Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(3):571-579

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Effects of coordination policies on logistics performance in supply chains

Wang Miao and Ren Peiyu

Business School, Sichuan University, Chengdu, China

ABSTRACT

With global competition, firms are redesigning their supply chains to meet the challenge. Logistics have played a particular important role where production is either of diffusion or of concentration. The transport coordination implies not only to reduce costs, but to respond quickly to final market. In the paper, an input-output model to analyze logistics flows is proposed, for supporting coordination policy at the level of the whole supply chain. Logistics flows between firms' processes are modeled and different coordination policies ranging from hierarchy to market are examined. The effects of such policies on logistics performance are evaluated.

Key words: Supply chain; Coordination; Input-output model

INTRODUCTION

SUPPLY CHAINS AND COORDINATION

A supply chain is defined [1] as a network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities producing value in the form of products and services. Then, a supply chain can be considered as a set of tightly interconnected manufacturing processes, constituting an input-output system, producing a specific good.

Several authors [2] have stressed the importance of coordination as a mechanism by which improving supply chain effectiveness and efficiency. The coordination of a supply chain is made difficult by a great degree of complexity, which is distinguished by Choi and Hong [3] in three different types: vertical, referring to the number of levels in the supply chain; horizontal, referring to the number of entities in the same level of the supply chain; spatial, referring to the average distance among the members of the supply chain. Referring to the spatial dimension, in the literature great attention has been kept on the problems related to manage and coordinate dispersal [4] supply chains.

In the following section we analyze the role played by logistics, in particular by transportation, and the importance of its coordination in supply chains.

TRANSPORTATION IN SUPPLY CHAINS

Classic trade theory neglects the role of transport and logistics [5], particularly the fact that transport costs have a fundamental impact on the amount of trade and goods exchange, as do traffic onstraints and opportunities in general. However, the increasing globalization, such as international trade, multinational corporations and the global division of labour/production, is revealing a different transportation perspective.

Moreover, the effective logistics coordination is particularly important for supply chains competitive advantage, especially when the actors are vertically disaggregated and located in different places. Logistics flows coordination can be achieved by means of consolidation strategies, which are the processes of combining different items, produced and used at different locations and different times, into single vehicle load. Hall [6] distinguishes among three different consolidation strategies: i) vehicle consolidation; ii) inventory consolidation; iii) terminal consolidation.

In this paper, logistics flows in a supply chain are analysed, adopting an enterprise input-output model based on production processes. Then, different coordination policies are identified and their effect on logistics performance is studied. Finally, a case study, related to the supply stage of an Italian company producing leather upholstery is considered.

INPUT-OUTPUT MODEL BASED ON PROCESSES

Input-output (I-O) approach has been typically applied to analyze the economic structure of nations and regions, in terms of flows between sectors and firms [7]. According to the different level of analysis, I-O models can be highly aggregated or disaggregated.

Enterprise I-O models constitute a particular set of I-O models, useful to complement the managerial and financial accounting systems currently used extensively by firms [8]. This level of disaggregation is useful to define a model better fitting real materials and energy flows. However, the drawback of a high level of disaggregation is represented by the higher variability in the technical coefficients. In this paper the supply chain is considered as a network of production processes, including transportation, which transform inputs into outputs. Then, an enterprise I-O model based on the processes is developed for accounting and planning purposes.

THE INPUT-OUTPUT MODEL

An industrial supply chain is composed by a network of production process. This network can be fully described if all the interrelated processes as well as input and output flows are identified. The proposed enterprise input-output model is based on a previous input-output model that uses physical units [14].

Let Z_0 be the matrix of domestic (i.e. to and from production processes within the supply chain) intermediate deliveries, f_0 the vector of final demands (i.e. demands leaving the supply chain), and x_0 the vector of gross outputs. If n processes are distinguished, the matrix Z_0 is of size n x n, and the vectors f_0, and x_0 are n x 1. It is assumed that each process has a single main product as its output. Each of these processes may require intermediate inputs from the other processes, but not from itself so that the entries on the main diagonal of the matrix Z_0 are zero. Of course, also other inputs are required for production. These are p primary inputs (i.e. products not produced by one of the n production processes) that include various types of energy. Next to the output of the main product, the processes also produce m by-products and waste. r_0 and w_0 are the primary input vector and the by-product and waste vector of size p x 1 and m x 1, respectively.

