BACKHAULING ECONOMICAL AND ENVIRONMENTAL ANALYSIS: A FOOD RETAILER/DISTRIBUTION COMPANY CASE-STUDY

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The strongest motivation for the construction of sustainable activities is nowadays a society clear concern. As a result, companies endeavor to build supply chains where their profit is obtained through the implementation of environmental positive activities. One good example of such practices is the logistics backhauling activity where a collaborative strategy exists between the buyer and the supplier aiming to share costs while minimizing environmental impacts and guaranteeing not only clients satisfaction, but also suppliers and company interests. The present paper addresses a real case-study of a food retailer/distribution company operating in Portugal where its backhauling activity is analyzed. An economical and environmental analysis of such operation is developed and important conclusions are obtained supporting the company corporative strategy towards sustainability.

Key-words: sustainability in logistics, supply chain backhauling, retail/distribution

1. INTRODUCTION

The sustainability concept according to what was defined by the World Commission on Environment and Development is the "(…) development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). This is often difficult to express in operational terms and its planning at the company's level is currently a concern. As stated by Labuschagne et al. (2003) it should: cover social and ecological sustainability; convert the sustainability concept to the institutional level; manage a long- and short- term strategic perspective taking into account the economic performance; advocate the rise of indicators that have this perspective and show how different initiatives relate to the sustainability concept. Within this context and as stated by (Barbosa-Póvoa, 2009) supply chain management can significantly influence the company goals towards sustainability. Substantial opportunities thus exist, along the supply chain, to reduce company's energy consumption resulting into more sustainable operations. This is the case where reverse flows are incorporated into the supply chain leading to the absorption of non-conform of even end-of-life products creating a better rationalization of resources (Salema et al 2010). Also, a better optimization of the supply chain flows associated with a reduction of transportation miles or even of empty miles can be seen as a possible strategy to build up environmental friendly supply chains. Knowing that the transport sector is responsible for about 25% of the gases emissions the optimization of the transportation distances is therefore a point to investigate along the supply chains (Ülengin, et al (2010). One activity that can efficiently explore this transportation rationalization is the backhauling activity. Backhauling allows a better use of empty or lightly filled return, highlight and consolidating. It appears when vehicles distribute goods and come empty to the depots resulting on an extension of the transport efficiencies (Daganzo, 2005). These empty kilometers can be reduced trough retailer-supplier collaboration and the empty trucks can then pick up the goods and deliver them to their depot destination. Overall, empty kilometers and wasteful expenditures are reduced while minimizing environmental impacts and guaranteeing not only clients satisfaction, but also suppliers and company goals.

The present work addresses this problem and studies the backhauling activity in logistics. A real case study of a food retailer/distribution company operating in Portugal is addressed and the current backhauling is analyzed through an economical as well as an environmental perspective.

2. CASE-STUDY

This work focuses on the logistics activity of the Jerónimo Martins (JM) Group, a well known food retail/distribution company in Portugal. JM retail involves the strategic process management of planning and implementing the control of materials or products, services and information from its origin to the final selling points. It involves the flow of products through several agents of the distribution channels. JM guarantees that the goods are efficiently delivered to the final clients. For that, JM objective is to go directly to the supplier, or the producer of the raw materials, allowing for the creation of quantity discounts and assuring that it gets the right product in an efficient way, through a professional transport system and with the right quality and competitive price to the final customer.
JM Retailing and Distribution area is supported by a logistics structure formed by three Distribution Centres (DCs), responsible for all the elements of the group (Figure 1): South Region, DC of Azambuja: responsible for the area below the axis (Coimbra/Viseu); North Region, DC of Guardeiras and Vila do Conde: responsible for the area above the axis (Coimbra /Viseu); Finally, the Madeira and Açores islands are not included as the transportation is done by sea and the origin of the materials is from both regions (not seen in Figure 1).

