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A green profitability framework to quantify the impact of green supply chain management in South Africa

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Background: The greenhouse gas emissions of South Africa are the largest contribution by a country in the African continent. If the carbon emissions are not reduced, they will continue to grow exponentially. South Africa's emissions are placed in the top 20 in the world when considering per capita emissions.

Objectives: The aim of the research article was to investigate how the impact of implementing environmental initiatives on business profitability and sustainability can best be quantified in a South African business.

Method: Various methods, theories and best practices were researched to aid in the development of the green business profitability framework. This framework was applied to two case studies in different areas of the supply chain of a South African fast-moving consumer goods business.

Results: Results indicated that the green profitability framework can be used successfully to quantify both the environmental and profitability impact of green supply chain initiatives. The framework is therefore more suitable for the South African company than other existing frameworks in the literature because of its ability to quantify both profitability and sustainability in short- and long-term planning scenarios.

Conclusion: The results from the case studies indicated that the green business profitability framework enabled the tracking of environmental initiatives back to logistics operations and profitability, which makes it easier to understand and implement. The developed framework also helped to link the carbon emissions to source, and to translate green supply chain actions into goals.

Introduction

Problem statement

Preliminary research suggests that there is a need to quantify the impact of implementing green supply chain initiatives in a business, based on the profitability and sustainability of that company's supply chain. However, the existing methods used to do this are not focused on monitoring the impact on the complete supply chain, from operational activities to longer term strategic initiatives (Marchal *et al*. 2011:1; Porter & Van der Linde 1999:1; Schaefer & Kosansky 2008:2). A new framework is therefore required to assess the profitability and sustainability impacts of green initiatives on businesses and their supply chains.

Background

To remain competitive in the market, many businesses in South Africa are pressured to reduce costs whilst improving customer service through more efficient operations (Kumar 2013:16). One way to achieve this is to shift from a functional to an end-to-end, or total, supply chain view (Kumar 2013:16). Properly designed green supply chain initiatives can lead to cost savings when the total supply chain cost of a product is considered. Implementing properly designed green supply chain initiatives can therefore increase the competitiveness of a company in the market (Porter & Van der Linde 1999:1).

When considering the total supply chain cost of a product, properly designed green supply initiatives have the potential to save costs and improve a business's competitiveness. Business leaders often focus disproportionately on the cost of implementation and the potential cost savings of green initiatives, instead of calculating the net effect of the investment on the business. An excessive focus on cost savings, with no regard for the potential impact that the change might have on another part of the supply chain, can provide an inaccurate indication of the actual cost of making the change. It is therefore critical to consider the end supply chain impact before implementing an initiative (Porter & Van der Linde 1999:1).

Objectives

The main objective of the article is to develop, apply and test an approach to quantify the impact of implementing environmentally friendly initiatives on business profitability and sustainability in South Africa. Secondary objectives are (1) to develop a framework that can be used to quantify the impact of green supply chain initiatives on the profitability and sustainability of a business's supply chain and (2) to apply the framework to a South African company's supply chain to determine whether the framework can successfully quantify the environmental and business profitability impact.

Literature review

Existing frameworks and techniques

Before the new framework could be developed, existing frameworks or techniques in the literature were selected through an initial screening process and thoroughly investigated to understand how they could be used to quantify the business impact of implementing green initiatives.

The initial screening entailed understanding the main functions and determining whether business profitability, costing and environmental sustainability are addressed by the models and frameworks.

The considered principles, techniques and frameworks are the following: the Electric Utility Industry Sustainable Supply Chain Alliance (EUISSCA) sustainable supply chain framework (EUISSCA n.d.), GreenSCOR (Supply Chain Council n.d.), the Toyota 5R waste management principle (Black & Phillips 2010:6), the life cycle assessment (LCA) (Clift & Wright 2000:281–295), the Environmental Engineering Group Environmental Costing (EEGECOST) model (De Beer & Friend 2006:6) and the United Kingdom's Department of Environment, Food and Rural Affairs (DEFRA n.d.).

Electric Utility Industry Sustainable Supply Chain Alliance sustainable supply chain framework

EUISSCA (n.d.) released a set of voluntary standards that aim to raise awareness of the actions of utility suppliers and their impact on the environment. These standards also outline a list of initiatives that can be implemented to improve environmental performance (EUISSCA, n.d.). One of the key features of the framework outlined by EUISSCA (n.d.) is its ability to enable the alignment of reporting about environmental factors with corporate strategy. Another key feature of this framework is its ability to enable the integration of sustainable environmental practices into business practices.

One shortcoming of the EUISSCA (n.d.) sustainable supply chain framework is that it focuses more on compliance, with little regard to the cost of green supply chain initiatives. However, the framework can be a useful resource in understanding the process of moving from mere compliance to leadership in green supply chain management.

Green supply chain operations reference

Stewart (1997:62) explains that the supply chain operations reference (SCOR) model is a framework to measure supply chain performance across industries. The SCOR model provides a combined structure that links metrics, processes, best industrial practices and people to enable the improvement of supply chain management in businesses (Supply Chain Council n.d.).

The SCOR model also assists in evaluating supply chain activities against performance measures, increasing inventory turns and system implementation, and supporting learning programmes by providing the basic building blocks, flows and best practices of processes (Supply Chain Council n.d.).

The basic building blocks of the SCOR model are the *Plan, Source, Make, Deliver, Return* and *Enable* management processes (level 1 processes). The SCOR model provides a good method for measuring the total environmental impact of the end-to-end supply chain through an addition, referred to as GreenSCOR (Wilkerson 2009:3). As with the basic SCOR model, GreenSCOR includes environmental processes, measures and best practices to enable businesses to measure the total environmental footprint of their entire supply chain, compare it with industry standards and determine what best practices can be considered to increase the environmental performance (Wilkerson 2009:3).

Some of the advantages of using GreenSCOR to determine the environmental impact of supply chains are the ability to link carbon emissions to a specific process, to aid efficiency improvement in the supply chain, to aid in translating strategic carbon emission plans by linking them to specific activities and to understand the root cause when targets are not met (Cash & Wilkerson 2003:6). Although GreenSCOR cannot quantify the impact on business profitability, it provides a suitable base for the development of the new framework and helps ensure that the whole supply chain is covered from the *Plan, Source, Make, Deliver* and *Return* perspectives.

Toyota 5R waste management principle

Black and Phillips (2010:6) state that the goal of green manufacturing is to limit waste at the end of the supply chain. The Toyota Production System was developed by Toyota and focuses on reducing any form of waste in the manufacturing environment flowing over to the rest of the supply chain. Toyota also developed the 5R program to help reduce pollution at source in the manufacturing line.

One shortcoming of the Toyota 5R approach is that it focuses mainly on the manufacturing environment and not on the supply chain as a whole. However, it can be used to manage the waste of the manufacturing component of the supply chain. The concepts of *Refine*, *Reduce*, *Reuse*, *Recycle* and *Retrieve energy* can be helpful to identify other green options in the rest of the supply chain.

Life cycle assessment

Clift and Wright (2000:281) summarise LCA as an approach where the whole supply chain must be included. This approach considers all the major stages in the life cycle of a product and measures the impact of the different processes in the product life cycle on the environment (Williams 2009:1–23).

LCA measures the environmental impact by quantifying resource usage, waste and emissions per area of the supply chain; it does not measure the impact on business profitability (De Bruijn, Van Duin & Huijbregts 2004:16). However, because of its modular approach to calculating carbon emissions, the LCA model is used as a resource for the development of the new framework (De Beer & Friend 2006:6).

