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Social Organizational Life Cycle Assessment of Transport Services: Case Studies in Colombia, Spain, and Malaysia

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Abstract: Freight operations are relevant for economies but can negatively impact society due to the performance of activities related to fuel production, vehicle manufacturing, and infrastructure construction. This study applies the social organizational life cycle assessment (SO-LCA) methodology to analyze the social performance of companies involved in the supply chain of road transport companies located in different contexts such as Latin American, European, and Asian. The results of the three case studies are compared to analyze the methodology's robustness and the influence of development and culture on how social performance is perceived. An approach for the SO-LCA, based on the UNEP/SETAC guidelines, was applied to freight companies in Colombia, Spain, and Malaysia. This integrated approach considers the key components of the transport system: fuels, vehicles, and infrastructure. A multi-tier inventory analysis was performed for 26 social impact subcategories, and reference scale assessments were applied to obtain single and aggregated social performance indexes. Interviews with stakeholders were used to aggregate indexes and identify priorities for decision-making in different contexts. First, the stakeholders concurred that freight companies must focus on labor rights to improve their social performance. The second social category in order of importance was human rights, except in the Spanish case study, where it was socioeconomic repercussions. These results indicate that social impact subcategories are influenced by socioeconomic development and the culture or beliefs of its inhabitants. These specificities help identify hotspots and stakeholder concerns toward which transport companies should direct their efforts. This study expands the range of indicators for social impact measurement and the known literature by investigating social matters for different categories of stakeholders spanning three continents. When these indicators are fully developed, their consideration in management practices could benefit business practitioners.

Keywords: S-LCA; social organizational LCA; freight services; road transport; industrial ecology

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1. Introduction

Transport sector operations have been widely evaluated based on the greenhouse gas emissions generated, as shown by numerous studies that reference the Ecoinvent report No. 14 "Transport Services" [1]. Due to its relevance in socioeconomic development, actions to mitigate the greenhouse gas emissions of this sector have been mainly focused on introducing alternative fuels and intensifying energy efficiency. Some strategies implemented to reduce emissions from vehicle traffic could also have negative socioeconomic impacts in other sectors, such as the biofuel production industry, and indirectly affect the agriculture sector in the regions of producers [2].

The reduction in the environmental impacts of the transport sector could backfire in a society without a systemic and interdisciplinary approach that considers the critical components of the transport system: vehicle manufacturing, fuel production, and infrastructure

construction. Few studies have addressed this systemic analysis of the transport system using a life cycle assessment perspective [1,3,4]. Most only consider the environmental indicators and social costs of the associated pollution. Therefore, studying the social impact of transportation is of interest to the transport industry, administrators, and academics.

Furthermore, studies that included social indicators have mainly focused on analyzing the monetization of traffic externalities, such as congestion, noise, emissions, and infrastructure damage; setting pricing policies; and compensating society [5]. However, most of these studies on external costs report harmful burners and ignore the positive benefits of service value chains [6,7], which are essential considerations in the social life cycle assessment (S-LCA) methodology. In this context, the S-LCA methodology has been developed to address these issues with significant success in recent years [8]. One of the most relevant contributions to the S-LCA methodology is the framework created by the UNEP/SETAC initiative to assess products [9]. This framework was also recently updated to provide additional information and consensus-based guidance based on contributions from different authors over the past decade [10]. Thus, we propose this approach to analyze the social performance of management behaviors that affect society, local communities, suppliers, and clients, as well as to evaluate decisions at the process level that affect the workers of companies in the freight transport sector.

More often than for products, services require shared facilities of more than one organization, such as equipment and infrastructure. The cradle-to-grave or the cradle-to-cradle aspects are hard to define. For a transport service, conducting a single-standing LCA would only analyze a small part of the overall issue, leaving out many valuable insights for sustainability. Here is where the organizational life cycle assessment (O-LCA) enters, as it focuses not only on the organization but also on its supply chain, making an allowance for scope three and assessing a multi-set of impacts, whatever the dimension of sustainability [11–13].

Currently, freight or passengers are the primary services most transport companies provide. Thus, it is more feasible to analyze the social performance of this sector from an organizational approach using SO-LCA.

Contrasting environmental impacts, social impacts are not determined by physical flows but rather by how an organization acts in front of its stakeholders (employees, local community, government/public administration, and customers) [14]. The evaluation of an organization's social performance could be influenced by the relative judgment of the stakeholders involved in the value chain of the product or service. In this sense, this paper aims to analyze the social performance of the life cycle of freight transport services in diverse contexts located on three continents.

This study uses the methodological approach and the results of a previous case study for the integrated SO-LCA of freight transport systems in the city of Kuala Lumpur in Malaysia [15], to be applied in Pereira, Colombia and Zaragoza, Spain.

Aspects such as the availability of information, the relevance of some social impact subcategories, and the stakeholders' perceptions can affect the analysis's development and results. Thus, the results tested in different geographic and socioeconomic contexts have particular relevance in advancing social impact knowledge. The application to three case studies is used to analyze the robustness of the integrated SO-LCA approach for transport systems, the influence of development, and the influence of cultural and socioeconomic aspects on social performance perceptions and their effects on the aggregation of results.

As a complementary outcome, this research expands the range of indicators for measuring social impacts, thus contributing to the development of the SO-LCA methodology. We also provide a new system definition to solve the absence of data and the difficulty related to identifying impacts generated by companies.

The remainder of this paper proceeds as follows. Following this introduction, we describe the study methodology and its application to road freight services in Section 2. The results of three continental case studies are discussed in Section 3. Finally, the conclusions of the analysis are summarized in the last section.

2. Materials and Methods

The applied SO-LCA methodology was based on a revised approach for transport services in Malaysia [15], using the UNEP/SETAC guidelines [9]. In this case, the updated method was also applied to new case studies in Colombia and Spain.

