made from cotton grown in India, manufactured in China, and sold in Japan. Meanwhile, some T-shirts may be made from cotton grown in the U.S., manufactured in Vietnam, and so on. By integrating each stage of production according to each supply chain, the evaluation of each supply chain is possible. This is one of the advantages of the S-LCA method. The data used from SHDB are mostly from 2011 to 2015, depending on the indicators.

### Classification

Table 1 shows the classification of labor problems.

| The classification of labor problems | After rephrasing                  |
|-------------------------------------|-----------------------------------|
| 1 The freedom of association and collective bargaining | Labor rights |
| 2 Child labor                       | Child labor                        |
| 3 Fair salary                       | Unfair wages                       |
| 4 Hours of work                     | Working hours                      |
| 5 Forced labor                      | Forced labor                       |
| 6 Equal opportunity/discrimination  | Gender inequality                 |
| 7 Health and safety                 | Occupational accidents             |
| 8 Social benefit/social security    | Social welfare                     |
Calculation of WTP (direct survey)

To calculate WTP for solving each labor problem, online questionnaires were distributed to a total of 203 participants through a social networking service. Direct questions were asked for calculating the WTP for organic cotton, a better laundry requirement, and to avoid the eight labor problems identified by UNEP. Questions included personal attributes such as purchase frequency of one’s own clothes, the amount of money one spends for clothes in a year, age, and gender. The questionnaire was distributed in both Japanese and English, with 149 and 54 respondents, respectively. Some of the labor problems were rephrased to similar indicators since some indicators were not available or because this change would make it easier for respondents to answer (Table 1). The T-shirt was set as a long-sleeve style and was made of 100% cotton material.

Distribution of WTP to each stage of the supply chain

Working hours were used for distributing the WTP to each stage of the supply chain. According to the SHDB, the working hours ratio of the three stages of textile, transportation, and wearable apparel was 0.48: 0.01: 0.51 (see Fig. 2).

Using working hours enables us to assess the social impacts more quantitatively because the impacts would be larger in sectors where many people work for long hours. This methodology has been used in Benoit-Norris et al. (2012) and Tsalidis et al. (2020).

Quantification of social cost

The seriousness of labor problems in SHDB was quantified in the range between zero and one. This weight was calculated based on the principles listed in Table 2.

For some labor problems, SHDB did not have data. For these problems, the principle shown in Table 3 was adopted to standardize the indicator in the range between zero and one.

Following these principles, each labor problem in each country included in the T-shirt supply chain was quantified.
Freedom of association and collective bargaining

This indicator includes collective bargaining rights, freedom of association, and the right to strike from the SHDB, as there are no clear standards on the same (Dong and Ng, 2015). One of the main sources of this indicator was the 2011 Human Rights Report (U.S. Department of State 2012a). In the SHDB, situations regarding these three rights were described. The best case was defined as “rights recognized” and the worst case was “no laws to secure rights.” The three aspects of labor rights were summarized equally.

Child labor

The definition of child labor varies among organizations. This research cited SHDB’s definition of child labor from the “2011 Findings on the Worst Forms of Child Labor” (U.S. Department of Labor’s Bureau of International Labor Affairs 2011): the percentage of children aged 5–14 years engaged in labor. The seriousness of the problems was cited from the SHDB: risk of child labor in the sector (qualitative).

Fair salary

In the SHDB, the legitimacy of fair salary was evaluated based on a comparison between the legal minimum wage and the average wage of workers in an industry. Weights were calculated according to the principles listed in Table 2.

| Table 2  | Principle of quantifying the seriousness of labor problems (1) |
|----------|---------------------------------------------------------------|
| Level of Seriousness | Value of indicator | Number used for weighting | Weight |
| Very High | Larger than $X_1$ | $X_1$ | 1 |
| High | From $X_2$ to $X_1$ | $\frac{X_1+X_2}{2}$ | $\frac{X_1+X_2}{X_1}$ |
| Medium | From $X_3$ to $X_2$ | $\frac{X_2+X_3}{2}$ | $\frac{X_2+X_3}{X_1}$ |
| Low | Smaller than $X_3$ | $X_3$ | $\frac{X_3}{X_1}$ |

| Table 3  | Principle of quantifying the seriousness of labor problems (2) |
|----------|---------------------------------------------------------------|
| Indicator | The number for weight | Weight |
| $X_1$ | $1 - X_1$ | $(1 - X_1)/(1 - X_a)$\(^a\) |

