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Reorganization of the Sugar Beet Supply Process as an Opportunity for a more Sustainable Transport: Based on a Model for the Polish Sugar Sector

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Abstract

This paper presents the impact of reorganization efforts on the ability to enhance the sustainability of the sugar beet supply process, as illustrated by the example of the Polish sugar sector. As a result of the solutions deployed, the farmers spend less on beet transport and may therefore allocate the freed-up resources to other activities. The professionalization of transport also contributed to reducing the farmers' expenditure on logistical activities involved in sugar beet farming and delivery. These are benefits that directly affect the economic viability of sugar beet farming. As regards the environmental and social impact of transport, it was concluded that making consistent efforts to restrict the transport operations handled directly by the growers contributed to reducing (i) carbon exhaust emissions and (ii) nuisance caused by agricultural vehicles on public roads. In the period under review, the reorganization of beet supply to sugar refineries resulted in decreasing the CO_2 emission ratio from 6.38 kg/t to 4.07 kg/t (by 36%).

Keywords: sugar beet supply process; transport sustainability; sugar sector; CO_2 emission ratio.

Introduction

Though generally accepted, the sustainable development strategy becomes problematic to implement in supply chains on an end-to-end basis. This is particularly noticeable in supply chains extending to multiple intermediaries who rely on different norms and standards (Zecca & Rastorgueva, 2014). Undoubtedly, these include agri-food supply chains where sustainability seems to be a priority for all countries, at least for two reasons. The first one is the need to safeguard food security for the country and to guarantee the production of healthy food. The second one is the heavy environmental impact of food production (Petersen, Nussel & Hamer, 2014, Gebresenbet & Bosona, 2012).

Generally, logistical processes are believed to be among the supply chain processes with considerable environmental impact. According to a report published at the World Economic Forum (2009), logistics activity accounts for 2,800 megatons of CO_2 emissions annually or about 6 per cent of the total 50,000 megatons produced by human activity. In turn, the results of a research based on lifecycle assessment, performed at the Carnegie Mellon University in the United States, suggest that transport processes account for 11% of 8.1 million tons of annual greenhouse gas emissions related to food consumption (Gant, Trautrims & Wong, 2015).

Meanwhile, the World Bank estimates that logistical processes account for ca. 15% of total greenhouse gas emissions (Irigoyen, 2014), with 60% being generated by transport processes.

In this context, note that transport processes were among the first ones to initiate a search for green solutions. The scope of this search gradually extended to shipping and logistical processes. The continued evolution towards green logistics resulted in addressing socially-oriented aspects, just like in CSR. These were the grounds for a new concept of logistical processes, defined as *logistics social responsibility* (Carter, Jennings, 2002).

The supply chain related to sugar production is one of the most finance-intensive chains. In European countries, the sugar beet production cost ranges from 13.5 EUR/ton in Ukraine to 42.2 EUR/ton in Germany (Řezbová, Belová, Škubna, 2013), and represents from 66% to as much as 90% of the product price.

Also, because of its specific nature (internal transport during the production of beet roots; heavy quantities of roots to be transported to the refinery in short time; and root cleaning processes), the beet supply chain generates high logistical costs, at an average level of 30-35% of total production costs (Žitňák & Korenko, 2011), while also having a strong environmental impact due to energy, water and fuel consumption, CO_2 emissions, and other factors (Stephan & Kromer, 1999, Gorzelany, 2010). Therefore, an adequate reorganization of transport processes throughout the sugar beet supply chain seems to be a key aspect both for an improved economic viability and for environmental sustainability.

Another determinant which makes it necessary to reorganize the sugar supply chain are the important amendments to the regulations for the European sugar market (Polowczyk & Baum, 2016, Szajner, 2017). The amendments are related to the abolition of European Union sugar production quotas. Currently, the three largest European sugar producers (Südzucker, Nordzucker and British Sugar[1]) take noticeable steps to adjust to the changing macroeconomic conditions.

Over the last ten to twenty years, the Polish sugar industry has also undergone important changes involving not only the technologies but also the organization of specific processes. One of the reshaped processes is the supply of sugar beet from growers to the refinery.

In light of the above, it is important that the logistical processes be reorganized so as not only to ensure economic viability but primarily to balance the supply chain, including the particularly burdensome transport processes.