Environmental Engineering Group Environmental Costing model

Social and environmental liabilities can be converted into environmental costs through environmental accounting (Chowdhury & Hamid 2013:122–129). To this end, the EEGECOST model was developed to explain and quantify environmental accounting principles in South Africa.

De Beer and Friend (2006:6) note that the two main functions of the model are accounting and budgeting, where the accounting function includes allocating environmental costs to specific cost types (cost centres) and budgeting is used to plan the next financial year by creating cost centre budgets and monitoring spend. They conclude that the model is suitable for quantifying the environmental costs per functional unit, and environmental costs are compared annually to understand the impact of direct and indirect environmental initiatives. However, the EEGECOST model only focuses on production and activities related to the production of a functional unit; it does not model the impact on profit and the rest of the supply chain. Despite this, the model's concept of breaking costs down into functional units and allocating economic value to them was considered during the development of the new framework.

Product costing and cost-to-serve

Norek and Pohlen (2001:37) state that not knowing the true cost of serving a customer makes it difficult to design the optimal supply chain: the optimal design must consider both the cost of serving a customer and the revenue of that customer.

One aspect of determining the cost of serving a customer is product costing. Activity-based costing (ABC) is a product costing technique that works on the principle that all the activities involved in producing the product are identified, and the cost of these activities is determined and used to calculate the total product cost (Jooste & Van Niekerk 2009:3).

ABC is thus used in the new framework to determine the cost of serving customers so that businesses can calculate the costs for each activity and trace product flow and cost from customers to warehouse facilities. This will support customer-specific and detailed analysis. Using ABC in the new framework can also assist businesses to assign costs to different routes and customers in order to increase the profitability per route and ensure that a customer group can receive customised service packages. Using the ABC method also provides a solid systematic approach to understanding customer profitably, which can help businesses to focus on sustainable long-term solutions instead of short-term ones (Jooste & Van Niekerk 2009:4).

Jooste and Van Niekerk (2009:4) and Ernst and Young (n.d.) demonstrate that the full end-to-end supply chain cost can be accessed by using the ABC method. The impact of environmental cost on product costing can also be analysed by using the ABC method, as illustrated by Capusneanu (2008:57–62). This is done by assigning costs to processes, activities and products, and by adding the environmental impact to these costs to analyse the combination of environmental and product costing. However, the impact of ABC costing needs to be taken further and related to business profitability.

Business profitability modelling

Business profitability modelling (BPM) combines product costing and cost-to-serve modelling to determine the full end-to-end supply chain cost. BPM calculates the profit contribution at customer, product and route levels and considers all company costs to determine the true cost of serving customers (Ernst & Young n.d.).

The new framework presented in this article addresses this need. It uses a combination of various techniques, including ABC costing, to determine the impact of environmental initiatives on overall company and customer-level profitability and sustainability.

Department for environment, food and rural affairs

DEFRA (n.d) is a government department in the United Kingdom that is responsible for environmental protection, food production and standards, agriculture, fisheries and rural communities in Great Britain and Northern Ireland.

According to DEFRA (n.d.), greenhouse gases (GHGs) consist of seven main gases that contribute to climate change. As defined by the Kyoto Protocol, these gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). DEFRA (n.d.) also states that CO_2e is the universally accepted measurement to indicate the global warming potential (GWP) of GHGs, which is reported as the GWP in units of CO_2.

For each activity, there are predefined factors that can be used to calculate the carbon emissions. DEFRA (n.d.) explains that, to calculate the carbon emissions, the data per activity must be converted into carbon emissions using a predefined carbon emissions table with standard conversions.

Research methodology

Development of framework

From the research, it is clear that there is no single framework that can address both profitability and sustainability at the same time. The green business profitability framework presented in this article combines elements of LCA, SCOR, product costing, cost-to-serve, ABC, BPM, DEFRA and GreenSCOR into one model to quantify the financial and environmental impact of green supply chain management initiatives in businesses (Dawson Consulting n.d.; DEFRA, n.d.; Ernst & Young n.d.; Jooste & Van Niekerk 2009:4; Lessner 1991:87).

Figure 1 illustrates the full green business profitability framework with metrics and best practices. The first level of the framework determines which supply chain area should be focused on first, and then performs an as-is assessment of the current cost and carbon emissions. The second level identifies improvement opportunities that can result in less distance travelled, and therefore a reduction in carbon emissions and possibly cost. The business profitability and sustainability (in terms of carbon emissions) improvement opportunities are then determined in the last level. This indicates the feasibility of implementing potential initiatives. The green business profitability framework can also be used to monitor actual performance after implementation, and to determine how the actual results compare to predetermined estimates.

The framework was developed using previous research, the application of other frameworks and case studies. The developed framework was applied to a series of case studies in different parts of the case study company's supply chain. Building the theory was the largest part of the method, followed by testing the theory and application research. Theory building included researching current green supply