The method considers the four phases described by the ISO 14040 standard [16] regarding a detailed analysis of social impact categories and stakeholders. The system boundaries and impact subcategories are defined in the first phase. In the second phase, the multi-tier inventory analysis method is presented based on the depth and level of detail of the data collection for the activities identified in each stage of the supply chain. In the third phase, the assessment method, defined as a multi-level valuation scale (MLVS), is applied to obtain each transport system's social performance index (SPI). In the fourth phase, the interpretation of results and recommendations are stated for each case study.

2.1. Goal and Scope Definition

The Colombian company was the logistic operator TCL, located in Pereira, the capital of Risaralda, with ~957,000 inhabitants and a GDP per capita of USD 9500 [17]. The system function analyzed in this company was the unitary road freight service in a Chevrolet diesel truck from Pereira to Quibdó, refueled at the Terpel Pereira service station. The Spanish case study was based on the company Vía Augusta, located in Zaragoza, the capital of Aragón, with a population of 1,318,738 inhabitants and a GDP per capita of EUR 26,328 [18]. The system function analyzed was the unitary road freight service in a Scania diesel truck from Zaragoza to Almusàfes, refueled at its service station. Finally, the Malaysian company was Prima Transport & Trading Bhd, located in the metropolitan area of Kuala Lumpur, with ~7.3 million inhabitants and a GDP per capita of USD 24,000 [19]. The system function analyzed was the unitary freight service in a Nissan diesel truck from Kuala Lumpur to its primary customer in Kulim, refueled at the Petron South City service station.

The reporting units in these case studies were all reporting organizations, as suggested by the SO-LCA approach. Despite this fact, for the system boundary definition, the system functions were also necessary to identify the value chains in each transport system component, their geographical locations, and the affected stakeholders.

In this sense, each system component was split into different stages to identify the companies in charge of each activity. Retail distribution was excluded because retailers, such as truck dealers, fuel stations, and road operators, are subsidiaries of the corresponding parent company; therefore, it was assumed that they followed the sustainability-related guidelines imposed by the brands they represented. Through questionnaires to the managers of the companies and preliminary analyses of direct suppliers through secondary sources, the companies involved in the value chains were identified and are shown in Figure 1, where (a) is for the Colombian case study and (b) is for the Spanish case study.

The corresponding system functions were as follows: for the Colombian case study, Colmotores manufactured the Chevrolet NPR truck mostly with Colombian-made auto parts [20]. Terpel was the wholesaler of diesel purchased from Ecopetrol, the only diesel producer in Colombia, mostly from local oil [21]. For the Spanish case study, Scania trucks were manufactured and assembled in different factories in Sweden, The Netherlands, and France. For this reason, only actions by the companies in these countries were analyzed. The main parts of the trucks were manufactured in Swedish Scania plants [22]. Vehicles refueled with diesel at service stations from their own company, mainly supplied by Repsol. The diesel was produced in Spain from imported oil, mostly from Nigeria, the leading oil supplier in the assessed period (14.9%) [23]. Finally, in the Malaysian case study, the truck was manufactured by Nissan Diesel Motor Co. in Ageo, Japan, which later changed its name to UD Trucks Corporation [24], with Japanese-made auto parts. The refueling station, flagged by Petron Malaysia, was supplied by the same company with locally refined and produced oil [25,26]. The utilized highway was built by Projek Lebuhraya Utara-Selatan Berhad [27,28]. The primary road materials were acquired locally [28].

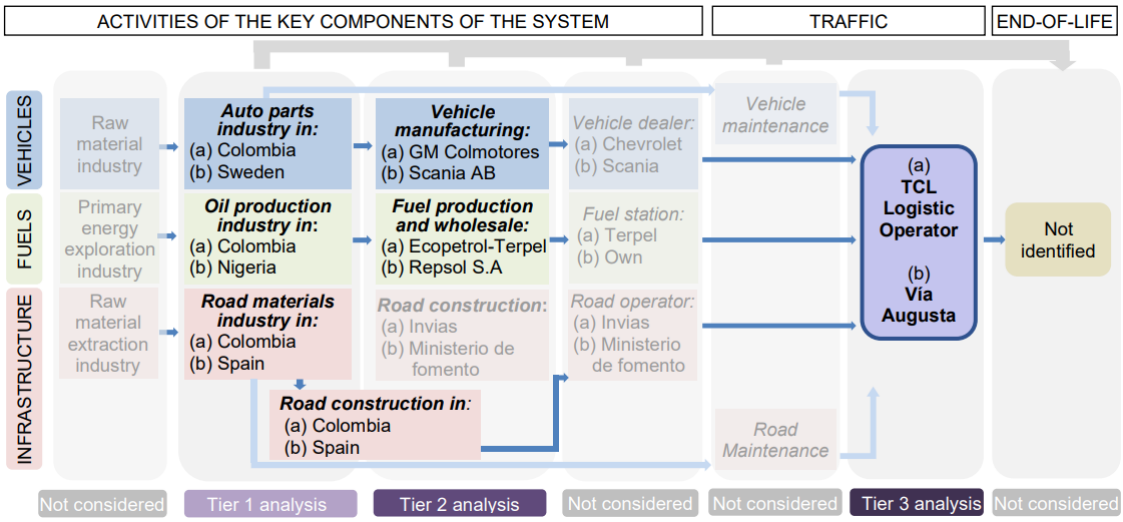

Figure 1. Delimitation of the transport systems.

For the Colombian and Spanish case studies, the roads were not constructed for one identifiable company or consortia [29,30], and the respective states performed the road operation and maintenance activities. Therefore, an adjustment in the road construction inventory analysis needed to be proposed, as detailed in the next section. The road construction materials were mainly locally manufactured in both case studies [31,32]. End-of-life activities were not considered because of the lack of traceability or information.