\(^a\) $X_a$ is the worst score in terms of ranking
**Hours of work**

The percentage of workers who worked 60 h a week was obtained from the SHDB website; this standard has been used as a cut-off in studies (Nakamura et al. 2012; Ogawa et al. 2018).

**Forced labor**

Forced labor is particularly difficult to define. Here, the “Risk of Forced Labor by Sector” in the SHDB, based on data from the U.S. Department of State, Country Reports on Human Rights Practices (U.S. Department of State 2008), was adopted as the only indicator. We used the following definition for forced labor: “to force someone to work based on physical violence, mental violence, illegal behavior or fraud” (U.S. Department of State 2012b).

**Equal opportunity/discrimination**

In evaluating the case of equal opportunity in a country, SHDB does not have much data. One of the most frequently updated indicators of equal opportunity is the “indices of gender equity.” Here, the 2017 score for the Gender Gap Index published by the World Economic Forum (WEF) was adopted (World Economic Forum (WEF) 2017) as the only indicator to quantify equal opportunity. This indicator was selected because it includes economic, political, educational, and health aspects of gender equity and is published almost every year. In the calculations, “1 – score” was used as an indicator of seriousness since a score of one represents the absence of gender inequality (Table 3).

**Health and safety**

Fatal injury rate by sector per 100,000 workers and non-fatal injury rate by sector was used as the indicator for health and safety. There was no clear standard or data in the SHDB to judge how many fatal injuries are equivalent to a certain number of non-fatal injuries. Therefore, they were equally summed.

**Social benefit/social security**

The social welfare system of a country is complicated and difficult to quantify. Here, the 2017 score of the Human Development Index (HDI) by the United Nations Development Programme (UNDP) was adopted (United Nations Development Programme (UNDP) 2017) and calculated as shown in Table 3.
Integration of all stages

There are various stages in a T-shirt supply chain. As noted before, working hours were used to integrate the stages of supply chains (Fig. 3).

Results

Results of direct survey

The direct survey consisted of two questionnaires. Version 1 asked the WTP for child labor, forced labor, gender inequality, and social welfare. Version 2 asked the WTP for fair salary, health and safety, hours of work, freedom of association, and collective bargaining. The number of respondents and the nationalities of the English respondents are shown in Tables 4 and 5.

Incorrect responses were excluded, including negative WTP responses, answers that indicated clothing spending of only five JPY per year, and other responses.

Table 4  Respondents of direct survey

| Number of respondents | Japanese | English | Total |
|-----------------------|----------|---------|-------|
| Version 1             | 102      | 43      | 145   |
| Version 2             | 47       | 11      | 58    |
| Total                 | 149      | 54      | 203   |

Table 5  Nationalities of the English language survey respondents

| Region of the respondents’ nationalities | Number of respondents |
|-----------------------------------------|-----------------------|
| Asia                                    | 39                    |
| Europe                                  | 7                     |
| North America                           | 6                     |
| Oceania                                 | 1                     |
| South America                           | 1                     |
| Total                                   | 54                    |
Table 6 shows the results of the direct survey. WTP for solving labor problems varied from 344 to 596 JPY. The average WTP for organic cotton was 591 JPY, or 23% of the average price of T-shirts.

**Table 6**  WTP results

| Labor problems          | WTP (JPY) |
|-------------------------|-----------|
| Child labor             | 596       |
| Forced labor            | 534       |
| Unfair wages            | 497       |
| Gender inequality       | 494       |
| Social welfare          | 469       |
| Occupational accidents   | 353       |
| Working hours            | 353       |
| Labor rights             | 344       |

Table 6 shows the results of the direct survey. WTP for solving labor problems varied from 344 to 596 JPY. The average WTP for organic cotton was 591 JPY, or 23% of the average price of T-shirts.

