

# Study on Function Mechanism & Simulation of “Chain Mode Innovation” Policy in the Optimization and Upgrading of the Industry Structure

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**ABSTRACT:** This article explicitly stated the concept of national value chain and “chain mode innovation” from the two perspectives: first is to organize capable enterprises embedded in the value chain of global industry, and urge them to stretch on both ends of the “smiling curve” to reach a higher level of cooperation, and then catch the leading position of the value chain; second is to construct technology innovation system that matches the development of related industries, cultivate the national prominent value chain of domestic companies, evolve the global value chain to a higher level through the continuous optimization and upgrading of the industrial structure; next is to explain function mechanism of “chain mode innovation” and framework of industrial policy mix, design and simulate the evolution process under the action of the policy, then evaluate the effect of the policy mix. Finally it is concluded that policy mix of “chain mode innovation” has the best effect.

**Keywords:** Chain mode innovation, Policy effect, Mechanism simulation, Industrial structure

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## 1. Introduction

The evolution of national value chain is involved in many aspects of the systems engineering. But intuitively speaking, it can be seen as a process grows out of nothing and upgrades continuously. The general rule of industrial development shows that many successfully transformed enterprises in the countries and regions transform from the initial lower end of the global value chain, build and form the national value chain. The main body of composition of the national value chain is the domestic local enterprises, which extend the industrial chain through the forward and backward association, realize the effective formula of various elements. It is an inter-enterprise network organization that connects processes of research and development, production, sales, recycling in order to realize more value-added goods or services. National value chain must survive and develop under the

protection of trade policy, and evolve gradually into global value chain with international competitiveness through the guidance of corresponding policies, replace international high value-added links partially or totally through the improvement of its own technology and management level, realize the extension of own industry value chain to high-end.

Given that, the research on evolution mechanism and construction of a simulation model of national value chain under the action of the “chain mode innovation” policy has important theoretical and realistic significance. First of all, it helps the optimization and upgrading of the overall industrial structure from the macro, as well as the promotion of enterprise’s value chain from the micro; secondly, the policy mix helps the rationalization of industry on the regional layout. “Chain mode innovation” will deeply study a country’s industrial structure evolution rules from several levels of the enterprise, industry, area, as well as the macroeconomic operation and so on. It not only evaluates the influence of industrial policy on the market behavior of microeconomic units through policy simulation, but also considers the construction of national value chain from the evolution of industrial structure and layout of regional economy, and then builds a complete industrial structure system of “chain mode innovation” from the perspective of the government’s macro policy decision; finally, the optimal combination of policy helps the adjustment of government department on industry structure. “Chain mode innovation” theory will help to establish and promote policy mix framework of the optimization and upgrading of industrial structure.

## 2. Literature Review

Key affecting factor of the evolution of the national value chain is the policy guidance of “chain mode innovation”. Inherent question is that the main body of enterprise adsorbs in the different levels of value chain by the policy guidance because of interest relations in the national value chain, and constantly climbs from low level to the top. For the research on this problem, this paper combed the previous literature and divided it into two classes.

First is research of enterprise behavior at different levels based on the value chain. From a macro perspective, the formation and operation of the global value chain was mainly driven by both aspects of producers and buyers (Kogut, 1985). The former should concentrate on the construction of competitive advantage in the field of manufacturing; the latter should emphasize the expansion of design capacity, brand building and marketing network. Its core was the control of strategic link (Zsidisin, 2003). Meanwhile, there were four patterns of enterprises upgrades in the global value chain: technology upgrade; product upgrade; function upgrade and chain upgrade (Humphrey & Schmitz, 2002). Based on the research of micro main body of enterprise, enterprise that had a rigorous organization structure, perfect internal control, low dependence on resources was more dynamic. The shorter the cycle of enterprise product innovation was, the smaller the resistance of enterprise transformation and upgrade would be (Pfeffer & Salancik, 2003). Study on medium specific industries, Ernst (2001) found that as the transformation of government policy from export-oriented strategy to import-substitution strategy, computer industry achieved from OEM to ODM and to OBM and implemented the typical manufacturing industry upgrade path under the government policy after the research on the upgrade path of personal computer industry of Hsinchu industrial park in Taiwan. Goch (2012) discovered that the method of processing trade of China’s enterprise was mainly the low end link of inserting into global value chain. In order to realize strategic adjustment and transformation and upgrading of China’s processing trade, we need to foster domestic high-end market, extend domestic value chain, optimize the enterprise structure of processing trade, and promote the reconstruction of enterprise value chain. Dallas (2014) studied the regional industrial upgrading of garment industry in Eastern Europe and found that the problems demanded prompt solution was enterprise agglomeration of the garment manufacturing enterprises caused by the structural transformation of regional economy and more competitiveness on enterprises how to realize the transformation and upgrading.

