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Moving Segmentation Up the Supply-Chain: Supply Chain Segmentation and Artificial Neural Networks

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1. Introduction

Market segmentation, a central concept of a market orientation has focused primarily on managing heterogeneities on the demand side of a market. However, in order to meet consumer demands that are becoming more complex (such as the mass customization of products), firms may find it beneficial to optimally manage and coordinate heterogeneities, not only on the demand-side of a market but also on the supply-side. In other words, to manage the supply chain more effectively, firms may need to segment the supply-side of the marketplace. Thus, the entire supply chain could deal with heterogeneities on both the demand and supply-side more effectively.

To do so, the concept of "supply-side segmentation" is presented, which is defined as "a state of supply chain heterogeneity, where the total supply pool can be disaggregated into segments that potentially can satisfy distinct demand functions in the market place (Erevelles et al., 2001)."By using segmentation at different levels of the supply-chain, firms can not only find an appropriate segment on demand side of a market that their product or service can satisfy relatively well, but also efficiently find a disaggregated supply-side segment that potentially can satisfy the needs of the previously identified demand-side segment or another supply-side segment in the supply chain.

Further, for the purpose of simultaneously aligning these supply-side and demand-side segments at all levels of supply chain, the concept of "transvectional segment" is suggested. This "transvectional" view of the supply chain goes beyond the "transactional" view, an implicit characteristic of market segmentation in most of the past literature. In this viewpoint, a firm is not just partnering with its immediate supplier in producing a product or service for the next immediate downstream customer, as viewed in a transactional approach to the supply chain. Rather, the firm is partnering simultaneously with all upstream suppliers, as well as with all downstream users to conglomerate and optimize all resources in the supply chain.

In order to analyze this complex heterogeneity of both the supply-side and demand-side of the market, the use of the Artificial Neural Network (ANN) is proposed. Although ANN has been applied in other disciplines, partly as a method of classification, its application in

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segmenting markets has been limited (Boone & Roehm, 2002). Considering the advantages of ANN to other types of classification methods, this is a bit surprising. ANN is an appropriate method especially in the classification of complex relationships (e.g., Hair et al., 1998), where many variables (i.e., segmentation criteria) are used for classification (Dreyfus, 2005, p.25) and where nonlinear relationships exist between the segmentation criteria and the behavior of individuals of interest (e.g., Clancy & Roberts, 1983). In segmenting each levels of the supply chain, and connecting these segments together as a "transvection," the perceived characteristics of the supplier or the product at all the levels of the supply chain have to be taken into account. Thus, the ANN would be an appropriate method of analysis to uncover the complex relationships among supply-side and demand-side segments simultaneously.

The concepts presented in this paper assume interdependencies among channel members that potentially could result in long-term benefits such as flexibility, reduced response time and cost reduction for all channel members. In sum, the concepts of supply-side segmentation and transvectional alignment provide a comprehensive and dynamic method for effectively managing the supply chain.

2. Literature review

Relationship between firms within a supply chain has been a topic of interest in both academic and trade literature. Ross and Robertson (2007) discuss the concept of "compound relationships," that are multiple, though distinct relationships (e.g., customer, competitor, partner, and supplier) between the same two organizations (i.e., a firm can have relationships as a customer and as a supplier with the same organization). Their paper is part of a growing body of research that focuses on how to improve the performance of relationships among multiple firms in a supply chain, rather than only relationships relating to a single "focal" firm in the supply chain. The focus of this paper also is on the relationships among firms in a supply chain, taken as a whole. But, while Ross and Robertson (2007) considered the multiple relationships of two firms as the unit of analysis, our paper focuses on the relationships of the entire "transvection," i.e., multiple firms at different levels of the supply chain, as well as customers.

