Input-output model for economic evaluation of the supply chain: the case of cut flowers exportation

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INPUT-OUTPUT MODEL FOR ECONOMIC EVALUATION OF THE SUPPLY CHAIN: THE CASE OF CUT FLOWERS EXPORTATION[1]

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Abstract: The main objectives are to evaluate the performance of the cut flower sector, concerning supply chain integration and foreign market competitiveness, and to heighten the understanding of the contributions and obstacles of logistics in floriculture. An IO model developed proved to be an important tool to evaluate the impact of changes in the processes involved in exportation chain. Data were colleted from representative actors of the chain, in the Holambra and Greater Sao Paulo regions, referring to every stage associated to the gerbera and lily exportation processes, i.e., from production (A), to internal distribution by highway modal (B), to external distribution by airway modal (C) and to external distribution by highway modal (D). Five scenarios were built to analyze deficit and surplus and to evaluate the impact of failures occurring in each process of the cut flower chain. Technical parameters were identified in the scenarios, mainly related to logistics, that could interfere in the cut flower exportation. The values of three of them - number of stems by box, exchange rate and air freight - were modified and combined to create 36 simulations to support the scenarios analysis. The results point to the need for differentiated logistic adjusts in each process, according to the type of relationship established among the actors involved in the stages. The development of the chain as a whole may be affected by lack of knowledge on the characteristics of the exported product, which causes distortions in the information forwarded to the actors. It was verified that failures occurring in each phase could increase costs and inhibit exportations in the event of unfavorable exchange rate movements. Also, an increased stem number commercialized by box represented an alternative to assuage cost increases through the chain. Although production is characterized by an important link throughout all stages, unless the minimum conditions for adequate storage and transport are fulfilled, there will be significant losses in the commercialized volume, thus reducing this product competitiveness abroad and discontinuing its exportation in the long run. Integration of the chain is essential to the optimization of exportation.

Keywords: cut flower, Brazilian exportation, process input-output model, logistics

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1 INTRODUCTION

Over recent years, Brazilian cut flowers have increasingly penetrated many countries' consumer markets, such as the well developed consumer markets in Holland and the United States. Brazil's flower sector is still inexpressive in terms of its participation in the country's total exports; although, there some very successful individual and corporate Brazilian flower producers. There are expectations that the Brazilian flower sector's participation in foreign markets will expand after implementation of the Brazilian Flowers and Ornamental Plants Exportation Program (Florabrasilis), created in 2000.

The Brazilian flower exportation sector has clearly advanced in its adjustment to world-wide trends as problems related to information flow within the chain are reduced and technological innovations linked with the production and commercialization of temperate and tropical flowers and foliage are implemented. Actors in Brazil's flower sector expect to achieve the revenue and employment growth enjoyed by other Brazilian agribusiness sectors.

Although the level of domestic flower consumption has not increased as much as hoped for, market alternatives in other countries have given Brazilian flower producers more flexibility as they attempt to level costly fluctuations in domestic flower demand. Foreign markets open sales options when local demand is slack and have provided niches that increase the productive potential of producer land. This flexibility in the distribution of a perishable, seasonal product has benefits that exceed the actual earnings from foreign markets; and the quality concerns of buyers in many of these markets has lead Brazilian growers to improve their cultivation techniques, storage methods, and shipping efficiency while increasing opportunities to enhance product durability and price.

The flower chain's complexity, especially in the multi-modal distribution segment, has led to the strict monitoring of operations to minimize accumulated cut flower losses.

Distribution complexity is exacerbated if the final consumer resides outside the local distribution area, and the farther away, the more complex distribution becomes. Exportation to markets in the Northern Hemisphere demands a higher level of distribution control than does the domestic market.

Because of their short shelf-life, logistic efficiency is paramount if Brazilian cut flower exporters are to gain a competitive advantage in foreign markets. Temperate and tropical flowers demand constant product monitoring to optimize logistic process in all chain stages and guarantee that quality and price will be competitive outside Brazil. Not only must Brazilian cut flower exporters organize efficient distribution methods to improve profitability, they must meet several severe handling and packaging conditions (cooling) to maintain product quality as it travels and is transferred between trucks and airplanes. By supplying the differentiated Brazilian flower products needed to meet consumer preferences in foreign markets, flower sales and producer flexibility in the domestic market should improve as demand for new products is created and domestic market niches are filled with products of greater value added.

Some critical differences between supplying the global cut flower market and supplying the domestic cut flower market must be addressed in the analysis of logistics in the Brazilian cut flower export chain. Commercial dealings in the international market imply an increase in total exporter costs over costs incurred supplying the domestic market. The exporter must ship over longer distances, adjust to longer lead times, submit to a new set of regulatory and currency exigencies, and pay higher taxes. Additionally, the exporter incurs increased risk from a lack of market understanding, reduced control of operations, added uncertainty during negotiations, and unusual, confusing contractual stipulations. These additional costs are greatly affected by the coordination and conflict resolution mechanisms that exist between each link in Brazil's cut flower export chain, and these mechanisms affect real export performance.

This paper presents an evaluation of logistic processes in the Brazilian flower sector over two years, 2002 and 2003, with a focus on the export segment. By further clarifying and quantifying the impact of logistical interactions between this chain's members, it is hoped that this study will be of aid as the Brazilian cut flower sector seeks to increase its competitive advantage.

2 LOGISTICS PROCESSES OF THE SUPPLY CHAIN

Brazilian companies involved in flower exportation have sought to increase their international competitive advantage through improved logistic competence. Although actors in the flower chain may have different objectives, the benefits to be gained by the rapid identification and correction of operational failures in the distribution system and control of real time product movements is recognized by all.

Organizations are analyzed as open, dynamic systems that exchange information with other actors, competitors, customers, suppliers, shareholders and the government. These organizations are united by sets of processes, sub-processes, activities, and tasks, all directed toward system improvement.

In terms of logistics, the integration of chain processes has assumed a prominent role in determining individual company and chain performance. According to the Council of Logistics Management[5], integrated logistics is the management, planning, and implementation of processes that control stock and goods flow from their origin to the final consumer so that this process is efficient and effective. Proper logistics integration leads to

[5] Informations are available in http://www.clm1.org

improvements in customer service, inventory control, forecasting, and customer satisfaction.

Efficient product movement depends on a coherently organized group of machines and people, with changes in the competitive environment demanding even greater supply chain integration. Wood & Zuffo (1998) consider integrated logistics to be related with the coordination of an entire business unit's logistic functions, from the arrival of raw materials and supplies, through production control, and eventually to the distribution of end products.

Cooper, Lambert & Pagh (1997) determined that the level of supply chain integration is linked with the level of partnership formed among the chain's companies, and supply chains made up or companies using more advanced technology often show tighter integration than chains made up of less technologically developed companies. Davenport (1994) emphasized that the logistics process, defined as the orderly administration of stocks, materials, and delivery, is one area where the use of information technology is beneficial.

