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Ecologically Friendly Sourcing in Developing Countries: A Non-Food Case Study

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Abstract: The purpose of this paper is to investigate how nearby sourcing versus long-distance sourcing affects the ecological friendliness—operationalized in terms of energy efficiency—of a supply chain for a non-food item in a developing country. Using case research, we show that the average energy needed to supply a pair of imported shoes to a retailer in Morocco is less than the average energy needed to supply a pair of locally produced shoes. These findings highlight the need to assess the true total energy effects of nearby sourcing versus long-distance sourcing since the outcomes of such assessments may be more complicated than they appear upon first glance, particularly in developing countries.

Keywords: energy consumption; supply chains in emerging markets; developing countries; sustainable supply chains

1. Introduction

Sustainability is the ability to meet the needs of the present generation without compromising the ability of future generations to meet their needs [1]. Ways to achieve sustainability include green purchasing and supplier selection [2] and eco-friendly product promotion. Eco-friendly products are those that foster green living, help conserve resources like water and energy, or do not contribute to air, water and land pollution [3]. Locally sourced products are claimed to be more ecologically friendly compared to imported products [4]. However, some argue that imported products put fewer burdens on the environment and are more energy efficient than locally produced ones [5–7].

In the existing literature, most scholars focus on agricultural produce when discussing the eco-friendliness of imported versus local products. Although the concepts of 'wood miles' and 'flower miles' have appeared occasionally in media publications, there is little academic research on the eco-friendliness of non-agricultural products. There is, however, no logical economic reason why food should be the singular focus for such studies [8]. In addition, much of the academic research related to the sustainability performance of imported versus local products has been conducted in only a handful of European Union countries, with Sweden, Denmark, the Netherlands, and the United Kingdom (UK) the most common sites [9]. Few studies have analyzed the energy performance of non-food products in developing countries, although a significant number of products are exported to the developing world on an annual basis.

In this study, we analyze the eco-friendliness of an imported versus a locally produced pair of shoes in a developing country (Morocco). Both are sold to consumers in the Moroccan market. We compare the amount of energy consumed in the supply chains of each of the two examined products.

This paper is structured as follows. The first section briefly reviews the literature on methods used to evaluate the eco-friendliness of different products (food miles, energy consumption, and greenhouse gas emissions) and outlines the method of choice for our analysis. We then present our research methods, data analysis, and a discussion of our research findings. Finally, we identify the limitations of the study and offer suggestions for further research.

2. Theoretical Background

There are several methods used to compare the eco-friendliness of imported and local products. A popular way to depict the burden of a production or action on a planet's environment is through measuring footprints. There are several methods dependent on the issues they address [10], including carbon footprinting (addressing climate change), water footprinting (addressing freshwater use), land footprinting (focused on land use) or material footprinting (focused on material use). A second method, the so-called food miles analysis, estimates the physical distance a product travels from the first-tier supplier through various stages of production until it reaches the supermarket and, finally, the home of the consumer (Saunders et al., 2006). The concept of food miles is often used to "encourage people to think about where their food comes from and how it is produced and got to them, not just what they consume" [11]. Within the food sector, transport has the greatest influence on total costs due to the typically bulky character of food. Furthermore, as transport has a large effect on the environment (e.g., in terms of carbon footprint), reducing food miles is deemed to be an ecologically friendly strategy. A third method monitors the average energy that a product consumes throughout its entire supply chain. It requires converting all figures on energy consumption, both at supply chain nodes and on supply chain arcs, into one of three standardized measurement units: (1) grams of oil equivalent (i.e., energy produced by burning one gram of oil); (2) British thermal unit (i.e., the amount of heat energy needed to raise the temperature of one pound of water by one degree); or (3) megajoule [12,13].

The International Energy Agency [14] shows an ever-growing energy need of the developing world due to, for example, infrastructure expansion and economic growth, which will pose major challenges. For that reason, we focus on the energy consumed in the nodes of the focal supply chain in our study. The measurement of the total energy demanded in this supply chain will help a local company to understand how much energy it takes to produce its products and ship them to final customers, and thus recognize the existing inefficiencies and opportunities for improvement. Furthermore, including the energy consumption in the supply chain decision making of a company will help managers to rationalize the energy use of the company and thus optimize the energy bill.