Second is research of industrial policy factors on affecting corporate behavior. Since the middle of the last century, the influence of government how to use industrial policy means on behavior of micro enterprise became a research emphasis of theoretical system of modern industrial policy. DeFraja and Delbono (1989) deeply analyzed the impact of domestic industrial policy on corporate behavior without considering the effects of foreign industrial policy, which provided the analysis framework for mechanism of enterprise behavior of government industrial policy. Fjell and PaI (1996) analyzed the impact of industrial policy on the behavior of multinational corporations without considering the effects of trade policies. Sargent and Matthews (2009) depicted the change of China’s state-owned enterprises behavior under preferential policies; found that the efficiency of enterprise will change significantly when introducing a new incentive mechanism. Vousden and Campbell (1994) focused on influence of production subsidies on corporate behavior; found that the increase of enterprise production subsidies can significantly improve the management efficiency of enterprises. Pal and White (1998) pointed out that if the optimal subsidy policy was put in place, companies tended to themselves accumulation behavior that can increase the welfare. Simpson and

Bradford (1996) proved that under the hypothesis of imperfect competition between enterprises, a country's domestic strict environmental policy can make the transformation of profits from foreign enterprises to domestic enterprises through the establishment of a policy model. Mohr (2002), Mohr and Saha (2008) respectively put forward the model of technology spillover, and found environmental policy will promote the development of technology, which made the transformation of an industry from the balance of a low R&D investment into a balance of high R&D Pareto improvement.

To sum up, the research of the past scholars have made some achievements. However, this paper argued that shortcomings still existed. One is that the research of enterprise behavior at different levels in value chain generally lacks of systematicness from the perspective of macroscopic. Study of micro enterprises and medium specific industries has no generality and universality. One is that research of industrial policy factors on corporate behavior mostly measures the impact effect of specific industry policy on the real market behavior of enterprise through the specific policy selection. Although the results of these studies have clear research ideas and relatively accurate research results, few scholars explore and study how to analyze the complexity of dynamic selection of industrial policy means and the influence mechanism of the industry policy means on enterprise behavior especially from the perspective of dynamic research in combination with the objective laws of evolution of industrial structure. The other one is how to measure the influence of industrial policy means on enterprise behavior at the different stages of evolution of the national value chain, then draw a conclusion that a country realizes the dynamic adjustment mechanism of industrial policy of the domestic industrial structure optimization and upgrading by means of industrial policy of dynamic adjustment have not yet been discussed in the over-all situation of the evolution of the global value chain. In view of this, this article took the modeling method of "bottom-up", innovatively put forward policy mechanism and simulation framework design of "chain mode innovation" by taking the breakthrough point of policy impact on corporate behavior and the research object of the evolution of the national value chain from the perspective of complex economic system to overcome the deficiency of previous research.

### **3. The "Chain Mode Innovation" Theory And Policy Framework In Optimization And Upgrading of Industrial Structure**

#### **3.1 The connotation and type classification of national value chain**

The main body of composition of national value chain is the domestic local enterprises. The connotation of the national value chain refers to the inter-enterprise network organization connects research and development, design, processing, assembling and marketing process in order to realize the more value-added goods or services and achieve the effective ratio of various elements through the forward and backward association. The relevant enterprises gather specific industrial value chain and rely on its own technology and the improvement of management level through the guidance of policies to make the expansion of value chain of domestic enterprises to the high-end, and then realize the overall improvement of value chain.