As customers are increasingly becoming more involved in the creation of products or services (e.g., co-creation), customers become a source of competence in a market (Prahalad & Ramaswamy, 2000; Vargo & Lusch, 2004). This makes it especially important to construct a supply chain that meets the needs of customers more effectively and efficiently. However, as Prahalad and Ramaswamy (2000) note, scholars have focused more on how companies can achieve a competitive advantage by "competing as a family" and less on how companies can also include customers in their network of value creation.

To resolve this issue, some scholars have proposed the concept of demand chain management. Demand chain management can be defined as "a set of practices aimed at managing and coordinating the whole demand chain, starting from the end customer and working backward to raw material supplier (Selen & Soliman, 2002; c.f., Juttner et al., 2007)." Juttner et al. (2007) argue that demand chain management starts with understanding the heterogeneous needs of the customers, and how to satisfy these demands instead of starting with the supplier or manufacturer. Thus, the flow of designing the demand chain is from downstream customers to upstream suppliers. In order to build an effective and efficient demand chain, a firm needs to efficiently align the heterogeneity of the "supply side" with the heterogeneity of the "demand side." Consistent with this notion, Reekie and Savitt (1982) state that a firm's position in a market depends on how a firm can effectively match supply and demand. Regarding the heterogeneity of demand side and the supply side, Alderson (1965, p. 29) notes that "each market segment of demand can be satisfied by one unique segment of supply" when the market is completely heterogeneous. Our concept of "supply side segmentation" and "transvectional segmentation" provide a systematic solution to align the supply-side and demand-side heterogeneity more effectively.

3. Theoretical framework

Supply-side segmentation

Using the concept of market segmentation, where the heterogeneity of preferences for products/services in demand side of a market are assumed, firms react to these heterogeneous needs of customers by (1) adding new offerings, (2) modifying current offerings, or (3) repositioning the current offerings when it is beneficial to do so (Green and Krieger, 1991). The most of the discussion about market segmentation is about how a single firm can deal with many types of preferences of customers. However, heterogeneity exists not only in demand side of a market but also in the supply side of a market. For instance, some suppliers are good at offering computer parts at a relatively low cost. Other suppliers may be good at producing specialized computer parts for ultra portable laptop computers. In 1960's, Alderson (1965, p. 29) explicitly mentioned the heterogeneity of supply side of a market by stating that the major function of a market is to match "differentiated segments of demand with the corresponding segments of supply". Alderson asserts that when heterogeneity of supply side and the heterogeneity of demand side are matched perfectly, no products or services are left unsold.

Dickson and Ginter (1987) illustrated market demand in the following equation.

From a manufacturer's perspective, the buyer's demand function is:

$$Q = f(p_c, x_1, \ldots x_n),$$

where:

- "Q" represents demand for a particular product offered by a manufacturer
- "p_c" represents the price offered by the manufacturer to a buyer, and
- "$x_{1\text{-}n}$" represents buyer perceived product characteristics.

This demand function can be applied to all the levels of supply chain. In other words, the demand function for offerings of a certain supplier by its immediate customers in the supply chain can be expressed as follows;

$$Q = F(p_c, y_1, \ldots, y_n) \text{ --- } (2)$$

- p_c: represents the price offered by a supplier to its immediate customer
- y_1, y_2, y_3, --- y_n: Perceived supplier/product characteristic

This function can be generalized for each level of supply chain

$$Q_{k-1} = F_{k-1} (p_c , y_{1k},...,y_{nk}) \text{ --- } (3)$$

- p_c : represents the price offered by a supplier to its immediate customer
- k: levels of supply chain
- y_{1k}, y_{2k}, y_{3k}, --- y_{nk}: Perceived supplier/product characteristic for a supplier in kth level of supply chain

Based on the heterogeneity of demand at k-1 level of the supply chain, the supplier or offerings at kth level of the supply chain can be divided into certain number of segments. That heterogeneity of demand is based on the perceived characteristic of a product or a supplier (please see figure 1 for the illustration using the example for personal computer industry).

