

DISTRIBUTION NETWORK RELATIONS IN CHEMICAL INDUSTRY

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Abstract

The paper aims to investigate the process of establishing distribution network. The paper takes network paradigm (Achrol, 1997; IMP Group, 1982; Romyantseva, Tretyak, 2003) as a main basis of investigation looking at the development of distribution networks in Russian chemical industry.

Recently Business to Business distribution has been undergoing a process of significant evolution (Gadde, 2000; Gadde, Snehota, 2001; Frauendorf et al, 2007; Tretyak, Sheresheva, 2005; Vaskin, 2008). Formerly distributor was mainly considered as a passive collector of orders. Now distributor is more and more considered as an agent having the core position in the supply chain. Its activity is crucial for establishing relations with numerous agents: transport companies, finance organizations, custom brokers etc. The interconnection of firms' activities generates, and is increased by, interconnected relationships that outline the network approach within the supply chain (Cantu et al, 2009).

We aim to look at the process of distribution network creation using the mathematical tool of Markov's chain theory.

Firstly, we will give a brief overview of relevant theory. Secondly, we will describe situation in chemical industry in Russia. Focusing on the question of the current structures of distribution chains, we aim to identify the main features of distribution models of each type.

We aim to describe the process of choosing a partner from the set of homogenous agents providing similar goods or services for distributor (product, credit, transport, storehouse, etc.). There are two options for actors:

- opportunistic behavior, where the choice of partner is driven solely by the price offer and
- networking behavior, where choice of partner is based on well-established supplier-distributor relationships.

Finally, using empirical data we will make up matrix of agent behavior using time-homogeneous Markov chains. These matrix aims to describe possible variants of agent

during the process of choosing. The empirical section of the paper is based on the analysis of distribution networks in Russian chemical industry.

Keywords: distribution networks; relationships; transaction costs; Russia

Literature review

The paper takes network paradigm as a main basis of investigation looking at the development of distribution networks in Russia. In line with this tradition, interaction between companies in industrial markets is seen from a relationship perspective (Håkansson and Snehota 1995), where relationship was defined as “mutually oriented interaction between two reciprocally committed parties”. Over the past two decades, the literature has increasingly moved to consider inter-firm networks as an efficient form of organizing business activities. Network approaches vary significantly being numerous and diverse but having all together formed foundation for the development of a new paradigm (Rumyantseva and Tretyak, 2003).

There is a number of features in Russian economy, determining potential differences in developing distribution network, among them higher instability of relationships in the market, lack of information about potential partners due to short-term history of market economy, low information disclosure readiness, higher readiness for opportunistic behavior and higher time pressure (Ford et al, 2006, Johanson 2007, Halinen, Salmi, 1996). Russia as an economy in transition provides a unique opportunity to investigate changing and adapting network structures, stakeholder interaction and relationship constellations (Smirnova et al., 2009). The development of business relationships was the subject of cultural analysis and attempts to find a “specific Russian way” to relationship building (e.g. Davis, Patterson, and Grazin, 1994). Some studies exist which analyze the nature of these new relationships, building on frameworks within a market economy (e.g. Johanson, 2007; Smirnova, Kousch, 2007; Tretyak, Sheresheva, 2005).

Weber (Weber J.A., 2001) was quite right to admit that resource sharing in distribution serves as foundation for building sustainable competitive advantage, due to the increase of resource body available to the company and increase of flexibility.

Distribution in Russia is characterized by some trends including shift in distribution channels' structure, cutting number of distributors in many industries, internalization of distribution networks, and growing role of information infrastructure (Sheresheva, 2005).

Theoretical foundation

Formally, a Markov chain is a discrete random process with the Markov property. A discrete random process means a system which can be in various states, and which changes randomly in discrete steps. It can be helpful to think of the system as evolving through discrete steps in time, although strictly speaking the "step" may have nothing to do with time. The Markov property states that the probability distribution for the system at the next step

(and in fact at all future steps) only depends on the current state of the system, and not additionally on the state of the system at previous steps. Since the system changes randomly, it is generally impossible to predict the exact state of the system in the future. However, the statistical properties of the system at a great many steps in the future can often be described. In some applications these statistical properties are important.