National value chain can be divided into two types from the general sense: value chain form with international competitiveness dominated by multinational companies is one kind. It removes the low-end manufacturing to value chain form of China's domestic production activities without trade protection. This kind of situation can be seen as an extension of the global value chain in China, and can be divided into two types of strong embeddedness and weak embeddedness according to its roots and integration situation in China. Chinese companies may adopt different ways according to its embeddedness: for national value chain with strong embeddedness, they mainly stretch on both ends of the value chain through embedding, learning successfully, finally lead or copy the high-end link of multinational companies; for the national value chain with weak embeddedness, they mainly as a demonstration samples, Chinese enterprises can learn advanced experience of the research and development, design, brand image, organization and management to achieve industrial concentration and climbing of the value chain. The value chain form without temporary international competitiveness dominated by domestic companies under the trade protection or support of national industrial policy is the other kind. This is Chinese national value chain, which can be divided into two stages of immature and mature according to their level of development. The national value chain of immature stage grows up to be a national value chain with international competitiveness mainly through cultivation, research and development and support, but also grows up to be a mature national value chain through embedding the form of global value chain.

#### **3.2 Theories and its way of "chain mode innovation"**

National value chain has two levels of immature and mature. Under the influence of industrial upgrading policy factors on the enterprise behavior, the evolution of national value chain should realize the node of "chain mode innovation".

- The connotation of "chain mode innovation". "Chain mode innovation" is to embed new technology, new organization forms into each node of national industrial value chain through the guidance ways of encouragement, support, specification and

constraint, in order to achieve the extension of national industrial value chain, raised level, increased competitiveness, become the dominant value chain and “chain Lord”, eventually dominate the high-end of global value chain with international competitiveness.

• Two types of “chain mode innovation. First, improve the national value chain. Domestic enterprises (or industries) belong to the low level national value chain in the early stage of development., the core competitiveness enterprise is improved through guidance and norms of relevant industrial policy, and then embed the whole industrial chain into national value chain, realize the evolution of national value chain from low level to high level through the optimization and upgrading of industrial structure. The evolution of domestic enterprises to the national value chain is realized through guidance and cultivation of conscious policies, which helps better integration of enterprises into the global value chain, and creates conditions for occupying global value chain with international competitiveness. Second, embed global value chain. In the development process of domestic companies (or industries), the production and business operation activities are conducted by the way of inserting into global value chain. The core technology of leading enterprises is realized in the value chain by protecting a country’s trade policy, and gradually possesses international competitiveness, replaces all or part of the global value chain link of high-end on the key technology elements, eventually cultivates the national value chain that has the equal competitiveness with global value chain. The embedment method of global value chain can realize the replacement of the foreign advanced enterprise ultimately in the value chain of each link in the form of independent brands and own technology from imitation innovation to independent innovation by the learning, the introduction, digestion, absorption of the high-end link of global value chain. (2) The single mapping between service system and the Petri net. According to the process of SOMA service modeling method, this paper proposes a service modeling method PN - SM based on Petri net. This method can establish a layered service model, and can establish the transformation between different hierarchical model; This method does not belong to describing language and implementing technology, its application scope is broad, and can guide service system development. PN - SM service modeling is dependent on the main frame of the general service modeling method, this paper constructs service modeling method process suitable for the field of information management software based on the SOMA service modeling method process, according to the classification rules of the service and principles of service design and combined with Petri net. This paper defines the process of PN - SM service modeling as shown in figure 1.

### **3.3 The “chain mode innovation” policy framework in optimization and upgrading of industrial structure**

#### **3.3.1 The framework of industrial policy**

• Industrial structure policy is to realize the relationship between industries and achieve the industrial structure rationally and highly. Different ways of “chain mode innovation” are adopted to realize the optimization of industrial structure according to different positions of the national value chain in various industries.

• Industrial organization policy is to realize the relationship in internal relations of enterprise and achieve rationalization of organization. The policy mainly refers to the internal industry realizes the rising of value chain through merger and restructuring in view of the different enterprises.

• Industrial distribution policy is to break the interests’ barriers between regional units. It encourages conditional enterprise to form a union, extend the value chain, increase added value and cultivate value chain according to the own laws and regional resources endowment of the industry chain and value chain, reasonable and orderly flow of productive factors.

• Industrial technology policy is to promote scientific and technological innovation and progress of enterprise technology. The establishment of an unified platform of production, study and use promotes the transformation of applicability scientific and technological achievements to productivity; combines enterprises, colleges and universities (scientific research institutions), government and market organically; improves the technology and equipment level of enterprise and management ability; implements talent cultivation and use policies of encouraging innovation, respecting and paying attention to human capital; establish science and technology innovation fund; adopts taxes, subsidies and other all-round supports for large enterprises, scientific research institutions in research and development.