Chopra & Meindl (2001) note that the supply chain, looking to maximize value generated along the entire chain, must be seen as an instrument used to meet consumer needs. To meet these needs, supply chain managers must have a constant flow of information. They need data from companies in the chain (raw material suppliers, manufacturers, distributors, wholesalers, retailers) in regards to timing, quantities, capital available, and costs; but most importantly, they need information from and about the origin of revenue: the final consumers. The final consumer's decisions have the greatest impact on the success or failure of each firm in the chain. In accordance with Fisher (1997), the evaluation of the supply chain's strategies begins with a demand analysis for a company's products.

As previously observed, there must be convergence between supply chain capacities and consumer needs if a company's objectives are to be met (Chopra & Meindl, 2001). Henkoff (1994) adds that increased competitive advantage is a hoped for result from the logistics process's improvement, since improved logistics should improve price adjustment efficiency, product quality for the end consumer, and delivery control (the right quantity delivered at the right time). These understandings, when combined with Porter's (1996) finding that strategic adjustment is often necessary to sustain the connection between many activities, directly implies that a flexible distribution strategy, especially when dealing with a seasonable, perishable product, will improve the chances of consumer-company convergence.

According to Fawcett & Clinton (1996), the performance of logistic processes is affected by the way companies have carried through their logistics planning, by the types of relationship established among the companies, and by the form of change made in these processes. Quite often, in order to improve logistic processes, behavior must be altered so that the phrase "this is the way this has always been done" is not an accepted rational for inefficient stagnation. Kahn & Mentzer (1996) point out that chain integration necessitates interaction within a company and collaboration with actors inside the company and that collaboration itself is necessary but insufficient to guarantee integration because it often involves unsettling cultural change within a company. In the Dutch poultry chain, for example, Vorst, Dijk & Beulens (2001) observed that restricted coordination due to limited harmony between actors reduces performance as predicted by the model applied to this chain. The level of chain integration is linked with the level of partnership formed among the chain's companies. In this context, concepts such as integrated logistics and supply chain management come into play.

At every stage of Brazil's flower chain, traditional business norms have been changed to improve inter chain coordination. This has lead to increased investment in human capital to reduce the high costs related to the strong information asymmetry, in agreement with Okuda (2000), Aki (1997) and Oliveira (1995). According to Lummus & Vokurka (1999), the chain's successful companies have lowered investment in stocks, reduced the cash flow cycle time, reduced materials acquisition costs, increased employee productivity, and have better met consumer needs at times of peak demand.

The breakdown in chain coordination, often caused by the agents' unequal access to information, incorrect information, conflicting priorities, or communication failures, is one obstacle to profit maximization. Chopra & Meindl (2001) have noted that this situation can lead to a chain performance below the expected value, causing a "bullwhip effect." In conformity to Lee, Padmanabhan and Whang (1997), the bullwhip effect is for the most part caused by out of date demand forecasts that generate unexpected demand oscillations, unmet orders, and price fluctuation. According to Donovan (2002), these effects can be dampened if product supply and demand information is exchanged between chain members in a clear, timely manner.

Logistics analysis in the context of the global economy, as opposed to the domestic market, involves more uncertainty and generally higher costs, according to Bowersox & Closs (1996). The authors found that this cost increase is mainly the result of increased transportation distances, greater lead times, less market knowledge, and reduced operations control capacity. Companies moving from the domestic market into the international market must modify their organizational structures to adjust to the new context. Dornier et. al. (2000) stress that the level of cooperation among organizations and their level of understanding of the specific business environment are factors that greatly influence coordination and conflict resolution, mainly in the logistics area.

The chain integration findings summarized in the preceding paragraphs make it appear that the effects of change in one specific logistics system factor, such as the installation of cold storage facilities at an airport, on the chain as a whole can be determined through analysis using adequate tools and sufficient data. Once the effects of alterations are known, alternatives to improve flower chain logistics can be evaluated.

3 PROCESS INPUT-OUTPUT MODEL

A process input-output model was used to analyze cut flower exportation chains. The model was proposed by Anefalos (2004) and developed from the models of Lin & Polenske (1998) and Albino, Izzo & Kühtz (2002). The basic structure of the model is described in the following:

$$\sum_j Z_{ij} = Y_i \quad \forall i \tag{1}$$

where $\mathbf{Z} = \left[Z_{ij}\right]$ is the matrix of intermediate consumption of main products, or it represents how much the total production of production process j is used to produce a unit of final demand of production process i ; $\mathbf{Y} = \left[Y_i\right]$ is the vector of main products final demand.

$$\mathbf{Y} = \mathbf{AX} = \mathbf{ZT} \tag{2}$$

where $\mathbf{T} = \left[T_{j1}\right]$, $\mathrm{T}_{j1} = 1$ is the unitary column vector.

$$\mathbf{X^i} = \mathbf{BX} = \mathbf{IT} \tag{3}$$

where $\mathbf{X^i}$ is the vector of the total consumption of each purchased input k, k=1, 2, ..., i; $\mathbf{I} = \left[I_{kj}\right]$ is the consumption matrix of purchased inputs k in process j; $\mathbf{B} = \left[B_{kj}\right]$ is the matrix of direct input-output coefficients for purchased inputs k in the process j.

$$\mathbf{X^w} = \mathbf{CX} = \mathbf{WT} \tag{4}$$

where $\mathbf{X^w}$ is the vector of total production of each intermediate component and residue *k*, *k*=1, 2, ..., *w*; $\mathbf{W}=\left[W_{kj}\right]$ is the production matrix of the intermediate components and residues *k* in process *j*; $\mathbf{C}=\left[C_{kj}\right]$ is the matrix of direct input-output coefficients for intermediate components and residues *k* in process *j*.

$$\mathbf{X^z}+\mathbf{X^m}=\mathbf{AX}=\mathbf{(Z+M)T} \tag{5}$$

where $\mathbf{X^m}$ is the vector of total importation of each main product, *k*, *k*=1, 2, ..., *m*; $\mathbf{M}=\left[M_{ij}\right]$ is the importation matrix of the main products moving from process *i* to process *j*.

$$\mathbf{X^v}=\mathbf{DX}=\mathbf{VT} \tag{6}$$

where $\mathbf{X^v}$ is the vector of total consumption of each primary input *k*; $\mathbf{V}=\left[V_{kj}\right]$ is the consumption matrix of primary inputs *k* in process *j*; $\mathbf{D}=\left[D_{kj}\right]$ is the matrix of direct input-output coefficients for primary inputs *k* in process *j*.

After the model's initial structure was determined, the elements of all matrices were adapted to cut flower exportation to evaluate the logistics performance of every process. The matrix of purchased inputs was divided into inputs purchased for production (**I**) and logistical inputs (**L**), and the matrix of components produced during the production process and residues was reorganized to pick up the logistics product through the efficiency of order cycle (**W**). For example, the exportation of determined products is divided into processes. The main products (cut flowers), called Z_{IJ}, where *I*, *J* correspond to *A*, *B*, *C* and *D*, and logistics products, called PLG*i* (in this case *i*=1), are produced in each process. PLG*i* measures the efficiency of the main products order cycle in each process stage by the addition or deduction of the monetary value of the final product. These products are altered at each stage through the addition of inputs purchased for their production, called IPRi (i = 1, 2,..., 20), through logistical inputs, called ILGi (i = 1, 2, ..., 15), and through primary inputs, called IPMi (i = 1, 2, ..., 6). Some items are measured by quantity, such as main products and some production inputs, to better characterize the chain. The inclusion of unitary prices is also essential in these cases to make product and process comparisons.