The changes of state of the system are called transitions, and the probabilities associated with various state-changes are called transition probabilities.

Formal definition

A Markov chain is a sequence of random variables X_1, X_2, X_3, \dots with the Markov property, namely that, given the present state, the future and past states are independent. Formally,

$$\Pr(X_{n+1} = x | X_1 = x_1, X_2 = x_2, \dots, X_n = x_n) = \Pr(X_{n+1} = x | X_n = x_n).$$

The possible values of X_i form a countable set S called the state space of the chain.

Markov chains are often described by a directed graph, where the edges are labeled by the probabilities of going from one state to the other states.

Variations

- Continuous-time Markov processes have a continuous index.
- Time-homogeneous Markov chains (or stationary Markov chains) are processes where

$$\Pr(X_{n+1} = x | X_n = y) = \Pr(X_n = x | X_{n-1} = y)$$

for all n . The probability of the transition is independent of n .

- A Markov chain of order m (or a Markov chain with memory m) where m is finite, is a process satisfying

$$\Pr(X_n = x_n | X_{n-1} = x_{n-1}, X_{n-2} = x_{n-2}, \dots, X_1 = x_1) \\ = \Pr(X_n = x_n | X_{n-1} = x_{n-1}, X_{n-2} = x_{n-2}, \dots, X_{n-m} = x_{n-m}) \text{ for } n > m$$

In other words, the future state depends on the past m states. It is possible to construct a chain (Y_n) from (X_n) which has the 'classical' Markov property as follows:

Let $Y_n = (X_n, X_{n-1}, \dots, X_{n-m+1})$, the ordered m -tuple of X values. Then Y_n is a Markov chain with state space S_m and has the classical Markov property.

An additive Markov chain of order m where m is finite, is where

$$\Pr(X_n = x_n | X_{n-1} = x_{n-1}, X_{n-2} = x_{n-2}, \dots, X_1 = x_1) = \sum_{r=1}^m f(x_n, x_{n-r}, r)$$

Markov chains

The probability of going from state i to state j in n time steps is

$$p_{ij}^{(n)} = \Pr(X_n = j \mid X_0 = i)$$

and the single-step transition is

$$p_{ij} = \Pr(X_1 = j \mid X_0 = i).$$

For a time-homogeneous Markov chain:

$$p_{ij}^{(n)} = \Pr(X_{n+k} = j \mid X_k = i)$$

And

$$p_{ij} = \Pr(X_{k+1} = j \mid X_k = i).$$

so, the n-step transition satisfies the Chapman–Kolmogorov equation, that for any k such that $0 < k < n$,

$$p_{ij}^{(n)} = \sum_{r \in S} p_{ir}^{(k)} p_{rj}^{(n-k)}$$

where S is the state space of the Markov chain.

The marginal distribution $\Pr(X_n = x)$ is the distribution over states at time n. The initial distribution is $\Pr(X_0 = x)$. The evolution of the process through one time step is described by

$$\Pr(X_n = j) = \sum_{r \in S} p_{rj} \Pr(X_{n-1} = r) = \sum_{r \in S} p_{rj}^{(n)} \Pr(X_0 = r).$$

Note: The superscript (n) is an index and not an exponent. (Sokolov, Chistyikova, 2005).

Market situation

There are three main stages of distribution channel formation in Russia which correlate with the drastic changes in economic and social environment. Distribution chains in the USSR were hieratical structures strictly managed by government under conditions of non-market economy. Over the post-Soviet decades, the Russian market has undergone numerous changes, with distribution chains being at first badly destroyed. During the first post-Soviet decade demand exceeded supply in almost all segments of Russian market. In the highly uncertain and unstable political and economic environment, long-term relations were almost impossible. A lot of “fly-by-night companies” established in 1990s purchased and distributed goods without any commitment. The 1998 default led to decreased number of international trade contacts and impressive slump of import. Still, during the next decade the basic economic infrastructure had been formed and then distribution chains restored step by step at a new voluntary basis. Due to ICT intensively spread in Moscow and then in other regions of Russia, building of inter-firm networks became less costly, and a number of sustainable distribution networks started to grow. It is precisely this last decade developments that will be the main focus of our research based on the data on chemical distribution channels of western part of Russian Federation.