• Industrial support policy is to realize supports for specific enterprise and industry through fiscal expenditure, tax deduction and exemption. Promote modern agriculture, advanced manufacturing and modern service industry development through increasing financial support and tax deduction and exemption; support the development and grow of strategic emerging industries; restrict and eliminate backward production capacity; give play to the adjustment role of export rebates to the export trade; expand the international market through introducing investment from abroad and establishing lateral ties at home; join the

rank of international value chain gradually through the introduction, absorption and re-innovation, substitution strategy of domestic enterprises.

- Industry protection policy is to use WTO rules reasonably mainly in international trade. Provide space for grow of domestic infant industries; improve its value proliferation; go global eventually; become the enterprise which has the advantage of global value chain.

### 3.3.2 Policy mechanism

The first four aspects are corresponding to the first way of the “chain mode innovation” in the framework of the industrial policy, which focus on the enhancing of national value chain level of domestic enterprises. The latter two aspects are corresponding to the second way of the “chain mode innovation”, which focus on embedding in global value chain for domestic enterprises. These two ways of “Chain mode innovation” exist interaction, so these six aspects content are not in isolation in the industrial policy system.

Through the mechanism of action of formation and evolution of the “chain mode innovation” in national value chain, select policy combination that is advantageous to the evolution of the value chain; set up corporate behavior simulation model; set parameters for related policy to conduct simulation study; evaluate implementation effect of policy; and then adjust the policy content, simulate, try and adjust continuously, finally form the optimal policy mix.

## 4. The Evolution Modeling of Enterprise Behavior Under The Effect of “Chain Mode Innovation” Policy

The key factor influencing the “chain mode innovation” is the industrial policy; the essence is evolution mechanism of enterprises behavior in the value chain based on the above analysis of theoretical framework. Accordingly, the evolution model of enterprise behavior under the effect of “chain mode innovation” policy is built.

### 4.1 The mathematical model of role behavior of the individual enterprise in the value chain

The role of enterprise in this project refers to basic activities or ancillary activities engaged in by different enterprises in the value chain. Role behavior modelling of enterprise is role transformation problem of research enterprise in the value chain under the situation of development and changes of their behavior ability. For example, an enterprise was in the original processing and manufacturing link in the value chain, their own behavior ability changed, role transformed, with the passage of time which may become research and development or the sales link, also may be out of the value chain.

Mathematical modeling is set up:  $f(a_i + e_{t+j}) = f(a_i + e)$ . ( $i, j = 1, 2, \dots, n$ ) expressed transformation relation of role behavior of enterprise, in which,  $a$  expressed be 0 prise,  $t$  expressed time, expressed the category of roles.

### 4.2 Mathematical model of the competitiveness evolution of individual enterprise in the value chain

We analyzed from the above behavior characteristics of enterprise and its influencing factors in the value chain that in the hypothesis of enterprise behavior ability influenced by four factors of competitiveness, income, risk and policy aspects in the certain situations of risks and benefits, the mathematical model  $C_t = g(C_{t-1}, POL)$  of competitiveness evolution of enterprise is set up to describe the changes of enterprise competitiveness in different periods under the effect of policy. Among them,  $C$  expressed competitiveness,  $t$  expressed time,  $POL$  expressed policy.

### 4.3 Markov model of role behavior evolution of enterprise in the value chain

We assume that enterprise is in three levels of low, medium and high in the value chain respectively and the interior of each level and the hierarchies have role transformation problem of collective enterprise. The probability ( $p_{ij}$  ( $i, j = 1, 2, \dots, n$ )) of different role transformation of the enterprise is determined by Markov model.

### 4.4 Network model of the evolution of the value chain system

A specific industry is picked up from the reality on the basis of the establishment of a network model of the evolution of the value chain conformed to the reality. It is assumed that enterprise is in three different levels in the value chain as shown in figure 1, the initial number of enterprise in each level is certain; each node represents the enterprise of different roles. is confirmed through market research with a cycle for five years on the basis of the above modeling steps of (1) - (3). When different policy mixes are imported, the survey of the number of enterprise stays in each level in order to find the anticipated and satisfied optimal policy mix.