It must be noted that coefficients A_{ij}, B_{kj}, C_{kj} e D_{kj} are estimated and are relative to a specific firm and/or supply chain. The construction of the model employed in this study begins with the specification of inputs, products, and actors from each process in the cut flower sector exportation chain, which are identified in **Figure 1**.

3.1 STUDY ENVIRONMENT

The environment shaped in this work and the data sources contacted are made up of producers, cooperatives, customs brokers, exporters, and importers all located in Brazil's Holambra and Greater São Paulo regions. The preferred method of data collection was through questionnaires applied during personal interviews. Due to interviewee time constraints, some questionnaires were sent by e-mail. The data sources are representative of all Brazilian flower exportation logistic processes. As shown in **Figure 2**, these processes are aggregated into the following four categories: production (A); internal distribution using the highway mode (B); external distribution using the air mode (C), and external distribution using the highway mode (D). Chain analysis was restricted due to the difficulty in collecting indispensable primary data.

Two distinct types of cut flowers, lily and gerbera (Transvaal Daisy), and three producers, one lily and two gerbera (Gerbera 1 & 2), were used for analysis. All flowers were destined for export to United States. The same distribution channels were considered for all three products. The years taken for analysis were 2002 and 2003. The collected data were only concerned with the exportation activities of each actor in the chain; although, all three producers also distribute in the domestic market. Because the analysis is carried through by process and not by agent, information from one or more actors can be added at each stage to determine the costs and revenues associated with that stage.

4 LOGISTICS SCENARIOS

To better evaluate the performance of each process and the chain as a whole, modifications were made in some of the relationships between chain actors when constructing the scenarios. The modifications were defined from the verification of relevant problems that could arise in the chain.

Technical parameters that could intervene in the cut flower exportation process were identified and used in the composition of the scenarios. For the most part, these parameters were related to logistics and are as follows:

a) number of stems by box (75, 80, or 100 stems), changing according to the customer requirements and the type of flower;

b) nominal exchange rate in Brazilian currency ("real") per US dollar and per euro (R$/US$ and R$/€$);

c) highway freight costs to the airport - Guarulhos or Viracopos; these values vary according to distance traveled;

d) logistics trust, a parameter that adjusts some product distribution to airport costs proportionally among shippers through their union in a consortium that is justified by the small volumes exported by individual producers (on average, there are products from four small to medium sized producers per shipment);

e) number of shipments, which can vary from two per week to three per day depending on the time of year and the available volume of flowers for shipment;

f) airfreight costs, which can vary depending on the volume exported per shipment and the rate negotiated with the airfreight companies;

g) percentage of flowers lost during each process due to faults in immediate post-harvest handling, storage, transfer, and transportation from origin to final destination;

h) efficiency of the order cycle is a gauge, an example of which is shown in **Table 1,** used to detect a slowdown (logistics deficit) or exceptional efficiency (logistics surplus) at each stage of the distribution cycle;

i) amount of overtime that the truck remains at the airport loaded with flowers, delayed due to organizational, mechanical, or customs clearance problems;

j) rent of cooled container ("cold chamber") to keep the temperature of the flowers between 2 ^{o}C and 3^{o}C at Guarulhos or Viracopos airports;

k) flower fumigation before shipment from Brazil, done by the exporter, if it was not done by the producer;

l) flower fumigation at the airport in U.S.A. due to the detection of insects in load during agricultural inspection;

m) lack of refrigeration in the vehicle that carries the flowers from the producer to the distribution center;

n) physical loss of the freight during flight because of failures in the cold chain;

o) pre-cooling at the airport in the United States to improve the chances that the flowers will remain in saleable condition;

p) delay of the flight in Brazil due to customs clearance problems that entail additional payments to the air shipping company.

In the construction of each of the 5 scenarios, all the parameters noted above were kept fixed except for the number of stems per box, the exchange rate, and the airfreight rate. It was found that variation in the values of these three parameters can cause more meaningful modifications in chain performance. Each combination of these three parameters' values was characterized as a simulation within the scenario.

The R$/US$ and R$/€$ exchange rates are important parameters because they affect chain input and output prices. In the scenarios, the minimum, medium and higher exchange rates from three months during our study period, January 1999 to January 2004, were chosen to simulate the effect of exchange rate changes. The mimimum exchange rates for January 1999 was found to be R$1.50/US$ and R$1.60/€$; the medium exchange rates for February 2002 were R$2.41/US$ and R$2.10/€$; and the higher exchange rates for October 2002 were R$3.81/US$ and R$3.73/€$.

Thirty-six simulations were generated and analyzed. They were modeled using combinations of the three exchange rates (R$ 1.50/US$, R$ 2.41/US$ and R$ 3.81/US$), three quantities of stems per box (75, 80, or 100 stems), and four air freight rates (US$ 1.10, US$ 1.25, US$ 1.40, and US$ 1.50 per kg), as shown in **Table 2**. The lily and two gerberas chains are assumed to make two weekly shipments to Viracopos airport. All shipments are from Brazil to Miami and are contracted by a logistics trust dividing the costs among four producers.

Using the model proposed in Chapter 3, each simulation's main variables, cost, revenue, and profit, are calculated for the chain as a whole and for each process. The unitary profits from every production process within each flower chain are used to study each stage separately. Gross profits are related to each process's gross production, and final profit is associated to each unit sold to the final consumer.

Secondary variables were calculated to assist in the chain analysis. These variables were the total cost to profit ratio, the percentage of total costs that were logistic costs, the percentage of total inputs used in each processes, and the cost, revenue and total profit indexes for the chain as a whole. For each flower type, the first simulation of every scenario was determined to have an index base equal to 100. This simulation had the strongest Brazilian currency (lowest exchange rate ratio), the fewest number of stems per box, and the least expensive airfreight rate.

The five scenarios created for this study's analysis are distinguished by the following characteristics: Scenario 1–logistics deficit (distribution slowdown) in all chain processes; Scenario 2–logistics deficit in the chain that is more efficient in the production process; Scenario 3–logistics surplus (exceptionally efficient distribution) in all chain processes; Scenario 4–logistics deficit in the chain from failures in internal distribution processes that depend on road transportation; Scenario 5–logistics deficit in the chain from failures in the external distribution processes that depend on air transportation. The five scenarios characteristics are quantified in **Table 3**.

4.1 GENERAL ANALYSIS OF THE LOGISTICS SCENARIOS

The following presents a more detailed analysis of costs, revenues and profits generated in each flower chain scenario.

It was verified that simulating a weaker Brazilian currency resulted in higher logistics costs, excluding logistics inputs, in all scenarios but Scenario 4. These costs were controlled in Scenario 4 by increasing the number of stems per box. The simulated highest costs incurred in each scenario are shown in **Table 4**.

Simulation 12 generated the highest costs in all scenarios and for all flowers after adding logistics inputs. Simulation 12 contained the weakest local currency, the highest airfreight costs, and the fewest stems per box. There were serious problems at the airports in Scenario 5 that significantly influenced the increment of costs for all flowers, excessively damaged profit, and, consequently, reduced each chain's competitive position.

