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Research and Empirical Analysis of Supply Chain Integration Dynamic Model and Control in Supply Side

Yi CHAI[1], Quanxi LI[2], Jian ZHANG[3], Jiahui XU[4]

Abstract

In the context of the new normal economy, the supply-side reform has become the main idea of a macroeconomic policy that stimulates economic growth. The economic development patterns of all enterprises need to be improved in the context of supply-side reform. One of the most important issues is the change in the supply chain of enterprises. In the supply chain, the integrated model problem of supply, manufacture, and sales is the most important research area in the supply chain. In this paper, an integrated model including suppliers, manufacturers, and distributors is established. This model contains linear equation of state and neural network nonlinear model. This paper presents the objective function and constraints of the supply chain, such as inventory cost, supply cost, production level and so on. For the integration model of supply chain, the simulated annealing method was used to optimize and the initial conditions were empirically analyzed on the background of Liaohua Company.

Keywords: supply side, supply chain, integration dynamic model, empirical analysis, management, reform policies.

Introduction

In the rapidly developing global economy, customers are expecting more and more products or services, and their production models and organizational structure are facing more and more challenges. With the rapid development of information technology and the utilization improvement of information resources, great changes have taken place in the ways and means of enterprise management, and the traditional management mode has been greatly challenged. In late 2015,

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Xi Jinping first proposed the concept of "supply-side structural reform" at a conference on central economic work (Golub & Mbaye, 2015). The meeting pointed out: While moderately expanding general demand, our country should strive to strengthen supply-side structural reforms. Based on seeking economic development momentum on the supply side, we strive to establish an effective supply mechanism as a guarantee and give full play to the role of the market in allocating resources to achieve the full release of economic and social vitality (Taticchi *et al.*, 2015). The cost of the enterprise is closely related to the interests of the enterprise, especially for the chemical companies that have a great variety of products, complicated product cost structures and intertwined business departments.

Each node of integrated supply chain in the enterprise supply chain business all the business as a whole process in order to perfect the implementation of the supply chain, making it become competitive. The development of integrated supply chain system is a continuous integration step. The ultimate goal is to achieve the integrated dynamic control of each resource inside and outside the enterprise in order to achieve the overall dynamic balance of the supply chain (Carter, Rogers, & Choi, 2015; Devlin, 2014). Agile supply chain of modern Western countries puts forward the concept of agile manufacturing, focusing on the open sharing and integration of information networks. Agile supply chain management is the basic concept of enterprise resources owned by the expansion of the community as a whole. They formed the alliance of interests for the same interests and used agile manufacturing strategies to implement supply chain management. Supply chain partner selection, supply chain management, the optimization and integration of each resource is accomplished effectively in accordance with the cooperation and coordination among all members in the supply chain (Stadtler, 2015; Wu & Barnes, 2016). Cooperating with partners is a key part of supply chain management.

Integrated supply chain management

Supply chain management (abbreviated as SCM) is a new management mode. The concept of SCM is proposed after the emergence of global manufacturing and the grouping and internationalization of business operations. With the advent of economic globalization and the era of knowledge economy, Supply chain management has been widely used. The supply chain is a network of logistics by suppliers, manufacturers, warehouses, distribution centers and distributors. An enterprise may become different nodes of a network, but more often, different enterprises form different nodes in a network (Heckmann, Comes, & Nickel, 2015). Once the supply-side structural reform strategy has been put forward, all local governments and business units have introduced new policies to respond to the country's reform policies (Guerzoni & Raiteri, 2015; Mohseni, Jafari, & Babaeei, 2015; Wu & Barnes D, 2016). Among them, "lowering costs" is also a key task to be considered by all local governments and business units. How to reduce the cost of the enterprise by combining the integrated supply chain with advanced cost management methods has become a key task of the chemical industry in the context of “supply-side” reform.

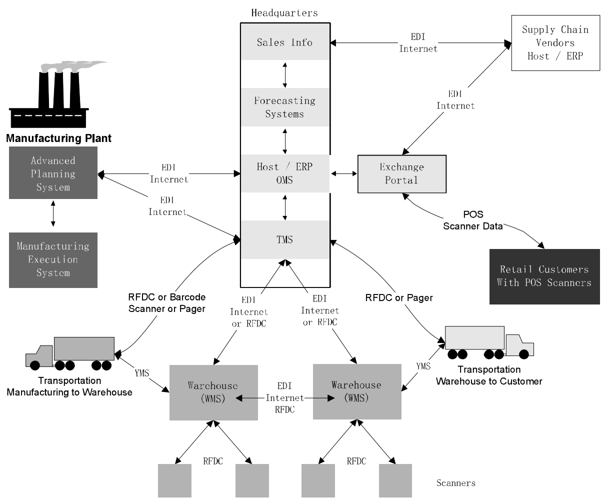

Figure 1. Integrated Supply Chain

Integrated supply chain management is the management of complex networks of suppliers, manufacturers, distributors, retailers and customers. Businesses redesign, plan and control the flow of information, logistics, and capital in the supply chain network (Ivanov *et al.,* 2016). Businesses reduce their overall supply chain costs by improving customer satisfaction by sending the right product or service to the right place at the right time. Therefore, the development of the supply chain is a continuous process of integration.