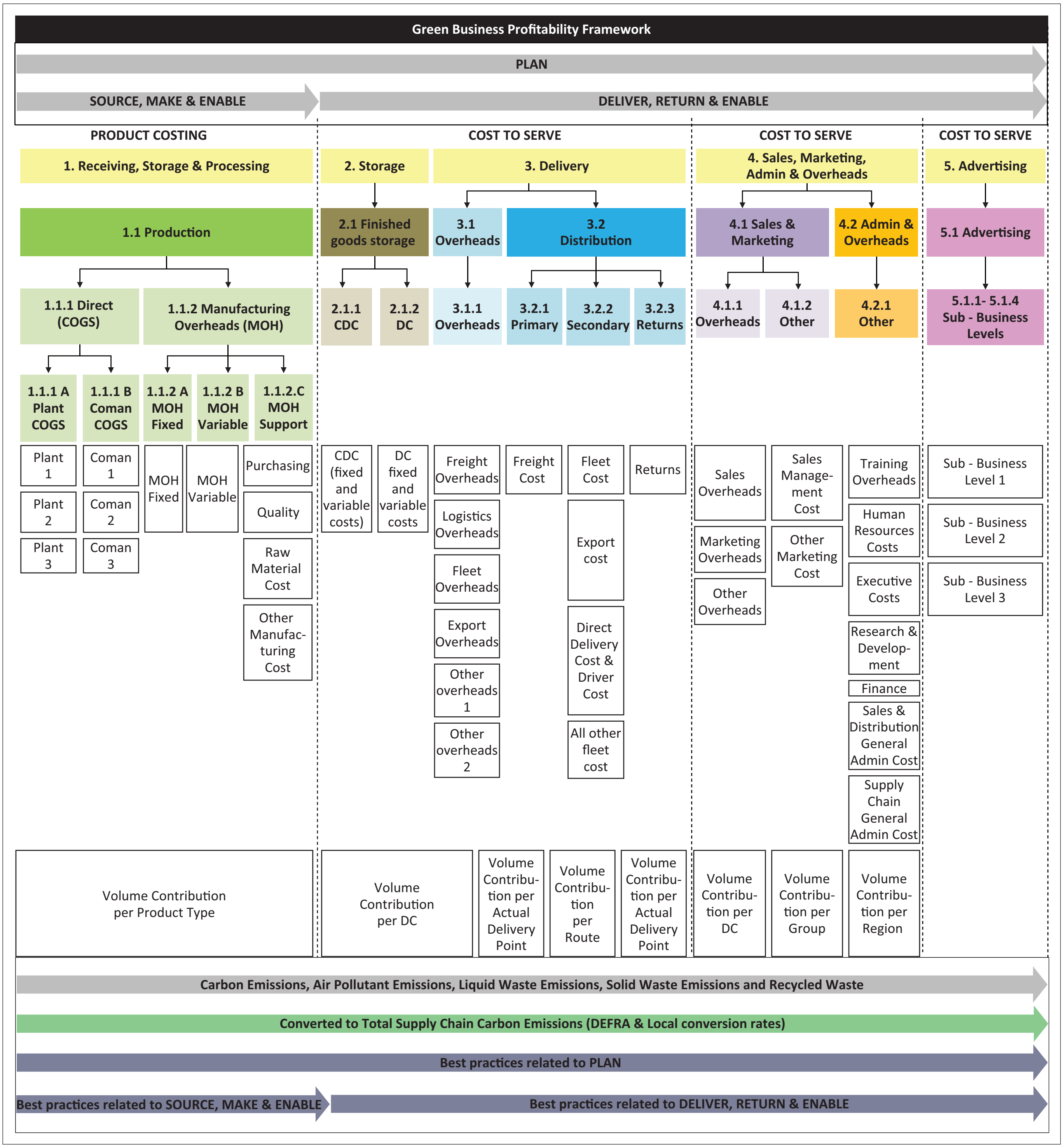


FIGURE 1: Developed Green Business Profitability Framework.

chain management frameworks, evaluating suitability and also the core function of the framework, whilst keeping in mind that the main goal is to determine the environmental as well as financial impact on a company's supply chain.

The theory testing and application research was done by applying the framework to multiple case studies at a single case study company in order to quantify the impact of implementing environmentally friendly initiatives on business profitability and sustainability at a selected company. The developed framework was tested at a strategic level and at the lowest detail activity level to investigate whether the framework can successfully quantify the environmental and business profitability impact. The baseline (actual) is compared with the different scenarios to understand the full impact of green supply chain initiatives. The framework was developed using the step-by-step approach summarised below.

Step 1: Segmentation of supply chain building blocks

The development of the framework will begin by using the SCOR methodology to segment the supply chain building blocks into *Plan, Source, Make, Deliver, Return* and *Enable* activities (Supply Chain Council [SCC] n.d.b). In the framework, the *Source*, *Make* and some *Enable* activities contribute towards the product costing, and the *Deliver*, *Return* and some *Enable* activities fall under the cost of serving customers. The *Plan* activities are in both product costing and cost-to-serve.

Step 2: Arranging cost centres into supply chain processes

The cost centres of a company are then arranged into receiving, storage, processing, delivery, sales, marketing, admin, overheads and advertising within these high level SCOR building blocks. Then, the LCA model's approach of incorporating all the building blocks into a systematic process overview is used to group the cost centres into a supply chain view (De Beer & Friend 2006:10).

Step 3: Activities are grouped into work centres

The different activities across the supply chain, from receiving to dispatch, are grouped into work centres for which costs must be calculated. This serves as the base level of costing for the business. Work centre cost drivers must also be aligned between key stakeholders and identified before the cost can be allocated per product type in order to determine how cost will be divided between work centres.

Step 4: Costs are allocated to products at different levels

Products are then grouped into levels to which different costs are allocated, based on manufacturing activities and the number of units considered. When the product costing calculations are completed, the costs are linked to different customers as part of the cost-to-serve calculations. Product costing includes raw material receiving, raw material storage and processing or production costs, whereas cost-to-serve includes finished goods storage, delivery, sales, marketing, administration, overheads and advertising costs.

This approach to costing can benefit a business by making visible the non-value-added activities and biggest cost contributors; it can also improve overall profitability by monitoring and reporting total life cycle cost and product performance. The overall process of budgeting by identifying the cost-per-performance relationships for different customers and product types can also be improved by using this approach (Tsai, Lin & Chou 2010:189).

Step 5: Calculate cost per business level

When the product costing and cost-to-serve calculations are completed, the cost per different business levels is determined by calculating costs as described above for each section of the supply chain. The SCOR processes *Plan, Source, Make* and *Enable* apply to the receiving, storage and processing functions, whilst storage, delivery, sales, marketing, admin, overheads and advertising functions relate back to the *Plan, Deliver, Return* and *Enable* processes.

Step 6: Business profitability

The business profitability is then incorporated into the model. The current approach is to group all expenses together and subtract the total from the gross profit (GP) in order to find the net profit, as shown in Figure 2 (Jooste & Van Niekerk 2009:13).

The green business profitability framework's approach to calculate business profitability differs from this approach by splitting all the revenues and costs per product across all customers (see Figure 2). In this way, a business can see how customers and products contribute to profitability on an individual level.

When all revenues and costs are allocated to customers, various GPs are calculated to indicate which products and customers result in financial losses. The calculated GPs include different levels of GP calculations for GP1–GP6. This can enable businesses to identify potential improvement areas in the supply chain.

Step 7: Add discount and allowances

Discounts and allowances are also included in the business profitability modelling process. These are included in the green business profitability framework to determine the net profit. Product costing and cost-to-serve values are then subtracted from the net profit to find the business profitability of different levels: overall business level, sub-business level (local and export), sales regions, go-to-market methods, major customer group, central distribution centre, distribution centre, brand, route and customer.

Step 8: Determine the business sustainability analysis using Department of Environment, Food and Rural Affairs (n.d.)

Further to determining the impact of initiatives on the profitability of the business, the impact of the business on the environment should also be determined. This is done by adding GreenSCOR metrics to the *Plan*, *Source*, *Make*, *Deliver* and *Return* processes. The metrics are then converted into

Current Calculations:

Revenue
Less Cost of Goods Sold (COGS)
Gross Profit (GP)
Less Other Expenses
Net Profit/Loss

Product Costing

Revenue
Product A Revenue
Product B Revenue
Less Cost of Goods Sold
Product A COGS
Product B COGS
Gross Profit
Product A GP
Product B GP
Less Other Expenses
Product A Expenses
Product B Expenses
Net Profit/Loss
Product A Profit/Loss
Product B Profit/Loss

Cost to Serve

Revenue
Product A, Customer A Revenue
Product A, Customer B Revenue
Product B, Customer A Revenue
Product B, Customer B Revenue
Less Cost of Goods Sold
Product A, Customer A COGS
Product A, Customer B COGS
Product B, Customer A COGS
Product B, Customer B COGS
Gross Profit
Product A, Customer A GP
Product A, Customer B GP
Product B, Customer A GP
Product B, Customer B GP
Less Other Expenses
Product A, Customer A Expenses
Product A, Customer B Expenses
Product B, Customer A Expenses
Product B, Customer B Expenses
Net Profit/Loss
Product A, Customer A Profit/Loss
Product A, Customer B Profit/Loss
Product B, Customer A Profit/Loss
Product B, Customer B Profit/Loss

Gross Profits

Revenue
Less Cost of Goods Sold (COGS)
Gross Profit 1 (GP1)
Less Storage
Gross Profit 2 (GP2)
Less Delivery
Gross Profit 3 (GP3)
Less Sales & Marketing
Gross Profit 4 (GP4)
Less Admin & Overheads
Gross Profit 5 (GP5) (Net Profit Before Tax)

Source: Jooste, M. & Van Niekerk, H., 2009, 'Why consider cost to serve modelling?', paper presented at the Sapics 31st Annual Conference, Sun City, South Africa, July 12–13, 2009, p. 4

FIGURE 2: The detailed gross profit approach in the developed framework of splitting gross profits.

carbon emissions and incorporated into the model by applying them to the other levels using the DEFRA (n.d.) carbon emission factors. Because of the power generation differences between the United Kingdom – on which the DEFRA framework is based – and South Africa, a local electricity conversion to carbon emissions is used. The same rule applies to the natural gas conversion for which a local conversion rate will be used.