**Distribution of WTP**

The WTP calculated as above was distributed to each stage of the supply chain using working hours. For example, the WTP for solving child labor problems was 596 JPY. This amount of money was distributed as shown in Fig. 4.

**Quantification of the social cost in each stage**

According to SHDB, in 2011, Japan’s business service industry imported wearable apparel mainly from China, Indonesia, and Vietnam. Therefore, T-shirts made in these countries, including Japan, were evaluated in this study. SHDB was used to identify countries which exported the textiles to the previously noted manufacturing countries.

Two steps were used to quantify the social costs. First, the information seriousness of labor problems in the respective industries of the corresponding countries
| Country  | Labor rights | Child labor | Unfair wages | Working hours | Forced labor | Gender inequality | Occupational accidents | Social welfare |
|----------|--------------|-------------|--------------|---------------|--------------|-------------------|------------------------|---------------|
| India    | 0.67         | 1.00        | 0.50         | 1.00          | 1.00         | 0.68              | 1.00                   | 0.56          |
| China    | 0.95         | 1.00        | 1.00         | 1.00          | 1.00         | 0.67              | 0.23                   | 0.38          |
| Vietnam  | 0.81         | 1.00        | 1.00         | 0.50          | 0.92         | 0.62              | 0.69                   | 0.47          |
| Thailand | 0.86         | 0.75        | 1.00         | 1.00          | 1.00         | 0.63              | 0.69                   | 0.38          |
| Indonesia| 0.76         | 0.75        | 1.00         | 1.00          | 0.92         | 0.64              | 0.23                   | 0.47          |
was collected from SHDB and other databases such as WEF’s (2017) Global Gender Gap Report or UNDP’s HDI. The seriousness was calculated following the principles explained in the methods section (Tables 2 and 3). An example of the results for the textile producing countries (hereafter, “textile country”) is presented in Table 8.

Second, the WTP distributed to each stage of the supply chain was multiplied with the seriousness to quantify the social cost in each sector.

Integration

Next, the social costs in each stage of the supply chain (step 3.3) were summarized (shown in Table 9). Based on these social costs, one can observe the problematic areas of supply chains in each stage. India had the most serious worker issues as a textile producing country, while Vietnam was the most unfriendly for workers as an apparel producing country (hereafter, “apparel country”). Because the numbers in Table 9 are weighted by working hours, companies can identify labor problems that have a larger impact. Since companies have limited money and must pursue profits, having this information can be meaningful for prioritizing specific problems for resolution.

SHDB has data on the input of each industry in its corresponding country. Based on the input of the apparel industry, the input (in USD) from the textile industry was first arranged in ascending order. By multiplying working hours per USD by imports, the working hours dedicated to textile countries were then calculated. As noted earlier, the effects of labor problems are proportionate to working hours. Therefore, the working hours were used to weight cotton from different countries. Countries were selected if the textile industry input seemed to be less than 90% of the sum of inputs from the textile industries of all countries. After the major countries were selected, the weight by hours was normalized assuming that the major countries were the only countries that exported cotton to a specific country. As shown in Table 10, each supply chain was backtracked to the point of cotton production. The country of transportation was set as the same country as the wearable apparel country.

All related countries were weighted based on working hours and summarized after clarifying the supply chain. The results are tabulated in Table 11.

The results in Table 11 show that T-shirts exported by Vietnam to Japan have the largest impact on workers. Indonesia was the least harmful for workers as a textile country. However, after summarizing the whole supply chain, T-shirts made in Japan were the least harmful T-shirts for workers.