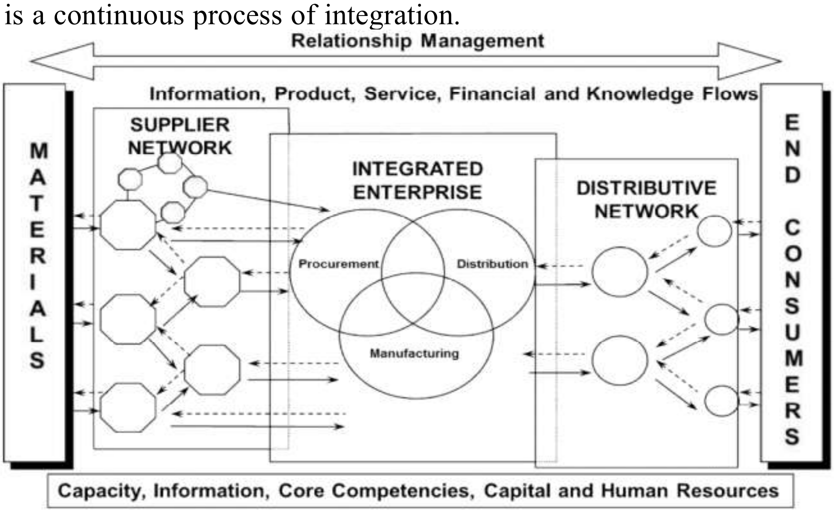

Figure 2. Generalized Supply Chain Model

With the increase of competitive pressures and diversified customer needs, the degree of integration within the supply chain will continue to increase. Today's competition is no longer a single business competition, but the supply chain and supply chain competition (Srai *et al.,* 2015). The practice of many enterprises in the past ten years has also fully demonstrated that the effective management of the supply chain is one of the most important symbols of the success of an enterprise.

Model Building
(Data Sources, Model Building, Results and Discussion)

Integrated dynamic model of the supply chain

We can integrate supply, manufacturing and sales into one system. We propose a new dynamic model of supply chain integration. It consists of a 3-part model of the supply, manufacturing and sales phases. The dynamic model of the supply stage is the supplier inventory equation:

$$X_{1,k+1} = X_{1,k} + u_{1,k} - V_{1,k} \quad (1)$$

In equation (1), $X_{1,k}$ $X_{1,k}$ is the supplier's inventory at time k k. The n_1 is the state vector $u_{1,k}$ is the supply at time k k and the n_1 is the control variable. The amount of material is $V_{1,k}$ $V_{1,k}$ supplied to the manufacturer by the supplier at time k k, and n_1 is the control variable. Equation (1) is a typical discrete-time inventory state equation. We can note that $V_{1,k}$ $V_{1,k}$ is an exogenous variable in the general inventory equation. Here, the equation serves as a dynamic process for suppliers in the supply chain. In the equation, $V_{1,k}$ $V_{1,k}$ is controllable.

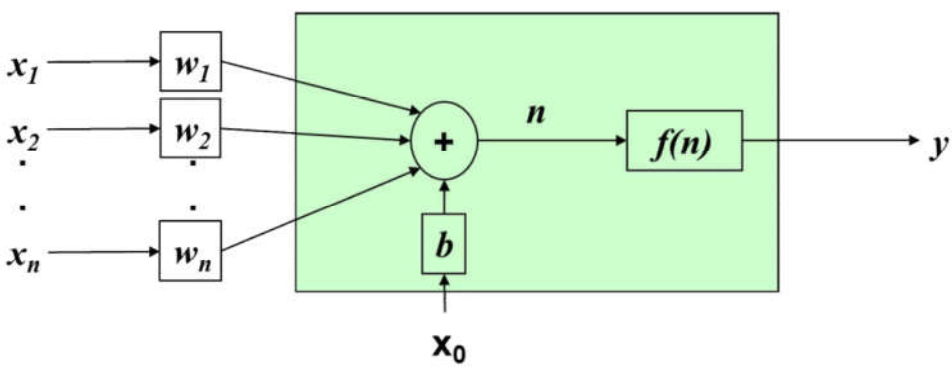

Figure 3. Artificial neural network mathematical model

The manufacturing phase of the dynamic model consists of two equations. It is the neural network equation of the production process.