The best logistics conditions were combined in Scenario 3, which partially compensated for losses decreasing from chain efficiency although increasing costs. The greatest total revenues were found in this Scenario, peaking when the dollar was quoted at R$ 3.81: a very weak Brazilian real. It is observed that this Scenario's logistics inputs and outputs greatly improved profitability.

Table 5 presents the minimum total cost, revenue and profit values for each chain by scenario. The minimum total costs for all flowers were found in Scenario 1. Scenario 1 costs, including logistics inputs, were lowest in Simulation 25. This simulation includes the weakest Brazilian real, the lowest airfreight costs, and the greatest number of stems per box (Table 2). Inclusion of a great number of stems per box has the drawback of increasing risk of loss due to failures in the cold chain or the fumigation process. Minimum total revenues and profits were verified in Scenario 5 when a weak Brazilian "real" was simulated.

The Lily chain had the largest profit and highest costs of the studied chains. The Gerbera 1 chain generated the least profits and costs. It was the only chain that suffered losses in all scenarios when Brazilian exports were disadvantaged by the simulation of less competitive conditions, probably due to its small scale. The Gerbera 2 chain performed well, a result of this chain's ability to adapt to exchange rate variation, which differentiated it from the Gerbera 1 chain.

Logistics costs represent an important component of each chain's accounts. **Figure 3** presents logistics costs as a percentage of total costs in the three chains' 5 scenarios. The concentration of the logistics costs was minor in Scenario 3 because chain failure was minimized. Although lesser problems occurred in some Scenario 3 processes, several stages showed profit arising from a logistics surplus. Scenario 5, which was characterized by failures at the airport and during air transportation to the foreign market (external distribution using air mode, process C), showed the highest logistics costs for all studied flowers.

In general, the scenarios trended toward reduced logistics costs as the simulated number of stems per box increased; although, the majority of logistics costs are measured by number of boxes shipped. It was verified that the Gerbera 2 chain presented higher logistic costs than the other two chains. As the three chains used the same channels of commercialization, this finding is probably related to the Gerbera 2 chain's productive structure, which made relatively more use of cold chambers and had higher packing costs than the other chains. The production process employed in the Gerbera 1 chain made more intensive use of fertilizer and did not use climate controlled storage and packing facilities. The Lily chain was more influenced than the other chains by expenses on imported bulbs and for packing.

According to the World Bank (2002), transportation costs significantly affect growth in the exportation of primary goods by reducing long term profit. These costs also impact the importation of capital inputs and sales to end markets. In general, higher costs applied to one country's products puts that country's exporters at a competitive disadvantage, restricts market penetration, and reduces the exporting country's potential for growth.

Logistics improvement has contributed to reduce transportation costs in Brazil. One way Brazilian logistics costs have been reduced is through the development and implementation of the Integrated System of Exterior Trade (SISCOMEX). This system has lead to more efficient bureaucratic processes, thereby reducing the time needed to approve export product documentation. However, airport operations still need to be rationalized to reduce transaction costs and speed the custom's clearance of perishable products. Any move to reduce time in transit and transaction costs involves proper coordination between actors; and the more distant the end markets, the greater the difficulty coordinating the actors' actions.

Another issue that affects the cost of flower exportation concerns air freight rates, especially for producers in developing countries. According to the World Bank (2004), developing countries, often located in regions more distant from large economic centers and using small scale operations, are more susceptible to significant economic loss from high air freight rates but very dependent on equally little airfreight companies that maintain unreliable schedules and charge high rates. During this study, it was observed that a 10% increase in the air traffic volume caused a 1% fall in the air freight rate. High air freight rates not only add to direct costs but also may negatively affect the product.

According to Thoen et al. (2001), high air freight rates caused Kenyan producers to put additional stems in each box of exported flowers, which lead to reduced product quality due to overfilling and precooling deficiencies. According to these authors, only very large exporters have the ability to invest in installations that allow the continuous control of product temperature. Through the creation of joint ventures with freight companies and freight forwarders, these large exporters are also able to supervise product distribution and better guarantee that the flower arrives at its final destination unspoiled. Small exporters commercialize inferior products because they cannot make this additional investment and have much greater difficulty enticing freight companies into partnerships. According to Salin & Nayga Junior (2003), the efficient use of equipment and processes to maintain the cold chain, influences the differentiation and the competitive advantage of merchandise with a higher aggregate value.

A ratio between total profit and total cost that considered logistic inputs and outputs was used to compliment the scenario and simulation analyses conducted in our study. This ratio is broken down by flower, scenario, and simulation, as shown in **Figure 4**. In each scenario, changes in the relation between profits and costs occur as parameters are modified, and these modifications directly affect the performance of every chain processes.

The lowest lily producer earnings were generated in Scenario 5. The profit to cost ratio for lilies in this scenario oscillated between 54.00 and -15.20: for each R$ 1.00 spent by the chain for flower exportation, earnings ranged from R$ 54.00 and R$ -15.20. Higher lily profit to cost ratios were reached in simulations 27, 30, 33 and 36, simulations with the weakest Brazilian currency and the greatest number of stems per box.

Scenario 3 showed the best lily chain performance, with higher profit to cost ratios observed when an intermediate or weak "real" was simulated. Peak ratios were reached in simulation 27, with a profit to cost ratio of 133: for each R$ 1.00 spent a total chain profit of R$ 133.00 was registered. This value corresponds to nearly a 145% increase in total profit over the same simulation in Scenario 4. Analysis of the five scenario results shows that expenses for packing, commercialization, highway and air freight, customs clearance, and cold chamber use were the most significant lily chain logistics inputs.

Similar results were observed for the Gerbera 1 chain, however the changes simulated had smaller impacts when compared with the lily chain. The greatest Gerbera 1 profits were found when a weaker Brazilian currency was simulated in Scenario 3. A maximum Gerbera 1 value, 71.80, was reached in the 3rd Scenario's 27th simulation, while this scenario's minimum value, -16.5, was found in the 10^{a} simulation. As with the lily chain, the worst Gerbera 1 performance was found in Scenario 5, with the relation oscillating between 7.70 and -47.10.

The performance disparity between Scenarios 3 and 5 was most clearly demonstrated by the Gerbera 2 chain. This chain presented negative values in all Scenario 5 simulations, with its worst results appearing when the "real" was strongest (R$ 1.50 per 1 US$). This chain's highest profit to cost ratio, 164.60, was reached in the 3rd Scenario's 27a simulation, the highest ratio of all studied flower chains.

A "logistics consortium" is often used by Brazilian flower sector exporters to reduce shipping costs. The consortium allows multiple producers to combine their product shipments and share shipping expenses as determined by the proportion of total product that each ships to market. This mechanism is seen to be justified for producers that export only small amounts. Based on data collected from flower sector representatives, a logistics consortium of four producers per shipment was adopted in all scenarios. In order to better understand the economic effects of various sized logistics consortia on all flower chains in both the best and worst scenarios, we also calculated shipping efficiency gains (shipping cost reductions) that can be attained through association in consortia of 4, 10, and 20 exporters, as shown in **Table 6**.