Transvectional Segmentation Strategy

Once the suppliers at each level of the supply chain is segmented into a certain numbers segments, how can a firm or a set of firms in the supply chain can make use of this supply-side segments to adapt better in today's turbulent environment (e.g., modify an offering to the changing needs of customers)? In order to answer the question, the concept of transvectional segmentation is presented in this section. Alderson and Martin (1965) introduced the concept of transvection, in contrast to transaction. They assert, "the transactions as such are limited only to the successive negotiations of exchange agreements." So, in figure 1, transactions are exchanges between supplier at level k and its immediate customer (supplier at level k-1). These exchanges are expressed as a form of demand function Qk-1. In contrast, Alderson and Martin (1965) defined a transvection as "a unit of action of the marketing system resulting in placing a final product in the hands of the consumer but reaching all the way back to the raw materials entering into the product." They also mention, "a transvection is in a sense the outcome of a series of transactions." Thus, in our framework, transvection can be defined as a series of transactions (expressed as demand function Qk) between a supplier and its immediate customer, which result in offering a final product to a consumer. Then, transvectional segment can be defined as a cross-section of the marketplace, consisting of suppliers, manufacturers and customers, optimally aligned to fulfill the demand function of a supplier at each level of supply chain. The demand function of transvection consists of a series of demand functions in each level of a supply chain. This means that the demand function of a transvection is affected by the change of demand function of end customers (e.g., change of preference of customers). (For further elaboration on supply-side segmentation and transvectional segmentation strategy, please see Erevelles et al. 2001 or Erevelles & Stevenson, 2006.)

4. Artificial neural networks in market segmentation

Although the concept of Artificial Neural Networks (ANN) has been applied in many disciplines, its application in marketing has been limited. Boone and Roehm (2002) note that "only a handful of marketing researchers have examined ANNs as a market segmentation tool." It may be beneficial to apply ANN to our supply side segmentation approach. As discussed, we believe that ANN is especially appropriate to assess the supply-side and demand-side heterogeneities of the entire supply chain, which tend to be complex and nonlinear.

The major components of an artificial neural network are input nodes (where each node represents a single variable), output nodes (that process the input from the input nodes and compute the final output value that is used for classification) and hidden nodes (i.e., what is located between input nodes and output nodes) (Hair et al., 1998). As Hair et al. (1998) suggest, the advantage of the neural network model is its capability of dealing with complex problems and that of improvement by learning. More specifically, they argue that the hidden layer that serves like a cushion between input and output nodes gives the model a capability of processing complex problems including nonlinear relationships better than other types of classification methods. Also, they argue that the learning capability allows the model to improve the model fit by itself; the error (i.e., the difference between the actual and estimated classification) is sent back to the model and the weight given in each path is re-calculated to reduce the error. This learning capability allows researchers to apply the model without priori assumptions in terms of the relationship in the model, since the model itself examines data and "maps an approximation of the relationship" (Fish et al., 1995).

Because of these advantages, ANN applications have been used in traditional market segmentation, albeit in a limited manner (e.g., Fish et al. 1995; Natter, 1999; Dasgupta et al., 1994; Boone & Roehm, 2002; Hruschka & Natter, 1999; Kuo et al., 2002). For instance, Fish et al. (1995) applied the artificial neural network (ANN) for market segmentation in a B2B context and compared its classification capabilities with other methods (e.g., discriminant analysis and logistic regression). They note the superior classification ability of ANN when compared with discriminant analysis and logistic regression. Natter (1999) argues that ANN performs better than other types of stepwise approach in the formation of market segments that shows both good homogeneity and distinct behavior. Kuo et al. (2002) applied ANN to determine the number of clusters and then, used K-means method to form the clusters. Their two-stage model takes advantage of ANN's learning capability of figuring out the optimal number of clusters by itself. This advantage is crucial in market segmentation since, "if the appropriate number of segments are over specified, marketers may over-segment the market and treat audience segments separately that could effectively be treated inclusively" (Boone & Roehm, 2002).

