LOGISTIC PERFORMANCE OF CUT FLOWER EXPORTS:
A PROCESS INPUT-OUTPUT MODEL APPLICATION[1]

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ABSTRACT: *The main objective of this study is to evaluate the performance of the cut flower sector in terms of supply chain integration and foreign market competitiveness, to heighten the understanding of the contributions of logistics to floriculture and the obstacles presented. The input-output model developed proved to be an important tool to evaluate the impact of changes in the processes involved in the exportation chain. The results point to the need for differentiated logistic adjustments in each process, according to the type of relationship established among the actors involved in each stage.*

Key-words: *cut flowers, Brazilian exportation, process input-output model, logistics.*

DESEMPENHO LOGÍSTICO DA EXPORTAÇÃO DE FLORES DE CORTE:
UMA APLICAÇÃO DO MODELO INSUMO-PRODUTO DE PROCESSO

RESUMO: *O principal objetivo deste estudo foi avaliar o desempenho das atividades do setor de flores de corte, com relação à integração da cadeia e à competitividade no mercado externo, assim como aprimorar o entendimento das contribuições e entraves da logística para a floricultura. Para isso, foi desenvolvido um modelo insumo-produto que se revelou como ferramenta importante para avaliar os impactos de alterações nos processos os quais fazem parte dessa cadeia de exportação. Os resultados obtidos sinalizaram para a necessidade de ajustes logísticos diferenciados em cada um dos processos, variando em função do tipo de relacionamento estabelecido entre os agentes envolvidos nas diferentes etapas.*

Palavras-chave: *flor de corte, exportação brasileira, modelo insumo-produto de processo, logística.*

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1 - INTRODUCTION

The market for flowers and ornamental plants markets have experienced increasing global competition in recent years, due mainly to an increase in both quality and variety of products to meet demand from higher *per capita* revenue countries.

Besides the impressive exported quantity of bulbs and seedlings, the penetration of Brazilian cut flowers into foreign consumer markets has progressively increased, as can be seen in the U.S. and Dutch markets, the latter of which was the main destination for exports of Brazilian cut flowers in 2009, according to Junqueira and Peetz (2010). In spite of the success of some individual and corporate flower producers, the sector remains relatively insignificant in terms of its participation in the country's total exports. The Brazilian flower sector's participation in foreign markets was expected to expand after implementation of the Brazilian Flowers and Ornamental Plants Exportation Program (Florabrasilis), created in 2000.

According to Brasil (2011), exports of ornamental flowers and plants have continuously increased from 2000 to 2008, and the highest export FOB value of recorded in that timeframe, US$35.6 million, was obtained in 2008. The North American crisis that began in September 2008 led to a drop in this value, resulting in a 19% reduction of Brazilian exports in 2010 from this 2008 peak.

The growing area given over to flowers and ornamental plants in Brazil has expanded continuously. According to the Brazilian Institute of Floriculture (IBRAFLOR, 2011), the total area now covers 9,000 hectares, 50% higher than in 2008. The growing area includes 304 counties in 12 production regions, and the flower industry has led to the creation of over 194,000 jobs, or 3.5 direct jobs per hectare. Over 50% of the total area is given over to ornamental plant production, 29% for cut flowers, 13% for potted flowers, and 11% for foliage and other products. São Paulo state is the major growing area in the country, and is the main point of distribution to domestic and foreign markets, but flower and ornamental plant production is an important industry in other states of the country as well. Consequently, São Paulo state concentrates the larger public and private wholesaler centers.

In addition to the improvement of production and commercialization structures, this sector offers a wide range of trade interest products, and this facilitates the exploration of niche markets. According to the São Paulo state Chamber of Flowers and Ornamental Plants, there are over 1,000 species grown commercially. The most popular types in the country are: potted flowers (chrysanthemum, violet, kalanchoe, begonia, azalea, orchid, bromeliad, and lilly); cut flowers (rose, chrysanthemum, lilly, gerbera, tango, gladiolus, aster, and gipsophila); and green plants (ficus, chefera, singonio, samambaia, and tuia). It is important to emphasize that there is a potential market for tropical flowers and plants over and above the demand for temperate species.