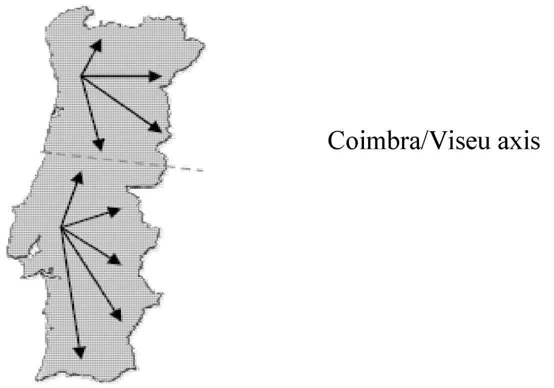

Figure 1- JM Distribution Structure

Such logistics structure, deals with two types of products: the perishables and the non- perishables products. The first ones, are characterized by a short life time and consequently no stock should be constituted. On the other hand, for the non-perishable products the life time is long and stocks can exist at the DC´s. These products characteristics influence the type of storage policy utilized. The perishables products (as vegetables, etc.) are generally managed according to a Just-In-Time (JIT) policy while the remaining products are managed on a stock base approach and in JIT. This however varies according to the DCs.
In terms of products flows, the warehouses receive the products directly from the suppliers or trough a backhauling activity. At the DC the products are handled and, based on the final clients demands the different orders are dispatched. The final orders are in most of the cases distributed to the final clients (the supermarkets) through the DC of the closest region. The distribution is guaranteed by a set of trucks that constitute JM´s cargo.
JM entails an active position in what concerns a sustainable activity. It has the particularity of doing backhauling in Portugal for the last 19 years and being the only one doing it within the distribution companies, to the best of our knowledge. This activity is performed with the non-perishables warehouse (functioning in a stock base and Just-In-Time (JIT)), the fresh products, the fruits and vegetables and the fish warehouse working all in JIT.
The backhauling activity adds an extra level of complexity to the logistics operation where not only the stores

but also the suppliers are included. JM has around 400 stores in Portugal (340 of Pingo Doce brand) supported by three platforms of Food Service.
Being the backhauling activity a complex operation JM has been wondering if such activity is both economical as well as environmental positive. In order to address such concern the present work studies how the backhauling activity is integrated on JM's logistics structure and what is its contribution towards the company economical as well as environmental objectives. To achieve this purpose the 45 current backhauling suppliers are analyzed involving 174 of the 340 Pingo Doce's stores.

3. BACKHAULING ANALYSIS METHODOLOGY

Backhauling opportunity appears when vehicles distribute goods and come empty to the depots. These empty miles can be reduced trough retailer-suppliers collaboration allowing that empty trucks can pick up the goods and deliver them to their depot destination. As a result, an extension of the transport efficiencies is achieved in which not only the company gains, but also the suppliers. In order to study such activity different factors are important and need to be characterized with some detail:

Backhauling route: The routes are not always the same; however suppliers are associated to the last store of one route.
Period of time between the arrival and the loading of the truck: The time spent at the supplier and at the warehouse.
Quantity ordered: The costs and the revenues taken with a certain supplier are proportional to the quantities ordered.
Frequency of the orders per month: This is based on the number of times backhauling is performed with a supplier per month.
Distance from the warehouse to the supplier: The distances performed interfere on the use of the resources fuel, driver and truck and the costs are proportional to them.
Distance from the DC to the store: The truck must deliver the goods at the stores daily .
Distance from the store to the supplier: This corresponds to the real deviation of the original route.
Store's frequency orders: The number of times the truck goes to a store.
Drivers' shifts duration and its compatibility with the backhauling route: There is a limit of time for a driver to be on the road, in addition if the truck goes to a supplier it implies that it won't be at the DC or performing another route during that period.
Times associated with the change of the route due to backhauling: Time spent travelling and at the warehouses.
Limitations on the trucks capacity in terms of space and weight (defined by law): The truck has to bring the backhauling supplies and the containers to the DC, so the restrictions of the space and weight capacity have to be considered.
Containers devolution: It is restricted by the storage capacity in the stores, the space available at the truck to load the containers, and at the DC to load the goods to supply the stores.

It is important to notice that these parameters should be studied together since treating them separately can lead to wrong conclusions (e.g. if the frequency of the orders is high it is not clear that is the supplier is good to perform backhauling, the effect of the distances and the quantities are equally important).
Considering these factors and in order to calculate the actual gains or losses of the backhauling activity a set of opportunity costs were defined. These involve the difference of costs incurred when performing or not backhauling (equation [1]).

$$\textbf{Opportunity Cost} = \textbf{Cost with Backhauling} - \textbf{Cost without backhauling} \tag{1}$$

Based on this costs a model was developed where such costs were quantified in terms of the main resources involved in the backhauling activity: fuel, driver and truck and are classified respectively as opportunity cost 1 (opcost1), opportunity cost 2 (opcost2) and opportunity cost 3 (opcost3).

The model considers two approaches: the JM and the Global perspective. The JM perspective involves mainly the costs incurred by the company, as when there is no backhauling the supplier is responsible for the transportation and delivery of the products at JM's DC. On the Global perspective the study considers the total costs incurred including not only JM costs, but also the involved suppliers.
Such approaches are developed on two analyses: an environmental and an economical analysis.