Step 9: Green supply chain operations reference best practices

Finally, the best practices for GreenSCOR are incorporated into the framework once the carbon emissions are known in the supply chain. The best practices are a source of ideas to optimise the environmental output of the supply chain by reducing carbon emissions. Best practices for the *Plan* process include the following: minimise energy use, minimise packaging, maximise loads and minimise the returns. The framework will be able to estimate the cost implication when implementing best practices to determine what impact they might have on the profitability of the product. The framework is helpful when making strategic decisions and running various scenarios. It makes it possible to understand the predicted financial impact on the various cost centres in the framework. For example, to model the impact of moving a distribution centre (DC) location, resulting in increased travelling distances to customers, primary and secondary transport costs – which fall under the distribution cost centre – will rise.

The framework was developed using previous research, the application of other frameworks and case studies. The developed framework is applied to a series of case studies in different parts of the single case study company's supply chain.

Research method

Gulsecen and Kubat (2006) comment that the case study research method is best for understanding difficult problems and is mainly used when in-depth research is required. The case study method must show that it is appropriate to address the problem statement, that the proper guidelines are followed and that there is enough evidence to come to an accurate conclusion. In-depth research is required to quantify the impact of environmental initiatives on business profitability and sustainability because of the detailed kind of financial data required, and to ensure that enough evidence is considered for an accurate conclusion. Various green supply chain methods are evaluated for their suitability for use in a series of case studies in different sections of the supply chain at the case study company.

Furthermore, Zainal (2007) notes that it is important to prove that the case study approach is the only way to obtain reliable data from the source in light of the problem statement. The quantitative proof of the analytical framework is methodically recorded, and the backbone of the case study is a theoretical framework. A theoretical framework is developed, and – because of the level of input data required for the framework – the case study approach allows reliable data collection: actual financial data will serve as quantitative proof of the outcome by comparing it with the original set of values. The financial statements provide detail-level general ledger and actual expense data. Because of the high granularity of this data, a case study is the most suitable method to answer the problem statement. To ensure a methodical approach, the supply chain is assessed in terms of the SCOR model top-level processes: Plan, Make, Source, Deliver, Enable and Return.

The use of a case study research strategy makes it possible to understand a problem in great detail – something that is necessary when dealing with financial data and when working in a natural setting to understand the full impact on the end-to-end supply chain (Gulsecen & Kubat 2006; Zainal 2007).

Seuring (2008) adds that case studies can be useful when analysing a problem in its natural setting because they make it possible to carry out direct observation. Thus, the case study method was used at the selected fast-moving consumer goods (FMCG) company to perform multiple case studies, given that the application of a single case study is beneficial when it is representative of a critical example, represents a larger group, is exclusive and can be a trial for multiple case study research in the future (Seuring 2008). The proposed series of case studies at the case study company will be indicative of one of the major role players in the FMCG industry, and the analytical framework applied to it will be built in a generic manner. The study will allow the framework to be applied to multiple case studies at other companies for future research. The generic manner of the framework will allow companies to select the level at which they want to analyse, and is dependent on the amount of data they have available and what section of the supply chain they want to analyse. The model allows for different views of the financial data to be included in it, and it is flexible enough to calculate the environmental impact of initiatives. This will allow a company to track the impact of green supply chain initiatives, and not simply to implement them.

Results

In this section, the developed green business profitability framework is applied to two case studies at a South African FMCG. The purpose of these case studies is to investigate whether the framework is suitable for determining the financial and environmental impacts of green initiatives in a business. The two case studies presented in this section are structured according to the *Plan* and *Source* supply chain building blocks.

Plan case study

As with other strategic projects at the case study company, the central Gauteng region, with four regional distribution centres (DCs), is the focus for the *Plan* case study. Secondary transport is currently an in-house operation, and the last network and route optimisation project was conducted more than 5 years ago. This case study determines whether it is worthwhile to optimise the current secondary transportation network by reducing the distance travelled to deliver to customers; it also investigates the impact of reduced distances, for each of the four DCs, on profitability and sustainability of the business.

To achieve this, the actual fixed and variable secondary transport costs for the previous year, geocodes of current customer locations, current delivery routes and sales data for the previous year are gathered. The optimal routing plan is then determined using JDA's network design and optimisation solution, JDA Supply Chain Strategist (SCS). JDA is an American software company that provides supply chain management and planning solutions (JDA n.d.). This optimal routing plan reallocates customers to DCs based on their location. The current and optimised routing plans are then compared to determine potential improvement initiatives. Finally, the impact of improvement initiatives on the profitability and sustainability (in terms of carbon emissions) of a business is determined, using the new green business profitability framework.

The current customer groupings per DC are not ideal, and part of the exercise is to reallocate the customers to a closer DC. The current state per DC is summarised by the number of trucks operating from the facility, the number of drops, the number of kilometres driven per week and the average number of drops per vehicle (Tables 1–4).

TABLE 1: Distribution centre 1 plan case study baseline.

Weekday	Drops	Vehicles	Weight	Base fleet	Average drops per vehicle	Km	Average km per vehicle
Monday	274	25	6580	31	11	2767	111
Tuesday	282	26	8613	31	11	2812	108
Wednesday	250	27	8116	31	9	2285	85
Thursday	298	26	8158	31	12	3272	126
Friday	227	24	7835	31	10	3753	156
Total	**1331**	**128**	**-**	**-**	**10**	**14 890**	**116**

TABLE 2: Distribution centre 2 plan case study baseline.

Weekday	Drops	Vehicles	Weight	Base fleet	Average drops per vehicle	Km	Average km per vehicle
Monday	122	14	3839	20	9	1626	116
Tuesday	109	13	4034	20	8	902	69
Wednesday	127	14	7534	20	9	1090	78
Thursday	140	13	6951	20	11	915	70
Friday	128	14	4667	20	9	1305	93
Total	**626**	**68**	**-**	**-**	**9**	**5838**	**86**

TABLE 3: Distribution centre 3 plan case study baseline.

Weekday	Drops	Vehicles	Weight	Base fleet	Average drops per vehicle	Km	Average km per vehicle
Monday	192	20	4253	25	10	2943	147
Tuesday	225	14	7301	25	16	4040	289
Wednesday	238	26	5773	25	9	4158	160
Thursday	228	27	7945	25	8	4901	182
Friday	195	20	4076	25	10	2313	116
Total	**1078**	**107**	**-**	**-**	**10**	**18 356**	**172**

TABLE 4: Distribution centre 4 plan case study baseline.