Existing research comparing the energy demanded by supply chains of local and imported products has focused heavily on food products. Often the scope of these studies is limited to a single stage of the supply chain, primarily the main transport leg. For example, it was found that transporting wheat from the US to Sweden requires 23 times more energy than transporting home-produced wheat [15]. Swedish apples were claimed to require 3.5 megajoules of energy per kilogram as compared to shipping apples sourced from overseas, which required 8.6 megajoules of energy per kilogram [16]. Similarly, shipping apples from Chile to Sweden was found to require 7 times more energy than shipping domestically produced apples [17]. And food imported to Iowa, USA from overseas was found to use 4 to 17 times more fuel than Iowa-based regional and local transport systems [18]. Since food can be grown inside or outside of greenhouses, significant energy differences can also be observed within a region. A study focusing on the production stage of tomato and lettuce supply chains found that tomatoes grown in greenhouses in Europe use 10 to 18 times more energy than openly grown crops overseas; and greenhouse-grown lettuces use 9 to 21 times more energy than openly grown ones [19].

Few studies have attempted to analyze the energy consumed at the supply-chain level. Results from Blanke and Burdick [20] for an apple supply chain confirmed the findings of Carlsson-Kanyama et al. [16]: German domestic apples were found to require less primary energy than imported produce. In the UK, however, researchers could not find clear support that a local supply of apples was superior to a European or Southern Hemisphere supply [21]. Lamb grown in New Zealand and then imported to Germany was claimed to have lower energy inputs than lamb produced in Germany [5]. Similarly, Saunders et al. [6] found that the energy use associated with importing dairy products, lamb, apples, and onions from

New Zealand to the UK is lower than the energy use associated with alternative domestic sources. Other studies focusing on dairy production only found that the UK uses double the energy per tonne of milk solids produced compared to New Zealand, even when factoring in the energy associated with transport from New Zealand to the UK [22,23]. Tomatoes grown in the UK require 36.2 gigajoules of energy per tonne produced; but only 13.2 gigajoules of energy is required if they are imported to the UK from Spain [24]. Similarly, roses grown in Kenya and then imported to Europe consume 100 megajoules of energy; whereas, Dutch roses grown and consumed in the Netherlands consume 317 megajoules of energy [25]. Carlsson-Kanyama compared the energy consumption of Swedish-grown versus imported carrots and found that energy consumption for the imported carrots was double that of the domestic produce [26]. Similarly, the total energy needed to import green beans grown in Kenya to the UK was found to be 12 to 13 times greater than for UK produce [27]. Although research is inconclusive, many studies seem to suggest that local supply chains are not always more energy efficient than import supply chains.

3. Methodology

As described above, several studies (e.g., [5,6,26,27]) have provided empirical results on energy consumption within supply chains of local and imported products. We have observed three limitations of these studies: they are typically focused on food products, they only study part of the supply chain, and they consider trade-offs between local and imported food products from a developed-country perspective only. In our study, we aim to examine the entire supply chain for a non-food item in a developing country.

Case research is a recommended method for examining empirical results in more detail and validating them. Moreover, having fewer cases allows for deeper study and analysis given a fixed set of available resources [28]. The purpose of our study is to first measure and then compare the energy demanded by the supply chains of two similar products: one locally produced and one imported. We analyze the supply chain of shoes since it is a commonly used and relatively frequently purchased product that is available from both international and domestic manufacturers. Since the imported shoes selected for the study are distributed and sold only in Casablanca, we have confined the study to one common geographical area (the Casablanca region) in order to allow for cross supply-chain comparisons.

This study focuses on: (1) the energy used to ship the raw materials from the first-tier suppliers to the manufacturer; (2) the energy used in the production phase; (3) the energy used to ship the finished product from the manufacturer to the wholesaler; (4) the energy used by the wholesaler to store the finished product; (5) the energy used to ship the finished product from the wholesaler to the retailer; and (6) the energy used by the retailer to store the finished product. The study will then identify the causes of any differences in energy consumption between the two investigated supply chains.