3.1 Environmental impact analysis

In terms of the environmental approach it was chosen to look only at a global perspective. This global perspective looks to the company and the supplier emissions. As the emissions are directly associated to the distances performed and the fuel consumption, there is only the opportunity cost 1. This opportunity cost is related to the kilograms of CO_2 saved or extra emitted for performing or not the activity.

3.2 Economical impact analysis

In such analysis the fuel consumption is considered apart from other aspects. Therefore, more than the cost that it takes to perform the kilometers in terms of fuel, it is also necessary to quantify the driver cost. This is done by considering the time spent on the route and the cost of the resource per hour. Also, the cost of having the need of considering an extra truck due to the backhauling activity was considered (e.g if the backhauling is performed an extra resources may be required to deliver the goods to the stores). To calculate this, the periods of time required when performing or not backhauling are quantified. It is important to mention that the JM and the Global perspectives are also different in terms of time. JM has to manage the time that the drivers spend on the road and limit this to their shifts periods defined by law. In a Global perspective more than one resource truck and driver are being considered (suppliers and JM's trucks and respective drivers).

4. RESULTS FOR THE CURRENT SUPPLIERS

The methodology above described is now applied to the JM backhauling activity. First the model was validated with a small set of suppliers and after this the full set of backhauling suppliers was studied (the 45 suppliers). The results obtained in each approach are presented on Table 1. From here it is possible to see that the backhauling activity, in a broad perspective, has a positive impact both in environmental as well as in economical terms, since:

- Globally are saved approximately 38424.10 Kg of CO_2 emissions;
- JM spends 5962.67 € per month by performing backhauling;
- The sum per month of the suppliers savings is of 25932.10€: (Supplier savings = Global savings (-19969.42 €) - JM's savings (5962.67 €));
- The total gain for performing backhauling is of 83141.59 € per month.

On the above results it is important to notice that there are some exceptions on the backhauling expected routes. These were considered in order to approximate the analysis to the reality and also analyze their impact on the backhauling results as they are being considered on that category by the company. These correspond to the cases when the carrier goes directly to the supplier to pick up the products without incorporating the pickup with a delivery route. These arise due to JM previous agreements and it is evident for the suppliers 106235, 108613, 113140, 119535 and 124865.
From Table 1 it can be observed that:

- The exceptions for the cases when the supplier delivers at the DC or when the carrier goes directly to the supplier to pick up the products appear as an opportunity cost of zero (suppliers 106235, 108613, 113140, 119535 and 124865). The distance performed with or without backhauling is equal, differing only in who is performing it (the supplier or the JM's carrier);
- Performing backhauling in 40 of the 45 cases studied (88.89%) results in a minimization of the CO_2 emissions in a total of 38424.10 kg ;

- There are no suppliers with a positive value on the environmental impact, so the kilometers performed are always less when performing backhauling;
- Performing backhauling in 38 of the 45 cases studied (84.44%) results on a minimization of the economical impact in a global perspective with a total of 20942.46€;
- Performing backhauling in 35 of the 45 cases studied (78%) results on an increase of the economical impact in a JM perspective with a total of 9224.24€;
- JM has a good performance with the cooperation with 42 of the 45 backhauling suppliers (93.33%) having a total of 90294.63€.