Following the methodology described by Osorio et al. [15], 5 stakeholders (workers, clients, local community, society, and other actors) and 26 impact subcategories were considered among those recommended in the methodological sheets for subcategories in S-LCA [33]. The "client" stakeholders were included because a delayed delivery or damaged goods could importantly affect users. The stakeholder "other actors" represents suppliers, competitors, and public administration.

For this impact subcategory selection, risk assessment through secondary sources was performed. However, given that companies in the supply chain operate in different countries, many subcategories with high risks of adverse impacts were obtained. In this sense, it was decided to analyze the same 26 subcategories for the three case studies, some of which might be notably relevant for some countries and others not. For example, aspects such as child and forced labor or impacts on indigenous communities are not pertinent issues in Spain. However, the analyzed road freight company had indirect suppliers from Nigeria, where these social aspects might be significant issues.

2.2. Inventory Analysis

We applied a multi-tier inventory analysis to evaluate the different organizations involved in the value chains. Organizations fully identified, such as suppliers of the freight companies, were assessed by specific data. On the other hand, suppliers of these recognized organizations were evaluated on a sectorial basis using generic data because there can usually be many different organizations, making it difficult to analyze each one by specific data. Therefore, analysis performed by generic data was defined as Tier 1, while analyses conducted by detailed data were described as Tiers 2 and 3, presented at the bottom of Figure 1.

The Tier 1 analysis was based on open-access international reports and rankings, periodically published with recognized rigor and impartiality. For the Tier 2 analysis, data were gathered from sustainability and CSR reports of each company, as well as complemented and contrasted by reports from public and non-governmental organizations or objective media. The collected information was limited to actions performed in national territories over the past five years. The Tier 3 analysis represents an in-depth analysis conducted on the freight transport company, complementing the specific analysis with

information from primary sources, such as visits to the organization's facilities and semi-structured interviews with stakeholders. These interviews were also used to collect data for weightings to be utilized later for aggregating results in the impact assessment phase.

For both generic (Tier 1) and specific (Tier 2 and 3) analyses, we defined lists of indicators per impact subcategory presented in Supplementary Material S1, in Tables S1-1 and S1-2, respectively. For the specific analyses, we utilized three indicators per impact subcategory to collect data related to compliance with a basic requirement and the organizations' positive or negative actions. Most of these indicators were defined based on publications such as the methodological sheets for subcategories in S-LCA [33], the subcategory assessment method (SAM) [34], and the PSIA Handbook [35]. The utilized interview and questionnaire templates for primary data collection are also presented in Supplementary Material S1.

The inventory data for the case studies are presented in Supplementary Material S2. For the stakeholder interviews, the profiles of the respondents are given in Table S2-1. In accordance with confidentiality and data protection policies, the names of the interviewees and the company or institution to which they belong are not listed.

The inventory analyses for the cases in Colombia and Spain included an adjustment in the applied Tiers presented in Figure 1. As a result of the concessions of the roads in Colombia and Spain not granted to individual organizations, in contrast with the previous case study conducted in Malaysia [15], the analyses of the road construction subsectors in Colombia and Spain have been defined as Tier 1+. In this new level of analysis based on generic data indicators, information was collected for the subsectors plus complementary indicators to achieve greater precision in the subcategories for which generic data were only obtained at the country level. A list of complementary indicators is presented in Table S2-2.

2.3. Impact Assessment

The multi-level valuation scale method characterizes the results of each inventory analysis level through valuation in an intensity scale of qualitative polytomous variables. Subsequently, a weighted aggregation of the 26 impact subcategories into five more general social impact categories was conducted. Additionally, weighting of the results was performed to obtain a single index of the social performance of the system.

2.3.1. Social Impact Subcategory Classification and Characterization Methods

Given the different resolution or detail of the data collected in each level of inventory analysis, impact measurement methods based on referencing scales or performance reference points (PRPs) were applied. These PRPs address the indicators' values according to international, national, sectoral, and regional thresholds. For the Tier 1 and +1 analyses, the reference scales were based on international conventions and best practices as benchmarks to categorize the sectoral performance into five labels. The labels were defined mainly by quintiles of the lists or rankings of the referenced sources, as presented in Supplementary Material S3, in Table S3-1. Impact subcategories analyzed by generic data usually reveal the risk level of encountering negative or/and positive impacts [36] and are therefore often assessed by four labels (e.g., low, medium, high, and very high risk). However, given that a low risk of adverse impacts might suggest a very positive social behavior of the sector or country to reduce the adverse effects above the international standards, we proposed to evaluate the Tier 1 and +1 analyses with five labels ranging from very negative (score 1) to very positive (score 5) performance. The complementary data collected for Tier +1 analyses refine the results by improving or worsening the obtained score by one scale, as described in Table S3-2.

For specific inventory analyses, the results were calculated by combining the data from the three indicators per subcategory, obtaining scores from 0 to 10—starting from a base score of 5 and adding or subtracting up to 5 points based on the positive or negative findings. A neutral score means that there are no behaviors in the impact subcategories with negative tags (e.g., forced labor, corruption, or unfair competition) or that the company only meets the minimum legal requirements in the impact subcategories with positive tags

(e.g., equal opportunities and respect for indigenous rights). In this sense, a score over 5 points means that the company conducts activities to reduce harm or improve positive impacts beyond the legal requirements. The reference scale assessment guide is presented in Table S3-3.

The impact assessment results for each level of inventory analysis are presented in Supplementary Material S4 and normalized to scales from 1 to 5, as shown in Table 1 and presented in Table 2. Although the obtained social performance indexes on the scale from 0 to 10 are converted to a scale of 1 to 5, as used in the Tier 1 analysis, and color is added, the scores for specific analyses in Table 2 were kept on a 0–10 number scale to identify slight differences in the findings for each company.

In Table 2, the results in the column "Transport company" were calculated using Table S3-3 comprising primary data collected by questionnaires and visits to the assessed freight companies. On the other hand, the results in the column "Stakeholders interviews" were based on the scores given by representatives and experts about the perceived social performance of road freight companies in the region for each impact subcategory; questions B.6 to B.10 are presented in Supplementary Material S5. These scores were only utilized to contrast significant variations in the "Transport company" column and revalidate, correct, or justify the data collected for each impact subcategory.