Weekday	Drops	Vehicles	Weight	Base fleet	Average drops per vehicle	Km	Average km per vehicle
Monday	67	8	3844	9	8	1212	152
Tuesday	83	9	2649	9	9	1285	143
Wednesday	69	8	3776	9	9	1004	126
Thursday	73	10	1866	9	7	2184	218
Friday	47	6	3858	9	8	1106	184
Total	**339**	**41**	-	-	**8**	**6791**	**166**

Optimising the current secondary distribution of the central Gauteng region has an impact on the number of drops per DC, the number of vehicles required and the number of kilometres driven. By optimising the routes for the four DCs, the base fleet of DC 1 reduces by three vehicles and there is a 36% reduction in the kilometres travelled. For DC 2, the base fleet requirement decreases by 10 vehicles and there is an 8% reduction in the kilometres travelled. For DC 3, the base fleet increases by six vehicles and there is a kilometre reduction of 13%. For DC 4, the base fleet increased by one vehicle and there was a kilometre reduction of 18%. The detail change per DC can be viewed in Tables 5–8.

In summary, the changes in the four inland central DCs brought about by the network optimisation project are an average increase of four drops, an increase in the average drops per vehicle by three, an average reduction of four in the number of vehicles and an average reduction of 8941 km travelled, which represents 19% of the total kilometres travelled.

Green business profitability framework: Plan

The GreenSCOR model links best practices to the *Plan* processes, as illustrated in Figure 3. The suggested best practices applicable to this case study (*minimise vehicle fuel usage, maximise loads* and *minimise returns*) link to the process *P4 Plan deliver* (*carbon emissions*). These level 3 best practices then flow into the level 2 process *Plan carbon emissions* and into *total supply chain carbon footprint* (level 1). This was used as a guideline in the case study to review the number of kilometres travelled to customers that would reduce carbon emissions. The GreenSCOR model identified the best practice that can be used by the green business profitability framework.

The impact of optimising the Gauteng central secondary transport routing leads to a 19% reduction in fuel costs and kilometres travelled, as well as the variable costs of the vehicles. There is also a reduction in the fixed costs of vehicles by removing four trucks, where the fixed costs can include fleet, overheads, equipment, rental and insurance cost. Variable costs are those that vary with the number of kilometres driven. They can include fuel, oil, tyres, repair costs, maintenance, toll fees, depreciation, traffic fines and drivers' salaries. The fixed and variable costs are assigned to a product type and customer based on the percentage of the truck capacity and sales volume of the route that the customer and the product will consume. This is based on a percentage allocation.

The total variable cost is reduced by ZAR 628 448 and the fixed cost by ZAR 454 278. The total annual cost reduction (saving) for the changes discussed is ZAR 1 082 726. The four central Gauteng DCs' annual savings are ZAR 709 550 for DC 1, ZAR 294 272 for DC 2, ZAR 14 434 for DC 3 and ZAR 64 468 for DC 4.

Applying the green business profitability framework, it can be seen that the change is experienced at the GP3 level because reducing the secondary distribution cost is part of reducing the delivery cost. To calculate the different GP levels, the cost of goods sold (GP1), storage cost (GP2),

TABLE 5: Distribution centre 1 plan case study optimisation results.

Weekday	Drops	Vehicles	Weight	Base fleet	Average drops per vehicle	Km	Average km per vehicle
Monday	265	23	6190	28	12	1670	73
Tuesday	274	26	8726	28	11	1947	75
Wednesday	220	18	8646	28	12	1708	95
Thursday	284	28	7252	28	10	1941	69
Friday	201	21	5164	28	10	2247	107
Total	**1244**	**116**	-	-	**11**	**9513**	**82**

TABLE 6: Distribution centre 2 plan case study optimisation results.

Weekday	Drops	Vehicles	Weight	Base fleet	Average drops per vehicle	Km	Average km per vehicle
Monday	135	13	4691	10	10	1079	83
Tuesday	116	11	4913	10	11	783	71
Wednesday	153	13	5398	10	12	1157	89
Thursday	148	14	5702	10	11	887	63
Friday	146	17	5472	10	9	1475	87
Total	**698**	**68**	-	-	**10**	**5880**	**86**

TABLE 7: Distribution centre 3 plan case study optimisation results.

Weekday	Drops	Vehicles	Weight	Base fleet	Average drops per vehicle	Km	Average km per vehicle
Monday	179	19	4587	31	9	2359	124
Tuesday	227	24	5087	31	10	3280	137
Wednesday	240	25	6121	31	10	3797	152
Thursday	235	24	7964	31	10	3997	167
Friday	197	22	3895	31	9	2556	116
Total	**1078**	**114**	-	-	**9**	**15 988**	**140**

TABLE 8: Distribution centre 4 plan case study optimisation results.

Weekday	Drops	Vehicles	Weight	Base fleet	Average drops per vehicle	Km	Average km per vehicle
Monday	74	9	5624	10	8	1317	146
Tuesday	84	8	5087	10	11	874	109
Wednesday	70	8	3919	10	9	1103	138
Thursday	77	9	1946	10	9	1237	138
Friday	53	8	3943	10	7	1021	128
Total	**358**	**42**	-	-	**9**	**5553**	**132**

delivery cost (GP3), sales and marketing (GP4), administration and overheads (GP5) and advertising and marketing (GP6) are deducted from the revenue. The business profitability impact can be displayed by business, sub-business, sales region, go-to-market, major group, central distribution centre (CDC), DC level, item brand level and route level.

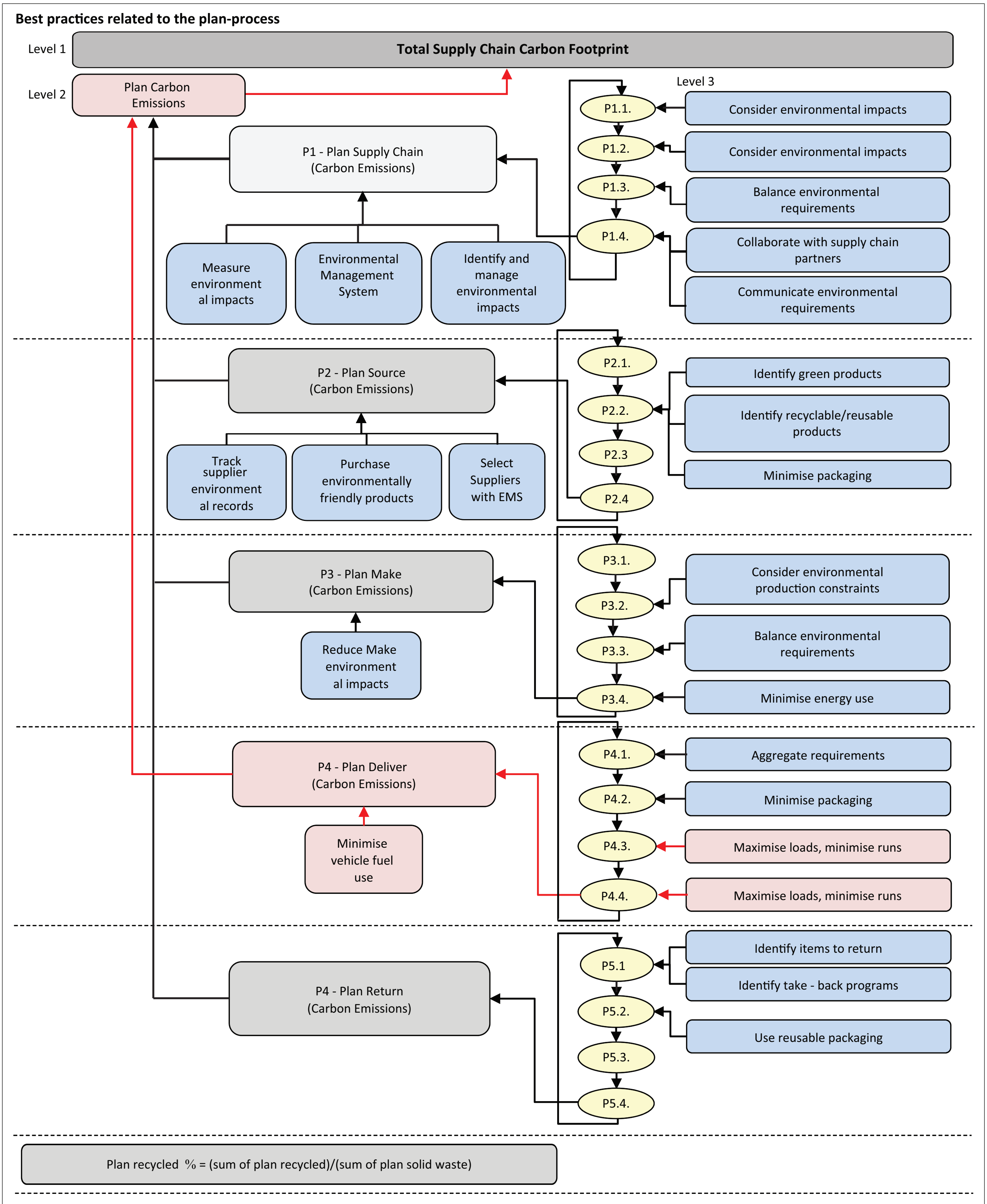
The GP3 impact is 0.04%; if only the *Plan* case study change is considered and the rest of the costs are kept constant, this will result in a total business impact (GP6 impact) of 0.04% and a total saving of ZAR 1 million.