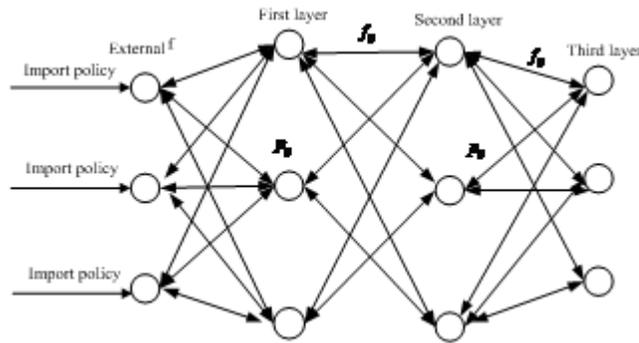


Figure 1. The network model of system evolution in national value chain

#### 4.5 The network model of role evolution of enterprise in the value chain

The network model of role evolution of enterprise in the value chain is established in the expansion of general situation as shown in figure2.

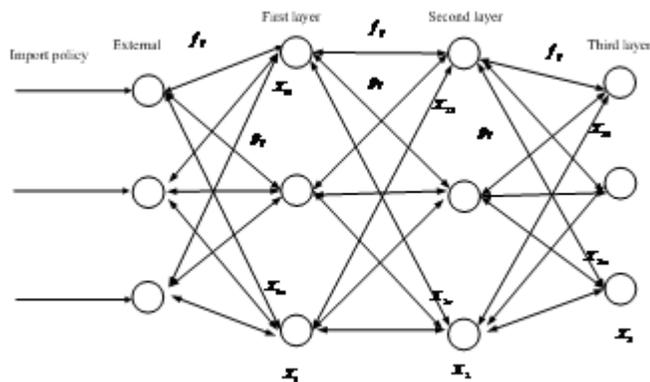


Figure 2. The network model of role evolution of enterprise in the national value chain

Among them, each node represents different roles of enterprise, which namely indicates a kind of enterprise. For example, enterprise specializes in products manufacturing.  $X_{1n}$  expresses some kind of enterprise quantity in the first node of the first layer.  $X_{1n}$  expresses some kind of enterprise quantity in the n node of the first layer. Therefore,  $X_1$  expresses all roles of the enterprise quantity in the first layer;  $X_2$  expresses all roles of the enterprise quantity in the second layer;  $X_3$  expresses all roles of the enterprise quantity in the third layer.  $f_{ij}$  expresses role transformation relation of enterprise in the value chain,  $p_{ij}$  expresses transition probability of state. When different policy mixes are imported, the change of  $X_1, X_2, X_3$  is analyzed with a cycle for five years in order to find the anticipated and satisfied optimal policy mix.

#### 4.6 Simulation experiment of corporate role behavior evolution under the action of “chain mode innovation” policy

Simulation experiment of corporate role behavior evolution under the action of “chain mode innovation” policy is conducted based on Matlab simulation platform according to the above modeling technology. The details as follow: firstly, this paper drew a lesson from neural network model, selected three-layer network model, input evolution function ( $f$ ) of role behavior of enterprise and role transition probability ( $p_{ij}$ ); secondly, the article set relevant parameters including parameter of “chain mode innovation” policy of different combinations, evolution period (5 years), required accuracy, etc. and conducted the normalization processing for input data; thirdly, the network model was trained repeatedly until meeting the requirements; fourthly, input “chain mode innovation” policy of different combinations, observe the state of enterprise quantity change at different levels in the network model of value chain system, find the anticipated and satisfied enterprise quantity at different levels, evaluate and predict the different policy mixes; fifthly, compare the results with the reality, analyze the stability of the model.

#### 4.7 The evaluation and suggestion of policy effect

Based on the mechanism and the simulation results of “chain mode innovation” policy in our country’s industrial structure

optimization and upgrading, the effects of relevant policy are evaluated, high-end scientific countermeasure and the suggestion are put forward to promote enterprise dominated national value chain in our country and climb to the global value chain.

### 5. Conclusion

This article built evolution model of national value chain and realized the evolution of local industry from the value chain of different levels to the global value chain through the study on incentives, constraints, and standard effects of “chain mode innovation” policy for enterprise behavior. The paper further established evolution model of the national value chain system based on Markov model, and constructed a simulation model for the evolution process, which aimed to put forward policy mix suggestion as the breakthrough point of “chain mode innovation”. The mechanism and the simulation framework of “chain mode innovation” policy as shown in figure 3.