2.3.2. Aggregation and Presentation of Results

The results of the reference scale assessment were aggregated into five more general impact categories (human rights, labor rights, heritage and communities, socioeconomic repercussions, and governance) to obtain social performance indexes (SPIs). This vertical aggregation was performed on a weighted basis because some subcategories could be more relevant than others in each impact category. Hence, we calculated priority indexes from interviews with stakeholders, where respondents ranked each subcategory in its corresponding impact category. The priority indexes of the impact subcategories derived from the stakeholders' interviews are presented in Table 3.

The priority indexes in Table 3 reflect the relevance of the stakeholders and experts to each impact subcategory, which were analyzed in questions B.11-1 to B.11-5, presented in Supplementary Material S5. The value for each subcategory was calculated by the sum-product of the times ranked in the position by the inverse scale of the ranking.

Table 1. Aggregation of scores on a scale of 1 to 5.

Original Scale	New Scale		Color	Label
Continuous	Discrete	Continuous		
0.00–1.99	1	1.00–1.79		Very negative
2.00–3.99	2	1.80–2.59		Negative
4.00–5.99	3	2.60–3.39		Neutral
6.00–7.99	4	3.40–4.19		Positive
8.00–10.00	5	4.20–5.00		Very positive

Table 2. Reference scale assessment results for the (a) Colombian and (b) Spanish case studies. Background colors indicate the scores' labels presented in Table 1.

Impact Subcategory		Tier 1						Tier 1+		Tier 2					Tier 3			
		Auto Parts Manufacture		Oil Production		Road Materials		Road Construction		Truck Manufacture		Fuel Production			Transport Company		Stakeholders Interviews	
	Case study	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a) [1]	(a) [2]	(b)	(a)	(b)	(a)	(b)
Child labor										6	7	9	9	8	5	6	4.2	5.3
Forced labor										5	7	8	8	8	5	5	7.2	4.6
Equal opportunities										5	6	5	7	9	4	4	5.4	4.0
Freedom of association										3	7	5	5	9	5	7	6.3	5.6
Fair salary										9	5	10	5	10	4	8	7.0	4.8
Fair work hours										6	8	3	5	10	5	5	4.4	3.6
Health and safety at work										7	5	9	8	9	6	6	6.3	4.8
Social benefits										6	6	9	9	7	6	7	6.7	4.9
Transparency on social issues										8	9	10	8	9	3	6	1.8	4.8
Confidentiality customer info										7	7	8	7	8	6	6	7.3	6.1
Feedback mechanisms										9	7	9	8	9	6	8	7.0	7.0
Delocalization and migration										5	7	6	5	6	5	5	5.1	6.0
Respect for local traditions										6	5	6	6	8	5	5	4.4	5.0
Respect for indigenous rights										5	5	7	5	7	5	5	6.9	5.0
Community involvement										6	6	8	6	10	7	5	2.6	4.9
Healthy and safe living										4	5	4	6	8	5	7	3.8	5.9
Access to material resources										7	6	8	5	8	5	5	5.3	4.9
Access to intangible resources										7	6	8	7	9	5	6	5.0	5.6
Creation of local employment										6	3	10	9	6	9	7	6.2	4.7
Contribution to economy										6	6	10	10	7	7	7	5.8	5.1
Prevention of armed conflicts										7	6	7	6	6	3	5	5.1	5.2
Technological development										8	10	7	8	10	4	8	3.3	6.7
Corruption										6	7	3	7	9	4	5	1.9	5.8
Commitment on sustainability										9	7	8	8	7	5	5	3.8	5.8
Suppliers relationship										8	6	8	7	8	6	7	5.0	7.1
Unfair competition										6	5	5	4	4	7	6	3.6	5.0
Average score	(Scale of 1 to 5)	3.04	4.00	2.96	2.58	2.96	3.62	2.85	3.65	3.57	3.52	3.92	3.74	4.22	3.11	3.40	3.02	3.13
Standard deviation		0.77	0.94	1.15	1.14	0.87	0.90	0.83	0.75	0.60	0.56	0.84	0.64	0.59	0.53	0.45	0.64	0.33

[1] Oil refiner [2] Fuel distributor.

Table 3. Priority indexes of subcategories by impact categories for the case studies.

Impact Categories	Impact Subcategory	Priority Indexes		
		Colombia	Spain	Malaysia
Human rights	Child labor	0.42	0.28	0.40
	Forced labor	0.30	0.35	0.31
	Equal opportunities/discrimination	0.27	0.37	0.29
Labor rights	Freedom of association	0.15	0.13	0.14
	Fair salary	0.26	0.25	0.24
	Fair work hours	0.19	0.21	0.22
	Health and safety at work	0.21	0.23	0.24
	Social benefits/social security	0.19	0.18	0.16
Heritage and communities	Delocalization and migration	0.11	0.11	0.08
	Respect for local traditions/cultural heritage	0.08	0.09	0.13
	Respect for the rights of indigenous communities	0.14	0.07	0.13
	Community involvement	0.14	0.14	0.15
	Healthy and safe living conditions	0.17	0.20	0.17
	Access to material resources	0.12	0.13	0.12
	Access to intangible resources	0.10	0.11	0.08
	Transparency on social issues	0.14	0.14	0.14
Socioeconomic repercussions	Creation of local employment	0.23	0.23	0.18
	Contribution to the national economy	0.20	0.16	0.19
	Prevention and mitigation of armed conflicts	0.12	0.12	0.10
	Technological development	0.13	0.16	0.15
	Suppliers' relationships	0.13	0.15	0.14
	Confidentiality with customer information	0.10	0.10	0.13
	Feedback mechanisms	0.08	0.09	0.11
Governance	Public commitment to sustainability issues	0.30	0.37	0.25
	Corruption	0.39	0.30	0.40
	Unfair competition	0.30	0.33	0.35