Application of Artificial Neural Networks in Supply-side Segmentation

"Transvections" are formed by connecting supplier segments across multiple levels of the supply chain (e.g., raw material supplier, sub-component supplier, manufacturer etc.). Thus, transvectional segments tend to become more complex than traditional types of demand-side market segments that include only one level of the supply chain. Since the input variables include the perceived supplier or product characteristics at *all* levels of the supply chain, the analysis needs to simultaneously consider a large number of input variables. As Dreyfus (2005, p. 25) argues, the neural network is an appropriate method of analysis when the number of variables is relatively large. Also, the demand function in a transvection reflects the demand function of all successive downstream members of the supply chain. As table 1 indicates, manufacturers often deal with a substantial number of suppliers. As a method of investigating this complex phenomenon, ANN may have an advantage over other types of methods of analysis.

In addition, as Fish et al. (1995) suggests, ANN does not require a priori assumptions in modelling the relationships. The model basically let all the variables connect to all the nodes in hidden layers. The model computes the magnitude of the relationships (Fish et al. 1995) as a form of weight. This characteristic of the model allows us to illustrate transvectional segmentation in a realistic way. Since perceived characteristics of a supplier at level k in the supply chain are more likely to be associated with multiple transvectional segments in the hidden layer, the capability of the model for computing the magnitude of the relationships from each node of input level to each node at the hidden layer is crucial to our analysis of transvectional segmentation.

Traditional Market Segmentation vs. Transvectional Market Segmentation

Traditional market segmentation takes a demand-side approach, considering only downstream demand. Thus, from a manufacturer perspective, the buyer's demand function only includes the buyer's perceived product characteristics in the context of simple buyer and seller perspective.

Thus, from a manufacturer's perspective, the buyer's demand function is (please see Dickson and Ginter, 1987):

$$Q = f\ (p_c, x_1, \ldots x_n),$$

where:

- "Q" represents demand for a particular product offered by a manufacturer
- "p_c" represents the price offered by the manufacturer to a buyer, and
- "$x_{1\text{-}n}$" represents buyer perceived product characteristics.

However, we suggest that market segmentation can be extended to manage *upstream* demand more effectively and efficiently. In other words, by segmenting multiple levels of the supply chain both *upstream* and *downstream*, the manufacturer, for instance, can choose appropriate suppliers up-the-supply chain in an efficient manner that effectively meet downstream customers' demands. Eventually, the manufacturer and the other members of the supply chain can form trans-intermediary alignments called "transvectional segments" (please see Erevelles et al. (2001) for elaboration). Therefore, the transvectional demand function takes a supplier, manufacturer, customer and other supply chain members into consideration. The artificial neural network model can be used to segment existing relationships across the supply chain to form a transvectional segment (each node in the hidden layer) based on the perceived supplier or product characteristics of customers, manufacturers, and multiple levels of suppliers (input nodes). In a practical sense, a researcher may identify existing relationships in the supply chain and assess the perceived characteristics of each channel member in that relationship to identify the transvectional segment.

The output from each node in a transvectional segment can be calculated as follows (see Fish et al, 1995):

$$Z = \Phi \sum_{k=1}^{l} \sum_{n=1}^{j} (w_{nk} \cdot y_{nk} - \theta)$$

where

- Z: output value from input node into the hidden node
- y_{nk}: perceived supplier/product characteristics

- w_{nk}: connection weights
- n: the number of supplier/product characteristics in each level of supply chain
- k: the number of levels of supply chain
- θ: activation threshold
- Φ: differentiable function

Once this output from the hidden node is sent to the output node, the output node computes the final value and compares the value with the actual value (if any). The ANN calculates the error between the estimated value and the actual value. Then, w_{nk} (weight) is adjusted to minimize the error. This weight that is an indicator of the magnitude of the relationship between the input node and the hidden node will allow us to figure out which characteristic in which level of the supply chain is associated better with a certain transvectional segment (Please see figure 2 for illustration).