The logistics infrastructure is one of the most relevant components in guaranteeing the distribution and marketing of Brazilian flowers and ornamental plants in the domestic and foreign markets. The physical integrity of this perishable product can only be maintained if the activities of each stage of the chain are carried out in a timely manner. The integration of each link of the chain must occur so that the process that transfers production to the final consumer will be more efficient, the products will be of good quality, and losses will decrease.

The Brazilian flower exporting 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 revenue and employment growth similar to that 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. For example, each Brazilian consumer spends on average only US$4.70 per year on flowers, while the average annual consumption is US$31.00 *per capita* in the United States and US$72.00 *per capita* in the Netherlands. Foreign markets open sales options when local demand is slack, and provide market niches that increase the productive potential of producer land. This flexibility in the distribution of a perishable, seasonal product offers benefits that exceed the actual earnings from foreign markets; quality demands of buyers in many of these markets has led Brazilian growers to improve their cultivation techniques, storage methods, and shipping efficiency, while increasing opportunities to enhance product durability and price. Although the exchange rate is a real problem, Brazilian flower exports continue to increase. In 2007 the sector's exports attained an FOB value of US$35.3 million, representing a 9.2% increase over to 2006, a 27.6% increase over 2005, and a 193.7% increase over 2000 (Brasil, 2011). These results indicate that the Brazilian flower sector has improved its production and distribution structure and the quality of the exported product enough to guarantee competitive prices in the foreign market. The implementation of actions to continuously improve the sector is essential to increase the performance of the chain and Brazilian participation in the foreign market.

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: the farther away, the more complex distribution becomes. Export 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 the 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 rigorous handling and packaging conditions (refrigeration) to maintain product quality as the product 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 added value.

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 those 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 arising 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.

The main objective of this study is to analyze the impact of changes in the logistic processes involved in the cut flower export chain, which can influence the performance of this sector. This paper presents an economic assessment of logistic processes in the Brazilian flower sector over two years, 2002 and 2003, with a focus on two segments of cut flower exportation, lily and gerbera, where a specific process input-output model is used to enhance the results of the simulations. By further clarifying and quantifying the impact of logistical interactions between the agents, or links, in this chain, it is hoped that this study will help the Brazilian cut flower sector to increase its competitive advantage.

2 - LOGISTICS PROCESSES OF THE SUPPLY CHAIN

Brazilian companies involved in flower export 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 universally recognized.

In terms of logistics, the integration of chain processes plays a prominent role in determining individual company and chain performance. According to the Council of Logistics Management, integrated logistics is the management, planning, and implementation of processes that control stock and goods flow from their origin to the final consumer in an efficient and effective manner. Proper logistics integration leads to improvements in customer service, inventory control, forecasting, and customer satisfaction.

3 - PROCESS INPUT-OUTPUT MODEL

Like the input-output model, the process input-output model is based on the Leontief system. According to Kurz and Salvadori (2000), Leontief's writings of 1928 and 1939 form the basis of the instrumental analysis of the economic system, enabling closer approximation between theory and practice, in order to better understand its main bottlenecks. It has been most frequently applied in the analysis of relations between economic sectors. The context of the analysis can be restricted to a certain state, region, or country, sectors in different regions, or even economic blocs such as Mercosul. More details about this model are described in Leontief (1986) and Miller and Blair (1985).

According to the latter, the production functions of this system are linear and homogeneous, with direct and indirect technical coefficients that indicate the level of economics interdependency. Besides that, both models - input-output and process input-output - use the same input-output theory assumptions: a) general equilibrium in the economy at a certain level of prices; b) economic agents are free from money illusion; c) constant returns to scale; and d) constant prices.