All consortia were more efficient than the single exporter, but the gain in shipping efficiency is not directly linked with the increase in consortium size. It was found that the shipping cost for a single lily exporter in Scenario 3 was 3.30 percent higher than the cost for an exporter in a consortium of 4 shippers, 4 percent higher that the cost for a shipper in a consortium of 10 exporters, and 4.2 percent higher than for an exporter in a consortium of 20 shippers. In the case of the Gerbera 1 chain, a chain that exported a small volume, the cost benefits from combining shipments and dividing transport expenses is greater than that for the other chains.

The results from analysis of this study's scenarios and simulations made clear the importance of maintaining effective control of each stage of the cut flower exportation process to minimize, mitigate, and correct chain failures. It was found that the construction of logistics scenarios simplified visualization of the impacts of changes in relations between processes and between actors, drew attention to the link between chain performance and a country's political and economic environment, allowed flexibility in the analysis of each chain input, and would facilitate chain evaluation and management over the short and long terms.

From the relationship between cut flower exportation processes and scenario results, it can be deduced that production is the vital link in each flower chain. This seems reasonable as the exported product is produced and its peak quality determined in this stage. If the flower is not cultivated and harvested properly, careful handling throughout all the other processes will not result in the flower receiving the highest possible market value.

In Scenarios 1, 2 and 4, operational failures in the productive process (A, Figure 2) influenced processes further down the chain. Problems in Scenario 1's production process were related to handling difficulties while culturing the plant and were reflected by higher flowers losses at this stage. Scenario 2 established that these problems could be ameliorated through the use of improved cultivation techniques and more appropriate post harvest technologies; however, that does not eliminate the potential for procedural failures by other actors down the chain.

Scenario 4 results show the importance of a clear understanding of international post-harvest handling regulations by actors in the production processes (A) and during internal distribution using the highway mode (B, Figure 2). A muddied understanding of these requirements erected obstacles to entry into the international market that slowed final distribution and led to product quality deterioration. The effects of this problem were exacerbated a failure to meet minimum storage and transportation requirements in subsequent stages.

Although failures by actors in processes A and B can cause serious quality degradation, Scenario 5 demonstrates that problems at the airport (C, Figure 2) can also lead to a loss in quality through delay. Problems at the airport can even lead to a breakdown in negotiations between importer country agents and the domestic flower suppliers. The involved actors, especially at the domestic airport, may lack the knowledge needed to deal with perishable goods or may be disinterested in meeting these requirements and prioritizing the shipment of a product that has a low aggregate value when compared to other exported merchandise.

Our study demonstrated that process failures can occur at any stage of handling and transport and that these failures are frequently related to a technical breakdown, not in the equipment or infrastructure, but among the actors. Scenario 3 shows the actors' ability to improve each process's effectiveness through mutual cooperation and to amicably adjust lead times to meet existing realities often determines supply chain efficiency. Good relations among actors lead to better chain performance.

5 CONCLUSIONS

Analysis of this study's logistic scenarios made clear that integration among actors is very important to the optimization of each process and the maximization of chain profit. Failures occurring in any stage cause exportation efficiency to fall and negatively affect total chain profit. While there are specific relations among agents for each type of chain, and these relations influence each process's efficiency differently, each chain member must be able to advise and accept advice from others in the chain to rapidly correct failures.

Although static, the process input-ouput model was a tool that supported evaluation of the impacts of alterations in several parameters that significantly affect flower chain exportation processes and profits. The model also permitted information to be more extensively aggregated while providing a detailed overview of every chain stage. Assuming that conflicts among actors are resolved or, at least, minimized, the model can be used to suggest strategies for efficient supply chain management, detail methods to improve access to foreign markets, and enhance competitiveness and yield over the long term.

In general, logistics costs represented a significant percentage of each company's total costs. This study made clear that misallocated logistic inputs in any process can cause a more accentuated increase in total chain logistics costs, reduce chain flexibility, and under some circumstances make the exportation of flowers impracticable. Of course, chain failures as opposed to misallocation in any individual process, made these problems worse.

It was found that flower cooperatives are important actors in this chain. The union of various producers in a cooperative reduces the individual producer's cost for technologies that can be used to enhance and preserve flower quality. The cooperative can also act as a broker in negotiations between the domestic producer and the international market.

It is important to emphasize that although the model proposed in this study only worked with five scenarios for three distinct flower chains–Lily, Gerbera 1 and Gerbera 2 – whose product was destined solely for North American market, very detailed information was acquired through the effort of many actors involved in the exportation process. The proposed model can be applied to other export chains, other end markets, and other processes, such as distribution to the end consumer (E, Figure 2). These other avenues were not explored in this study due to data and time restrictions.

Similar analyses using minor time periods (months, quarters) are suggested for future studies. Analyses of shorter term impacts may lead to improved chain planning; and by including real exchange rate fluctuations, the influence of this parameter in the model will be better understood. Reducing the time period under study will also make the model more detailed, leading to a more complete understanding of the role played by agents involved in each chain stage and the relative contribution each stage makes to total chain productivity.

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Figures

Figure 1 – Structure included in the cut flower exportation process input-output model