Having this in mind, the question is how to redesign the organization of logistical process in the sugar supply chain to make it more sustainable? Therefore, the purpose of this paper is to present a model solution for the reorganization of the sugar beet supply process, and to identify the impact of the model used on the reinforcement of the sustainability of transport processes. The model solution was implemented in practice in a Pfeifer & Langen Polska sugar refinery chain.

Materials and research methods

Characteristics of Pfeifer & Langen Polska S.A.

Pfeifer & Langen Poska S.A. started their activity in Poland in 1995 by acquiring a controlling interest in the Środa Wielkopolska sugar refinery. The next years witnessed more mergers with refineries active in the Wielkopolska region. By 2001, they acquired a controlling interest in 10 other refineries: Głogów, Gniezno, Gosławice, Gostyń, Góra Śląska, Kościan, Miejska Górka, Witaszyce, Zbiersk and Zduny. The Glinojeck refinery was acquired in 2009.

Until as late as 2002, beet was delivered by farmers to 56 buying stations active in the region where Pfeifer & Langen Polska S.A. operated. The farmers also delivered beet directly to the refinery with their own vehicles. Using light duty vehicles involved a large number of deliveries (see Table 1). Furthermore—as night deliveries were impossible under these circumstances—to meet the processing capacity of the plant, beet was delivered from the buying stations to the refinery on an ongoing basis with the use of trucks and railway.

Research methods employed

1 http://kzpbc.com.pl/producenci-cukru-w-ue,21,pl.html, retrieved on July 16, 2017

This paper relies on a case study with a strong emphasis on practical applications, referred to as executive research (Czakon, 2011). The descriptive technique was used to analyze the changes in the organization of the sugar beet delivery process from the grower to the refinery. Pfeifer & Langen Polska S.A., which started to implement the changes in 2003, was selected to be the subject of the analysis. Therefore, the analysis covers the period from 2003 to 2016.

To assess the reorganization of sugar beet supplies, the following variables were defined for all years under review:

- number of deliveries performed by growers and organized carriers,
- quantity of beet delivered by growers and organized carriers,
- average load (clean beet) transported by growers and organized carriers,
- percentage share of growers and organized carriers in total deliveries,
- average distance traveled.

In turn, to assess the impact of the reorganization of beet supply to refineries on the sustainability of these processes, the CO_2 emission ratio was defined. The calculation was based on a formula compliant with REDcert, the systemic principles for the calculation of greenhouse gas emissions in accordance with Directive 2009/28/EC (2009). CO_2 emissions in beet transport are calculated with the following formula:

$$GHGep = (((ON \times Km \times 2) \times WO \times WE) \times BC) \,/\, 1000$$

with:

GHGep: total production of CO_2 (kg per ton of product)

ON: diesel fuel (l)

Km: average delivery distance of sugar beet

WO: diesel fuel energy value (MJ/kg)

WE: diesel fuel CO_2 emissions (gCO2eq/MJ)

BC: mass of sugar beet delivered (kg)

To calculate the amount of diesel fuel consumed, the following values were assigned to variables describing the growers' agricultural vehicles and the trucks used by the carriers providing their services to the refinery:

Assumptions for the growers' agricultural vehicles:

1. ca. 100 HP (73.55 kW) agricultural tractors

2. average consumption of diesel fuel per kWh: 272 g

3. average consumption of diesel fuel per hour worked: 24.04 l

4. average speed of delivery: 25 km/h

5. average delivery distance: the same as in the case of transport organized by the refinery

6. average payload of a two-trailer combination: 12 tons, minus average pollution (8%) = net weight of 11.04 tons (this is needed to calculate the number of deliveries/transport operations)

Assumptions for trucks:

1. average consumption of diesel fuel per 100 km: 37 l

2. average payload of a truck and trailer combination: 25 tons, minus average pollution (8%) = net weight of 23.0 tons (this is needed to calculate the number of deliveries/transport operations)

Results of the study

Description of the organization of raw material supply to the sugar refinery: the starting point

In the logistical system for the supply of sugar beet to refineries, the delivery processes are based on the following basic methods:

- the farmers' (sugar beet growers') own-account transportation,

- transportation handled by the sugar producer on account of the sugar beet producer.