Define the intermediate coefficient matrix A as follows:

$$A \equiv Z_0 \hat{x}_0^{-1}$$
(1)

where a "hat" is used to denote a diagonal matrix. We now have:

$$x_0 = Ax_0 + f_0 = (I - A)^{-1} f_0 \tag{2}$$

It is possible to estimate R, the p x n matrix of primary input coefficients with element r_{pj} denoting the use of primary input p per unit of output of product j, and W, the m x n matrix of its output coefficients with element w_{mj} denoting the output of by-product or waste type m per unit of output of product j. It results:

$$r_0 = R\, x_0 \tag{3}$$

$$w_0 = W\, x_0 \tag{4}$$

Note that the coefficient matrices A, R and Ware numerically obtained from observed data.

A change in the final demand vector induces a change in the gross outputs and subsequently changes in the input of primary products, and changes in the output of by-products and waste.

Suppose that the final demand changes into $\bar{f}$, and that the intermediate coefficients matrix A, the primary input coefficients matrix R, and the output coefficients matrix W, are constant (which seems a reasonable assumption in the short-run), then the output changes into:

$$\overline{x} = (I - A)^{-1}\overline{f} \tag{5}$$

Given this new output vector, the requirements of primary inputs and the outputs of by-products and waste are:

$$\overline{r} = R\overline{x} \tag{6}$$

$$\overline{w} = W\overline{x} \tag{7}$$

Where $\overline{r}$ gives the new p x 1 vector of primary inputs, and $\overline{w}$ the new m x 1 vector of by-products and waste types.

LOGISTICS FLOWS AND COORDINATION POLICIES
LOGISTICS FLOWS

In the previous section the use of an enterprise I-O model is proposed to analyse physical flows from and to processes in a supply chain.

Now let j and k be two production processes, where j supplies k and k produces the main output, representing the final demand. Let Φ_j^A, Φ_k^A, Φ_j^B, and Φ_k^B be the set of all processes similar to j and k located in the geographical areas A and B, respectively.

The logistics flows between the areas A and B can be represented as in Figure 1, where arrows correspond to aggregate flows.

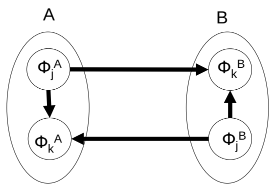

Fig.1: Logistics flows of intermediate deliveries between A and B areas

Now, it is assumed that the time interval considered for the analysis of process inputs and outputs can be divided into Nt time periods being t the generic time period adopted for the analysis of logistics flows to and from processes. So, during each time period t the flow $X_{jk}^{AA(t)}$ from j $\in \Phi_j^A$ to k $\in \Phi_k^A$, the flow $X_{jk}^{AB(t)}$ from j $\in \Phi_j^A$ to k $\in \Phi_k^B$, the flow $X_{jk}^{BB(t)}$ from j $\in \Phi_j^B$ to k $\in \Phi_k^B$, and the flow $X_{jk}^{BA(t)}$ from j $\in \Phi_j^B$ to k $\in \Phi_k^A$ may occur. Then, it results:

$$z_{jk}^{AA} = \sum_{t=1}^{N_t} \sum_{\Phi_j^A} \sum_{\Phi_k^A} X_{jk}^{AA(t)} \; ; \; z_{jk}^{AB} = \sum_{t=1}^{N_t} \sum_{\Phi_j^A} \sum_{\Phi_k^B} X_{jk}^{AB(t)} \tag{8}$$

$$z_{jk}^{BA} = \sum_{t=1}^{N_t} \sum_{\Phi_j^B} \sum_{\Phi_k^A} X_{jk}^{BA(t)} \; ; \; z_{jk}^{BB} = \sum_{t=1}^{N_t} \sum_{\Phi_j^B} \sum_{\Phi_k^B} X_{jk}^{BB(t)} \tag{9}$$

Similarly, main products can flow from each process k $\in \Phi_k^A$ and k $\in \Phi_k^B$ to their destinations located, for the sake of simplicity, in the geographical areas A (Φ^A) and B (Φ^B) (Figure 2).