A process input-output model, proposed by Anefalos (2004) and developed from the models of Lin and Polenske (1998) and Albino, Izzo and Kühtz (2002), was used to analyze the cut flower export chain. The model basic elements are defined by the input-output theory, but its general structure was conceived to aggregate logistic processes, agents, and products of the chain. It considers only one sector, analyzing the relationships among all processes which produce the main products, such as production and distribution processes at each stage of the chain and for the chain as a whole. The input and output data of each stage are useful for evaluating the performance of the various processes of the chain. Relevant additional information such as costs, revenues, and profits can be generated, taking into consideration logistics inputs and outputs, to enhance the assessment of logistic performance of the chain.

The basic structure of the process input-output model is described as the following:

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

where $Z = [Z_{ij}]$ is the matrix of intermediate consumption of main products, and represents how much of the total production of production process j is used to produce a unit of final demand of production process i; $Y = [Y_i] = X^z$ is the vector of main products of final demand.

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

where $A = [A_{ij}]$ is the matrix of direct input-output coefficients for main production of products; $X = [Z_{jj}] = [X_j]$ is the vector of production of the main product in process *j*; $T = [T_{j1}]$, $T_{j1} = 1$ is the unitary column vector.

$$X^z + X^m = AX = (Z + M)T \quad (3)$$

where X^m is the vector of total imports of each main product, *k*, *k*=1, 2, ..., *m*; $M = [M_{ij}]$ is the import matrix of the main products moving from process *i* to process *j*. In this case the vector of total importation of each main product is zero.

$$X^i = BX = IT \quad (4)$$

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

$$X^w = CX = WT \quad (5)$$

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

$$X^v = DX = VT \quad (6)$$

where X^v is the vector of total consumption of each primary input *k*; $V = [V_{kj}]$ is the consumption matrix of primary inputs *k* in process *j*; $D = [D_{kj}]$ 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 exports of cut flower in order 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), which are 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 product 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 IPR*i* (*i* = 1, 2,..., 20); through logistical inputs, called ILG*i* (*i* = 1, 2,..., 15); and through primary inputs, called IPM*i* (*i* = 1, 2, ..., 6). Some items, such as main products and some production inputs, are measured by quantity 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 export chain.

The costs of each process of the chain and the chain as a whole can be calculated from vectors of the total consumption and unitary prices of each input (purchased, primary and logistic). To calculate the revenues of each process and the whole chain, the vectors of total production and unitary prices of each intermediate component and residue are considered. In this case there is a main product (cut flowers) and a logistic output (efficiency of order cycle). The profits are calculated from the difference between revenues and costs for each process and the chain as a whole. Once data for all consumption and the unitary price of inputs and outputs are available, it is possible to obtain partial information for each process in the chain or for the whole chain, such as total profit not factoring logistic costs, and total revenue not considering logistics outputs. Besides this, other important data can be calculated, like the ratio between total profit and total cost given logistic inputs and outputs and the unitary profit of each unit sold to the final consumer.

3.1 - Study Environment

The environment outlined in this work and the data sources contacted consist 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 1, these processes are aggregated into the following four categories: production (A); internal distribution using the highway mode (B); foreign distribution using the air mode (C); and foreign distribution using the highway mode (D). Chain analysis was restricted due to the difficulty of 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 and 2), were used for analysis. All flowers were destined for export to the United States through the main airports of São Paulo State, Guarulhos and Viracopos. 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 out 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. The relationships among producers, exporters, and distributors were considered main flows, because the main products of the chain, the cut flowers, are generated from them. The other actors, such as brokers, truck lines and airfreight companies, are considered secondary flows and their costs were added to the costs of the main agents.

Integration among actors is very important for the optimization of each process of the cut flowers chain. A "logistics consortium" has contributed to enhance the relationship among producers, cooperatives, exporters and foreign distributors. Expenses are divided among producers proportional to the volume exported per shipment. This is a feasible way that cooperatives support exports by associates that have adequate products for foreign markets, but only a small quantity of flowers to be exported per shipment. A stronger arrangement among producers was established and this logistics trust works along rules to continuously guarantee quality and volume of exports. For this, annual planning is needed regarding the types and quantity of flowers exported by producers to the final consumer in order to equalize expenses, mainly customs. If a problem should occur in a particular shipment and the flowers of the lot are damaged, all airport expenses will be paid by producers, because it is unusual that cargo insurance be paid out at the airport.