$$P_{k+1}=f(P_k,V_{1,\ k}) \qquad (2a)$$

In equation (2a), P_{k+1} is the output of neural network at time $\mathbf{k}$ k and n_2 is the state variable. $\mathbf{V_{1,\ k}}$ $V_{1,\ k}$ is the control variable described in equation (1), which is the input of neural network. Stage production process is a complex nonlinear system. We assume that this unknown nonlinear production system can be approximated by neural network. We use the external delay feedback network, which consists of multilayer feed forward network and output delay feedback. We assume that the delay is 1, that is, $\mathbf{V_{1,\ k}}$ $P_{\ k+1}$ is the output of P_k and $\mathbf{V_{1,\ k}}$ $V_{1,\ k}$ become augmented input components.

Another model of the manufacturing phase is the production of inventory equation of state.

$$X_{2,k+1=}X_{2,k}+P_k-\mathbf{V_{1,\ k}}\ V_{2,k}\ \mathbf{X_{1,\ k}}\ \mathbf{X_{1,\ k}}\ \mathbf{X_{2,\ k+1}=X_{2,\ k}+P_k-V_{2,\ k}} \qquad (2b)$$

In equation (2b), $\mathbf{X_{2,\ k}}$ $X_{2,\ k}$ is the manufacturer's inventory at time $\mathbf{k}$ k and n_2 is the state variables. $\mathbf{V_{1,\ k}}$ P_k $\mathbf{P_k}$ is the production output at time k in the production process in equation (2a). The target product is $\mathbf{V_{2,\ k}}$ $\mathbf{V_{1,\ k}}$ $V_{2,\ k}$, n_2 is the control variables. Equation (2b) is also a typical inventory equation of state. Similarly $\mathbf{V_{2,\ k}}$ $\mathbf{V_{1,\ k}}$ $V_{2,\ k}$ is exogenous, but it has a controlling effect.

The dynamic model of the sales phase is the inventory equation of the seller.

$$X_{3,k+1}=X_{3,k}+V_{2,k}-d_{3,k} \qquad (3)$$

In formula (3), $\mathbf{V_{1,\ k}}$ $X_{3,\ k}$ is the seller's inventory, $n_3=n_2$ $n_{3=}n_2$ is the state vector. The product provided by the manufacturer to the seller in formula (2b) is $V_{2,k}$ and $n_3=n_2$ $n_{3=}n_2$ is the control variable. The sales volume of the seller is $\mathbf{d_{3,k}}$ $d_{3,k}$, $n_3=n_2$ $n_3=n_2$ $n_{3=}n_2$ is the exogenous variable.

$$X_{1,k,}X_{2,k},X_{3,k},P_k\geq 0\ \mathbf{X_{1,\ k}}\ \mathbf{X_{1,k}\text{、}X_{2,k}\text{、}X_{3,k}\text{、}P_k\geq 0} \qquad (4)$$

Equation (4) shows that supply, manufacture and sales in stock supply and production volume are all non-negative. In summary, formula (1) - (4) constitute the supply chain model. Model integration has three characteristics: First, supply, manufacturing, sales are integrated in a system. Second, linear and nonlinear dynamics are integrated. Third, state equations and neural networks are integrated. This integrated model not only allows the supply phase of the supply chain to promote the entire supply chain, but also allows the sales phase of sales to promote the entire supply chain.

Objective function in supply chain system

The objective function of supply chain management is to change the low-level operation of the original suppliers, manufacturers and sellers separately, positively affect the inventory level, supply cost, and production cost of each link in the chain and ultimately improve the service level to the customers. This paper argues that the core of the supply chain is the optimization of the chain system. The paper proposes that the effective principle of supply chain management is to keep low inventory and fast delivery of low-cost supply.

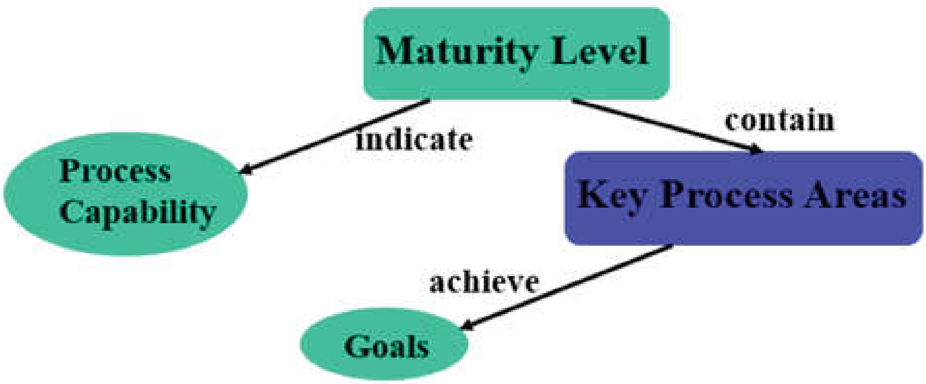

Figure 4. The main building block of integrated maturity

For the objective function of the supply chain system (1) (4), consider some sub-objective functions as follows: The objective function of the inventory of the supply chain system is