This vertical aggregation was performed by a sum-product of the results of Table 2 with the priority indexes of Table 3, as shown in the cells for the weighted SPI in the impact assessment spreadsheet of Supplementary Material S6. Subsequently, we further aggregated these results to obtain single SPIs by impact categories for the whole systems by performing a horizontal aggregation of the different activities in the supply chain, as presented in Figure 2. This horizontal aggregation (from the perspective of Figure 1) was conducted by giving greater weight to the companies or activities closest to the area of operation and to the results obtained with specific analyses, instead of calculating simple averages, based on the weighting factors of activities presented in Table S4-1. This analysis responds to the stakeholders' pressure to define the social performance of transport companies in the region and to present the results to shareholders and society in general by a lower number of indexes. Noteworthily, these higher weights given to activities near the road freight company could be argued. For example, to give more relevance to negative impacts such as child and forced labor when they occur in Spain—than in third countries where the suppliers are located—would be immoral. As SO-LCA also considers the positive

performance of companies that contribute to the economic development and well-being of the local community (such as investments in infrastructure, knowledge transfer, royalties, local employment, and scholarships, among other activities), these benefits have little to no impact on the Spanish community when their suppliers socially contribute to another country. Nevertheless, given that these weighted aggregations in SPIs can incorporate subjectivity, sensitivity analyses were necessary and are presented in the next section.

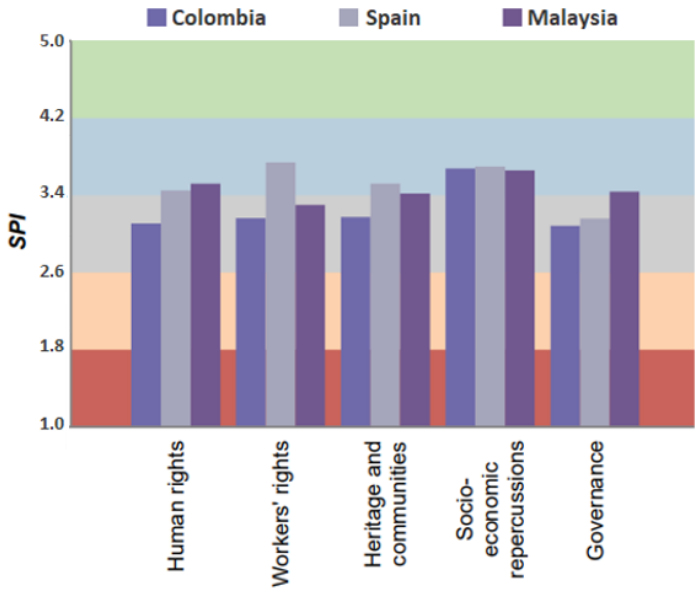

Figure 2. SPIs of the system by impact category. Note: Background colors correspond to the aggregated valuation labels for the new continuous scales in Table 1 (from very negative to very positive). The underlying data used to create this figure can be found in Supplementary Material S7.

To calculate the ASPIs of the systems, Figure 3 shows the priority indexes for the five impact categories, obtained similarly to the priority indexes of subcategories, from information collected in question B.12. Hence, the obtained ASPIs of the systems for the case studies in Colombia, Spain, and Malaysia were 3.22, 3.54, and 3.45, respectively. The complete spreadsheet for the indexes' calculation is presented in Supplementary Material S6.

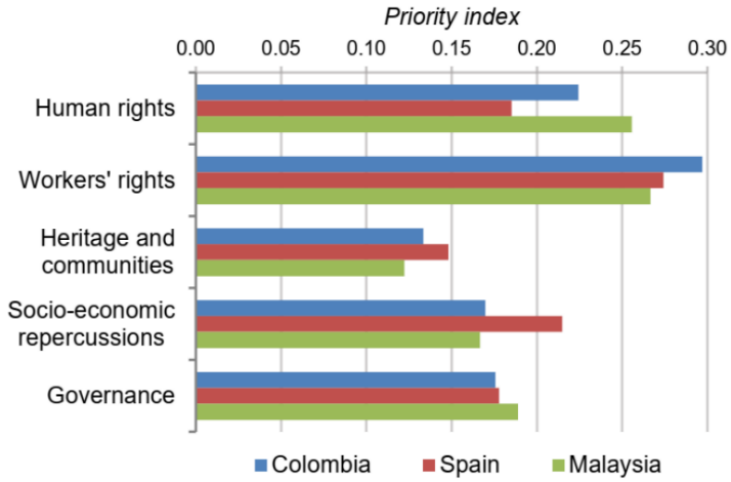

Figure 3. Priority indexes of social impact categories. Note: The underlying data used to create this figure can be found in Supplementary Material S7.

2.4. Interpretation of Results

2.4.1. Preliminary Conclusions

The Colombian case study's ASPI of 3.22 is in the neutral performance range. The components with the highest contribution in the socioeconomic repercussions category were traffic and fuels, mainly due to the impact subcategories of creation of local employment and contribution to the national economy, which had the highest priority indexes in this category. However, the positive SPI in this category did not increase the ASPI to a greater extent because this category had low relevance for stakeholders (Figure 3).

The fuel component had a positive SPI for the human rights category due to companies' policies and efforts to prevent child and forced labor. The human rights SPI was affected by the low participation of women in the entire system. For labor rights, the SPI for the infrastructure component was negative, mainly due to weaknesses in the health and safety of workers and limitations for the freedom of association given the type of temporary hiring and the safety risks [36,37]. Overall, this negative SPI was offset by the very positive scores in fair salaries and social benefits in vehicle manufacturing and fuel production activities. The infrastructure component also yielded a negative SPI in the governance category due to corruption in the sector and unfair competition by cement companies [38]. The transport company presented a negative performance related to the absence of mechanisms to prevent corruption and public reporting of company activities. Another low score was obtained in technological development due to evidence of outdated facilities, equipment, and vehicles.