A higher volume of exports facilitates cut flower exports and can help reduce or control relevant costs at the airport, mainly through a low exchange rate ratio with a stronger Brazilian currency. For example, airfreight costs are negotiated with the airfreight companies. They vary depending on the volume exported, the distance traveled and the temperature requirements of the products. Airfreight costs with a temperature requirement of 0 to 7 ºC will be higher than at 15 to 20 ºC. From 2003, an additional fuel tax was added to airfreight costs. According to Valor OnLine (ANAC, 2008), the National Civil Aviation Agency of Brazil (ANAC) has carried out price adjustments on the fuel tax (the last one was in 2006) and fixed a maximum value. A free fuel tax is desired for air companies mainly when fuel prices are continuously increasing.

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 on the properties, machines and implements, labor
Internal distribution/highway mode	B	Cooperatives, brokers, truckers, exporter	Truck, labor, tolls, lead time, cold chambers in the warehouses
Foreign distribution/air mode	C	Brokers in Brazil and exterior, exporters, forwarding agent, customs brokers in Brazil and destination country, Federal Revenue Department, Ministry of Agriculture, INFRAERO, importers	Cold chambers in the airport, airplane, labor, customs tariffs, customs documentation, lead time, phytosanitary control
Foreign 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 1 - Characterization of all Chain Processes.
Source: Research data.

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 by verifying relevant problems that could arise in the chain.

Technical parameters that could intervene in the cut flower export process were identified and used in composing 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 customer requirements and 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 Guarulhos or Viracopos airports, which vary according to distance traveled, volume exported and temperature requirements of the products; 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, each shipment includes products from four small to medium-sized producers); 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 as a gauge, as 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 2ºC and 3ºC at Guarulhos or Viracopos airports; k) flower fumigation before shipment from Brazil, performed by the exporter if not done by the producer; l) flower fumigation at the airport in U.S.A. due to the detection of insects in the shipment 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 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.

Table 1 - Estimates of the Total Lead Time of the Logistics Cycle for air Transport, 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 durplus
A	92.00	91.00	87.00		
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		

Source: Research data.

In the construction of each of the five 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 fluctuations, according to BCB (2004). The mimimum exchange rates, in January 1999, were found to be R$1.50/US$ and R$1.60/€; the medium exchange rates, in February 2002, were R$2.41/US$ and R$2.10/€; and the higher exchange rates, in 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). The lily and two gerbera 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 section 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 with 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 arising from logistics, the percentage of total inputs used in each process, 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 used 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 most efficient in the production process; scenario 3 - logistics surplus (exceptionally efficient distribution) in all chain processes; scenario 4 - logistics deficit in the chain due to failures in internal distribution processes that depend on road transportation; scenario 5 - logistics deficit in the chain due to failures in the foreign distribution processes that depend on air transport. the five scenarios characteristics are quantified in table 2.

Table 2 - Scenario Characteristics

Characteristics	Scenarios (% of total number of shipments)[1]				
	1	2	3	4	5
Losses in process					
A (production in rural link)	10	5	2	10	5
B (internal distribution/highway mode)	0	0	0	1	0
C (foreign distribution/air mode)	2	2	1	2	7
D (foreign distribution/highway mode)	3	3	1	3	3
Process investment					
A (production in rural link)	10	10	12	10	10
B, C, D (internal distribution/highway mode, foreign distribution/air mode, foreign distribution/highway mode)	0	0	1	0	0
Use of refrigerated vehicle in process A	0	0	100	0	0
Use of container at Brazilian airport	0	0	100	0	0
Fumigation at Brazilian airport	0	0	0	15	0
Delay of the flight	0	0	0	0	10
Freight loss in flight	0	0	0	0	5

[1]Description of the scenarios: 1 - logistics deficit in all chain processes; 2 - logistics deficit in the chain that is more efficient in the production process; 3 - logistics surplus in all chain processes; 4 - logistics deficit in the chain due to failures in internal distribution processes that depend on road transportation); 5 - logistics deficit in the chain due to failures in the foreign distribution processes that depend on air transport.
Source: Research data.