The number of kilometres travelled is directly related to the fuel used, which is the main driver of carbon emissions. The total kilogram carbon emission (kgCO_2e) per DC is calculated and summarised as an overall impact by using the green business profitability framework. For the calculation, the average vehicles category (up to 3.5 tons) of distribution conversions is used; this matches all the secondary fleet sizes currently used in the business. The conversion factor indicates that 1 km is equal to 0.24999 kgCO_2e. Table 9 summarises the carbon emission factors and Table 10 summarises the total carbon emission impact of the *Plan* case study.

Source case study

The *Source* case study focuses on determining the financial and environmental impact of considering different strategic plans for a future co-manufacturing facility location. The aim of this case study is to determine whether the framework can successfully aid the company's strategic planning.

The case study company currently sources raw materials for the co-manufactured product from farms located in the Free State, Mpumalanga, and Northern Cape provinces of South Africa. The product is manufactured by suppliers in the Free State and Western Cape provinces. With increasing demand, there are various options to increase manufacturing capacity in other provinces, whilst limiting the cost and environmental impact of the supply chain. These options include investing in a manufacturing facility in the North West province, increasing capacity in the Western Cape province or increasing capacity in Kwazulu-Natal (KZN) province.



Source: The Supply Chain Council (SCC), n.d.a, *SCOR Revision 11*, viewed 07 April 2015, from http://www.apics.org/sites/apics-supply-chain-council/frameworks/scor and Van Zyl, I.P., 2012, Developing a model for measuring the environmental performance of the Safcor Panalpina operations and third party logistics service provided to clients, with a further aim of developing a consultancy capability as a further service offering, Final Year Project, Department of Industrial Engineering, University of Pretoria, Pretoria, p. 22

FIGURE 3: Best practices related to the plan process using Green supply chain operations reference.

TABLE 9: Department of Environment, Food and Rural Affairs' carbon emission conversions for distribution.

Activity	Type	Unit	Diesel			
			kg CO_2e	kg CO_2	kg CH_4	kg N_2O
Vans	Class I (up to 1.305 tons)	ton.km	0.61214	0.607749	0.000215	0.004175
		km	0.144477	0.143441	0.000051	0.000985
		miles	0.232514	0.230846	0.000082	0.001586
	Class II (1.305 tons – 1.74 tons)	ton.km	0.633423	0.628961	0.000141	0.004321
		km	0.228331	0.226723	0.000051	0.001558
		miles	0.367463	0.364875	0.000082	0.002507
	Class III (1.74 tons – 3.5 tons)	ton.km	0.502728	0.499203	0.000095	0.00343
		km	0.267749	0.265872	0.000051	0.001827
		miles	0.4309	0.427879	0.000082	0.00294
	Average (up to 3.5 tons)	ton.km	0.529972	0.526249	0.000108	0.003615
		km	0.24999	0.248233	0.000051	0.001705
		miles	0.402319	0.399493	0.000082	0.002745

Source: Adapted from Department of Environment, Food, and Rural Affairs (DEFRA), n.d., Carbon emissions factors, viewed 20 May 2015, from http://www.ukconversionfactorscarbonsmart.co.uk/

TABLE 10: Plan case study: Overall carbon emission reduction.

Carbon emission conversion	Value
kgCO_2e per kilometre	0.24999
Kilometres travelled As-Is annually (*based on one return trip per DC per week to the CDC*)	2 385 469
Kilometres travelled Proposed annually (*based on one return trip per DC per week to the CDC*)	1 920 547
Kilometres reduction annually	464 922
Current carbon emissions (tons) annually	596
Proposed carbon emissions (tons) annually	480
Carbon emission reduction (tons) annually	116
% Carbon emission reduction	19%

DC, distribution centre; CDC, central distribution centre.

To investigate this, the various alternatives are modelled and compared with the current network to determine potential cost savings. MS Excel and JDA SCS (JDA n.d.) are used for the analysis. The results of the three scenarios are summarised as follows:

- Adding additional capacity in KZN province and expanding the KZN customer region to include the Eastern Cape province also can result in an annual cost saving of ZAR 6.3m. This can result in a ZAR 4.6m manufacturing cost saving, ZAR 1.22m primary transport saving, and ZAR 515 200 warehouse cost saving.
- Adding additional co-manufacturing capacity in the Western Cape province and extending the Western Cape service area can result in a potential annual cost saving of ZAR 25.6m. This consists of a ZAR 18m manufacturing cost, a ZAR 5.6m transportation cost and a ZAR 2m warehousing cost.
- The third scenario investigates the opportunity to add an additional manufacturing facility in the North West province. The potential annual cost saving that can be realised is estimated to be ZAR 9.01m, with a manufacturing cost saving of ZAR 6.6m, a transportation cost saving of ZAR 1.5m and a warehouse cost saving of ZAR 910 628.

The financial and environmental impact per scenario is analysed with the green business profitability framework.

Green business profitability framework: Source

Best practices are linked to the sourcing practices by using GreenSCOR (Figure 4). The suggested best practices (*relative team member executes deliveries from different customers*) link to the level 2 process *bundle deliveries*. From there, this links to the level 3 process (*source stocked product*) and into the process *source carbon emissions*. This contributes to the overall L1 process (*total supply chain carbon footprint*). In the case study, the green business profitability framework uses the best practice of the GreenSCOR model as a guideline to review network designs in the three scenarios.