Discussion

Here, we discuss the validity and significance of the proposed methodology. Regarding validity, first, the WTP computed in this study was reasonable. The questionnaire showed that most people cared about labor problems and were willing to pay extra to solve those problems. WTP for solving labor problems varied from 344 to 596 JPY. The average WTP for organic cotton was 591 JPY, which
| Stages      | WTP × Seriousness | Labor rights | Child labor | Unfair wages | Working hours | Forced labor | Gender inequality | Occupational accidents | Social welfare | Total (JPY) |
|------------|-------------------|--------------|-------------|--------------|---------------|--------------|-------------------|-----------------------|---------------|------------|
| Textile    |                   |              |             |              |               |              |                   |                       |               |            |
| India      | 110               | 286          | 120         | 170          | 256           | 162          | 169               | 125                   |               | 1398       |
| China      | 159               | 286          | 239         | 170          | 256           | 160          | 39                | 86                    |               | 1394       |
| Vietnam    | 134               | 286          | 239         | 84           | 236           | 148          | 116               | 107                   |               | 1351       |
| Thailand   | 142               | 215          | 239         | 170          | 256           | 150          | 116               | 85                    |               | 1373       |
| Indonesia  | 127               | 215          | 239         | 170          | 236           | 151          | 39                | 107                   |               | 1284       |
| Transportation |               |              |             |              |               |              |                   |                       |               |            |
| Vietnam    | 2                 | 4            | 4           | 2            | 4             | 3            | 2                 | 2                     |               | 24         |
| China      | 2                 | 4            | 3           | 2            | 5             | 3            | 0                 | 2                     |               | 21         |
| Indonesia  | 2                 | 2            | 4           | 4            | 4             | 3            | 0                 | 2                     |               | 22         |
| Japan      | 2                 | 0            | 0           | 2            | 4             | 4            | 0                 | 0                     |               | 13         |
| Wearing apparel |            |              |             |              |               |              |                   |                       |               |            |
| Vietnam    | 142               | 304          | 253         | 90           | 272           | 157          | 124               | 113                   |               | 1456       |
| China      | 168               | 228          | 253         | 181          | 272           | 170          | 41                | 92                    |               | 1406       |
| Indonesia  | 134               | 106          | 253         | 181          | 251           | 161          | 41                | 113                   |               | 1240       |
| Japan      | 142               | 0            | 63          | 135          | 182           | 179          | 41                | 2                     |               | 743        |
is 21% of the average price of T-shirts. Although direct survey response data are sometimes considered unreliable, this figure is consistent with the findings of Ellis et al. (2012) and Anh et al. (2020), who find values of 25% and 21%, respectively, for organic clothes. Therefore, our WTP for solving labor problems seems reasonable.

Second, the estimated social cost in the supply chain of T-shirts is also reasonable. In this study, the utility of solving labor problems was summarized linearly to quantify labor problems. The estimated social cost in the supply chain of T-shirts made in Vietnam was 2,835 JPY. This is approximately the same price as the original T-shirt. Although this price seems high, two points should be considered. First, these results do not include the positive impacts of supply chains, such as local employment and economic development (Umair et al. 2015; UNEP 2020), Including these indicators would reduce the estimated social cost. Second, while the average premium for socially responsible products is 16.8%, a higher WTP can be expected depending on the type of product and the domain of impact (Tully and Winer 2014). Rousseau (2015) studied the willingness to pay for the fair-trade chocolate in Belgium and found that consumers pay a premium of 2.04 EUR/100 g for fair-trade chocolate. The median price of chocolate used for the

| Table 10 | Calculating working hours ratio in textile countries |
|----------|------------------------------------------------------|
| Wearing apparel country | Textile country | Import (USD) | Working hours per USD | Working hours per USD × Import (USD) | Working hours ratio |
| Japan | China | 1.2 × 10⁻¹ | 2.1 × 10⁻³ | 2.4 × 10⁻⁴ | 0.40 |
| Indonesia | 9.3 × 10⁻³ | 2.1 × 10⁻² | 1.9 × 10⁻⁴ | 0.31 |
| Thailand | 6.7 × 10⁻³ | 4.6 × 10⁻³ | 3.1 × 10⁻⁵ | 0.05 |
| Vietnam | 6.6 × 10⁻³ | 1.7 × 10⁻² | 1.1 × 10⁻⁴ | 0.18 |
| India | 3.0 × 10⁻³ | 1.2 × 10⁻² | 3.6 × 10⁻⁵ | 0.06 |
| China | China | 4.8 × 10⁻¹ | 2.1 × 10⁻³ | 1.0 × 10⁻³ | 1.00 |
| Indonesia | 3.3 × 10⁻¹ | 2.0 × 10⁻² | 6.7 × 10⁻³ | 1.00 |
| Vietnam | 1.4 × 10⁻¹ | 1.7 × 10⁻² | 2.4 × 10⁻³ | 0.89 |
| China | 1.5 × 10⁻¹ | 2.1 × 10⁻³ | 3.1 × 10⁻⁴ | 0.11 |