The chosen market segment is polymerized vinyl chloride (PVC) market. Traditionally this market includes three main groups of raw materials for PVC production:

- 1) PVC resins – the basic component;
- 2) PVC plasticizer – which is added to the resins in order to get necessary viscosity of plastic mass (such as DOP, DINP);
- 3) Additives – which are added to the plastic mass to improve the production process and for giving necessary properties to manufactured goods. This group includes thermo stabilizers, lubricants, flame retardants, coloring agents, etc.

PVC market in Russia had an impressive dynamics during the decade having grown 2.4 times in years 2000-2007. In 2008-2009 the dynamics became slower due to crisis but some companies including Ruskhimset still managed further growth. In 2009 there was a remarkable reduction of PVC consumption in Russia. In the first half of the year the consumption of PVC was 40 % in comparison with 2008. In summer 2009 the highest prices were fixed due to unprecedented deficit; PVC prices increase in January- June 2009 was about 48,5 %. So, the market has obtained seasonality in the last years. It is also important to mention a 27 % increase of PVC price in Europe and that of 14,8 % in Asia.

Average price for domestic PVC resin remained at the level of 1.05 euro while the price for import PVC resin did not exceed 0.7 – 1 euro per kg on the terms Ex Works storehouse in Europe.

The Russian domestic market volume is estimated by 974.4 thousand tons in 2008. About a half of this amount (578.6 thousand tones) counts for domestic production, the rest was imported.

Russian government takes measures protecting local producers in spite of the fact that domestic production capacities are unable to satisfy demand for PVC raw materials. The custom duty for PVC resin is 15 %, and in October 2009 the additional euro compound was brought in (0,12 euro per Kg).

Volatility of prices and inability of production capacities to supply the demand by domestic raw product are the main difficulties facing Russian market of PVC products.

There are numerous actors at the market, including large producers, small trade companies and a lot of consumers. The range of PVC products is rapidly increasing. As a result, it is very difficult to reach any consensus within the PVC market community. Under these circumstances networking may be crucial for obtaining stability and predictability of the market.

Characteristics of «Ruskhimset» company

The first step of the empirical study draws on the case method (Eisenhardt & Graebner 2007; Flyvbjerg 2006). As a matter of fact, single case often provides better theoretical insights

than multiple-case research based on creating good constructs (Dyer and Wilkins, 1991). The case study approach implies the detailed examination of a single example of a class of phenomena.

The Joint Stock Company Russian Chemical Net or «Ruskhimset» chosen for the case study started its operations in 2000. The company provides the following services: delivery, information support, storage, etc. Its annual turnover is now more than 50 million USD. There is about 30 employees in Moscow office and about 100 in regional representative offices. The main goal is to provide wide range of chemicals for small and medium producers which are the target market of the company.

Considering huge territory of Russian Federation, there is a need for establishing regional infrastructure. JSC «Ruskhimset» has sales representative offices and specialized warehouses in a number of regions including Moscow, Saint-Petersburg, Tambov, Volgograd, Kazan, Yekaterinburg, Yaroslavl, Ivanovo, Rostov-on-Don, Perm, Minsk (Belarus). JSC «Ruskhimset» is obviously using network distribution principles in its operations.

In order to understand the structure of value creation chain of «Ruskhimset» we aim to analyze the actors of network: 1) Suppliers (Domestic, External suppliers); 2) Transport companies (Internal, International); 3) Financial agents (Banks, Insurance agents); 4) Distribution network of representations.

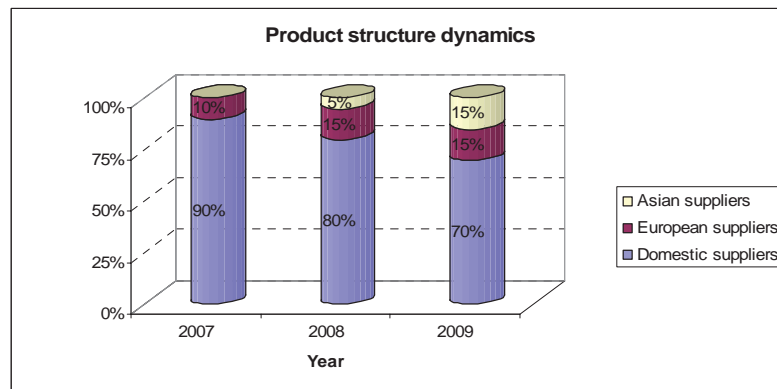
The starting point of analysis is to construct graphs of distribution channels. As a matter of fact, actors of channels have their own goals, producers being keen on promoting the product and expanding geographically, transport companies being interested in stable volume of cargo, consumers seeking for the best quality for less money, etc. Still, every actor is interested in gaining sustainable competitiveness and profit. Building the network and interact on the long-range basis is a way to raise their ability to create value and thus benefit from their position in the network.