For the Spanish case study, the ASPI was 3.54, which ranked in the positive performance range. Overall, the impact categories obtained positive SPIs, except for the governance category (Figure 2), mainly because of unfair competition in the value chain. The highest SPI was for labor rights, mainly due to Spain's positive scores for freedom of association and fair work hours. Meanwhile, the activity that negatively affected the ASPI was oil production in Nigeria (see average scores in Table 1), mainly because of the delocalization of people [39]; unsafe or unhealthy living conditions [40]; and disrespect for the heritage, traditions, and rights of indigenous communities [41–43]. This activity, being conducted outside Spain and one stage behind the fuel production value chain (see average scores in Table 1), had a low weight; otherwise, it would have affected the ASPI to a greater extent. In the transport company, few actions were taken to increase scores. Positive scores were found for fair salaries, technological development, and customer feedback mechanisms. The lowest score was due to the low participation of women.

The Malaysian case study's ASPI was 3.45, rating in the positive range and slightly beyond the neutral performance range. The highest SPI for the impact categories was socioeconomic repercussions. For human rights, good scores in the direct activities of the suppliers for the child labor subcategory were found, but low participation of women affected its SPI. Regarding labor rights, low scores were obtained in the supplier companies' fair work hours and health and safety at work, although the transport company had good performance in drivers' working hours. The highest SPI for the impact categories in the transport company was governance because of the internal anti-corruption policy.

2.4.2. Completeness and Consistency Analysis

Regarding the consistency of these results, since weighting/priority indexes add subjectivity to the study, a sensitivity analysis was necessary to observe how the results were affected when weighting was not applied and to validate the calculation process. In this sense, four scenarios were established, including the results presented in the previous phase, scenario (0). The scenarios shown in Figure 4 are as follows: (0) weighted, including priority indexes; (1) weighted, not including priority indexes; (2) unweighted, including priority indexes; and (3) unweighted, not including priority indexes.

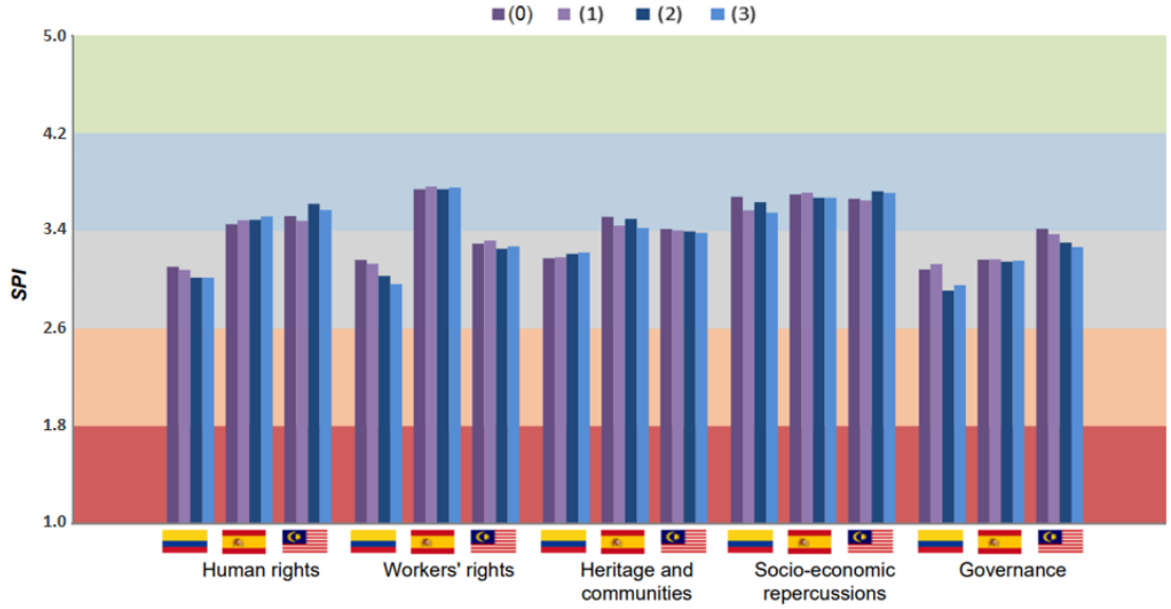

Figure 4. SPIs of the system by impact category and scenario. Note: Background colors correspond to the aggregated valuation labels for the new continuous scales in Table 1 (from very negative to very positive). The underlying data used to create this figure can be found in Supplementary Material S7.

For the Colombian case study, in scenarios (0) and (1), by giving greater relevance to the results of the specific analyses, better SPIs were obtained, except for the heritage and community categories, because the sectoral analyses brought similar results to the other stages of the value chain. The governance category showed high variability in the unweighted scenarios because the scores obtained for the sectors were negative, especially in the corruption subcategory. A significant SPI reduction in the unweighted scenarios was obtained for labor rights because of the negative performance in the sectoral analyses. The SPI for labor rights improved when priority indexes were included because the subcategory of fair salary obtained very positive scores—most important for the stakeholders.

For the Spanish case study, human rights obtained a slight SPI increase in scenario (3) due to the positive scores for child labor in the activities evaluated with the Tier 1 and 2 analyses. When considering the priority indexes, since child labor was less relevant than the other impact subcategories, the SPI for human rights was reduced. The use of priority indexes had a more notable effect in the categories of heritage and communities due to the low weight of subcategories with neutral scores such as delocalization and migration, respect for local traditions, and respect for the rights of indigenous communities.

For the Malaysian case study, human rights increased its SPI in scenario (2) because very positive performances were observed in the Tier 1 analyses for child labor. Regarding governance, the SPIs for scenarios (2) and (3) decreased due to the non-positive sectoral performance related to corruption in the road materials industry in Malaysia and unfair competition in the auto parts industry in Japan.