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 3.

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 increase 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 4 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. Inclusion of a higher number of stems per box has the drawback of a greater 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 greatest 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

Table 3 - Highest Simulated Costs, Revenues and Profits for Each Flower Chain Scenario (R$)

Items	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
Gerbera 1	195,371	196,464	211,780	198,236	196,464
Gerbera 2	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
Gerbera 1	291,684	295,512	310,089	294,370	338,970
Gerbera 2	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
Gerbera 1	378,256	397,169	421,194	374,473	369,134
Gerbera 2	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
Gerbera 1	351,627	369,209	514,893	348,087	342,241
Gerbera 2	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
Gerbera 1	96,163	111,727	121,464	90,401	51,366
Gerbera 2	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
Gerbera 1	156,330	172,823	303,193	150,512	145,855
Gerbera 2	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
Gerbera 1	182,959	200,783	209,494	176,898	172,748
Gerbera 2	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
Gerbera 1	69,535	83,767	215,163	64,015	24,473
Gerbera 2	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 scenario 4 and 3, 6, 9 and 12 for the other scenarios.
Source: Research data.

Table 4 - Lowest Simulated Costs, Revenues and Profits for Each Flower Chain Scenario (R$)

Items	Minimum values for each scenarios (R$)				
	1	2	3	4	5
Total cost excluding logistics input[1]					
Lily	833,425	836,588	881,126	842,211	836,588
Gerbera 1	169,475	169,895	175,919	171,753	169,895
Gerbera 2	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
Gerbera 1	228,241	229,948	235,808	230,356	243,433
Gerbera 2	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
Gerbera 1	148,920	156,366	165,824	147,430	145,328
Gerbera 2	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
Gerbera 1	-85,689	-80,268	-76,861	-90,017	-109,173
Gerbera 2	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
Gerbera 1	-31,116	-24,615	26,715	-35,372	-35,232
Gerbera 2	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
Gerbera 1	-20,630	-13,608	-10,174	-24,983	-24,645
Gerbera 2	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
Gerbera 1	-96,173	-91,276	-39,972	-100,405	-119,761
Gerbera 2	-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.
[2]Simulation 25.
[3]Simulations 1, 4, 7 .... 34.
[4]Simulation 10.
[5]Simulations 1, 4, 7, 10 for scenario 4 and 25, 28, 31 and 34 for the others.
Source: Research data.

rate variation, which differentiated it from the Gerbera 1 chain.

Logistics costs represent an important component of each chain's balance sheet. The concentration of logistics costs was minor in scenario 3 because chain failure was minimized. Although fewer 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 transport to the foreign market (foreign 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; however, the majority of logistics costs are measured by number of boxes shipped. It was confirmed that the Gerbera 2 chain presented higher logistic costs than the other two chains. As the three chains used the same marketing channels, this finding is probably related to the Gerbera 2 chain's productive structure, which made relatively greater 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 others by expenses for imported bulbs and packing.

According to the World Bank (2002), transportation costs significantly affect growth in the export of primary goods by reducing long term profit. These costs also impact the import 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 led 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 customs clearance for perishable products. Any move to reduce time in transit and transaction costs will involve proper coordination between actors, and the more distant the end markets, the greater the difficulty in coordinating their actions.

Another issue that affects the cost of flower export 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 also very dependent on equally small-scale airfreight companies with unreliable schedules and 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 may also negatively affect product quality.