Due to lack of data access, the energy consumption associated with the manufacturing of raw materials used in producing a pair of shoes (e.g., glue and leather) is excluded from the analysis. We did not investigate the energy used to transport the finished product from a retail store to a consumer home (the so-called last mile), since no differences are expected for this part of the supply chain. For similar reasons, the possible energy required by the consumer to use the finished product and the energy associated with waste management of the product at the end of its life cycle are also out of the scope of this research.

For this study, the product supplied via the first (local) supply chain is named 'Select Diffusion' and the product from the second (imported) supply chain is called 'Designo Originale' (real names are not disclosed for confidentiality purposes). 'Select Diffusion' shoes are produced and sold in Morocco; 'Designo Originale' shoes are produced in Italy and then exported to be sold, among others, in the Moroccan market. The 'Select Diffusion' and 'Designo Originale' supply chains have similar structures, contain similar components, and are similar in size. This last element is important because energy turnover is closely connected with business size [5].

In our study, we consider diesel as the source of energy used to fuel vehicles. The sources of energy considered to be used in production plants, warehouses, and retail stores are electricity and gas. For each of the different stages, we collected data concerning the quantity of products produced, shipped, warehoused and sold in addition to data regarding the amount of energy consumed. For this collection, we took one year as the time unit based on which we built our calculations.

In order to analyze the collected data, we converted figures for energy consumption into 'grams of oil equivalent' (goe) using coefficients defined in [29]. Converting energy figures into goe enables energy comparison across different energy sources. A differentiation was made between energy used to store goods in buildings (warehouses, plants, shops) and energy consumed while shipping them [12]. Furthermore, we distinguished between goods shipped using trucks versus ships.

For buildings the general formula is [12]:

$$\mathrm{ECP} = \frac{(\mathrm{L} \times 845) + (\mathrm{Ee} \times 121) + (\mathrm{Eg} \times 86) + (\mathrm{Ef} \times 845)}{\mathrm{V}}$$

where:

ECP = Energy consumption per product unit, in goe per kg.

L = Annual fuel use (diesel) for all "handling" vehicles in litres (845 is the conversion factor for diesel).

Ee = Annual electricity energy use in kWh (conversion factor 121).

Eg = Annual use of natural gas energy for heating or propulsion purposes in kWh (conversion factor 86).

Ef = Annual fuel use for heating in litres (conversion factor 845).

V = Annual volume of handled products in kg.

Applying the same principles to a road freight transport leg between two sites is fairly straightforward. The companies provide data on fuel use (litres/100 km) distance, load, truck type and empty runs. From these data, consumption is calculated using [12]:

$$\mathrm{ECP} = \frac{(\mathrm{L} \times (\mathrm{D} \div 100) \times \mathrm{E} \times 845)}{\mathrm{Q}}$$

where:

ECP = Energy consumption per product unit, in goe per kg.

L = Mean fuel use (diesel) computed from all vehicles in the fleet (in litres/100 km).

D = Distance travelled between origin and destination of the supply chain leg.

E = Empty running factor (1 = no empty running; 2 = one empty return trip).

Q = Load per trip in kg.

845 = Energy conversion factor for diesel fuel.

For vessels, we applied the following (Rizet et al., 2008):

$$\mathrm{ECP} = \frac{[(\mathrm{Fs} * \mathrm{ds}) + (\mathrm{Fp} * \mathrm{dp}) \times 1000 \times 952)}{\mathrm{Cmax} * \mathrm{Q} * \mathrm{L}}$$

where:

ECP = Energy consumption per product unit, in goe per kg.

Fs = Average fuel use (heavy fuel) from the vessel (in tonnes per day at sea, t/ds).

Fp = Average fuel use (heavy fuel) from the vessel (in tonnes per day in ports, t/dp).

ds = Number of days at sea from the maritime line.

dp = Number of days in ports for the maritime line.

Cmax = Maximal capacity of the vessel, in TEU.

L = Mean load factor of the observed route, loaded TEU in % of Cmax.

Q = Mean load of one TEU, in product units.

1000 = conversion tonne to kg Heavy Fuel Oil (HFO).

952 = Energy conversion factor for one kg HFO expressed in gram of oil equivalent.