Processes	Codes	Units/year	Processes			
			A	B	C	D
			Produ-tion	Highway internal distribution	Air external distribution	External highway distribution
Products						
Production	A	Number	Z_{AA}	Z_{AB}	Z_{AC}	Z_{AD}
Internal distribution/highway mode	B	Number	Z_{BA}	Z_{BB}	Z_{BC}	Z_{BD}
External distribution/air mode	C	Number	Z_{CA}	Z_{CB}	Z_{CC}	Z_{CD}
External distribution/highway mode	D	Number	Z_{DA}	Z_{DB}	Z_{BC}	Z_{DD}
Inputs purchased for production						
Bulbs	IPR1	Number	I_{1A}	I_{1B}	I_{1C}	I_{1D}
Seeds	IPR2	Number	I_{2A}	I_{2B}	I_{2C}	I_{2D}
Seedlings	IPR3	Number	I_{3A}	I_{3B}	I_{3C}	I_{3D}
substrates	IPR4	m^3	I_{4A}	I_{4B}	I_{4C}	I_{4D}
Defensives	IPR5	Kg	I_{5A}	I_{5B}	I_{5C}	I_{5D}
Fertilizers	IPR6	Kg	I_{6A}	I_{6B}	I_{6C}	I_{6D}
Plastic Boxes	IPR7	Number	I_{7A}	I_{7B}	I_{7C}	I_{7D}
Vases	IPR8	Number	I_{8A}	I_{8B}	I_{8C}	I_{8D}
Office equipment	IPR9	R$	I_{9A}	I_{9B}	I_{9C}	I_{9D}
telephone+communication	IPR10	R$	I_{10A}	I_{10B}	I_{10C}	I_{10D}
Vehicles insurance	IPR11	R$	I_{11A}	I_{11B}	I_{11C}	I_{11D}
Infrastructure	IPR12	R$	I_{12A}	I_{12B}	I_{12C}	I_{12D}
Structures (greenhouse,nursery)	IPR13	R$	I_{13A}	I_{13B}	I_{13C}	I_{13D}
Plastic[1]	IPR14	R$	I_{14A}	I_{14B}	I_{14C}	I_{14D}
Sombrite[1]	IPR15	R$	I_{15A}	I_{15B}	I_{15C}	I_{15D}
Irrigation[1]	IPR16	R$	I_{16A}	I_{16B}	I_{16C}	I_{16D}
Machines, implements and other vehicles	IPR17	R$	I_{17A}	I_{17B}	I_{17C}	I_{17D}
Eletricity[2]	IPR18	R$	I_{18A}	I_{18B}	I_{18C}	I_{18D}
Fuel	IPR19	R$	I_{19A}	I_{19B}	I_{19C}	I_{19D}
Water tanks and reservoirs	IPR20	R$	I_{20A}	I_{20B}	I_{20C}	I_{20D}
Logistics inputs						
Highway freight	ILG1	R$	L_{1A}	L_{1B}	L_{1C}	L_{1D}
Energy for storage of bulbs, seeds and seedlings	ILG2	R$	L_{2A}	L_{2B}	L_{2C}	L_{2D}
Energy for storage of final product (cut flower)	ILG3	R$	L_{3A}	L_{3B}	L_{3C}	L_{3D}
Cold chamber[1]	ILG4	R$	L_{4A}	L_{4B}	L_{4C}	L_{4D}
Energy for precooling	ILG5	R$	L_{5A}	L_{5B}	L_{5C}	L_{5D}
Precooling[1]	ILG6	R$	L_{6A}	L_{6B}	L_{6C}	L_{6D}
Labor for paletization	ILG7	R$	L_{7A}	L_{7B}	L_{7C}	L_{7D}
Paletization[1]	ILG8	R$	L_{8A}	L_{8B}	L_{8C}	L_{8D}
Cost for vehicle temperature control	ILG9	R$	L_{9A}	L_{9B}	L_{9C}	L_{9D}

Package for exportation	ILG10	R$	L_{10A}	L_{10B}	L_{10C}	L_{10D}
Labor for air cargo reservation	ILG11	R$	L_{11A}	L_{11B}	L_{11C}	L_{11D}
Custom clearance	ILG12	R$	L_{12A}	L_{12B}	L_{12C}	L_{12D}
Custom tariff	ILG13	Kg	L_{13A}	L_{13B}	L_{13C}	L_{13D}
Information system	ILG14	R$	L_{14A}	L_{14B}	L_{14C}	L_{14D}
Tax of commercialization	ILG15	R$	L_{15A}	L_{15B}	L_{15C}	L_{15D}
Logistics outputs						
Efficiency of order cycle	PLG1	R$	V_{1A}	V_{1B}	V_{1C}	V_{1D}
Primary inputs						
Capital Investment on process	IPM1	R$	W_{1A}	W_{1B}	W_{1C}	W_{1D}
Customs broker	IPM2	R$	W_{2A}	W_{2B}	W_{2C}	W_{2D}
Temporary labor (includes overtime)	IPM3	R$	W_{3A}	W_{3B}	W_{3C}	W_{3D}
Administrative labor	IPM4	R$	W_{4A}	W_{4B}	W_{4C}	W_{4D}
Operational labor[3]	IPM5	R$	W_{5A}	W_{5B}	W_{5C}	W_{5D}
land/property	IPM6	R$	W_{6A}	W_{6B}	W_{6C}	W_{6D}
Gross output of main products						
Vector X	PBX1	Number	X_A	X_B	X_C	X_D

[1]This item considered the annual cost for maintenance, interest rate and depreciation.
[2]The expense for energy for the supply of bulbs, seeds and seedlings (ILG3) and cut flowers (ILG5) was extracted from this item.
[3]The operational the expense for palletization labor (ILG7) was extracted from the item.

Processes	Code	Actors	Inputs
Production in the rural area	A	Producers, suppliers of inputs	Seeds, bulbs, seedlings, fertilizers, pesticides, cold greenhouses, packing, energy, cold chambers at the properties, machines and implements, labor
Internal distribution/ highway mode	B	Cooperatives, brokers, trucker, exporter	Truck, labor, tolls, lead time, cold chambers in the warehouses
External distribution/air mode	C	Brokers in Brazil and exterior, exporters, forwarding agent, customs brokers in Brazil and exterior, Federal Revenue Department, Ministry of Agriculture, INFRAERO, importers	Cold chambers in the airport, airplane, labor, customs tariffs, customs documentation, lead time, fitossanitary control
External distribution/highway mode	D	Importers, customs brokers and truckers in exterior	Labor, truck, lead time, quality control
Final distribution	E	Truckers, importer, distributor, retailer, final consumer	Labor, truck, lead time, quality control

Figure 2 - Characterization of all chain processes.