Even in the late 1990s, most of sugar beet supplies to Polish refineries were handled directly by the farmers with their own transport equipment. Agricultural tractors and trailers were mostly used for that purpose. That system was also common in other EU countries, e.g. in Germany where ca. 20% of the total weight of beet was transported using tractors (Nordzucker, 2016). The average weight of beet thus supplied was ca. 8 tons of clean beet per shipment ("clean beet" means beet after removal of organic contaminations such as parts of leaves and weeds, crowns, soil and stones). The farmers also made deliveries using their own or leased trucks. In 2003, the average weight of clean beet supplied by farmers (using agricultural tractors and trucks not owned by organized haulage undertakings) was ca. 12 tons (see Table 1). Assuming that the average beet processing capacity of Polish refineries in the 1990s was ca. 2,800 tons per day (STC, 2004), around 230–240 deliveries per day were required to meet that demand.

The organizational changes involved in the privatization of the Polish sugar industry, combined with the reorganization of the European Union sugar market, resulted in a decline in the number of active sugar refineries from 78 in 1989 to 18 in 2013. All of them more than doubled their beet processing capacity to ca. 6,200 tons per day (KZPBC, 2018). These changes made it necessary to look for new solutions and to reorganize the supplies of sugar beet to refineries. In order to meet the demand for ca. 6,000 tons of beet per day using their own transportation, the farmers would need to dispatch from 500 to 700 vehicle combinations. Also, the same number of weighing operations would be required.

Handling such a number of events (raw material supply for production) with shipments that directly address the refineries' demand (without taking carryover or rotated stocks into account) would involve the emergence of multiple critical points and moments in the supply chain (where errors or disturbances would be more than likely to occur).

Organizing the beet collection process with such an inefficient transport system would involve the following:

- establishing a detailed schedule for beet supplies to meet the demand of a specific refinery, taking into consideration the large number of carriers, low-capacity vehicles, and various transport and unloading technologies,
- updating the schedule and verifying the progress of deliveries on a continuous basis which would be strenuous because of the number of independent actors,
- implementing an adequate technical infrastructure in sugar refineries to take account of the following: waiting areas; weighing scales; areas and methods of unloading, including a conveyor solution that allows beet to be fed directly to processing units; additional cleaning of beet in the refinery, including contamination/waste management (the farmers do not own machinery for beet cleaning).

Complying with the above requirements would involve the need to invest large amounts of money in technical, infrastructural and organizational solutions to streamline the organization of handling such a large number of deliveries per unit time.

The previous model of sugar beet supply organization, as described above, was mostly based on the farmers' own transport, and was prevalent in Poland until late 1990s. The reorganization of beet purchase started only at the end of the first decade of ownership transformation in the Polish sugar industry. To reorganize that process, Pfeifer & Langen Polska refineries identified the following targets:

- to optimize the beet delivery fleet,

- to accelerate the information flow between process actors,
- to deploy state-of-the-art technologies for communications and messaging between process actors,
- to optimize the processes, taking into consideration the labor inputs and their impact on process actors and on the external environment.

Characteristics of the model solution for beet supply to refineries

The reorganization of the Polish sugar industry was triggered by Poland's accession to EU structures in 2004. Because of a host of infrastructural, natural, regulatory and political realities, the changes were an evolutionary rather than a revolutionary process. The complexity of the model of the beet supply process is reflected by the fact that it takes the above factors into consideration, as shown in Figure 1.