We had two sources of information to obtain the data required to perform the analyses described above. First, we obtained internal documents of the partners in the supply chain (first-tier suppliers, manufacturer, wholesalers and retailers). These were used to deepen our understanding of the internal process and activities of those partners.

We furthermore used focused interviews and semi-structured interviews to collect qualitative and quantitative data for the case studies. Candidates for focused interviews (see Table 1 for an overview) were contacted via telephone, provided with an outline of the value and relevance of the research, and asked if they would be willing to participate in the study. Fortuitously, all contacted candidates welcomed our research plans. The primary contact for our research was a family member of one of the authors, who is a wholesaler in the investigated supply chains, and who knows personally the partners of most of the other supply chains. This contact ensured and facilitated interview access to those best-informed to provide necessary information (i.e., key informants). His help proved to be particularly valuable in acquiring data considered to be sensitive in Morocco, e.g., annual turnover. After the research meetings were set up, but before they occurred, we sent an outline of the topics to be covered, the questions to be asked, and the data we required for the study, in order to ensure interviewees would be prepared for their meetings with us. Next, two or three structured short visits were conducted on site to collect the necessary information using focused interviews lasting 1–1.5 h. We conducted follow-up telephone conversations, as needed, to address any important topics that may have been missed or to clarify interview responses that were not fully apparent to the research team. Since the interviews were more focused on objective data, the benefits of taping were reduced [28]. Furthermore, it is not customary in the Moroccan culture to use tape recorders for interviews.

Table 1. An overview of candidates for focused interviews.

Interviewee ID	Job Position	Supply-Chain Stage	Product Type
Interviewee N1	President of firm	Manufacturer	Local
Interviewee N2	Plant manager	Manufacturer	Imported
Interviewee N3	Vice president of operations	Manufacturer	Local
Interviewee N4	Vice president of operations	Manufacturer	Imported
Interviewee N5	Logistics manager	Freight transportation	Imported
Interviewee N6	Owner and president	Wholesaler	Local/Imported

We also held additional interviews with the other supply chain partners (29 in total). These were conducted mostly via telephone since the number of questions to be asked was limited. However, on some occasions it was necessary to visit supply chain partners at their locations, as they were uncomfortable answering the research questions over the phone.

In order to increase the reliability of our research, multiple sources of data were used. In addition to the interviews, a wide array of relevant, objective operational data and documents were reviewed, including status reports, operational transportation data, and utility bills. In addition, we arranged field visits to several facilities in order to conduct a visual verification of data provided by interviewees, get an overall feel for the systems under study, and have an opportunity to engage informally with the different supply chain partners involved [28]. After gathering the necessary documents and materials on the two investigated supply chains (case studies), we presented the involved organizations with our written reports on the obtained data and asked them to make any necessary corrections or verify that the information was recorded accurately.

We aimed to establish an as complete picture as possible and obtain information from as many participants in the supply chain in scope. In the local supply chain (called 'Select Diffusion') we obtained energy use data and volume for 14 suppliers, 5 wholesalers and 21 retailers all located in Morocco (we cannot identify locations for confidentiality reasons). The import supply chain (called 'Designo Originale') consisted of 12 suppliers, 1 wholesaler and 10 retailers. For confidentiality reasons additional details (e.g., name, location) cannot be shared.

4. Results

We analyzed the total energy needed in the supply chain from shipment of raw materials to manufacturers through to storage of finished products on retail shelves. The energy consumed at the different stages in the supply chain is summarized in Table 2 below. As we discuss below, our findings with regard to energy efficiency differ per supply chain stage.

Table 2. Energy consumed at different supply chain stages per product type (retail in Casablanca region).