5. Conclusion

This paper explained the concept of supply-side segmentation and transvectional alignment, and applies these concepts in the artificial neural network (ANN). To the best of our knowledge, no research has applied ANN in explaining the heterogeneity of both the supply-side and demand-side of a market in forming relational entity that consists of firms at all levels of the supply chain and the demand chain. The ANN offers a way of operationalizing the concept of supply-side segmentation. In today's business environment, where competition occurs more among the networks that consist of sets of firms rather than simply among firms, researchers and practitioners need to understand the heterogeneity of the supply side of a market at all levels in the supply chain. Also, as firms co-create with customers to take advantage of their feedback to improve their offerings continuously (Vargo & Lusch, 2004), more firms are encouraged to adapt to the changes of customer preference in a precise manner. Supply-side segmentation offers a framework for a firm to manage the heterogeneity of the supply-side and demand-side at all levels of the supply and demand side of a market in a systematic way.

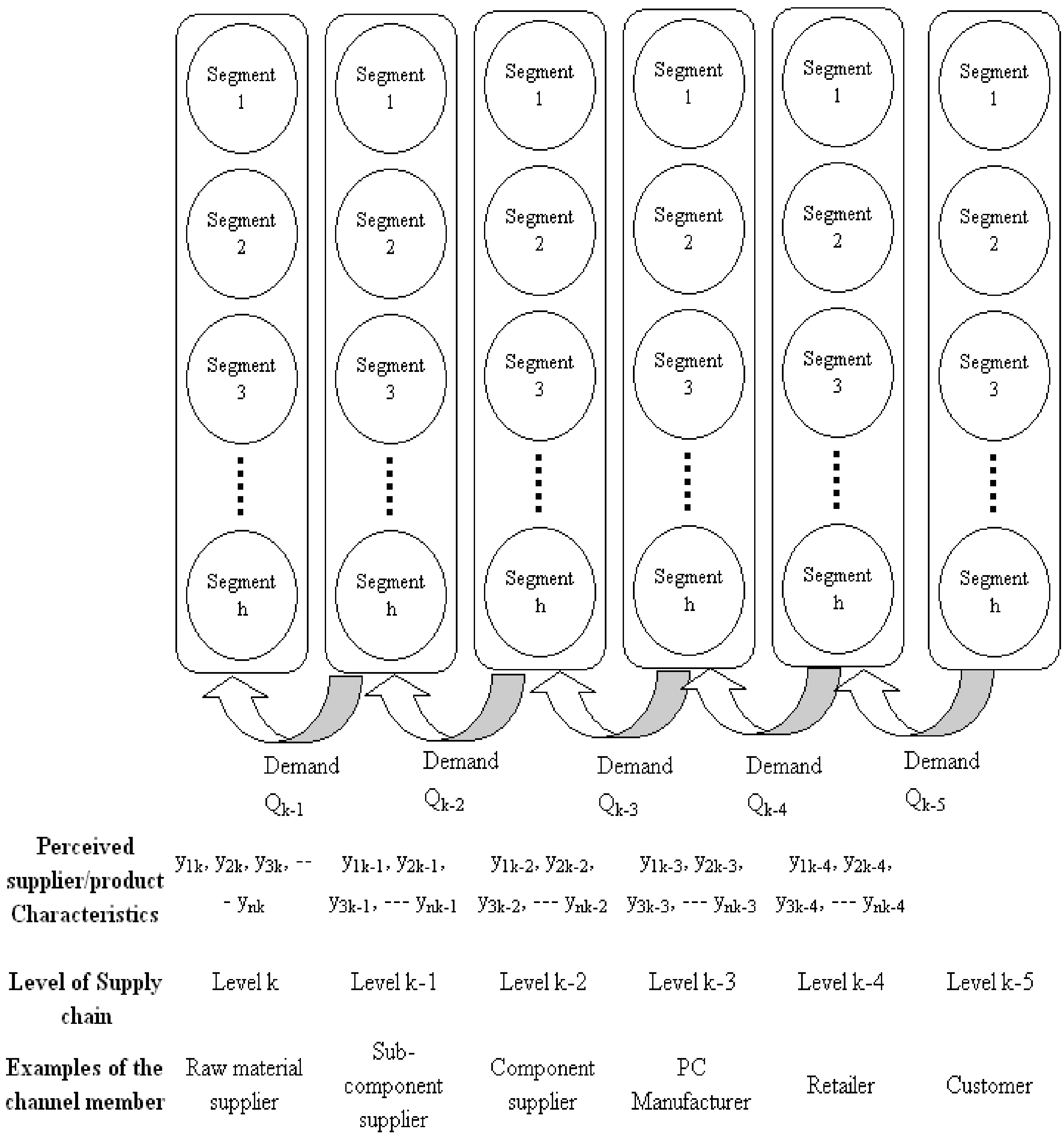

Figure 1. Illustration of Supply-side segmentation – supply chain for personal computer industry