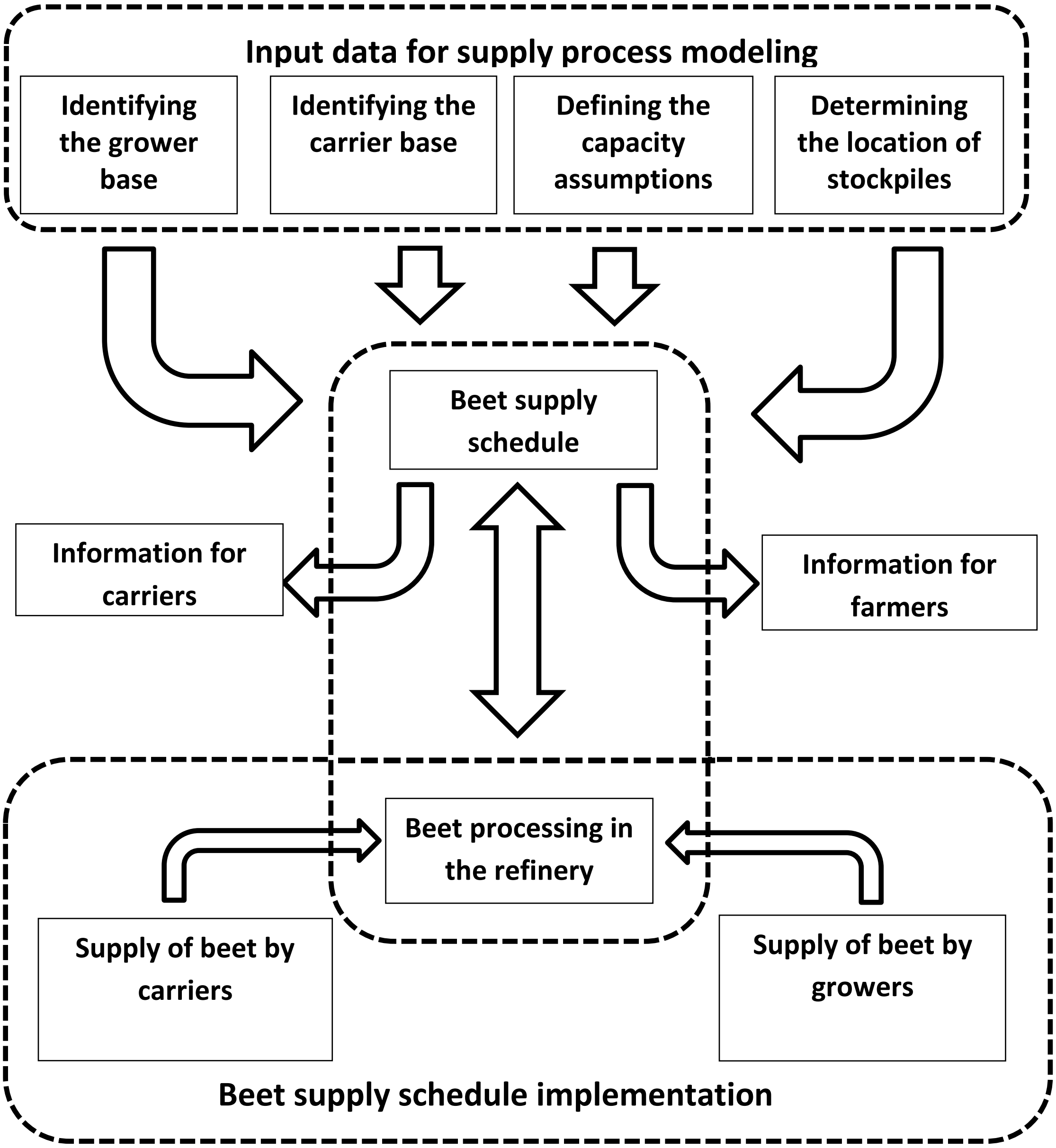

Fig. 1. Organization chart of the process of beet supply to sugar refineries, as deployed by Pfeifer & Langen Polska

Source: own study

Identifying the grower base. The whole process starts by identifying the base of sugar beet growers active in the year concerned. This is related to the European Union's policy for the agricultural sector, agricultural markets and internal markets. The objective of the current policy is to protect the EU internal market from an influx of sugar from global markets, especially when it comes to cheap cane sugar produced for instance in African, Caribbean and Pacific Group of States (ACP).

Identifying the carrier base. These are mostly permanent groupings of carriers acting as a part of several providers of specialized agricultural services. The services also include cleaning and loading beet with the use of specialized machinery (e.g. ROPA). The combination of vehicles with beet cleaning and loading machinery results in maximizing the flexibility of service delivery.

Defining the capacity assumptions. The restrictions, implemented for the first time in 1968, have been applicable to the Polish market since 2004. The regulatory instruments for the sugar market and sugar refineries include:

- sugar production quotas in different countries of the EU,

- restrictions imposed on sugar substitution products (isoglucose and inulin syrup),

- introduction of guaranteed prices: guaranteed price for sugar, intervention prices for sugar, and minimum prices for beet,

- requirement to market the out-of-quota sugar outside the EU,

- refunds for sugar consumption in the chemical industry,

- intervention buying in of surplus sugar,

- instruments for the protection of the internal market: customs duties and duty-free or reduced-tariff import quotas for sugar.