Distribution chain of PVC chemicals we describe in terms of five essential networking principles include establishing a clear purpose and creating communication links (Stamps, Lipnack, 1994).

«Ruskhimset» had established relationships with suppliers from all over the world. Actually, there are three types of supply chains managed by it:

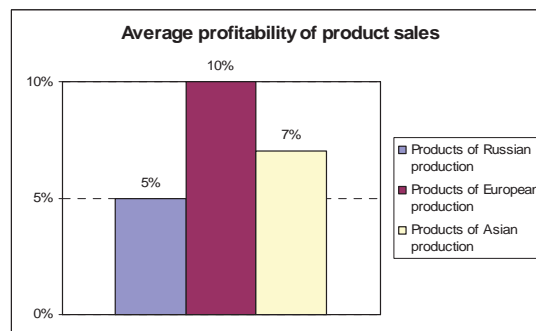
- 1) Russian – purchasing of goods from domestic producers.
- 2) European - purchasing of goods from the European suppliers: Germany, Hungary, Italy, Switzerland, Belgium, Holland and including USA.
- 3) Asian - purchasing of goods of Asian origin: China, Taiwan, South Korea, and India.

From these suppliers company forms its product range. This picture shows preliminary dynamic of product range structure. We can see annual increase of import goods share.



We suppose that this increase is stimulated by higher profitability of import goods. Probably it is connected with the fact that few companies have got enough financial and human intellectual recourse to start international relations.

So these facts let to increase profit-earnings. The picture below shows average profitability of sales.



Further in the research paper we will describe relations of «Ruskhimset» using ARA model. We will view at distribution through the relationships between the involved companies.

Each type has got its own specific. We aim to analyze these relationships describing resources, interaction parties, interaction process and activities.

Distribution on the domestic market

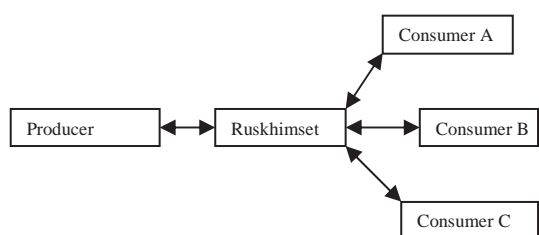
Initially in 2000 year «Ruskhimset» started its business with domestic producers. So first of all we are going to describe a supply chain between domestic market actors.

The majority of domestic suppliers have got common characteristic as following. It is a factory which was built in the times of Soviet Union. The quality of the goods is rather poor

due to the outdated equipment and low tech technologies. Obsolete facilities lead to the regular suspension of production and increase risk of phase out.

The competitive advantage is reached by the lower price. As we mentioned before government protect local producers by regulation of import duties. On the one hand government protection measures let factories to survive on the other hand its do not stimulate innovations and development.

Factories are not interested in promotion of goods. The main concern of managers is production, but not logistics or marketing. Products are sold on the Ex Works terms. The graph of distribution channel is as follows:



Producer is interested in relations with distributor, which purchase goods in bulk and guarantee payment in time. Distributor organizes transportation using its own transport facilities or service of carrier for delivery goods to the warehouse in Moscow region.

The chain can be even shorter if factory ships the goods directly to the final consumer.

Let's illustrate these relations on the certain example. Roshalskiy factory of plasticizers is one of the main partners of «Ruskhimset». Factory was established in 1960s for production of plasticizer - dioctyl phthalate (DOF). Now the factory is owned by private person.