During the time period t, let $f_k^{AA(t)}$ be the flow of the main product from k $\in \Phi_k^A$ to Φ^A, $f_k^{AB(t)}$ be the flow of the main product from k $\in \Phi_k^A$ to Φ^B, $f_k^{BB(t)}$ be the flow of the main product from process k $\in \Phi_k^B$ to Φ^B, and $f_k^{BA(t)}$ be the flow of the main product from process k $\in \Phi_k^B$ to Φ^A. Then, it results:

$$f^{A} = \sum_{t=1}^{N_t}\left(\sum_{\Phi_k^A} f_k^{AA(t)} + \sum_{\Phi_k^B} f_k^{BA(t)}\right) \tag{10}$$

$$f^{B} = \sum_{t=1}^{N_t}\left(\sum_{\Phi_k^A} f_k^{AB(t)} + \sum_{\Phi_k^B} f_k^{BB(t)}\right) \tag{11}$$

Where f^A and f^B are the final demands located in the geographical areas A and B, respectively.

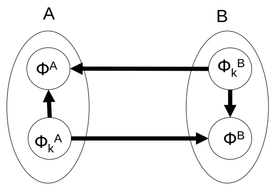

Fig.2. Logistics flows from processes k to final demand destinations located in the areas A and B.

COORDINATION POLICIES

The coordination of logistics flows is notably important for supply chains competition, especially when they are constituted by dispersal actors. In particular, consolidation strategies can be adopted as a coordination mechanism by which improving supply chain performance, reducing transportation time and cost. In the paper, two coordination policies are considered, namely hierarchy and market. In particular, hierarchy is based on the consolidation of logistics flows and it aims at minimizing the number of transportation trips to convey products. On turn, consolidation can be achieved by means of two different strategies, namely vehicle and inventory consolidation. The former involves picking-up and dropping-off products at different origins and destinations in each time period. In the latter, flows referring to different time periods can be consolidated. So, inventory consolidation involves storing products that are produced and used at different times.

These strategies can be related to different scenarios. In fact, consolidation can be applied to products flowing from a single process, similar processes, or different processes to the customers. Moreover, customers can be located in the same geographical area or in different areas.

Then, considering the simple supply chain previously analyzed, consolidation can be applied to the following logistics flows:

from Φ_j^A to Φ_k^A and/or Φ_k^B;

from Φ_j^A to Φ_k^A and/or Φ_k^B and from Φ_j^B to Φ_k^A and/or Φ_k^B;

from Φ_j^A to Φ_k^A and/or Φ_k^B, from Φ_k^A to Φ^A and Φ^B, from Φ_j^B to Φ_k^A and/or Φ_k^B, and from Φ_k^B to Φ^A and Φ^B.

Considering different logistics flows, other consolidation strategies can be applied. It is important to underline that consolidation can be applied to the logistics flows originating from different processes (e.g. j and k) only if the main products of these processes can be stored in the same load space.

Moreover, assuming that each transportation mean comes back to its origin, hierarchy policy coordinates the use of the transportation means for reducing the total number of means moved between the geographical areas.

In the market policy, each logistics flow is operated independently from all other flows and no consolidation is possible. In this case, logistics service is dedicated to each demand to be satisfied by each corresponding supply.

For both the coordination policies, in any time period the logistics flows are assumed to be period independent. Then, based on the actual data, each logistics flow is assumed to be equal to the average value of logistics flows over all time periods Nt (then, the index t will be omitted in the following).

Different coordination policies can be evaluate in terms of their impact on logistics performance of the supply chain. In the following, the number of transportation trips is considered.

Based on the different assumptions of each case, the following variables can be identified:
C_j and C_k as the maximum quantity of product of the processes j and k, respectively, that can be transported by the transportation means;

N_j^A and N_j^B as the number of transportation trips required to convey products from Φ_j^A to Φ_k^A and Φ_k^B,and from Φ_j^B to Φ_k^A and Φ_k^B, respectively, in each time period;

N_k^A and N_k^B as the number of transportation trips required to convey products from Φ_k^A to Φ^A and Φ^B, and from Φ_k^B to Φ^A and Φ^B, respectively, in each time period;

N^A and N^B as the number of transportation trips required to convey products from A to B, and from B to A, respectively, in each time period;

N as the number of transportation trips required to convey all products between A and B, in each time period;

Now, knowing actual values for all the logistics flows it is possible to compute N for each policy. The following equations permit the evaluation of logistics performance for the simple supply chain examined. More complex equations result for the generic case. In particular, it is assumed that when suppliers and customers are located in the same area, their distance can be neglected.