As a result of the above regulations, 3 sugar quotas were adopted in the EU: quota A for the amount of sugar intended for the internal market (to be consumed within the EU); quota B for the amount of sugar intended for subsidized exports or to supplement the supply of the EU internal market. Additionally, the refineries were allowed to produce sugar under quota C, applicable to sugar from beet exempt from minimum price regulations, intended for exports outside the EU in accordance with free trade principles. Export subsidies from the EU budget were not applicable to sugar under quota C.

In the 2005/2006 marketing year, the European Commission decided to reduce the sugar production quotas[2]. As a result of these measures, the total of A and B production quotas was reduced by 10.30%. For 25 EU countries this meant a reduction in white sugar production volumes from 17.40 million tons to 15.60 million tons. For Poland, the restrictions translated into reducing the production of sugar under quota A from 1.58 million tons to 1.50 million tons, and the production of sugar under quota B from 91.90 thousand tons to 86.90 thousand tons.

Determining the location of stockpiles. The use of state-of-the-art technologies and available devices provides visible results in the process of determining the location of beet stockpiles. To this end, use is made of cell phones (smartphones) with an application that assists the raw material consultants employed in refineries.

Beet delivery schedule. Once the data is prepared, it is appropriate to proceed to preparation of the sugar beet delivery schedule. The following is also considered at this stage:

- processing capacities of different refineries,

- available loading and transport equipment,

- location and size (tons of beet) of stockpiles,

- the planned start and completion date of the beet processing campaign,

[2] Regulation (EC) No. 1609/2005 of September 30, 2005

The proper preparation of this element is of crucial importance, so that all objectives may be pursued and all assumptions may be complied with during the sugar campaign in accordance with the company's commitment and accountability principles at different stages of logistical processes. The above translates into an optimized use of the truck fleet in sugar beet transport operations. As clearly shown in Table 1, over the recent years, the car fleet used by professional carriers has been optimized in terms of:

- the number of trucks in operation,
- the number of transport operations (scheduling the operations to make optimum use of the equipment),
- transport costs generated.

Even as late as in 2003, the farmers' own vehicles delivered 19.5% of the total volume of beet supplied to sugar refineries (members of the refinery group covered by this analysis). In 2016, that share was only 0.02%. This means that only after more than a decade, the reorganization of the sugar refinery logistical processes resulted in a situation where nearly 100% of beet deliveries to sugar refineries were made using the truck transport system organized by sugar producers.

The key assumption underpinning the reorganization of beet supply to sugar refineries was to gradually shift from deliveries made using the farmers' own vehicles to deliveries based on the sugar producer's truck transport system. Assuming that each truck may deliver 24 tons of clean beet per transport operation, around 260 deliveries per day (i.e. by ca. 60% less than in the case of individual deliveries handled by the farmers) are enough to meet the demand of the refinery.

Another argument for the reorganization is that the freight is delivered by specialized transport undertakings with appropriate, unified transport equipment adjusted to the technical needs of the refinery (e.g. unloading method). This solution provides the following advantages:

- there are only a few shipment undertakings to manage; this helps scheduling and validating the deliveries,
- it accelerates the flow of important information between different process actors,
- it reduces and unifies the technical infrastructure in each refinery of a sugar producer,
- it reduces the impact of an individual (the farmer who delivers beet to the sugar refinery) on the beet supply process; the driver from a transport company remains involved in the process throughout the sugar campaign.

Table 1. Quantitative changes in beet deliveries to sugar refineries in 2003–2016

transport organizer	Year	number of transport operations	amount of beet delivered (t)	average load of clean beet (t)	Share of transport types in total deliveries (%)	Average distance traveled (km/year)
grower	2003	29,815	329,152	12	19.5	33.90
carrier*		59,129	1,359,956	22	80.5	
grower	2004	7,147	78,900	11	3.8	40.50
carrier		86,458	1,988,531	22	96.2	
grower	2005	2,873	31,713	12	1.6	42.30
carrier		83,936	1,930,530	23	98.4	
grower	2006	4,399	48,570	15	2.6	47.50
carrier		78,683	1,809,720	23	97.4	
grower	2007	4,251	46,935	18	2.3	46.40
carrier		87,471	2,011,841	24	97.7	
grower	2008	1,160	12,805	19	0.97	44.90
carrier		56,691	1,303,885	24	99.03	
grower	2009	1,460	16,119	19	0.85	41.00
carrier		81,810	1,881,629	23	99.15	