Table 1- Backhauling Environmental and Economical Impact

Code	Route	Environmental impact (Kg of CO_2 emissions)	Rank Position	Economical impact - Global Approach (€)	Rank Position (Global)	Economical impact- JM Approach (€)	Rank Position (JM)	Performance (€)	Rank Position
100075	S->Az	-2198,45	4	-1767,27	2	72,47	33	1160,31	20
100995	S->Az	-201,19	33	-73,50	32	38,00	25	83,23	41
101183	S->Az->Gu	-655,80	21	-1360,07	5	61,04	32	1594,65	13
101675	S->Az	-1154,40	14	-987,55	8	95,21	37	730,28	25
101971	S->Az	-1737,56	9	-662,16	11	40,30	26	1677,80	11
102147	S->Az	-77,99	36	-26,63	34	21,32	19	4018,58	6
102269	S->Alc->Az	-938,06	17	-365,50	20	7,84	14	443,69	29
102706	S->Az	-268,23	30	966,31	45	34,89	23	743,63	24
102779	S->Az	-2006,47	6	-1692,14	4	59,62	31	1638,34	12
103019	S->Az	-3054,42	1	-1121,91	6	-2323,76	1	4515,09	4
103157	S->Az	-54,59	38	-12,32	36	56,41	30	25117,67	1
103171	S->Az	-930,08	18	-357,46	21	44,94	28	217,64	34
103403	S->Az	-2334,55	3	-2003,44	1	142,63	41	1412,03	16
103723	S->Az	-2081,07	5	-764,77	9	127,90	40	1441,04	15
104242	S->Az	-2918,88	2	-1107,27	7	566,31	44	-529,88	44
104681	S->Az	-314,83	29	-563,67	14	10,65	16	174,42	35
104958	S->Az	-541,83	25	-204,67	26	-344,17	3	882,15	23
105093	S->Az	-584,79	22	-189,76	28	89,59	36	718,95	26
105638	S->Az	-1801,36	8	-645,57	12	110,08	38	2407,36	10
105779	S->Az	-1008,16	16	-352,30	22	35,30	24	4226,76	5
106235	S->DC	0,00	41	0,00	39	0,00	7	1577,39	14
106250	S->Az	-1422,05	11	-495,61	15	76,79	34	98,77	39
106509	S->Az	-81,07	35	-11,87	37	19,98	18	991,98	22
106546	S->Az	-8,96	40	1,44	43	8,01	15	1213,36	18
106564	S->Az	-1291,67	12	-426,96	18	115,26	39	-34,14	43
108613	S->DC	0,00	41	0,00	39	0,00	7	5968,48	3
110436	S->Az	-392,39	28	-757,52	10	28,60	20	433,71	30
110624	S-Az	-219,36	32	5,28	44	219,34	42	1332,84	17
110805	S-Az	-1121,22	15	-436,86	17	6,46	13	2410,63	9
112826	S->Az	-576,07	23	-221,84	25	14,17	17	371,30	31
113034	S->Az	-541,68	26	-183,44	29	34,68	22	64,92	42
113140	S->DC	0,00	41	0,00	38	0,00	7	559,82	28
113241	S->Az	-792,34	19	-273,97	24	87,79	35	2567,64	8
113575	S->Az	-1960,21	7	-1700,24	3	276,50	43	12683,30	2
117952	S->Az	-1633,63	10	-602,64	13	33,87	21	1001,13	21
118335	S->Az	-734,15	20	-283,77	23	-1,24	5	92,47	40
119535	S->DC	0,00	41	0,00	39	0,00	7	138,00	36
120780	S->Az	-145,60	34	-51,10	33	3,72	12	1211,22	19
121291	S->Az	-72,25	37	-112,70	30	3,15	11	104,12	37
121420	S->Az	-481,25	27	-375,21	19	-0,96	6	102,12	38
121455	S->Az	-549,05	24	-200,75	27	-353,07	2	353,07	32
122076	S->Az	-243,16	31	-90,20	31	-238,36	4	238,36	33
124448	S->Az	-53,76	39	-17,53	35	50,98	29	569,08	27
124865	Carrier->S	0,00	41	0,00	39	6589,02	45	-6589,02	45
200006	S->Az	-1241,54	13	-442,31	16	41,44	27	3007,29	7
Total		**-38424,10**		**-19969,42**		**5962,67**		**83141,59**	

Key:
Carrier->S – The carrier goes directly to the supplier to pick up the products
S-> Az- The goods are brought from the supplier to the Azambuja's DC
S-> Alc->Az- The goods are brought from the supplier to Alcochete's DC and only then to Azambuja's
S->DC- The supplier delivers the goods at the DC

Next, the environmental and economical impact analysis will be studied in more detail in order to better understand the results obtained.

4.1- Environmental impact analysis

As mentioned before in environmental terms important savings are being obtained when backhauling activity is performed. It is possible to perceive that such activity permits a minimization of 35% of the CO_2 emissions what implies 38424.10 Kg of CO_2 emissions avoided (Table 2).

Table 2-Environmental impact

CO2 emissions quantification	kg of CO_2
Emissions with backhauling	71717,68
Emissions without backhauling	110141,78
Opportunity Cost	-38424,10
Opportunity Cost/ Emissions without backhauling (%)	-34,89%

Globally, it is possible to confirm that backhauling potentials a minimization of the harmful gases emissions. In most of the cases it brings savings, revealing the importance of the backhauling activity towards a sustainable company.

4.2- Economical impact analysis

As mentioned before the economical impact analysis focuses on the costs in a global and in a JM's perspective. On Table 3 it is possible to analyze the main differences of both perspectives and it can be seen that, as predicted, it were obtained more savings in the global perspective than on the JM's perspective. This difference is of around 17 % when comparing to JM's and corresponds to the suppliers' gains.