In 2000 «Ruskhimset» started to work with this factory as distributor. Since «Ruskhimset» had complementary skills and competences the cooperation was acknowledged as mutually beneficial.

There is strong social interaction between companies now.

There are monthly agreements on schedule of delivery and price. While negotiating the factory captures dominant position being not at all flexible. It aims to dictate prices, volumes, and terms of delivery. Still, well established social contacts between staff of both companies always help to come to the mutually beneficial agreement. So, the channel is stable under turbulent environment and hard economic conditions mostly due to extensive social interaction.

The relationship between partners faced a serious challenge: Roshalskiy factory of plasticizers ceased the production for several months due to Energy Company refused to

provide energy (as a matter of fact, the factory had at the time a huge debt). In order to fill in the gap «Ruskhimset» had to diversify suppliers, and the additional supply from European companies was considered a best decision.

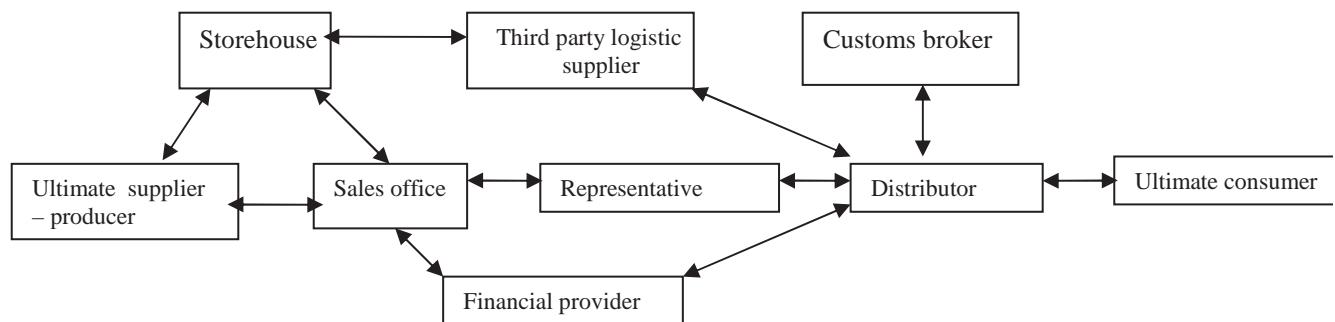
Distribution with European market

Cooperation with foreign supplier is also good opportunity to expand the assortment, which allows finding new consumers. It is important to mention that international relations affects favorably on the image of the company.

In 2006 «Ruskhimset» had started to develop international business. Company employed a specialist in international trade and established “International relation department” in the company structure.

The well-known European companies are open to the cooperation, and most of them have got representative offices in Moscow which are good help to facilitate development of relationships.

The scheme of distribution channel in this case is as follows:



As we can see the channel is rather complex.

Products in this chain are usually unique, branded, of high quality and thus expensive.

Large European chemical producers provide financial support, e.g. postponement of payment, to the reliable partners but it takes certain time and efforts to prove the reliability.

Communications in this case are to a certain extent formalized and poorly developed. On the one hand, formalizing communications seem quite sound in terms of some business processes, such as placement of orders, arrangement of shipment receipt of shipping documents, payment etc. On the other hand, underdeveloped communications prevent taking into account special demands and requests of consumer.

Information exchange occurs mainly between representative working in Russian office and customer care manager in the point of shipment. Therefore the distribution efficiency strongly depends on personal relationships and individual qualities of certain persons. As to strategic issues of business relationships, they are usually defined on the CEO level.

European suppliers consider the BRIC markets to be very perspective and thus are intended to expand looking for further projects. As a result, transactions tend to increase constantly being quite regular and stable.

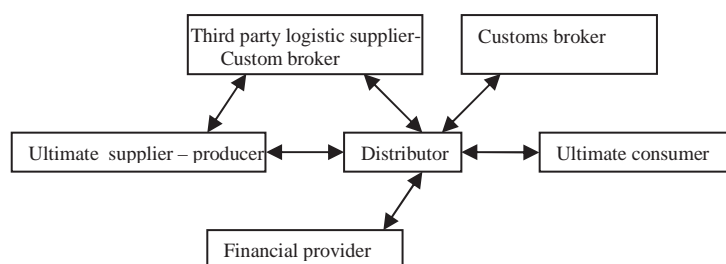
European products are not yet well known for Russian companies. The overall demand for these products is quite modest. It appears to be one of the important obstacles in development of interactions. But in fact the main obstacle for effective development of relations with European companies is high price of the goods. The lower price could be provided by Asian suppliers.