| Table 11 | Integrated social cost in the supply chain |
|----------|-------------------------------------------|
| Wearing apparel manufacturing countries | WTP × seriousness of labor problems in textile | WTP × seriousness of labor problems in transportation | WTP × seriousness of labor problems in wearing apparel | (JPY) Total |
| Vietnam | 1355 | 24 | 1456 | 2835 |
| China | 1394 | 21 | 1406 | 2822 |
| Indonesia | 1284 | 22 | 1240 | 2546 |
| Japan | 1351 | 13 | 743 | 2107 |
choice experiment was 2.50 EUR. This means that the premium is almost the same as the price of the chocolate. Therefore, our estimated social costs are consistent with past studies.

Next, we discuss two points regarding the significance. First, this study’s WTP approach enabled the cost–benefit analysis that considers various labor problems. This methodology can help in evaluating labor problems whose solutions may be difficult to evaluate and firms cannot simply use the cost control approach. Moreover, while the control cost approach only focuses on the cost to improve or compensate the indecent supply chain, this methodology considers the benefit a company can gain by improving its supply chain. By estimating the cost of improving or changing the supply chain case by case, a company can investigate what measures will be in their interest.

Second, evaluating labor problems from the consumer’s perspective can help visualize issues that are more important to consumers. This study successfully weighted eight labor problems, especially child labor and forced labor problems were the most worrisome for consumers. When we simply sum up the seriousness of labor problems on a scale of 0 to 1 without using WTP, the social costs of T-shirts manufactured in China and Vietnam are 0.763 and 0.758, respectively. This result seems contrary to our finding that Vietnam is the most worker unfriendly. However, this is because of the use of WTP: in Vietnam, child labor is the most serious issue, while China’s most serious issues are labor rights and gender inequality. Participants assigned a higher WTP for solving child labor than labor rights and gender inequality.

Conclusions

We established a methodology to quantify labor problems in supply chains in monetary terms from the consumer’s perspective. We used WTP to quantify labor problems and working hours to weight the different stages of the supply chain. Furthermore, we compared various labor problems among different supply chains using this single indicator. This can be helpful in decision-making in the supply chain strategy. Moreover, since this method is based on the consumer’s view of labor problems, it can be particularly useful for cost–benefit analysis of supply chain changes.

Our case study helped identify the supply chain with the most serious labor problems among the T-shirt supply chains. Child labor in India at the textile stage and child labor in Vietnam at the wearing apparel stage were identified as major problems. Overall, T-shirts manufactured in Vietnam were rated as the supply chain with the worst labor problems. Consumers are suggested to pay 728 JPY more per T-shirt if a company moves its production site from Vietnam to Japan to address labor problems.

Two directions for future research emerge. First, the relationship between personal attributes and WTP can be examined. Ellis et al. (2012) and Anh et al. (2020) mentioned that Asians perhaps pay less for organic cotton. Hwang et al. (2015) also suggested that women are more likely to purchase products made of organic materials, fair-trade labels, and recycled materials. Furthermore, focusing on personal
attributes facilitates targeted marketing. Second, research can consider the positive impacts of supply chains. As discussed, this study only considers the negative impacts of the supply chain by accumulating social costs from labor problems. A more comprehensive discussion of the various impacts of the supply chain can expand the significance of S-LCA research.

Acknowledgements
The authors thank the respondents of the questionnaire for their cooperation in this study.