Table 3- Economical impact- Global and JM's approach

Perspectives	JM(€)	Global(€)
With Backhauling	140803,12	136971,05
Without Backhauling	134840,44	156940,48
Total Opportunity Cost	5962,67	-19969,42
Opportunity Cost / Without Backhauling(%)	4,42%	-12,72%

From Table 3 it is likely to conclude that the relative savings are higher for the supplier and there is an extra cost for JM. This is explained as the distances from the supplier to the warehouse are expected to be shorter than from the store to the warehouse; moreover the need of extra trucks costs and the exceptions have a major role on the final output. According to the results on Table 3, with backhauling are saved significant transportation costs for the supplier. This predicts that JM may have a high negotiation power in order to diminish the price charged per pallet by the supplier. The price per pallet, besides the profit margin, includes the value of the product and also the transportation cost. More than looking at the total costs obtained it is relevant to compare these results for each supplier. On Figure 2 and 3 are exposed the 45 suppliers' percentage, according to the output obtained, if backhauling implies costs higher, lower or equal to zero.

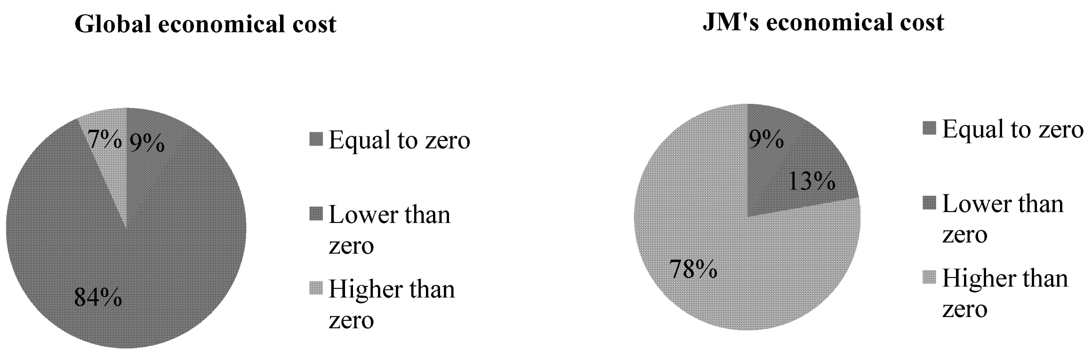

Figure 2 and Figure 3 – Suppliers economical impacts in the Global and JM's perspectives

From the figures it can be noticed that the 9% in both perspectives correspond to the exceptions in which the suppliers bring the products to the DC, having no impact on both approaches.
For the global perspective it can be concluded that in most of the cases the results are lower than zero reveling the importance of backhauling. Backhauling is then cheaper than the sum of the costs incurred by JM and the supplier when there is no cooperation. In terms of the JM's perspective the opposite occurs as in 78% of the cases the cost is higher. This is not a surprise since performing backhauling leads to a higher consumption of the resources fuel and driver and may lead to an extra truck cost for JM. Therefore, for the 13% that are saving money the main cause is associated to the efficiently use of the truck, compensating the costs linked to the other two resources mentioned. So, for the future JM's should decrease the costs using more efficiently the resource truck. In terms of the outputs obtained it is important to be aware that this increased cost with backhauling for JM can be compensated by the pallet cost. Furthermore, it is importance to mention that the global perspective is the one that should be considered as the most important since in on it that both suppliers and vendors interests are accounted simultaneously.

5. CONCLUSIONS

Companies nowadays aim to develop planning and operational strategies that can simultaneously guarantee economical and sustainability objectives. In this way they can remain competitive in the nowadays competitive market. One way to guarantee such goal is to act at the level of the supply chains where the transportation area plays an important role. Within this area the backhauling activity has been identified as an economical as well as environmental potential activity. The backhauling opportunity appears as vehicles distribute goods and come empty to the depots. These empty miles can be reduced trough retailer-suppliers collaboration and the empty trucks can then pick up the goods and deliver them to their depot destination. As result an extension of the transport efficiencies is achieved.
In this work it were performed an environmental and an economical analysis of backhauling activity. The model developed was applied to a real company, JM Group, where the current strategy for the backhauling activity was analyzed.
As final results it was demonstrated that the backhauling activity can be considered both as an economical as well as an environmental friendly activity to both the buyer and the supplier. In the case-study analyzed this allowed a global savings of approximately 38424 kg of CO_2 emissions (34.89%). Also the total gain for performing backhauling is of 83141.59 € per month.

Based on the model developed and through its application to a real case-study it can be concluded that the backhauling activity results both economical and environmental friendly activity. Therefore within the retailing/distribution sectors where the weight of transportation is high the backhauling activity can be seen as a sustainable activity to pursue. This will allow the development of sustainable strategies at the supply chain level.

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