Market policy results:

$$N_j^A = 2\left(\sum_{\Phi_j^A}\sum_{\Phi_k^A} \mathrm{int}_{\sup}\left(\frac{X_{jk}^{AA}}{C_j}\right) + \sum_{\Phi_j^A}\sum_{\Phi_k^B} \mathrm{int}_{\sup}\left(\frac{X_{jk}^{AB}}{C_j}\right)\right) \tag{12}$$

$$N_j^B = 2\left(\sum_{\Phi_j^B}\sum_{\Phi_k^A} \mathrm{int}_{\sup}\left(\frac{X_{jk}^{BA}}{C_j}\right) + \sum_{\Phi_j^B}\sum_{\Phi_k^B} \mathrm{int}_{\sup}\left(\frac{X_{jk}^{BB}}{C_j}\right)\right) \tag{13}$$

$$N_k^A = 2\left(\sum_{\Phi_k^A} \mathrm{int}_{\sup}\left(\frac{f_k^{AA}}{C_k}\right) + \sum_{\Phi_k^A} \mathrm{int}_{\sup}\left(\frac{f_k^{AB}}{C_k}\right)\right) \tag{14}$$

$$N_k^B = 2\left(\sum_{\Phi_k^B} \mathrm{int}_{\sup}\left(\frac{f_k^{BA}}{C_k}\right) + \sum_{\Phi_k^B} \mathrm{int}_{\sup}\left(\frac{f_k^{BB}}{C_k}\right)\right) \tag{15}$$

$$N = N_j^A + N_j^B + N_k^A + N_k^B \tag{16}$$

Hierarchy policy (vehicle consolidation)

If flows from the set Φ_j^A to the set $\Phi_k^A \cup \Phi_k^B$ are consolidated (scenario H1), then it results:

$$N_j^A = 2\,\mathrm{int}_{\sup}\left(\frac{\sum_{\Phi_j^A}\left(\sum_{\Phi_k^A} X_{jk}^{AA} + \sum_{\Phi_k^B} X_{jk}^{AB}\right)}{C_j}\right) \tag{17}$$

$$N_j^B = 2\left(\sum_{\Phi_j^B}\sum_{\Phi_k^A}\mathrm{int}_{\sup}\left(\frac{X_{jk}^{BA}}{C_j}\right)+\sum_{\Phi_j^B}\sum_{\Phi_k^B}\mathrm{int}_{\sup}\left(\frac{X_{jk}^{BB}}{C_j}\right)\right) \tag{18}$$

$$N_k^A = 2\left(\sum_{\Phi_k^A}\mathrm{int}_{\sup}\left(\frac{f_k^{AA}}{C_k}\right)+\sum_{\Phi_k^A}\mathrm{int}_{\sup}\left(\frac{f_k^{AB}}{C_k}\right)\right) \tag{18}$$

$$N_k^B = 2\left(\sum_{\Phi_k^B}\mathrm{int}_{\sup}\left(\frac{f_k^{BA}}{C_k}\right)+\sum_{\Phi_k^B}\mathrm{int}_{\sup}\left(\frac{f_k^{BB}}{C_k}\right)\right) \tag{19}$$

$$N = N_j^A + N_j^B + N_k^A + N_k^B \tag{20}$$

If flows from the set Φ_j^A to the set $\Phi_k^A \cup \Phi_k^B$ and from the set Φ_j^B to the set $\Phi_k^A \cup \Phi_k^B$ are consolidated (scenario H2), the, it results:

$$N_j^A = 2\,\mathrm{int}_{\sup}\left(\frac{\sum_{\Phi_j^A}\left(\sum_{\Phi_k^A}X_{jk}^{AA}+\sum_{\Phi_k^B}X_{jk}^{AB}\right)}{C_j}\right) \tag{21}$$

$$N_j^B = 2\,\mathrm{int}_{\sup}\left(\frac{\sum_{\Phi_j^B}\left(\sum_{\Phi_k^A}X_{jk}^{BA}+\sum_{\Phi_k^B}X_{jk}^{BB}\right)}{C_j}\right) \tag{22}$$

$$N_k^A = 2\left(\sum_{\Phi_k^A}\mathrm{int}_{\sup}\left(\frac{f_k^{AA}}{C_k}\right)+\sum_{\Phi_k^A}\mathrm{int}_{\sup}\left(\frac{f_k^{AB}}{C_k}\right)\right) \tag{23}$$