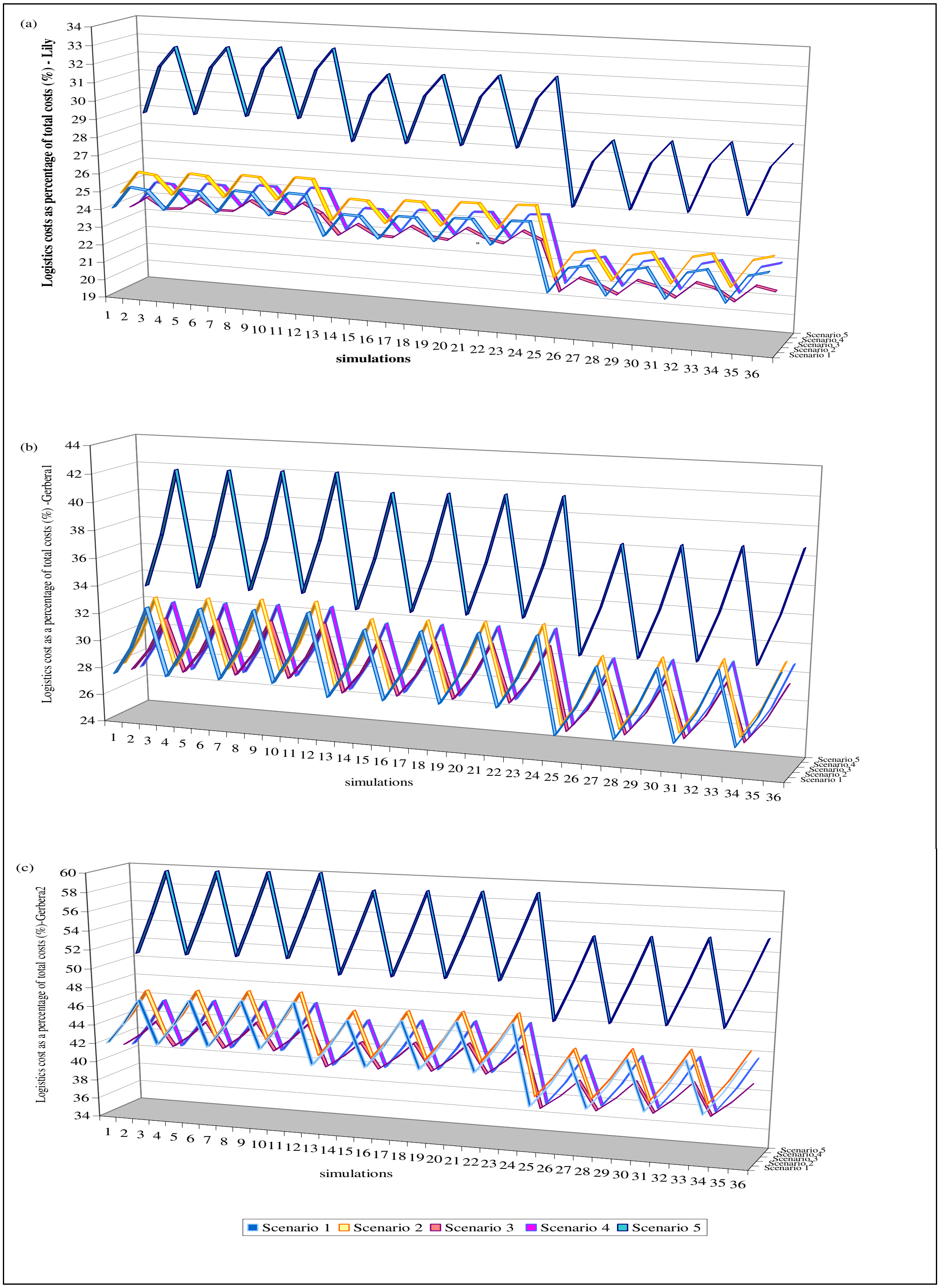

Figure 3 – Logistics costs as a percentage of total costs for the flower chains Lily (a), Gerbera 1 (b), and Gerbera 2 (c) from the 5 scenarios' 36 simulations

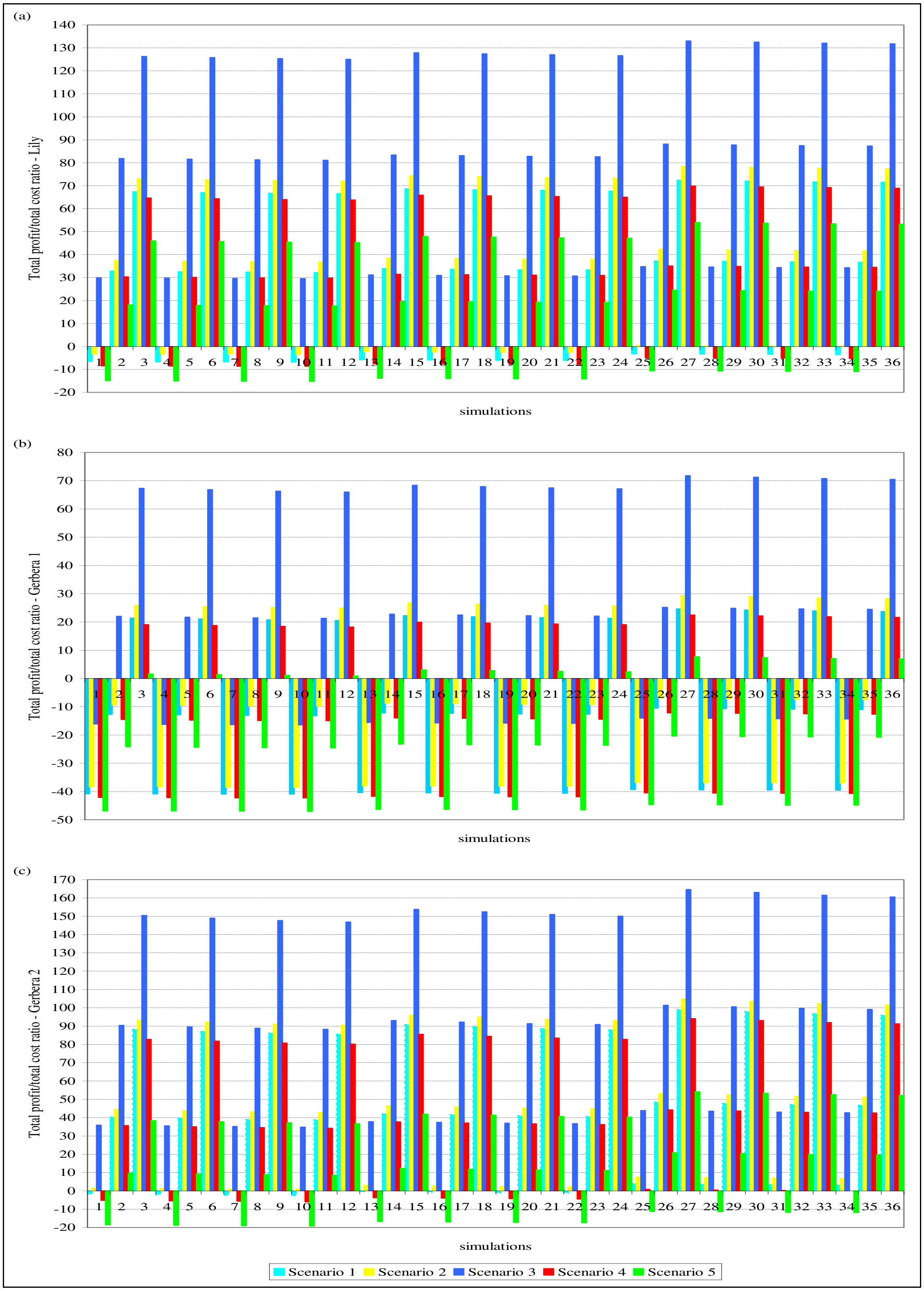

Figure 4 – Ratio between total profit and total cost, considering (a) Lily, (b) Gerbera 1, and (c) Gerbera 2 chain logistical inputs and outputs

Tables

Table 1. Estimates of the total lead time of the logistics cycle for air transportation, in days, and percentile variation from the adequate cycle (logistics surplus or deficit)

Processes	*lead time* (days)			Percentile variation from adequate	
	deficit	adequate	surplus	logistics deficit	logistics surplus
A	92.00	91.00	87.00	-1.10	4.40
B	1.10	1.08	0.77	-1.62	29.15
C	1.17	1.08	1.08	-7.69	0.00
D	2.00	2.00	2.00	0.00	0.00
Total logistics cycle	96.27	95.17	90.85		

Table 2. Simulated alterations considered for the construction of each Lily and Gerbera 1 and 2 scenario

Simu-lation	Parameters: Number of stems	Air Freight (US$/kg)	Exchange rate (R$/US$)	Simu-lation	Parameters: Number of stems	Air freight (US$/kg)	Exchange rate (R$/US$)
1	75	1.10	1.50	19	80	1.40	1.50
2	75	1.10	2.41	20	80	1.40	2.41
3	75	1.10	3.81	21	80	1.40	3.81
4	75	1.25	1.50	22	80	1.50	1.50
5	75	1.25	2.41	23	80	1.50	2.41
6	75	1.25	3.81	24	80	1.50	3.81
7	75	1.40	1.50	25	100	1.10	1.50
8	75	1.40	2.41	26	100	1.10	2.41
9	75	1.40	3.81	27	100	1.10	3.81
10	75	1.50	1.50	28	100	1.25	1.50
11	75	1.50	2.41	29	100	1.25	2.41
12	75	1.50	3.81	30	100	1.25	3.81
13	80	1.10	1.50	31	100	1.40	1.50
14	80	1.10	2.41	32	100	1.40	2.41
15	80	1.10	3.81	33	100	1.40	3.81
16	80	1.25	1.50	34	100	1.50	1.50
17	80	1.25	2.41	35	100	1.50	2.41
18	80	1.25	3.81	36	100	1.50	3.81