Scenario 1

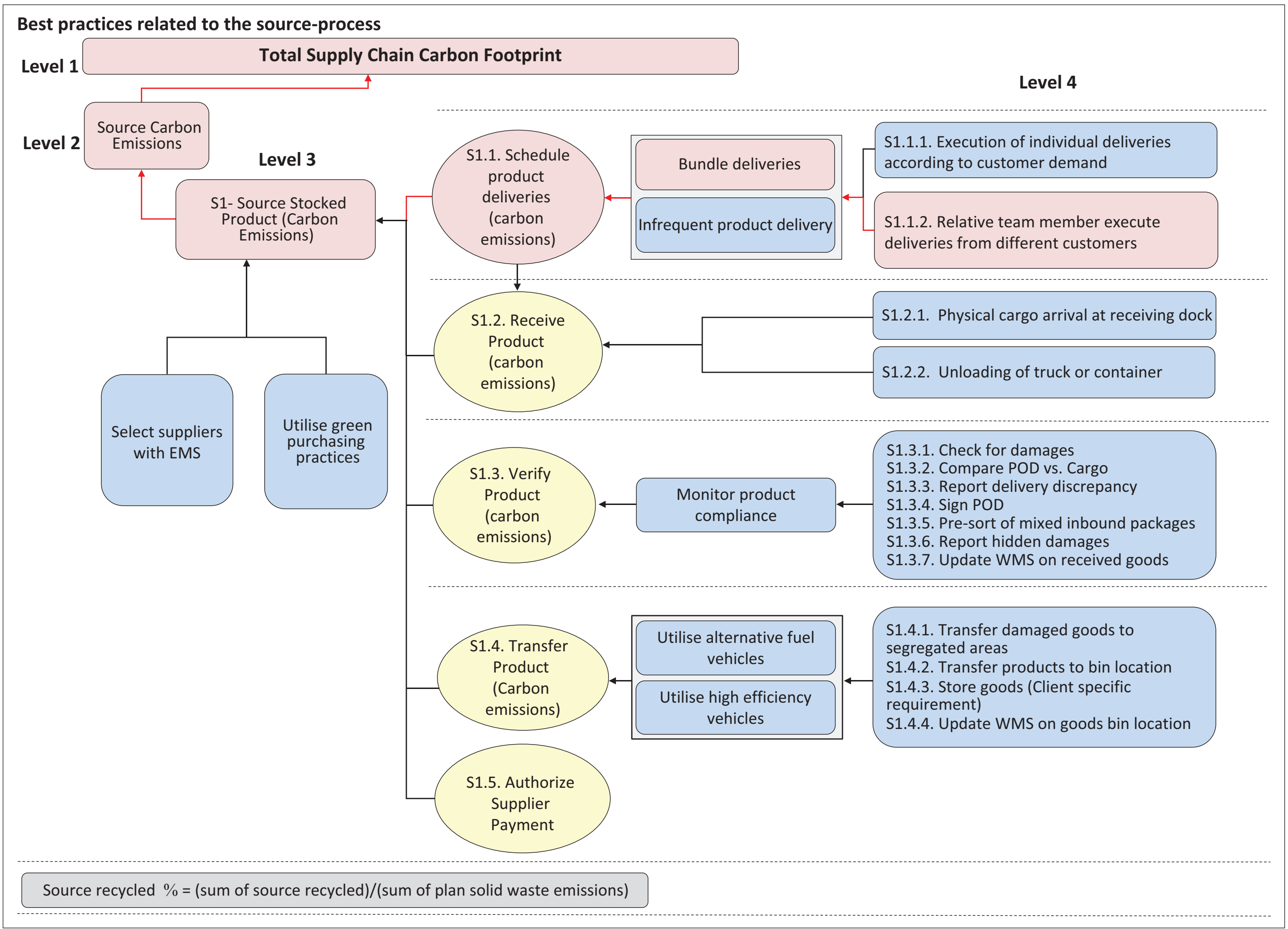
The manufacturing cost impact influences GP1, the warehouse cost saving influences GP2 and the transport cost saving influences GP3. The GP1 increase of 0.1% comes from the decrease in the manufacturing cost of ZAR 4.6m because of the lower rate input manufacturing cost.

The green business profitability framework results indicate that GP2 increases by 0.21%, which represents a ZAR 515 200 storage cost saving, and transportation cost decreases by ZAR 1.2m, causing an increase of GP3 by 0.26%. The total impact is a cost saving of ZAR 6.3m, which increases the total company profitability by 0.26%.

The number of kilometres driven directly influences the amount of fuel used, thus increasing the amount of carbon emissions. The total kgCO_2e produced by travelling from the CDCs to the customers and back is calculated and summarised into an overall impact. The carbon emission impacts of all three scenarios are calculated using the green business profitability framework, and the same conversion factors are used as in the *Plan* case study. Refer to Table 9 for the carbon emission conversion factor. Table 11 summarises the total carbon impact of the *Source* case study.

Scenario 2

The extra co-manufactured capacity results in a manufacturing cost saving of ZAR 18m, which increases the GP1 by 0.74% – although this is dependent on the manufacturing cost that the co-manufacturer can charge. The storage cost impact is a saving of ZAR 2m, and the transportation cost reduces by ZAR 5.6m. The overall impact is a total cost saving of ZAR 25.6m and a total company profitability increase of 1.05%.



Source: The Supply Chain Council (SCC), n.d.a, *SCOR Revision 11*, viewed 07 April 2015, from http://www.apics.org/sites/apics-supply-chain-council/frameworks/scor and Van Zyl, I.P., 2012, Developing a model for measuring the environmental performance of the Safcor Panalpina operations and third party logistics service provided to clients, with a further aim of developing a consultancy capability as a further service offering, Final Year Project, Department of Industrial Engineering, University of Pretoria, Pretoria, p. 22

FIGURE 4: Best practices related to the sourcing process using Green supply chain operations reference.

TABLE 11: *Source* case study scenario 1: Overall carbon emission reduction.

Carbon emission conversion	Value
$kgCO_2e$ per kilometre	0.24999
Kilometres travelled As-Is annually (*based on the current network*)	2 724 490
Kilometres travelled Proposed annually (*based on Scenario 1 of a KZN co-manufacturer*)	2 184 695
Kilometres reduction annually	539 795
Current carbon emissions (tons) annually	681
Proposed carbon emissions (tons) annually	546
Carbon emission reduction (tons) annually	135
% Carbon emission reduction	20%

KZN, Kwazulu-Natal.

TABLE 12: *Source* case study scenario 2: Overall carbon emission reduction.

Carbon emission conversion	Value
$kgCO_2e$ per kilometre	0.24999
Kilometres travelled As-Is annually (*based on the current network*)	2 724 490
Kilometres travelled Proposed annually (*based on Scenario 1 of a KZN co-manufacturer*)	2 798 681
Kilometres increase annually	74 191
Current carbon emissions (tons) annually	681
Proposed carbon emissions (tons) annually	700
Carbon emission increase (tons) annually	19
% Carbon emission increase	3%

KZN, Kwazulu-Natal.

Carbon emissions will increase by 19 tons per annum (3%) because of an increase in annual kilometres travelled (74191 km) and the results are summarised in Table 12. The potential annual cost saving of this scenario (ZAR 25.6m) seems very attractive, but implementing this scenario will have a bigger impact on the environment through increased carbon emissions.

Scenario 3

The extra co-manufacturing facility in the North West province results in a total cost saving of ZAR 9m, which results in an overall 0.37% GP increase. The production cost reduces by ZAR 6.6m, the storage cost reduces by ZAR 910 628 and the transportation cost reduces by ZAR 1.5m. The carbon emissions will increase by 41 tons per annum (6%) because of an increase in the distance annually travelled (165 449 km). The carbon emission results are summarised in Table 13.

Ethical considerations

Ethical clearance to perform the case study has been granted by the University of Pretoria in 2014, before the study commenced at the case study company. The case study company also gave the researcher signed permission to use the case study data.