Author contribution
All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Tatsuya Hirokawa. The first draft of the manuscript was written by Tatsuya Hirokawa and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Funding
This research was funded by the Strategic R&D Area Project “S-14” of the Environment Research and Technology Development Fund.

Data availability
The data are not publicly available due to their containing information that could compromise the privacy of research participants.

Declarations

Conflict of interest
The authors declare that they have no conflict of interest.

Open Access
This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

Anh PTC, Huong LM, Oanh VTK (2020) Generation Z willingness to pay for sustainable apparel: the influence of labelling for origin and eco-friendly material. J Int Econ Manag 20(3):42–59. https://doi.org/10.38203/jiem.020.3.0015
Benoit-Norris C (2018) Social Hotspots Database. http://www.socialhotspot.org. Accessed 6 Jan 2019
Benoit-Norris C, Cavan D, Norris G (2012) Identifying social impacts in product supply chains: overview and application of the social hotspot database. Sustainability 4(9):1946–1965. https://doi.org/10.3390/su4091946
Calvao F, Mcdonald CEA, Bolay M (2021) Cobalt mining and the corporate outsourcing of responsibility in the Democratic Republic of Congo. Extract Ind Soc. https://doi.org/10.1016/j.exis.2021.02.004
Dong YH, Ng ST (2015) A social life cycle assessment model for building construction in Hong Kong. Int J Life Cycle Assess 20:1166–1180. https://doi.org/10.1007/s11367-015-0908-5
Ellis JL, McCracken VA, Skuza N (2012) Insights into willingness to pay for organic cotton apparel. J Fash Mark Manag 16(3):290–305. https://doi.org/10.1108/13612021211246053
Faber B, Krause B, De La Sierra RS (2017) Artisanal Mining, Livelihoods, and Child Labor in the Cobalt Supply Chain of the Democratic Republic of Congo. Center for Effective Global Action Policy Report. https://escholarship.org/uc/item/17m9g4wm. Accessed 14 Nov 2021
Henisz W, Koller T, Nuttall R (2019) Five ways that ESG creates value: Getting your environmental, social and governance (ESG) proposition right links to higher value creation. Here’s why. https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/five-ways-that-esg-creates-value. Accessed 14 Nov 2021

Hwang CG, Lee Y, Diddi S (2015) Generation Y’s moral obligation and purchase intentions for organic, fair-trade, and recycled apparel products. Int J Fashion Des Technol Educ 8(2):97–107. https://doi.org/10.1080/17543266.2014.996917

Itsubo N, Murakami K, Kuriyama K et al (2015) Development of weighting factors for G20 countries—explore the difference in environmental awareness between developed and emerging countries. Int J Life Cycle Assess 23:2311–2326. https://doi.org/10.1007/s11367-015-0881-z

Kuwahara K, Imai T, Miyamoto T et al (2018) Sleep Duration modifies the association of overtime work with risk of developing type 2 diabetes: Japan epidemiology collaboration on occupational health study. J Epidemiol 28(7):336–340. https://doi.org/10.2188/jeaJE20170024

Lehr KA (2020) Addressing Forced Labor in the Xinjiang Uyghur Autonomous Region Toward a Shared Agenda. Center for Strategic and International Studies (CSIS). https://www.jstor.org/stable/resrep25656. Accessed 14 Nov 2021

Lenzo P, Traverso M, Salomone R, Ioppolo G (2017) Social life cycle assessment in the textile sector: an Italian case study. Sustainability 9(11):2092. https://doi.org/10.3390/su9112092

Manik Y, Leahy J, Halog A (2013) Social life cycle assessment of palm oil biodiesel: a case study in Jambi Province of Indonesia. Int J Life Cycle Assess 18:1386–1392. https://doi.org/10.1007/s11367-013-0581-5

Murakami K, Itsubo N, Kuriyama K et al (2017) Development of weighting factors for G20 countries. Part 2: estimation of willingness to pay and annual global damage cost. Int J Life Cycle Assess 23:2349–2364. https://doi.org/10.1007/s11367-017-1372-1