$$N_k^B = 2\left(\sum_{\Phi_k^B}\mathrm{int}_{\sup}\left(\frac{f_k^{BA}}{C_k}\right)+\sum_{\Phi_k^B}\mathrm{int}_{\sup}\left(\frac{f_k^{BB}}{C_k}\right)\right) \tag{24}$$

$$N = N_j^A + N_j^B + N_k^A + N_k^B \tag{25}$$

If flows from the set $\Phi_j^A \cup \Phi_k^A$ to the set $\Phi_k^A \cup \Phi_k^B \cup \Phi^A \cup \Phi^B$ and from the set $\Phi_j^B \cup \Phi_k^B$ to the set $\Phi_k^A \cup \Phi_k^B \cup \Phi^A \cup \Phi^B$ are consolidated (scenario H3), then, it results:

$$N^A = 2\,\mathrm{int}_{\sup}\left(\frac{\sum_{\Phi_j^A}\left(\sum_{\Phi_k^A}X_{jk}^{AA}+\sum_{\Phi_k^B}X_{jk}^{AB}\right)}{C_j}+\frac{\sum_{\Phi_k^A}\left(f_k^{AA}+f_k^{AB}\right)}{C_k}\right) \tag{26}$$

$$N^{B} = 2\,\mathrm{int}_{\sup}\left(\frac{\sum_{\Phi_j^B}\left(\sum_{\Phi_k^A} X_{jk}^{BA} + \sum_{\Phi_k^B} X_{jk}^{BB}\right)}{C_j} + \frac{\sum_{\Phi_k^B}\left(f_k^{BA} + f_k^{BB}\right)}{C_k}\right) \quad (27)$$

$$N = N^{A} + N^{B} \quad (28)$$

Hierarchy policy (vehicle and inventory consolidation)

If flows from the set Φ_j^A to the set $\Phi_k^A \cup \Phi_k^B$ are considered and inventory consolidation is extended to a number of period, for the sake of simplicity, equal to Nt (scenario H1), then it results:

$$N_j^{A} = 2\,\mathrm{int}_{\sup}\left(\frac{\sum_{\Phi_j^A} N_t\left(\sum_{\Phi_k^A} X_{jk}^{AA} + \sum_{\Phi_k^B} X_{jk}^{AB}\right)}{C_j}\right) \quad (29)$$

$$N_j^{B} = 2\left(\sum_{\Phi_j^B}\sum_{\Phi_k^A} \mathrm{int}_{\sup}\left(\frac{N_t X_{jk}^{BA}}{C_j}\right) + \sum_{\Phi_j^B}\sum_{\Phi_k^B} \mathrm{int}_{\sup}\left(\frac{N_t X_{jk}^{BB}}{C_j}\right)\right) \quad (30)$$

$$N_k^{A} = 2\left(\sum_{\Phi_k^A} \mathrm{int}_{\sup}\left(\frac{N_t f_k^{AA}}{C_k}\right) + \sum_{\Phi_k^A} \mathrm{int}_{\sup}\left(\frac{N_t f_k^{AB}}{C_k}\right)\right) \quad (31)$$

$$N_k^{B} = 2\left(\sum_{\Phi_k^B} \mathrm{int}_{\sup}\left(\frac{N_t f_k^{BA}}{C_k}\right) + \sum_{\Phi_k^B} \mathrm{int}_{\sup}\left(\frac{N_t f_k^{BB}}{C_k}\right)\right) \quad (32)$$

$$N = \left(\frac{N_j^{A} + N_j^{B} + N_k^{A} + N_k^{B}}{N_t}\right) \quad (33)$$

If flows from the set Φ_j^A to the set $\Phi_k^A \cup \Phi_k^B$ and from the set Φ_j^B to the set $\Phi_k^A \cup \Phi_k^B$ are considered and inventory consolidation is extended to a number of period, for the sake of simplicity, equal to Nt (scenario H2), the, it results:

$$N_j^{A} = 2\,\mathrm{int}_{\sup}\left(\frac{\sum_{\Phi_j^A} N_t\left(\sum_{\Phi_k^A} X_{jk}^{AA} + \sum_{\Phi_k^B} X_{jk}^{AB}\right)}{C_j}\right) \quad (34)$$

$$N_j^B = 2\,\mathrm{int}_{\sup}\left(\frac{\sum_{\Phi_j^B} N_t\left(\sum_{\Phi_k^A} X_{jk}^{BA} + \sum_{\Phi_k^B} X_{jk}^{BB}\right)}{C_j}\right) \tag{35}$$