From the sensitivity analysis, it was also possible to obtain different ASPIs for the system. For the Colombian case study, when introducing the priority indexes of impact categories, the ASPI slightly decreased because the category with the most positive SPI, socioeconomic repercussions, had less relevance than other categories such as labor rights. For the Spanish case study, the ASPI did not suffer significant variations because the negative results for oil production in Nigeria were offset by the positive results for the construction materials in Spain and auto parts in Sweden. In addition, a score similar to those of the transport company was obtained. Meanwhile, in the Malaysian case study, the ASPI remained practically the same because in each stage of the system, similar results were obtained in most subcategories.

2.4.3. Recommendations and Stakeholders' Contributions

In the case study in Colombia, the critical points and the stakeholders' concerns were focused on aspects related to improving worker and human rights and governance. The main problems were freedom of association, fair work hours, and health and safety at work.

Among the short-term decisions to improve the ASPI, the transport company might focus on actions related to its workers, local community, and customers because a change of direct suppliers would not generate significant improvements. Regarding fuels, changing the diesel distributor would not impact the results since it would acquire the fuel from Ecopetrol. For this reason, the only option could be changing the fuel type. At present, natural gas technology is still not technically and commercially mature enough in Colombia to meet the needs of the company's heavy-duty trucks. Changing vehicle suppliers is not an option in the short term since they are still at the beginning of the average service life of trucks in Colombia. Moreover, the utilized road is the only one available for its main destination.

For the case study in Spain, the critical points and the stakeholders' concerns were focused on improving workers' rights. Stakeholders' perception of the social performance of freight transport companies in the region was similar to that found with the evaluation of the transport company, except for the work hours subcategory, since stakeholders perceived that drivers had extensive and irregular working hours. However, in the evaluated company, the schedules are quite regulated.

The transport company could improve the ASPI by analyzing a change of fuel from a primary source other than fossil oil, maintaining the same supplier since the company in charge of oil refining had a very positive SPI. Although the evaluated manufacturer had a positive SPI for the acquisition of alternative fuel vehicles, this index could be better. Therefore, evaluating the social performance of other potential suppliers would be advisable. These recommendations coincide with some stakeholders' opinions, who affirmed that more investment in alternative fuel technologies would be necessary.

For the assessed case in Malaysia [15], the critical points and the stakeholders' concerns were focused on human and workers' rights. For workers, a fair salary was the essential aspect. An aspect belittled by employers and stakeholders was the safety and health at work, where mainly the road construction component had high accident rates. In addition, many truck drivers were not concerned about their safety, driving without safety belts in most vehicles. Another slighted aspect was gender equity, which was considered to a lesser extent than race and religion diversity.

The transport company could improve the SPI by evaluating the purchase of new diesel vehicles from local manufacturers after performing an S-LCA. The use of an alternative fuel was non-viable due to the market immaturity and the delay in developing policies that promote sustainable transport.

These recommendations also coincide with those collected with stakeholder representatives. The majority of respondents in Malaysia and Colombia agreed that to achieve better social performance, associativity should be strengthened, which would improve competitiveness and indicators related to workers' rights. For Spanish stakeholders, since there were already good practices of associativity in different sectors, their recommendations focused on promoting the investment in and development of local suppliers to boost the national economy and working conditions in the life cycle of freight transport.

The three studied cases highlight the implementation and due diligence of codes of conduct for the selection of suppliers and the increase in investment in technological development and environmental and social studies, duly published, serving as an example for competitors, customers, and suppliers, contributing to a more transparent and sustainable sector.

3. Discussion

The transport systems evaluated in Spain, Malaysia, and Colombia obtained ASPIs of 3.53 (positive), 3.45 (slightly positive), and 3.22 (neutral), respectively. These indexes

coincided with the order of the countries in different international rankings related to social aspects. However, the difference between these ASPIs is not considerable compared with the scores or positions of these countries in those international reports because the greater the risk of negative social impacts in the transport system is, the greater the opportunities are for companies to take positive actions against these risks. This way, the performance indexes are compensated and taken to a general level between neutral and positive, as is true for many of the activities evaluated in the case of Colombia. Similarly, despite being positive, the APSI obtained for the case study in Spain is not very distant from the other cases, as might be expected given the good indicators presented by Spain on social issues in many international reports. The reason could be that as there are no potential risks of showing negative social impacts in various subcategories, companies do not invest in positive actions related to them.

In general, the stakeholders in the three countries agreed that companies should give greater attention to workers' rights (Figure 4) to improve the freight transportation supply chain's social performance. The second category of importance was human rights, except for the case in Spain, where the category of socioeconomic repercussions was in second place, reflecting the context of the country in which the risk of human rights violations is low and there are other priorities such as economic recovery. In contrast, in the case of Malaysia, the importance given to human rights was similar to that given to workers' rights, which coincides with the efforts of the Malaysian government in the last decade to improve these social indicators, being one of the countries that has obtained the highest reductions in child and forced labor.

In this sense, the context of each country also influences the assignment of priority indexes of subcategories by impact categories (Table 3). For example, in the human rights category, stakeholders in Colombia and Malaysia gave greater relevance to the subcategory of child labor. However, in Spain, the most important was that of equal opportunities given that child labor is not a big issue in this country, with issues of gender equity and diversity being more critical in general. In the Spanish case, the subcategory of respect for the rights of indigenous communities was the least relevant in the community and heritage protection category, contrary to Colombia and Malaysia, where vulnerable indigenous communities can be found in their territory. Similarly, regarding governance, the subcategory of corruption was the least relevant in Spain, while in Colombia and Malaysia, it was the most relevant, consistent with reports of the corruption perception index [44], where Colombia and Malaysia presented worse results than Spain.