Supply Chain Stage	Average Energy Consumed by a Pair of 'Select Diffusion' (local) Shoes in *grams of oil equivalent (goe)*	Percentage (Local Shoes)	Average Energy Consumed by a Pair of 'Designo Originale' (imported) Shoes in *grams of oil equivalent (goe)*	Percentage (Imported Shoes)
Shipment of raw materials	62.35 goe	65%	16.28 goe	18%
Production	13.51 goe	14%	10.55 goe	13%
Shipment of shoes to wholesaler	0.78 goe	1%	41.07 goe	46%
Storage by wholesaler	3.81 goe	4%	3.81 goe	4%
Shipment of shoes to retailer	8.74 goe	9%	7.77 goe	9%
Storage by retailer	6.80 goe	7%	8.95 goe	10%
Total	**95.99 goe**	**100%**	**88.43 goe**	**100%**

4.1. Shipment of Raw Materials

The results indicate that the amount of energy needed to ship raw materials from first-tier suppliers to a manufacturer is larger for local shoes ('Select Diffusion') than for imported shoes ('Designo Originale'). The average energy needed to ship the necessary raw materials to a manufacturing plant is 62.346 g of oil equivalent to make a pair of local shoes and 16.28 g of oil equivalent to make a pair of imported shoes (see Table 2).

The large difference between the energy requirements to ship raw materials for locally produced shoes versus imported shoes has three main causes.

First, the Italian manufacturer (i.e., for the imported shoes) sources most of its raw materials from nearby local suppliers whereas the Moroccan manufacturer (the local producer) sources its raw materials from distant locations within the country. In fact, the farthest location from which the Italian manufacturer of 'Designo Originale' sources its raw materials is 120 km away from the manufacturing plant. By comparison, the farthest location from which the local manufacturer (Select Diffusion) sources its raw materials is 612 km away from the manufacturing plant. The average distance to ship all the raw materials for 'Designo Originale' is 85.43 km, while the average distance to source raw materials for 'Select diffusion' is 309 km. Hence, the difference in the average distance to suppliers of raw materials (and thus the local availability of key supplies) explains the difference in average energy consumed between locally produced and imported shoes.

Second, the Italian manufacturer ('Designo Originale') exclusively uses heavy-duty trucks and midsized trucks to transport raw materials to its manufacturing plant, while the Moroccan manufacturer ('Select Diffusion') additionally uses light trucks to ship its raw materials. More specifically, 'Designo Originale' transports 8 types (66%) of raw materials by midsized trucks and 4 types (34%) by heavy-duty trucks. At the same time, 'Select Diffusion' ships 5 types (36%) of its raw materials by light trucks, 5 types (36%) by midsized trucks, and 4 types (28%) by heavy-duty trucks. The average energy consumption per unit shipped by light trucks is larger than the average energy consumption per unit shipped by midsized and heavy-duty trucks because larger carrying capacity results in shipping economies of scale. Therefore, differences in the size of truck used to ship raw materials from first-tier suppliers to the manufacturer partly explain the difference in average energy consumed between locally produced and imported shoes.

Third, the Italian manufacturer sourced its raw materials from fewer suppliers than its Moroccan counterpart. 'Designo Originale' does business with 12 suppliers, compared to 14 for 'Select Diffusion'—a difference that stems from the latter sourcing its leather and glue from 4 different suppliers and the former sourcing the same materials from only 2 suppliers. Limiting the number of suppliers helps lower the energy consumption of 'Designo Originale' as compared to 'Select Diffusion'.

4.2. Production

The case data demonstrate that the amount of energy needed in the production phase of shoes is larger for the Moroccan manufacturer than the Italian manufacturer. The average energy needed to produce a pair of local shoes in the manufacturing plant of 'Select Diffusion' is 13.51 g of oil equivalent compared to 10.55 g of oil equivalent needed to produce a pair of imported shoes in the case of 'Designo Originale'. There were two main factors causing this large difference in energy requirements.

First, the machines used in the production plant of the Moroccan manufacturer are quite old, however, the machinery used by the Italian manufacturer is quite new. Not surprisingly, the newer machines used by 'Designo Originale' are more energy efficient than the dated production machinery of 'Select Diffusion'.

Second, 'Designo Originale' used fluorescents bulbs to provide the necessary light for its production plant and work offices, whereas 'Select-Diffusion' used incandescent bulbs. This difference is quite important as it has been shown that using fluorescent lighting instead of incandescent bulbs can reduce energy consumption by as much as 75% [30]. Therefore, both direct and indirect production processes were more energy efficient for the Italian manufacturer.