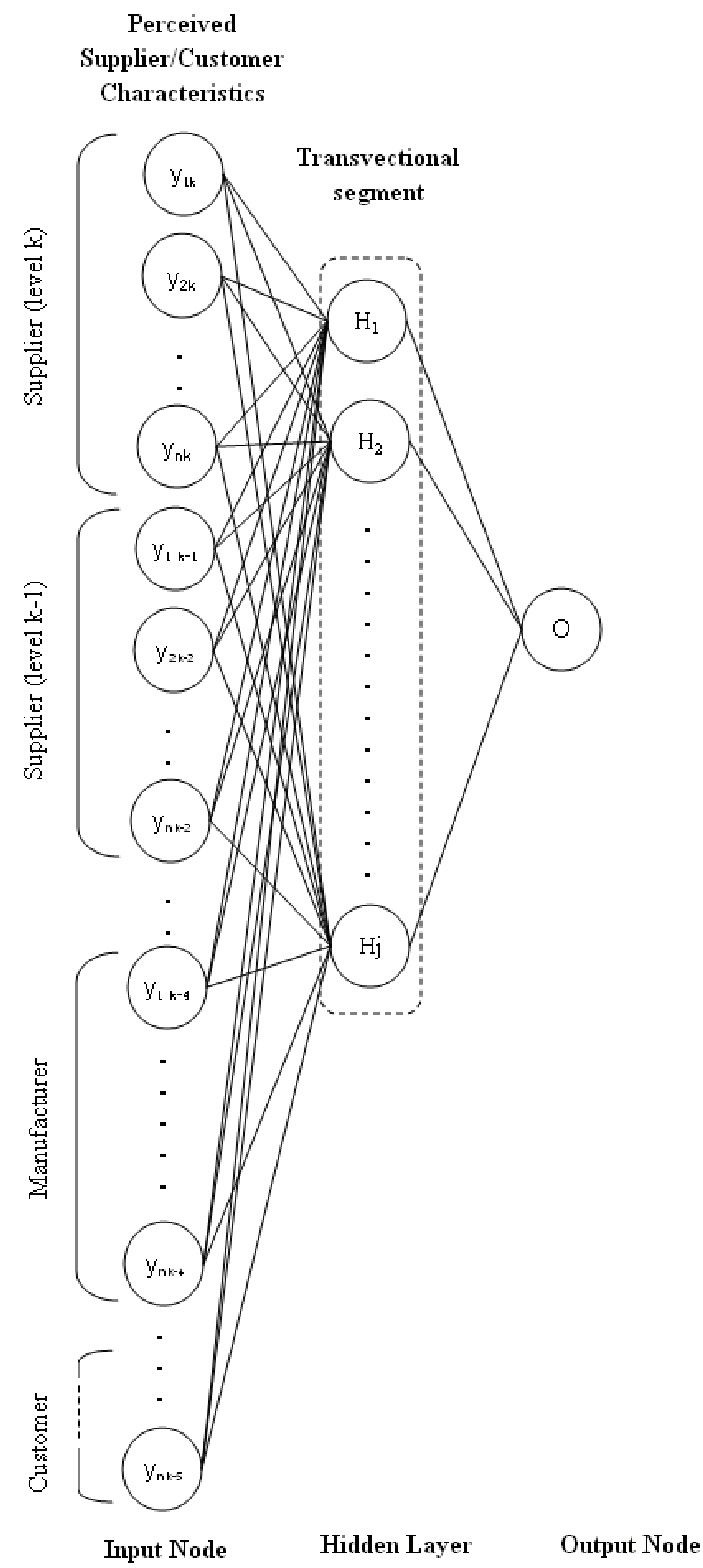

Figure 2: Illustration of Transvectional Segmentation with Artificial Neural Network

Company	*Number of direct suppliers*	*Comments*	*Source*
Boeing	20,406	Expects suppliers to produce larger assemblies rather than individual parts to reduce complexity of supply chain	Wilhelm (2001)
Ford	11,000	2,000 Production suppliers, 9,000 non-production goods and service providers	Ford Motor Company (2005)
General Electric	35,000	Utilize online market place where electronic auctioning, invoicing, and demand forecasting are available	Logistics Today (2003)
General Motors	10,000	General Motors reduced its suppliers to 10, 000 in 2000.	Entrepreneur.com (2003)
Hitachi	13, 000	Formed alliance with E2open to establish world's largest B2B e-commerce platforms	Spiegel (2002)
Wal-Mart	30,000	Expects suppliers to monitor the data daily and respond to problems immediately	Thomas (2002) D'Innocenzio (2003)

Table 1. Examples of Supply Chain Size

6. References

Alderson, W. (1965). Dynamic Marketing Behavior, Richard D. Irwin Inc., Homewood, Illinois.

Alderson, W., & Martin, M. W. (1965). Toward a Formal Theory of Transactions and Transvections. Journal of Marketing Research , 2(2), 117-127.

Boone, D. S., & Roehm, M. (2002). Evaluating the appropriateness of market segmentation solutions using artificial neural networks and the membership clustering criterion. Marketing letters, 13(4), pp. 317-333.