Working major European suppliers local distribution company becomes a part of complex relations of transnational corporations.

Distribution with Asian market

In search for cheaper supply «Ruskhimset» started to establish contacts with Asian suppliers, since Asian countries have recently gained quite good competitive positions as producers of chemical raw materials. Now production capacities of Asian region account for 20 mln. tones of PVC (about 50 % of worldwide capacities). Price-quality relationship for PVC from Asia is quite appropriate, and there are numerous suppliers. Still they have some common disadvantages, and the main problem is long period of delivery (45 to 60 days). The main way to start relationships with Asian companies is to take part in the exhibition. The interaction process between Russian and Asian firms is very intensive now but not very effective due to the language and culture differences.

The main problem in collaborating with Asia is long lead time. Working on the prepayment conditions «Ruskhimset» has to tie finance for 2-3 months. Another disadvantage is alteration of prices occurring almost every week. The final consumer price correlates strongly with fluctuations of ruble to dollar exchange rate. Price of the offer depends on stock exchange price and demand on the local (e.g. Chinese) market. Due to mentioned reasons transactions with Asian producers are quite risky. Aiming to decrease the uncertainty and to create mutual trust «Ruskhimset» facilitates development of distribution network with some partners from Asia. The chain of distribution in that third case usually is as follows:



Time-homogeneous Markov chain

Further we will try to apply the mathematical tool of Markov's chain theory to the process of distribution network creation, presuming that time-homogeneous Markov chain has got numerous similarities with the process due to the following:

1) Probabilities of future states of the process depend only on the present state. This can be used for description of opportunistic behavior of actors. It is applicable for description of network's agent behavior in case of inletting the permanent state which will be set indisputably (i.e. with probability one).

2) Existence of steps. Markov theory is applicable for description of process in discrete time. In our case it can be represented by sequence of transactions between economic agents.

We aim to describe the process of choosing a partner from the set of homogenous agents providing similar goods or services for distributor (product, credit, transport, storehouse, etc.).

Let the set of system's statuses (i_1, i_2, \dots, i_N) be the set of homogenous agents. Each step is one transaction with one of the agents. There are two options: opportunistic behavior (the choice driven solely by the price offer) and networking behavior (based on well-established supplier-distributor relationships).

In the case of opportunistic behavior we assign probabilities according to prices. For example: if a_1, a_2, \dots, a_N - prices that offer appropriate actors i_1, i_2, \dots, i_N and ξ is random variables that adopts the values i_1, i_2, \dots, i_N , then probability of choice actor i_k (distribution of ξ) can be set as

$$P(\xi = i_k) = \frac{(a_k)^{-1}}{\sum_{j=1}^N (a_j)^{-1}}$$

The probabilities of transition are for example

$$\Pr(\xi_{n+1} = j / \xi_n = i) = p_{ij} = I(a_j \leq a_i) \cdot \left(\frac{(a_j)^{-1}}{\sum_{(k: a_k \leq a_i)} (a_k)^{-1}} \right),$$

where $I(a_j \leq a_i)$ is an indicator function.

For example, if there are 3 transport companies and their transportation services rates are following: 3500 3650 3700 euro per ton.

The matrix of transition probabilities will be the following

$$\begin{pmatrix} 1 & 0 & 0 \\ 0,51773 & 0,48227 & 0 \\ 0,350825 & 0,326796 & 0,32238 \end{pmatrix}$$

This matrix shows probability of moving from one partner to another. We see that probability is higher for the transport company with the lower price. But there is always probability that we will not choose an agent with the best price offer.

The last stroke of matrix shows, that all companies may have equal chances. This situation appears because of two reasons. At first, the price difference is nonsignificant in our case. Secondly, the price does not play the key role in all relations.