According to Thoen et al. (2001), high air freight rates caused Kenyan producers to put additional stems in each box of exported flowers, which led 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 for 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 and 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 considers 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 2. In each scenario, changes in the relation between profits and costs occur as parameters are modified, and these modifications directly affect the performance of each chain's processes.

The lowest lily producer earnings were generated in scenario 5. The profit-to-cost ratio for lilies in this scenario varied between 54.00 and -15.20: for each R$1.00 spent by the chain for flower exportation, earnings ranged from R$54.00 to -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 currency 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 recorded. This value corresponds to a nearly 145% increase in

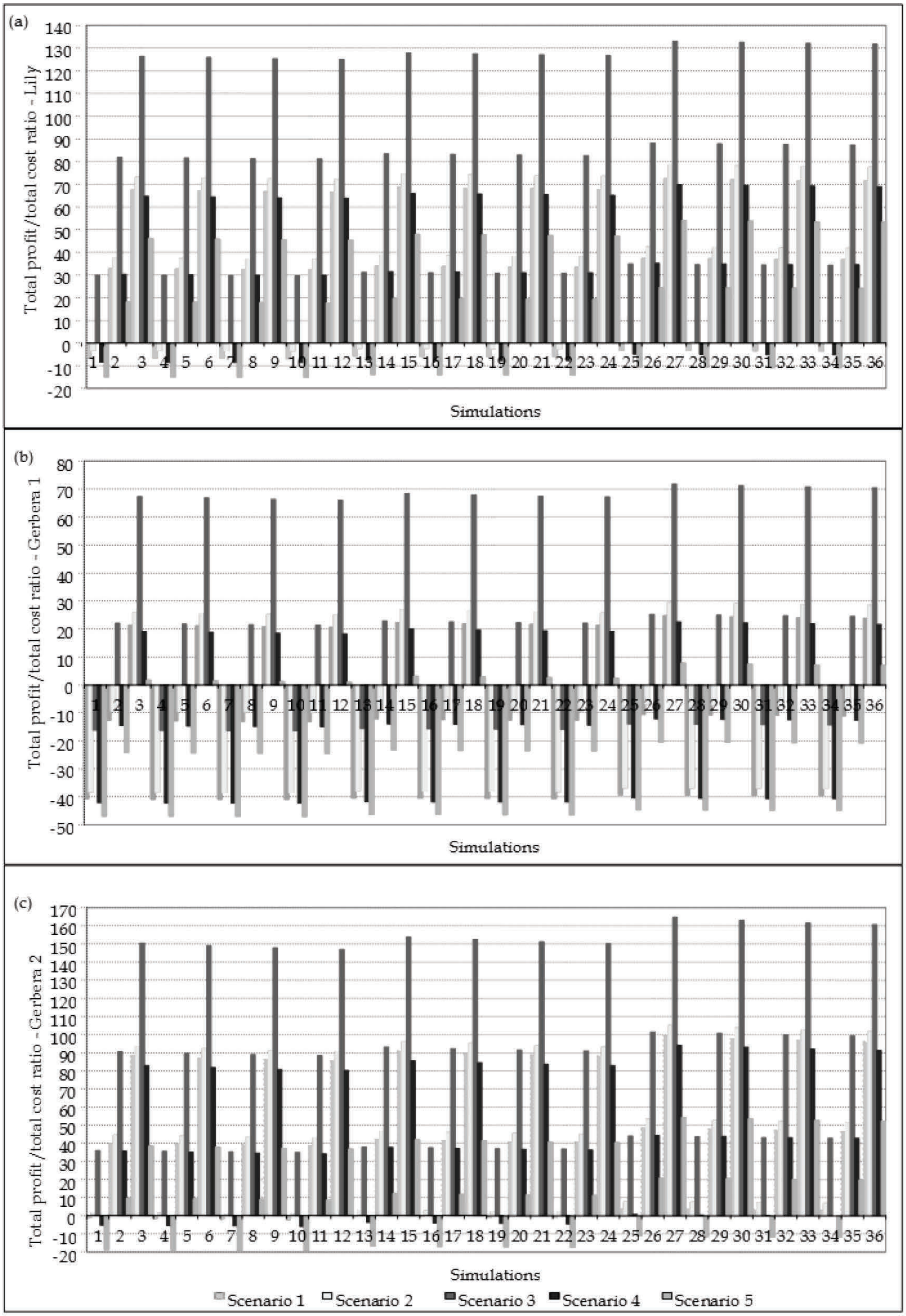

Figure 2 - Ratio Between Total Profit and Total Cost for (a) Lily, (b) Gerbera 1 and (c) Gerbera 2 Chain Logistical Inputs and Outputs.
Source: Developed by the authors based on research data.

total profit over the same simulation in scenario 4. Analysis of the five scenario results shows that expenses for packing, marketing, 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, but the changes simulated had smaller impacts when compared with the Lily chain. The greatest Gerbera 1 profits were observed when a weaker Brazilian currency was simulated in scenario 3. A maximum Gerbera 1 value, 71.80, was reached in the simulation 27 of scenario 3, while this scenario's minimum value, -16.5, was found in simulation 10. As for the lily chain, the worst Gerbera 1 performance was found in scenario 5, with the relation ranging from 7.70 to -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 currency was strongest (R$1.50 per 1 US$). This chain's highest profit-to-cost ratio, 164.60, was reached in simulation 27 of scenario 3, the highest ratio found in this study.

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 worthwhile for producers that export only small quantities. 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 logistics consortia of various sizes 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 5.

All consortia were more efficient than single exporters, 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 exports 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 export 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 the country's political and economic environment, allowed flexibility in the analysis of each chain input, and will facilitate chain assessment and management over both the short and long terms.

From the relationship between cut flower export 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 at this stage. If the flower is not cultivated and harvested properly, even 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 1) 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 flower 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, this does not eliminate the potential for procedural failures by other actors down the chain.