Nakamura S, Sakurai M, Morikawa Y et al (2012) Overtime work and blood pressure in normotensive Japanese male workers. Am J Hypertens 25(9):979–985. https://doi.org/10.1016/j.ajh.2012.37

Ogawa R, Seo E, Maeno T et al (2018) The relationship between long working hours and depression among first-year residents in Japan. BMC Med Educ 18:50. https://doi.org/10.1186/s12909-018-1171-9

Rousseau S (2015) The role of organic and fair trade labels when choosing chocolate. Food Qual Prefer 44:92–100. https://doi.org/10.1016/j.foodqual.2014.05.002

Sovacool BK (2021) When subterranean slavery supports sustainability transitions? Power, patriarchy, and child labor in artisanal Congolese cobalt mining. The Extractive Industries and Society 8(1):271–293. https://doi.org/10.1016/j.exis.2020.11.018

Tomono M, Yamauchi T, Suka M, Yanagisawa H (2021) Impact of overtime working and social interaction on the deterioration of mental well-being among full-time workers during the COVID-19 pandemic in Japan: focusing on social isolation by household composition. J Occup Health 63(1):e12254. https://doi.org/10.1002/1348-9585.12254

Tsalidis GA, Gallart JJE, Corbera JB et al (2020) Social life cycle assessment of brine treatment and recovery technology: a social hotspot and site-specific evaluation. Sustainable Production and Consumption 22:77–87. https://doi.org/10.1016/j.spc.2020.02.003

Tully SM, Winer RS (2014) The role of the beneficiary in willingness to pay for socially responsible products: a meta-analysis. J Retail 90(2):225–274. https://doi.org/10.1016/j.jretai.2014.03.004

U.S. Department of Labor’s Bureau of International Labor Affairs (2011) 2011 Findings on the Worst Forms of Child Labor. from https://www.dol.gov/ilab/reports/pdf/2011tda.pdf. Accessed 23 Jan 2019

U.S. Department of State (2008) 2008 Country Reports on Human Rights Practices. https://www.state.gov/j/drl/rls/hrrpt/2008/index.htm. Accessed 23 Jan 2019

U.S. Department of State (2012a) 2011 Human Rights Reports. https://www.2009-2017.state.gov/j/drl/rls/hrrpt/index.htm. Accessed 6 Jan 2019

U.S. Department of State (2012b) Trafficking in persons report. https://www.state.gov/documents/organization/192587.pdf. Accessed 23 Jan 2019

Umair S, Björklund A, Petersen EE (2015) Social impact assessment of informal recycling of electronic ICT waste in Pakistan using UNEP SETAC guidelines. Resour Conserv Recycl 95:46–57. https://doi.org/10.1016/j.resconrec.2014.11.008

United Nations Development Programme (UNDP) (2017) Human Development Indices and Indicators 2017 Statistical Update. UNDP, New York

United Nations Development Programme (UNDP) (2017) Human Development Indices and Indicators 2017 Statistical Update. UNDP, New York
United Nations Environment Programme (UNEP) (2020) Guidelines for Social Life Cycle Assessment of Products and Organizations 2020. https://www.lifecycleinitiative.org/library/guidelines-for-social-life-cycle-assessment-of-products-and-organisations-2020/. Accessed 14 Nov 2021

van der Velden NM, Vogtlaender JG (2017) Monetisation of external socio-economic costs of industrial production: a social-LCA-based case of clothing production. J Clean Prod 153:320–330. https://doi.org/10.1016/j.jclepro.2017.03.161

Wang T, Wang J, Wu P et al (2018) Estimating the environmental costs and benefits of demolition waste using life cycle assessment and willingness-to-pay: a case study in Shenzhen. J Clean Prod 172:14–26. https://doi.org/10.1016/j.jclepro.2017.10.168

World Economic Forum (WEF) (2017) The Global Gender Gap Report 2017. http://www3.weforum.org/docs/WEF_GGGR_2017.pdf. Accessed 23 Jan 2019