In the case of networking behavior we can equal to the highest value, for example 1, the probability of choice of established partner. Then probabilities to choose another partner are equal to 0.

$$p_{ik} = 1; p_{ij} = 0, j \neq k, \text{ if } ik \text{ is our established partner.}$$

For example, the second transport company is a partner in supply chain. Then the most probable choice will be that company. That is matrix of transition probabilities is the following one

$$\begin{pmatrix} 0 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & 1 & 0 \end{pmatrix}$$

This matrix shows probability, that probability of choosing of our permanent partner is equals to 100 %. In that case it does not matter for company how cheaper other transportation services rates are.

Appliance of Markov Chain theory is mostly convenient for step-by-step processes. Moreover some of the processes can be managed or controlled. In this case we have an optimization problem with some objective function. In our case we could try to control the supply chain formation by choosing an partners, that would provide an optimal value of this function.

The problem is trivial when the objective function is oriented only on product or service price. Than the minimal price would provide the optimal value of wealthy objective function.

The situation becomes nontrivial when the hazard component appears. Then we could try to apply some results from optimal control theory. It allows us to compare an opportunistic behavior that has no implicit profit (or implicit hazard) and networking behavior that may provide a compensation for lost profit.

We can formalize our value creation chain with the following criterion function:

$C_{dist} = Tr_{distE} + Ma_{distE} + Fn_{distE} + S_{distE} + Ma_{distI}$, where:

C_{dist} - cost in distribution network

Tr_{distE} – transport, explicit costs

Ma_{distE} - marketing, explicit costs

Fn_{distE} - finance, explicit costs

S_{distE} - storage, explicit costs

Ma_{distI} -marketing, implicit costs (BTL)

The first attempt will be applying Controlled Markov chain model that allows us to find an optimal strategy in terms of appliance opportunistic or networking strategy. Each transition is provided here by a profit (positive or negative) and we can choose some transition probabilities on each time step from special set.

The existing algorithms of optimization of Controlled Markov chains are quite complex even in small problem dimensions. In our case the simple “brute force” comparison is more compatible.

Markov Chain theory describes the model quite well, so the direction of the further researches is in searching more adequate and simple ways of comparison 2 models of behavior within the Markov Chain theory.

Conclusions: transition in distribution from hierarchy to networks

Our main conclusions are as follows.

We identified in Russia emerging distribution networks of chemicals yet characterized by unstable interrelations. They are a kind of dynamic network headed by focal firm ("chain captain") regulating distribution in commercial terms.

There are many small and medium producers of PVC in Russia. They execute mainly special orders for rather small quantities, so the individual client approach has to be applied and thus development of network relationships is reinforced.

Specific feature of "wholly domestic" chains are social contacts being the main base of business relations – close to the network type described by M.Granovetter (Granovetter, 1983; Granovetter 1985).

As to distribution networks including foreign partners, the main concern is the reputation of partners and their goods. Still, in case of «Ruskhimset» there is also an obvious search for partners providing fair prices.

Distribution network including European partners usually becomes a part of already existing European distribution chain and thus becomes a kind of "outlier" on the Russian market.

Cooperation with Asian partners is not yet well developed but concerned to be very perspective and thus has a good potential.

Due to distribution chain stability and flexibility gained through networking, the company could face and survive the crisis. As an example, long term cooperation served as a base for trust within the network, that's why it was possible to get some agent's payments postponed. It is important to underline that some competitors had to leave the market while the company's profit increased rapidly in 2009.

Our main conclusion based on analysis of value creation in distribution network of «Ruskhimset» Company is as follows. Network approach to distribution of chemical products is helpful in terms of competitiveness. So, networking does matter – moreover, it is of great importance in unstable environment. In Breyer's words, "The channel group is obviously more than mere collection of individual channels – it is in the nature of a network" (Breyer, 1964).

Companies on the market of chemicals are turning their hierarchical supply chains into strategic networks of partnerships but still fragmented. Networks are based on pooling complementary skills and resources by a huge number of actors whose activities are coordinated and synchronized by distributors.

In our case a focal company «Ruskhimset» initiated cooperation and establishing network relationships and managed to coordinate the flow of information and goods quite successfully.

Markov Chain theory describes the model of network formation quite well, so the direction of the further researches is in searching more adequate and simple ways of comparison 2 models of behavior within the Markov Chain theory.

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