Table 3. Scenario characteristics

Characteristics	Scenarios (% of total number of shipments)				
	1	2	3	4	5
Losses in process					
A	10	5	2	10	5
B	0	0	0	1	0
C	2	2	1	2	7
D	3	3	1	3	3
Process investment					
A	10	10	12	10	10
B, C, D	0	0	1	0	0
Use of refrigerated vehicle in process A	0	0	100	0	0
Use of container at the Brazilian airport	0	0	100	0	0
Fumigation at the Brazilian airport	0	0	0	15	0
Delay in the flight	0	0	0	0	10
Freight loss in the flight	0	0	0	0	5

Table 4. Highest simulated costs, revenues, and profits (R$) for each flower chain scenario

Itens	Maximum values for each one of the scenarios (R$)				
	1	2	3	4	5
Total cost excluding logistics input[1]					
Lily	1,164,175	1,172,310	1,285,841	1,175,222	1,172,310
Gerbera1	195,371	196,464	211,780	198,236	196,464
Gerbera2	256,831	259,781	299,584	266,488	259,781
Total cost including logistics input[2]					
Lily	1,563,360	1,588,349	1,694,331	1,573,200	1,744,162
Gerbera1	291,684	295,512	310,089	294,370	338,970
Gerbera2	489,916	502,212	541,468	499,071	647,984
Total revenue excluding logistics output[3]					
Lily	2,800,751	2,940,788	3,118,680	2,772,743	2,733,207
Gerbera1	378,256	397,169	421,194	374,473	369,134
Gerbera2	977,458	1,028,903	1,092,658	967,683	956,276
Total revenue including logistics output[3]					
Lily	2,603,255	2,733,418	3,813,596	2,577,043	2,533,751
Gerbera1	351,627	369,209	514,893	348,087	342,241
Gerbera2	908,444	956,257	1,336,405	899,297	886,404
Total profit including logistics input[4]					
Lily	1,290,984	1,408,713	1,482,231	1,255,861	1,088,253
Gerbera1	96,163	111,727	121,464	90,401	51,366
Gerbera2	521,107	562,023	587,582	504,559	381,247
Total profit including logistics output[5]					
Lily	1,439,366	1,561,408	2,528,064	1,404,367	1,361,742
Gerbera1	156,330	172,823	303,193	150,512	145,855
Gerbera2	651,863	696,739	1,037,092	635,036	626,886
Total profit excluding logistics input and output[5]					
Lily	1,636,861	1,768,778	1,833,148	1,600,068	1,561,197
Gerbera1	182,959	200,783	209,494	176,898	172,748
Gerbera2	720,877	769,385	793,345	703,422	696,758
Total profit including logistics input and output[4]					
Lily	1,093,489	1,201,343	2,177,147	1,060,161	888,797
Gerbera1	69,535	83,767	215,163	64,015	24,473
Gerbera2	452,093	489,377	831,330	436,173	311,377

[1] Simulations 3, 6, 9 and 12 for Scenario 4 and 27, 30, 33 and 36 for the other scenarios.
[2] Simulation 12.
[3] Simulations 3, 6, 9, ...36.
[4] Simulation 27.
[5] Simulations 27, 30, 33 and 36 for the Scenario 4 and 3, 6, 9 and 12 for the other scenarios.

Table 5. Lowest simulated costs, revenues, and profits for each flower chain scenario (R$)

Itens	Minimum values for each one of the scenarios (R$)				
	1	2	3	4	5
Total cost excluding logistics input[1]					
Lily	833,425	836,588	881,126	842,211	836,588
Gerbera1	169,475	169,895	175,919	171,753	169,895
Gerbera2	211,069	212,193	227,841	218,749	212,193
Total cost including logistics input[2]					
Lily	1,059,542	1,071,334	1,114,234	1,067,498	1,116,533
Gerbera1	228,241	229,948	235,808	230,356	243,433
Gerbera2	343,838	349,481	365,418	351,010	392,816
Total revenue excluding logistics output[3]					
Lily	1,102,658	1,157,791	1,227,827	1,091,631	1,076,066
Gerbera1	148,920	156,366	165,824	147,430	145,328
Gerbera2	384,826	405,080	430,180	380,978	376,487
Total revenue including logistics output[3]					
Lily	1,024,904	1,076,149	1,501,416	1,014,584	997,540
Gerbera1	138,436	145,358	202,714	137,042	134,741
Gerbera2	357,655	376,479	526,144	354,054	348,978
Total profit including logistics input[4]					
Lily	1,957	43,240	69,142	-19,815	-100,587
Gerbera1	-85,689	-80,268	-76,861	-90,017	-109,173
Gerbera2	18,293	31,710	40,156	4,834	-55,032
Total profit including logistics output[5]					
Lily	191,192	239,261	619,847	169,825	160,652
Gerbera1	-31,116	-24,615	26,715	-35,372	-35,232
Gerbera2	146,336	164,023	298,031	133,078	136,522
Total profit excluding logistics input and output[5]					
Lily	268,946	320,902	346,257	246,873	239,178
Gerbera1	-20,630	-13,608	-10,174	-24,983	-24,645
Gerbera2	173,507	192,624	202,068	1602	164,030
Total profit including logistics input and output[4]					
Lily	-75,798	-38,402	342,731	-96,863	-179,113
Gerbera1	-96,173	-91,276	-39,972	-100,405	-119,761
Gerbera2	-8,878	3,109	136,120	-22,090	-82,541

[1] Simulations 25, 28, 31 and 34 for Scenario 4 and 1, 4, 7 and 10 for the others are mentioned to it.

[2] Simulation 25 is mentioned to it.

[3] Simulations 1, 4, 7, ...,34 are mentioned to it.

[4] Simulation 10 is mentioned to it.

[5] Simulations 1, 4, 7 e 10 for Scenario 4 and 25, 28, 31 e 34 for the others are mentioned to it.

Table 6. Average total costs reduction (%) gained by individual producers from joining a consortium that divides exportation expenditures among 4, 10, and 20 producers (assuming all exporters ship equal amounts)

Scenarios/flowers chains	Average total cost reduction after division of expenditures (%)			
	between 4 producers	between 10 producers	between 20 producers	Difference between consortia of 4 and 10
Scenario 3				
Lily	3.30	4.00	4.20	0.70
Gerbera 1	16.60	20.60	22.00	3.40
Gerbera 2	10.00	12.30	13.00	2.10
Scenario 5				
Lily	3.50	4.20	4.50	0.70
Gerbera 1	16.90	21.00	22.50	3.50
Gerbera 2	9.60	11.80	12.50	2.00