The stakeholder concerns in most assessed aspects showed correlations with the country context. This correlation of the social performance index with the priority index was inversely proportional. In other words, the lower the social performance was, the higher the priority index was. However, in some specific cases, people's perceptions could hide issues, such as the non-positive valuations of gender equality. Equal opportunities or discrimination were often considered the less critical subcategories in the human rights category for those who believe it is not as necessary to give women more working opportunities as it is to abolish race and discrimination for religious beliefs.

Another aspect to highlight in the studied cases is the valuation given by the stakeholders on their perception of the freight companies' performance. These valuations correlated with the characterized results for the transport companies, demonstrating the representativeness of the results obtained by the proposed inventory analysis and impact assessment methods.

The results of these case studies disclose how local contexts affect individual and aggregated social indexes. Although the order of the ASPIs for the three case studies coincided with each country's international ranking related to social aspects, the difference between each of these ASPIs is not considerable. The explanation is that the greater the risk of negative social impacts is, the greater the opportunities are for companies to take positive actions against these risks.

In general, the stakeholders agreed that companies should pay greater attention to labor rights to improve the social performance of road freight services (Figure 2). The second category in order of importance was human rights, except in Spain, where the category of socioeconomic repercussions had greater importance, reflecting Spain's context in which risks of human rights violations are low and economic recovery is prioritized.

In most assessed aspects, stakeholders' concerns were aligned with the country's context. In other words, the lower the social performance was, the higher the priority index was. However, in some cases, people's perceptions may hide some issues, such as non-positive scores on gender equality. The freight performance of companies as perceived by the stakeholders coincided with the transport companies' assessment results, demonstrating the representativeness of these analyses.

Regarding the impact assessment method for Tier 2 and 3 analyses, because positive and negative findings were obtained from three indicators per impact subcategory, the reference scale from 0 to 10 provided a more comprehensive option than the other five-label scales (−2, −1, 0, +1, +2) [35,45]. The use of the 0–10 scale allowed the identification of the actions of a company that can slightly differentiate its performance from other companies. Similar to [46], which encountered the need to define new (sub)labels between the four labels established in the SAM method [34], the 0–10 scale was more flexible for stakeholder interviews. Another difference to the SAM is that this method did not directly consider the influence of socioeconomic contexts in the places of operation. Nevertheless, the positive actions of the companies, influenced by non-positive socioeconomic contexts, increased their performance scores.

A limitation of the assessment method is that when aggregating into impact categories, positive scores in some subcategories offset negative scores in other subcategories. However, priority indexes might reduce this offsetting when more relevance is given to an impact subcategory. Thus, the aggregated score is affected to a greater extent by a positive or negative score. Moreover, priority indexes can help identify where companies should focus their actions to improve their performance.

4. Conclusions

This study enhances the development of the SO-LCA methodology via an integrated assessment of transport systems, providing insights into negative and positive social repercussions related to the life cycle of road freight services in different socioeconomic and geographic contexts.

The results provide evidence on how social impacts are perceived on different continents. Although there is an increasing number of empirical SO-LCA studies, there is a gap in the application of specific indicators to measure the social impacts of highly polluting sectors. Our research aims to contribute knowledge to scholars and practitioners about the social dimension in an industry such as freight transport, both relevant and strategic for the sustainability realm. One of the outstanding novelties of the proposed approach is the organizational perspective, which is analyzed through the methodological contribution and the development of specific inventory analysis.

From this research, we conclude that using the weighting of activities and priority indexes can help measure the social impact of a highly polluting sector. In the framework of sustainability organization and reporting, the influence of the local context plays an essential role in SO-LCA, showing the importance of site-specific data collection to reflect actual social performance. This focus is often omitted by sectoral analyses, which neither consider the differences between regions nor include the negative performance of companies that operate in the informal economy. This study highlights that experts rarely believe, in detail, the social impacts in the analyzed sector at the micro-level. Undoubtedly, companies must implement environmental management measures in which the social dimensions of their activities are integrated with environmental and economic aspects as one of the three pillars of sustainability.

In this context, this study fills the literature gap by reporting social concerns for different categories of stakeholders. Moreover, the contribution of this study to practitioners would materialize through integrating the proposed indicators into management practices, as suggested by environmental and social-accounting scholars. Therefore, managers seeking CE business investments should increase employee engagement to improve specific innovation and management capabilities within firms with the participation of accounting structures. Similarly, policymakers can further promote the inclusion of social measurement in firms based on the net balance of the derived social impacts in a sustainability framework.

Besides their application to weighted aggregation, the priority indexes help identify the critical points with which stakeholders are concerned to establish organizational strategies in sustainability and CSR reports.

In addition to the loss of information when aggregating results, another significant limitation of this impact assessment approach is the combination of negative and positive findings for the initial score calculation, where scores are offset, thus generating a neutral score in many cases. However, their practical use when making business decisions stands out. Hence, expanding the research on how to appropriately aggregate and present the results of positive and negative findings separately is highly recommended.

Supplementary Materials: The following Supplementary Material can be downloaded at: https://www.mdpi.com/article/10.3390/su141610060/s1, Supplementary Material S1: Lists of indicators per impact subcategory for generic (Tier 1) and specific (Tier 2 and 3) analyses and templates for the primary data collection; Supplementary Material S2: Complete social life cycle inventory data for each case study, the profiles of the interviewed stakeholders, and the proposed complementary indicators for the inventory analysis of road construction subsector; Supplementary Material S3: Valuation guides for the reference scale assessment for the generic and specific inventory analyses; Supplementary Material S4: Impact assessment results for each case study and the weighting factors of activities for the aggregation into SPIs; Supplementary Material S5: Interview answers analysis and procedures for the calculation of scores for the road freight transport perceptions (Tier 3 analysis—stakeholders' interviews) and estimation of priority indexes for impact categories and subcategories; Supplementary Material S6: Calculation spreadsheets for the impact assessment of the Colombian case study; Supplementary Material S7: Underlying data used to create Figures 2–4.

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