Clancy, K. J., & Roberts, M. L. (1983). Toward an optimal market target: A strategy for market segmentation, Journal of Consumer Marketing, 1(1), pp. 64-73.

Dasgupta, C. G.; Dispensa, G. S. & Ghose, S. (1994). Comparing the predictive performance of a neural network model with some traditional market response models. International Journal of Forecasting, 10(2), pp. 235-244.

Dickson, P. R. & Ginter, J. L. (1987). Market segmentation, product differentiation, and market strategy. Journal of Marketing, 51 (2), pp.1-10.

D'Innocenzio, A. 2003. Wal-Mart suppliers flocking to Arkansas, The State.com, Sep. 21 (Available at http://www.thestate.com/mld/state/business/6824338.htm)

Dreyfus, G. (2005). Neural Networks: Methodology and Applications, Springer, New York.

Entrepreneur.com (2003). Ford, GM to sharply cut 2nd quarter output, small auto supplier expected to be hurt hardest., Autoparts Report, March 19, (Available at http://www.entrepreneur.com/tradejournals/article/98956237.html)

Erevelles, S. & Stevenson, T. H. (2006). Enhancing the business-to-business supply chain: Insights from partitioning the supply-side. *Industrial Marketing Management*, 35(4), 481-492.

Erevelles, S.; Vargo, S. & Horton, V. (2001). Supply-side and transvectional Segmentation, Marketing Management Journal, 11(2), 24-40.