grower	2010	1,985	21,915	18	1.35	40.60
carrier		69,685	1,602,754	23	98.65	
grower	2011	1,374	15,165	20	0.82	40.33
carrier		80,212	1,844,882	24	99.18	
grower	2012	3,031	33,462	21	1.60	41.10
carrier		89,585	2,060,450	23	98.40	
grower	2013	786	8,675	20	0.50	42.20
carrier		74,341	1,709,845	23	99.50	
grower	2014	578	6,376	19	0.29	42.50
carrier		96,237	2,213,462	23	99.71	
grower	2015	306	3,379	19	0.20	39.70
carrier		69,089	1,589,050	23	99.80	
grower	2016	43	474	17	0.02	40.20
carrier		87,287	2,007,595	23	99.98	

*professional carrier from the refinery's carrier base
Source: own calculations based on refinery documents.

The transport system organized by refineries also provides other advantages, namely:

- professionalization of services
- use of state-of-the-art loading and transport equipment,
- maximizing the use of vehicles throughout the beet delivery period,
- enhancing the refinery's social responsibility in accordance with PN-ISO 26000 (Polish Committee for Standardization, 2012).

Impact of the reorganization of beet supply to sugar refineries on the improvement in transport sustainability

Since the very beginning, the corporation's reorganization efforts have also been focused on the improvement in transport sustainability. In this area, the corporate strategy is primarily based on the CSR concept which has been evolving for several decades now. Generally, it may be noted that CSR addresses four basic objectives of enterprises who implement the principles of corporate social responsibility, namely: (i) focusing on long-term gain; (ii) focusing on socially responsible business operations; (iii) taking social expectations into consideration; and (iv) contributing to social wealth by behaving ethically (Garriga and Melé, 2004).

The CSR concept was also addressed by the International Organization for Standardization (ISO) who released ISO 26000 (Guidance on social responsibility) in 2010. It defines social responsibility as the responsibility of an organization for the impacts of its decisions and activities on society and the environment, through transparent and ethical behavior.

As mentioned earlier, P&L Polska have consistently improved their social responsibility, as defined in PN-ISO 26000, and have implemented their own measures in such areas as:

a) reducing the environmental impact by:

- using transport equipment which meets mandatory emission standards,
- reducing the time spent by vehicles waiting for beet loading and unloading which contributed to a reduced fuel consumption,

b) growth and development of transport companies cooperating with the sugar refineries:

- ensuring a stable labor market during the autumn-winter period,
- improving financial stability by entering into agreements that ensure access to a stable labor market,

- ensuring IT and technical support,

c) ensuring that the expectations of the stakeholders (sugar beet growers) are met as regards:

- advising on sugar beet growing (to the maximum possible extent),
- taking measures to maximize the amount of beet delivered: implementing a paperless acceptance system; minimizing the required involvement of farmers in the delivery acceptance process (even if the buying station operates on a 24h basis); minimizing the time of handling beet deliveries from different growers,
- ensuring continuous access to information through dedicated information portals,
- simplifying (and providing substantive and organizational support for) the settlement process between sugar beet growers and sugar producers,

d) enhancing the competitiveness of sugar beet growing compared to other crops,

e) improving the corporate organizational culture which underpins the relationships with contractors (e.g. farmers, carriers) to avoid dissatisfaction (or a drop in satisfaction) with the handling of logistical processes.