4.3. Transportation of Finished Products

The results indicate that the amount of energy needed to ship shoes from the manufacturing plant to a retailer is larger for imported shoes than for locally produced shoes. The average energy needed to ship a pair of shoes from the manufacturing plant of 'Designo Originale' to retail stores is 48.84 g of oil equivalent compared to 9.52 g of oil equivalent in the case of 'Select Diffusion'.

This large difference between the energy requirements to ship imported shoes versus locally made shoes is explained by the expected longer distance imported shoes must travel to reach retail stores. The imported shoes of 'Designo Originale' traveled on average 2350 km to reach retailers in the Casablanca region, while the locally produced shoes of 'Select Diffusion' traveled on average only 12 km. It is worthwhile stressing, however, that the energy required to deliver the imported shoes to the Moroccan market were less than they might have been as the shoes were transported using ships that traveled directly from the port of Livorno to the port of Casablanca. If, for instance, the shoes had been transported by ship from Italy to Tunisia, and subsequently trucked to Morocco, the energy consumption per unit shipped would have been much larger. The mode of transport is as important as the distance covered when it comes to the level of energy consumed [8].

4.4. Warehousing of Finished Products

The results indicate that the amount of energy needed to store imported shoes is commensurate to the energy required to store locally produced shoes. Specifically, the average energy needed to warehouse a pair of locally produced shoes is 10.61 g of oil equivalent compared to 12.76 g of oil equivalent in the case of imported shoes. This similarity is explained by the fact that the imported and locally produced shoes were stored at the same wholesalers. Furthermore, the retailers were located in the same region (Casablanca in Morocco), where storage conditions were reasonably similar.

5. Discussion

Table 2 summarizes the results of the analysis. In the case of the locally produced shoes, we found that the most energy-intensive part of the supply chain, as analyzed, was the transport of the raw materials to the manufacturing plant, which demanded 65% of total supply chain energy used.

The remaining 35% of total energy used along the 'Select Diffusion' supply chain was demanded by the following processes: 14% for production, 1% to ship the finished products to the wholesaler, 4% to store the finished products at the wholesaler, 9% to ship the finished products to the retailers, and 7% to store the finished products within retail stores.

In the case of the imported shoes, we found that the most energy-intensive part of the supply chain, as analyzed, was the transport of the finished product from the manufacturer in Italy to the wholesaler in Morocco, as it demanded 46% of total energy used. The remaining 54% of total energy used along the 'Designo Originale' supply chain was demanded by the following processes: 18% to ship the raw materials to the manufacturing plant, 13% for the production phase, 4% to store the finished products at the wholesaler, 9% to ship the finished products to the retailers, and 10% to store the finished products within the retail stores.

Combined, the average energy needed for a pair of locally produced shoes to move through its supply chain was larger than the energy required for a pair of imported shoes—specifically, 95.99 g of oil equivalent as compared to 88.43 g of oil equivalent.

We draw the following conclusions from our case analysis.

First, sourcing of raw materials had a major impact on the total energy used in the supply chains of the investigated shoes. More specifically, in the case of locally produced items, the transport of raw materials to the manufacturer had a major impact on the total energy consumption of the supply chain.

Second, the mode of transportation used affects the energy demanded in supply chains. Despite the large distance over which imported shoes were transported from Italy to Morocco, the average energy consumption per pair of shoes shipped was still relatively small (41.07 goe), which may have been related to the mode of transport used. The importance of mode of transport has been highlighted in a number of studies [16,27,31].

Third, the energy associated with the transportation of finished products, as well as product storage at different buildings, is notably less important in the case of shoes as compared to other studies focusing on agricultural products [20,21,32]. The main difference is that many agricultural products must be refrigerated; thus, refrigeration of vehicles, warehouses and retail shops results in greater energy consumption for agricultural products than for shoes.