Fish, K. E.; Barnes, J. H. & Aiken, M. W. (1995). Artificial neural networks: A new methodology for industrial market segmentation, Industrial Marketing Management, 24(5), pp. 431-438.

Ford Motor Company (2004). 2003/4 Corporate citizenship report. (Available at http://www.corporateregister.com/a10723/ford0304-cz-usa.pdf)

Green, P. E. & Krieger, A. M. (1991). Segmenting markets with conjoint analysis. Journal of Marketing, 55(4), 20.

Hair, J. F.; Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). Multivariate data analysis, Prentice Hall, Upper Saddle River, N.J., pp. 684-692.

Hruschka, H. & Natter, M. (1999). Comparing performance of feedforward neural nets and K-means for cluster-based market segmentation, European Journal of Operational Research, 114(2), 346-353.

Juttner, U.; Christopher, M., & Baker, S. (2007). Demand chain management-integrating marketing and supply chain management, Industrial Marketing Management, 36(3), pp. 377-392.

Kuo, R. J.; Ho, L. M. & Hu, C. M. (2002). Cluster analysis in industrial market segmentation through artificial neural network, Computers & Industrial Engineering, 42(2-4), p. 391.

Logistics Today. 2003. Logistics Today's 10 best supply chains. 44 (12): 20-23.
Natter, M. (1999). Conditional market segmentation by neural networks: a Monte-Carlo study, Journal of Retailing and Consumer Services, 6(4), pp. 237-248.
Prahalad, C. K., & Ramaswamy, V. (2000). Co-opting customer competence. Harvard Business Review, 78(1), pp. 79-87.
Reekie, W. D. & Savitt, R. (1982). Marketing behavior and entrepreneurship: A synthesis of Alderson and Austrian economics, European Journal of Marketing, 16(7), pp. 55-66.
Ross, W. T. & Robertson, D. C. (2007). Compound relationships between firms. Journal of Marketing, 71(3), 108-123.
Selen, W., & Soliman, F. (2002). Operations in today's demand chain management framework. Journal of Operations Management, pp. 667-673.
Spiegel, R. (2002). Hitachi, E2open form alliance. Electronic News (North America), June 24, 48 (26): 1.
Thomas, O. 2002. Lord of the Things. Business 2.0., 3 (3): 32.
Vargo, S. L., & Lusch, R. F. (2004). Evolving to a new dominant logic for marketing, Journal of Marketing, 68(1), pp. 1-17.
Wilhelm, S. 2001. In depth: Boeing, going, gone? - Local aerospace suppliers applaud Boeing strategy. American City Business Journals, Print Edition, March 30

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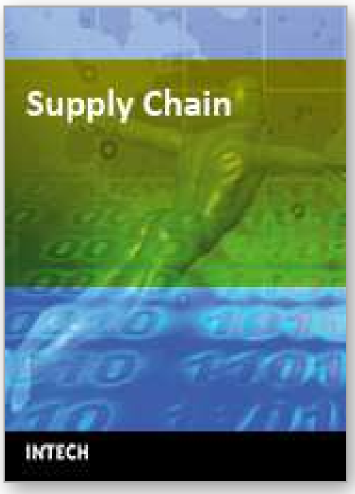

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Traditionally supply chain management has meant factories, assembly lines, warehouses, transportation vehicles, and time sheets. Modern supply chain management is a highly complex, multidimensional problem set with virtually endless number of variables for optimization. An Internet enabled supply chain may have just-in-time delivery, precise inventory visibility, and up-to-the-minute distribution-tracking capabilities. Technology advances have enabled supply chains to become strategic weapons that can help avoid disasters, lower costs, and make money. From internal enterprise processes to external business transactions with suppliers, transporters, channels and end-users marks the wide range of challenges researchers have to handle. The aim of this book is at revealing and illustrating this diversity in terms of scientific and theoretical fundamentals, prevailing concepts as well as current practical applications.