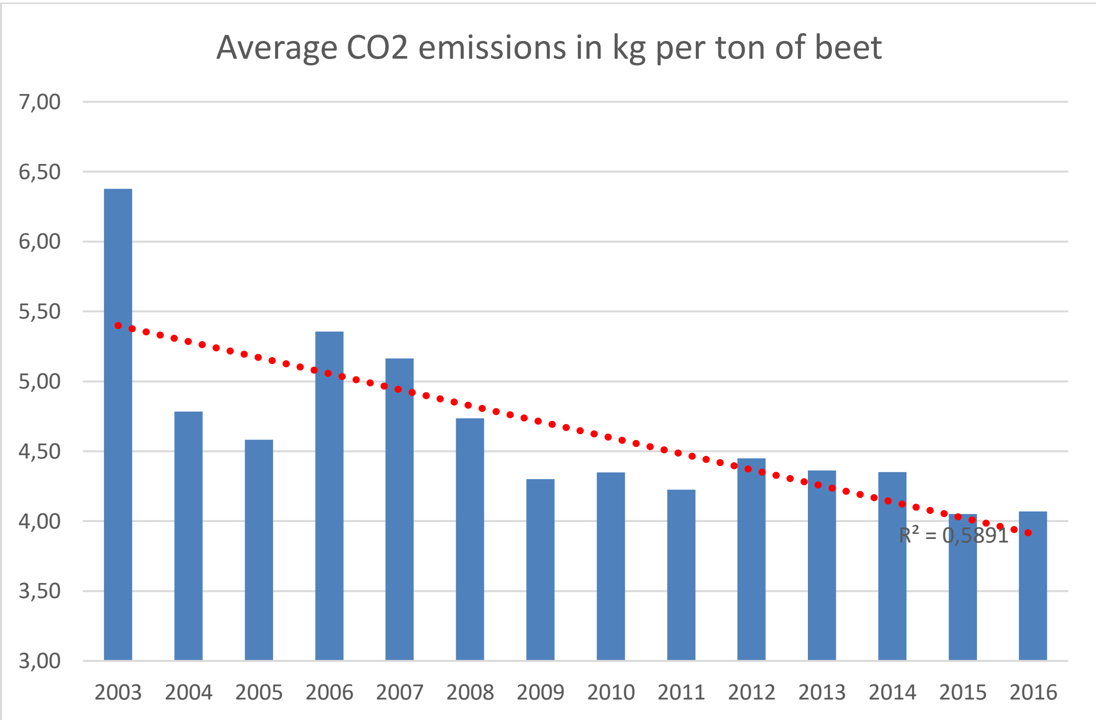

Fig. 2. Changes in CO_2 emissions in kg per ton of sugar beet delivered to Pfeifer & Langen Polska refineries in 2003–2016.
Source: own study

As regards the environmental and social impact of transport, it should be concluded that making consistent efforts to restrict the transport operations handled directly by the growers contributed to reducing (i) carbon exhaust emissions (cf. Fig. 2) and (ii) the nuisance caused by agricultural vehicles traveling on public roads. In the period under review, the reorganization of beet supply to sugar refineries resulted in decreasing the CO_2 emission ratio from 6.38 kg/t to 4.07 kg/t (by 36%). The other issue, i.e. the nuisance caused by the beet transport with the farmers' vehicles traveling on public roads, was almost totally sidelined. In 2016, the share of beet transported by farmers in the total mass transported was only 0.02%. These measures improved the corporation's image among local communities which neighbor the refinery sites.

Conclusions

As a result of the solutions deployed, the farmers spend less time and money on beet transport and may therefore allocate the freed-up resources to other activities.

The professionalization of transport also contributed to reducing the farmers' expenditure on logistical activities involved in sugar beet farming and delivery. These are benefits that directly affect the economic viability of sugar beet farming. A stronger economic viability contributes directly to farming incomes and, indirectly, to the farmers' satisfaction with their work. As a consequence, following the abolition of EU sugar quotas in 2017, the farmers have shown their commitment to sugar production.

The implementation of solutions focused on streamlining the refineries' business, combined with emphasis on the needs of suppliers, customers and other parties not directly involved in production and logistical processes, enables the establishment of long-lasting correct relationships. The right approach to defining and discovering the needs of different process actors is a way to improve their satisfaction with the economic situation and other aspects. By establishing proper links and partnerships with beet suppliers, the corporation develops a stable base of beet producers and suppliers who represent a great asset both for the corporation and for other actors of the supply chain. On the other hand, the proper involvement in, and responsibility for, the changes and optimization processes related to the handling of sugar beet deliveries establishes a long-term contractual relationship between the refineries and their partner providers of loading and transport services.

Implementing such far-reaching changes in the transport and processing area also contributed to the optimization of employment at different stages of sugar production. However, combined with adequate measures focused on local communities, the changes did not harm the company's image. On the contrary, with its favorable environmental impact, the reorganization of the beet delivery system clearly improved the company's image not only among the local community but also among consumers of sugar products. Therefore, the latter may make well-informed decisions knowing that the sugar industry has experienced, and continues to experience, transformations and changes that fully integrate a modern processing industry with a modern well-informed consumer society in an environmentally and socially friendly manner.

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