Fourth, there are issues specific to developing countries. Supply chains are often inefficiently long (i.e., they consist of many entities) and disintegrated (i.e., they consist of many small producers selling products to many small customers). Products might also be processed on a primary and secondary basis by small and medium companies [33,34]. Additionally, distribution networks in developing countries are complex and fine-meshed, as products move into multiple distribution layers including traders, wholesalers, and retail stores [35]. As in other developing countries, supply chains in Morocco consist of many product-handling operations and suffer from a lack of information exchange between partners. As a result, the level of efficiency of in-country supply chains in Morocco is low compared to counterparts in the developed world. Finally, warehouses and retail stores in Morocco are generally less energy intensive than warehouses and retail stores in developed nations due to the fact that they are relatively labor intensive and have little equipment available. This may explain the low energy consumption at the downstream part of the two investigated supply chains compared to similar studies performed in developed countries—such as the studies of Browne et al. [36] and Rizet et al. [12,13].

6. Conclusions

This research compared the average energy use associated with the supply chains of a pair of locally produced shoes and a pair of imported shoes, both sold in the Moroccan market. The supply-chain analysis included shipment of raw materials to the manufacturer, the production process, shipment of the finished products to the wholesaler, storage by the wholesaler, shipment of the finished products to the retailers, and storage by the retailers.

The case study in this project was carried out with the partners of two supply chains, one that supplies imported shoes to the Moroccan market and another that supplies Moroccan-produced shoes. This research has shown that the average energy needed to supply an imported pair of shoes to a retailer in Morocco (88.43 g of oil equivalent) is less than the average energy needed to supply a pair of locally produced shoes (95.99 g of oil equivalent). Our case study analysis suggests that:

- the amount of energy needed to ship raw materials for manufacturing is larger in the case of locally produced shoes compared to imported shoes;
- the amount of energy needed to produce domestic shoes is larger than that for imported shoes; and
- the amount of energy needed to deliver local shoes to retail outlets is lower than that for imported shoes.

The cases confirm that transport has a significant impact on the total energy consumed in the supply chain of imported versus locally produced shoes. As a result, studies that limit the scope of research to the main transport leg can provide important insights into overall supply-chain energy consumption. Our study also identifies the relevance of purchasing decisions for the sustainability of an organization since raw materials sourcing represented a key component in total energy demanded in the supply chains. Our study thereby confirms Tate et al. [37], who argued that supplier selection and managerial decisions related to environmentally friendly purchasing and supply management are key drivers of sustainability of an organization.

The case study results can be compared to some of the previous studies discussed in the literature review. In fact, many food-related studies have also found imported products to be superior to domestically produced products from an energy performance perspective [5,6,19,21–25]. Obviously, energy comparisons between different studies need to be treated with caution due to potential differences in systems boundaries, assumptions made in the work, and data sources used. However, the approach adopted in this case study enables the calculation and comparison of both energy used and environmental impacts for different products across the supply chain. It also provides the opportunity for companies and policymakers to assess the impact of policy measures on an entire chain rather than on a single supply chain link.

This research study has the following limitations. First, the energy needed by customers to go to retail stores to buy their shoes is excluded because there will not be differences between both products. The last mile to the consumer was found to be responsible for most of the energy consumption within a number of supply chains [31,32,36]. This is therefore a potential area to gain a fuller picture of energy use. The same holds for the manufacturing of raw materials: inclusion of this part will further enhance the total overview of energy use in the two supply chains.

Throughout our calculations of the energy needed to ship raw materials and finished products in the two studied supply chains, we assumed that full-truck loads were being used. However, this is not always the case as sometimes trucks are only partially loaded and sometimes they are loaded with more than their designed carrying capacity (the latter is a situation that is quite common in Morocco). Taking account of differences in shipment load is another area in which to extend this research. Third, we have considered a case in a developing country with extensive access to international trade via its seaports. Importing products to a landlocked country can lead to additional challenges and costs and may therefore yield different results. This requires additional research, just as research on other developing countries in other geographies (e.g., Asia). Additional research might also compare the energy consumption of shoes delivered by supermarkets versus shoes delivered by small shops. Although the methodology used is generically applicable, this research is focused on developing countries only. Similar research in developed countries (e.g., comparing countries in Europe) may therefore be another avenue for future research. Finally, more research is needed to compare the total energy demanded by industrial products having different product characteristics than shoes.

Author Contributions: Sander de Leeuw and Wout Dullaert conceived and designed the study; Abderrahim Ouaderzan performed data collection and analysis; together the authors wrote the paper.

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