Trustworthiness

To ensure validity, the case study included multiple sources of evidence partly from historical data and direct observation. The data used can be referred back to current processes and company records to establish a chain of evidence to ensure validity. The case study company signed off the study's results and the key informants reviewed the draft case study report to ensure the validity of the data and the findings recommended are practical to implement. To ensure external validity, replication logic was applied to the multiple case studies by ensuring that the same framework and analytical steps are followed, implementing the designed framework in different sections of the supply chain. Reliability is ensured by recording the detailed steps conducting the case study to ensure that the case study can be repeated and can yield the same results.

Discussion

Plan case study summary

The case study shows that GreenSCOR can be used to identify the best practices related to a process, and the DEFRA (n.d.) can be used to calculate carbon emissions. The green business profitability framework, however, combines LCA, product costing, the cost-to-serve methodology, ABC costing, BPM modelling, DEFRA and GreenSCOR to understand and quantify the impact of green initiatives on company profitability.

The final results of applying the green business profitability framework are summarised in Table 14. It is clear that DC1 has the biggest impact on business profitability and carbon emissions. DC2 has a reduction in cost and an increase in profitability, but the carbon emissions increase by 1% and there is an increase in the kilometres driven. DC 4 also has high carbon emission reductions and variable transport cost savings, mainly because of the reduction in kilometres travelled.

TABLE 13: *Source* case study scenario 3: Overall carbon emission reduction.

Carbon emission conversion	Value
$kgCO_2e$ per kilometre	0.24999
Kilometres travelled As-Is annually (*based on the current network*)	2 724 490
Kilometres travelled Proposed annually (*based on Scenario 1 of a KZN co-manufacturer*)	2 889 989
Kilometres increase annually	165 499
Current carbon emissions (tons) annually	681
Proposed carbon emissions (tons) annually	722
Carbon emission increase (tons) annually	41
% Carbon emission increase	6%

KZN, Kwazulu-Natal.

TABLE 14: *Plan* case study results per annum.

Indicator	DC 1	DC 2	DC 3	DC 4
Fixed secondary transportation cost (%)	36	29	1	0
Variable transportation cost (%)	26	4	1	11
Business profitability increase (gross profit) (%)	0.029	0.001	0.012	0.003
Carbon Emission reduction (%)	36	-1	13	18
Kilometre reduction (%)	5377	-42	2367	1239
Rating	1	4	3	2

The reduction in kilometres travelled through optimising the secondary transportation network is directly related to the carbon emissions, but not to the increase in business profitability. In the scenario, the net effect will be a reduction in carbon emissions and an increase in business profitability; however, DC2 will have an increase in carbon emissions and kilometres driven based on the network optimisation.

Source case study summary

The *Source* case study evaluated the suitability of using the green business profitability framework to create a five-year strategic road map. The results from the case study showed that GreenSCOR can be used to identify the best practices related to a process, and the DEFRA (n.d.) can be used for calculating carbon emissions. LCA, product costing, cost-to-serve methodology, ABC costing, BPM modelling, DEFRA and GreenSCOR are combined and integrated to form the green business profitability framework, thus making it possible to understand and quantify the impact of green initiatives on company profitability.

The results of applying the green business profitability framework in the three scenarios are presented in Table 15. From these results, it is clear that using a co-manufacturer in the KZN province (Scenario 1) will be the best option, as it increases business profitability by 0.26% and also has a carbon reduction of 20% in the overall network. Scenarios 2 and 3 both have higher business profitability increases, but the carbon emissions in both scenarios will also increase. The results indicate that the impact on profitability is not directly related to carbon emissions and, in some instances, there will indeed be a trade-off between profitability and sustainability.

Limitations of the study

Because of the sensitivity and confidentiality of the financial data, the framework was only applied to one South African FMCG company to determine whether the framework could be a suitable solution to quantify green supply chain management in a business. Therefore, not all the main role players in the FMCG industry in South Africa were analysed, and the study cannot be used to derive industry trends. However, the study serves as a good starting point for similar studies in the future.

Conclusion

Srivastava (2007:68) noted that most of the research into Green Supply Chain Management (GSCM) and optimisation

TABLE 15: *Source* case study results per annum.

Indicator	Scenario 1	Scenario 2	Scenario 3
Cost of goods sold (COGS) decrease (%)	0.3	1.2	0.4
Storage cost change decrease (%)	0.5	1.9	0.9
Delivery cost change decrease (%)	0.7	3.1	0.8
Business profitability increase (gross profit) (%)	0.26	1.05	0.37
Carbon emission reduction (%)	20	-3	-6
Rating	1	2	3

was conducted in different parts of the world with limited interaction between researchers. Most of the research is at a theoretical research level in papers and frameworks. Srivastava (2007:68) proposes that the way forward for green supply chain research is a practical framework that can determine the optimal way for a company to select initiatives and products to maximise profitability, whilst also keeping in mind the protection of brand integrity. He (2007:70) further proposes that for overall GSCM and design, a combination of traditional and new techniques along with various tools is needed. The green business profitability framework presented in this article combines elements of LCA, SCOR, product costing, cost-to-serve, ABC, BPM, DEFRA and GreenSCOR into one model to quantify the financial and environmental impact of green supply chain management initiatives in businesses (Dawson Consulting n.d.; DEFRA, n.d.; Ernst & Young n.d.; Jooste & Van Niekerk 2009:4; Lessner 1991:87).

The framework was developed and tested using previous research, applications from other frameworks and case studies. Case studies were identified on the basis of overview of the GHG emissions mentioned above and were used to determine the impact on the environment and profitability by implementing initiatives aiming at reducing the GHG emissions.

The results from the case studies indicate that the green business profitability framework enabled the tracking of environmental initiatives back to logistics operations and profitability, which makes it easier to understand and implement. The developed framework also helped to link the carbon emissions to source and to translate green supply chain actions into goals. Cash and Wilkerson (2003:6) found that GreenSCOR, which is part of the green business profitability framework, aids in green management by linking best practices to the detail processes and, if applied, can assist in reducing carbon emissions. GreenSCOR can only quantify carbon emissions; therefore, it needs to be used in conjunction with other frameworks and costing methods to determine the profitability impact. From the case studies, it can be concluded that not all optimisation initiatives will result in carbon reductions. The *Source* case study concluded that the impact on profitability is not directly related to carbon emissions and optimising in terms of profitability and sustainability will be a trade-off. The results from using the green business profitability framework to model a short-term strategic plan indicated that the reduction in kilometres driven through optimising the secondary transportation network is directly related to the amount of carbon emission but not to the increase in business profitability.

As South African businesses move from basic to optimised supply chains, and under the current economic pressure, they will need to look again at all possibilities to reduce costs. With carbon tax legislation looming, businesses need to be smarter about implementing sustainability initiatives that make financial sense. The green business profitability framework presented here is a possible tool for determining the profitability and sustainability impacts of green initiatives. The results can also enable businesses to investigate the trade-offs between profitability and sustainability so that they can make more informed decisions.

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Competing interests

The authors declare that they have no financial or personal relationship which may have inappropriately influenced them in writing this article.

Authors' contributions

N.C. contributed to the conceptualisation and design of the study, the collection and analysis of data, and the interpretation and analysis of results. W.L.B. provided focus and guidance for the study, revised the manuscript critically and ensured that the final manuscript meets acceptable standards for submission to the *Journal of Transport and Supply Chain Management*.

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