$$N_k^A = 2\left(\sum_{\Phi_k^A} \mathrm{int}_{\sup}\left(\frac{N_t f_k^{AA}}{C_k}\right) + \sum_{\Phi_k^A} \mathrm{int}_{\sup}\left(\frac{N_t f_k^{AB}}{C_k}\right)\right) \tag{36}$$

$$N_k^B = 2\left(\sum_{\Phi_k^B} \mathrm{int}_{\sup}\left(\frac{N_t f_k^{BA}}{C_k}\right) + \sum_{\Phi_k^B} \mathrm{int}_{\sup}\left(\frac{N_t f_k^{BB}}{C_k}\right)\right) \tag{37}$$

$$N = \left(\frac{N_j^A + N_j^B + N_k^A + N_k^B}{N_t}\right) \tag{38}$$

If flows from the set $\Phi_j^A \cup \Phi_k^A$ to the set $\Phi_k^A \cup \Phi_k^B \cup \Phi^A \cup \Phi^B$ and from the set $\Phi_j^B \cup \Phi_k^B$ to the set $\Phi_k^A \cup \Phi_k^B \cup \Phi^A \cup \Phi^B$ are considered and inventory consolidation is extended to a number of period, for the sake of simplicity, equal to Nt (scenario H3), then, it results:

$$N^A = 2\,\mathrm{int}_{\sup}\left(\frac{\sum_{\Phi_j^A} N_t\left(\sum_{\Phi_k^A} X_{jk}^{AA} + \sum_{\Phi_k^B} X_{jk}^{AB}\right)}{C_j} + \frac{\sum_{\Phi_k^A} N_t\left(f_k^{AA} + f_k^{AB}\right)}{C_k}\right) \tag{39}$$

$$N^B = 2\,\mathrm{int}_{\sup}\left(\frac{\sum_{\Phi_j^B} N_t\left(\sum_{\Phi_k^A} X_{jk}^{BA} + \sum_{\Phi_k^B} X_{jk}^{BB}\right)}{C_j} + \frac{\sum_{\Phi_k^B} N_t\left(f_k^{BA} + f_k^{BB}\right)}{C_k}\right) \tag{40}$$

$$N = \left(\frac{N^A + N^B}{N_t}\right) \tag{41}$$

Moreover, in both the hierarchy policies (vehicle and inventory consolidation), in order to minimize the number of trips, it is possible to coordinate the transportation means using the same means to convey products from A to B and from B to A. Then, an improvement can be obtained in terms of performance considered.

CONCLUSION

The relevance of logistics is increasing as the phenomenon of globalization progresses. The need to coordinate logistics flows is stressed by the impact of logistics performance on the competitiveness of companies. In this paper an enterprise input-output model is developed to analyze the logistics flows of a supply chain and to evaluate logistics performance. The model is proposed to compare the effects of different coordination policies, ranging from hierarchy (vehicle and inventory consolidation) to market, in terms of logistics performance. Further researches should be devoted to analyze the mentioned trade-offs, and to extend the model to different contexts, involving more than two areas.

Acknowledgments
This work was supported by the Major International Joint Research Program of the National Natural Science Foundation of China (Grant no. 71020107027), the National Natural Science Foundation of China (Grant no. 71001075), Doctoral Fund of Ministry of Education of China (Grant no. 20110181110034), Humanities and Social Sciences project of the Ministry of education of China (Grant no.12YJC630023), Social sciences program of Chengdu (Grant no.SKNHR13-07).

REFERENCES

[1] Lambert D M. *Traffic Engineering and Control*, v 53, n 10, p 375-378, November **2012**.
[2] Danese, P., Romano, P., Vinelli, A., *Journal of Purchasing & Supply Management*, 10, pp. 165-177, **2004**.
[3] Choi, T.Y., Hong, Y., *Journal of Operations Management*, 20, pp. 469-493, **2002**.
[4] Meixell M J, Gargeya V B. *Transportation Research Part E: Logistics and Transportation Review*, **2005**, 41(6): 531-550.
[5] Dicken P. Global shift: transforming the world economy[M]. **1998**.
[6] Hall R W. *Journal of Business Logistics*, **1987**, 8(2): 57-73.
[7] Studies in the Structure of the American Economy[M]. New York: Oxford University Press, 1953.
[8] Marangoni G D, Colombo G, Fezzi G. *Economic Systems Research*, **2004**, 16(1): 85-104.