Table 5 - Average Total Cost Reduction (%) Gained by Individual Producers Through Joining a Consortium That Divides Exportation Expenditures Among 4, 10 or 20 Producers (Assuming all Exporters Ship Equal Amounts)

Scenarios/flower 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

Source: Research data.

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 1). A muddied understanding of these requirements presented obstacles to entry into the international market that slowed final distribution and led to a deterioration of product quality. The effects of this problem were exacerbated by 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 1) can also lead to a loss in quality through delay. Problems at the airport can even lead to a breakdown in negotiations between agents in the importing country and the domestic flower suppliers. The actors involved, 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

Although static, the process input-output model was a tool that supported the assessment of variations in several parameters that significantly affect flower chain export processes and profits. The main logistics parameters definition of this model was a fundamental part of this study, supporting the technical information of each process as determined by the relation between producers, exporters, and distributors, as well as formulating strategic simulations that will enable an understanding of the system.

The input and output data of each stage were also useful for evaluating the performance of each chain process. Relevant additional information about chain logistics performance such as costs, revenues, and profits could be generated using this model, taking into consideration logistics inputs and outputs.

The model also allowed information to be more extensively aggregated while providing a detailed overview of every link in the chain. The scenario analysis provided differentiated information for this model, improving understanding of the chain. It was verified that the lowest lily producer earnings were generated under conditions of logistics deficit in the chain due to failures in the foreign distribution processes that depend on the air transport mode, as per scenario 5. For this chain, the most significant logistics inputs to be considered were packing, marketing, highway and air freight, customs release, and the cold chamber. It was verified that for each R$1.00 spent by flower chain exporters, there were gains in the range of R$54.00 to -R$15.20 in 36 simulations made in this scenario. It will thus be very difficult to sustain this business opportunity under conditions of the strongest possible Brazilian currency, because the gains will be lower or even negative due to logistic restrictions of foreign distribution processes.

Assuming that conflicts among actors are solved, or at least minimized, as shown in scenario 3, 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. The results of this model, obtained by the comparison of ideal conditions to the actual situation, will contribute to the chain's sustainability by serving as a strategic tool for players to achieve continuous improvement of each chain process.