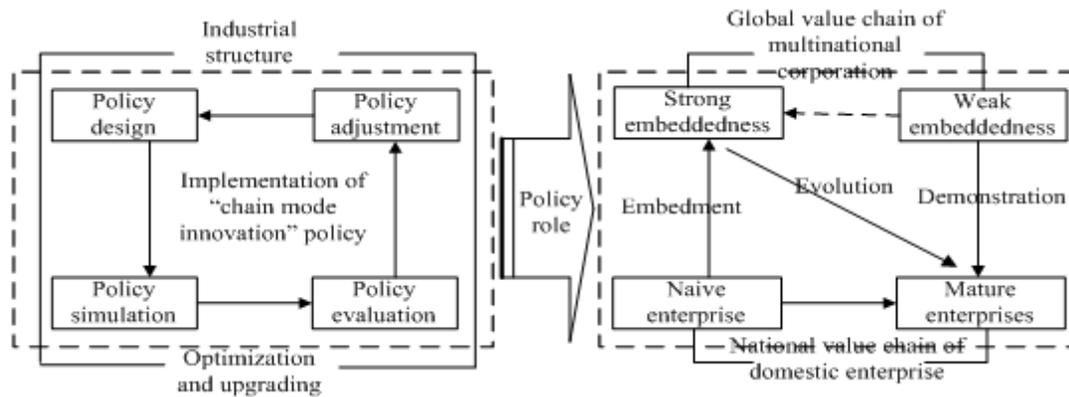


Figure 3. The mechanism and the simulation framework of “chain mode innovation” policy

### 6. Acknowledgment

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### References

[1] Dallas, M.P. (2014) Manufacturing Paradoxes: Foreign Ownership, Governance, and Value Chains in China’s Light Industries. *World Development*, 57. 47-62.

[2] De Fraja, G., Delbono, F. (1989). Alternative Strategies of a Public Enterprise in Oligopoly. *Oxford Economic Papers*, 41 (2) 302-311.

[3] Ernst, D. (2001) .Global Production Networks and Industrial Upgrading-A Knowledge-Centered Approach. East-West Center Working Papers. Economic Series, (25).

[4] Fjell, K., Pal, D. (1996). A Mixed Oligopoly in the Presence of Foreign Private Firms. *Canadian Journal of Economics*, 737-743.

[5] Goch, L. (2003) With Cargo Security Risks Rising: can Technology be a Solution? *Best’s Review*, 103: 10.

[6] Humphrey, J., Schmitz, H. (2002). How does Insertion in Global Value Chains Affect Upgrading in Industrial Clusters?. *Regional Studies*, 36 (9) 1017-1027.

[7] Kogut, B. (1985) Designing Global Strategies: Comparative and Competitive Value Added Chains. *Sloan Management Review*, 26 (4).

[8] Mohr, R D., Saha, S. (2008). Distribution of Environmental Costs and Benefits, Additional Distortions, and the Porter Hypothesis. *Land Economics*, 84(4): 689-700.

[9] Mohr, R D. (2002). Technical Change, External Economies, and the Porter Hypothesis. *Journal of Environmental Economics and Management*, 43 (1) 158-168.

- [10] Pal, D., White, M. D. (1998) Mixed Oligopoly, Privatization, and Strategic Trade Policy. *Southern Economic Journal*, 65 (2) 264-281.
- [11] Pfeffer, J., Salancik, G R. (2003). The External Control of Organizations: A Resource Dependence Perspective. Stanford University Press.
- [12] Sargent, J., Matthews, L. (2009) China Versus Mexico in the Global EPZ Industry: Maquiladoras, FDI Quality, and Plant Mortality. *World Development*, 37 (6) 1069-1082.
- [13] Simpson R D, (1996) Bradford III R L. Taxing Variable Cost: Environmental Regulation as Industrial Policy, *Journal of Environmental Economics and Management*, 30 (3) 282-300.
- [14] Vousden N, Campbell N. (1994) The Organizational Cost of Protection. *Journal of International Economics*, 37 (3) 219-238.
- [15] Zsidisin, G A. (2003). Managerial Perceptions of Supply Risk. *Journal of Supply Chain Management*, 39 (1) 14-26.