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 export efficiency to fall and negatively affect total chain profit. While there are specific relations among agents for each type of chain, and these relations have a different effect on the efficiency of each process, each chain member must be able to both offer and accept advice from others in the chain in order to rapidly correct failures.

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 export 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. These other avenues were not explored in this study due to data and time restrictions.

Similar analyses using smaller 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 on 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 link of the chain and the relative contribution each link makes to total chain productivity.

LITERATURE CITED

ALBINO, V.; IZZO, C.; KÜHTZ, S. Input-output models for the analysis of a local/global supply chain. **International Journal of Production Economics**, Amsterdam, Vol. 78, Issue 2, pp.119-131, 2002.

AGÊNCIA NACIONAL DE AVIAÇÃO CIVIL - ANAC. ANAC liberará taxa de combustível para carga. **Jornal Valor Econômico**, São Paulo, versão online, 25 jun. 2008.

ANEFALOS, L. C. **Modelo insumo-produto como instrumento de avaliação econômica da cadeia de**

suprimentos: o caso da exportação de flores de corte. 2004. 210 p. Tese (Doutorado) - Escola Superior de Agricultura "Luiz de Queiroz", Piracicaba, 2004.

Banco Central Do Brasil. **Câmbio e capitais estrangeiros**. Brasília: BCB, 2004. Full text: <http://www.bcb.gov.br>. Access: 13 mar. 2004.

Brasil. Secretaria de Comércio Exterior. **Exportação brasileira de plantas vivas e produtos de floricultura:** 2000-2010. Brasília: SECEX, 2011. Full text: <http://aliceweb.desenvolvimento.gov.br>. Access: 20 may 2011.

Instituto Brasileiro De Floricultura - Ibraflor. **Uma visão do mercado de flores**. Holambra: Ibraflor, 2011. Full text: <http://www.ibraflor.com/publicacoes/vw.php?=21>. Access: 20 may 2011.

Junqueira, A. H.; Peetz, M. S. Análise conjuntural do comércio exterior da floricultura brasileira: balanço 2009 e perspectivas 2010. São Paulo: Hortica, 2010. Full text: <http://www.hortica.com.br/news.php>. Access: 19 may 2011.

Kurz, H. D.; Salvadori. N. Classical Roots of Input-Output Analysis: a Short Account of its Long Prehistory. **Economic Systems Research**, London, Vol. 12, Issue 2, pp.153-179, 2000.

Leontief, W. **Input-Output Economics**. 2. ed. New York: Oxford University Press, 1986.

Lin, X.; Polenske, K. R. Input-output modeling of production processes for business management. **Structural Change and Economic Dynamics**, Amsterdam, Vol. 9, Issue 2, pp. 205-226, 1998.

Miller, R. E.; Blair, P. D. **Input-output analysis:** foundations and extensions. Englewood Cliffs, New Jersey: Prentice-Hall, 1985.

Salin, V.; Nayga Junior, R. M. A cold chain network for food exports to developing countries**. International Journal of Physical Distribution & Logistics Management**, Bradford, Vol. 33, Issue 10, pp. 918-933, 2003.

Thoen, R. et al. Equatorial rose: the keyan-european cut flower supply chain. In: Kopiki, R. (Ed.). **Supply chain development in emerging markets:** case students of supportive public policy, 2001. Washington: World Bank. Full text: <http://www1.wordbank.org/wbiep/trade/c/papers/roses2kenya supplychain.pdf>. Access: 14 feb. 2003.

World Bank. **Global economic prospects and the developing countries**. Washington: World Bank, 2002. 271 p. Full text: <http://www.worldbank.org/prospects/gep2002/ gep2002complete.pdf>. Access: 02 june 2004.

_______ . **Global economic prospects and the developing countries**. Washington: World Bank, 2004. 334 p. Full text: <http://www.worldbank.org/prospects/gep2004_full.pdf>. Access: 02 june 2004.

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