$$J_1 = \frac{1}{2}\sum_{k=0}^{N}\left[(X_{1,k+1} - X_1^0)^T Q_{11}(X_{1,k+1} - X_1^0) + X_{2,K+1}^T Q_{12} X_{2,k+1} + X_{3,K+1}^T Q_{13} X_{3,k+1}\right] \quad (5)$$

In the inventory objective function (5), $Q_{11}, Q_{12}, Q_{13} \geq 0$. The first one shows that the inventory in the supply phase should be kept at a safety stock level of X^0_1, which is actually a status-tracking goal. The second shows that the manufacturing phase inventory should be as little as possible. The third shows that the sales phase stock should be as little as possible. The inventory objective function reflects the requirements for supply, manufacturing, sales inventory security and inventory costs in the supply chain.

The objective function of supply cost of supply chain system is

$$J_2 = \frac{1}{2}\sum_{k=0}^{N}\left[U_{1,K}^T R_{11} U_{1,k} + V_{1,K}^T R_{12} V_{1,k} + V_{2,K}^T R_{13} V_{2,k}\right] \quad (6)$$

In the supply cost objective function (6), $R_{11}, R_{12}, R_{13} \geq 0$. The first term in Eq. (6) shows that the inventory supply in the supply phase should be kept as low as possible in order to reduce the supply cost. The second item indicates that the least amount of raw material is used during the manufacturing phase. The third shows that the supply of inventory at the stage of sale should be as low as possible in order to reduce supply costs while meeting inventory levels and exogenous marketing conditions.

The objective function in the supply chain system manufacturing stage is

$$J_2 = \frac{1}{2}\sum_{k=0}^{N}\left[\left(\widehat{\mathbf{P}}_{k+1} - \mathbf{P}^0\right)^T Q_3 \left(\widehat{\mathbf{P}}_{k+1} - \mathbf{P}^0\right)\right] \tag{7}$$

In the objective function (7) in the manufacturing phase, $\widehat{\mathbf{P}}_{k+1}$ is the forecast output $Q_3 \geq \mathbf{0}$ produced in the manufacturing stage. Equation (7) shows that the manufacturing stage of production should be in accordance with the planned level $\mathbf{P}^0$. This is based on the actual production process in the enterprise for the production plan and set.

The objective function of supply chain integration dynamic model is summarized as follows

$$\mathbf{J} = \mathbf{J}_1 + \mathbf{J}_2 + \mathbf{J}_3 \tag{8}$$

The exogenous distribution process in the sales phase of supply chain system can be divided into deterministic distribution and random distribution. The ultimate driver of the supply chain comes from the market demand, which is to rely on sales $\mathbf{d}_3$. This article only considers the deterministic sales distribution process, which is pre-set.

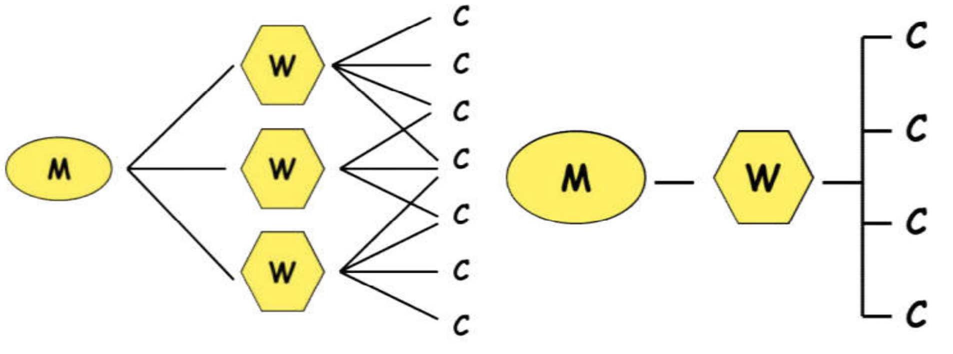

Figure 5. Traditional distribution model

Integrated Modeling Analysis of the problem

Further, we analyze the modeling problems in the three discrete cases of supply, manufacture and sales and the case of integration.

For the state equation (1) in the supply phase, we take into account the stock status tracking and supply $\mathbf{U}_1$ in the supply phase, in particular, the material quantity $\mathbf{V_1}$ $\mathbf{V_1}$ supplied by the supplier to the manufacturer as the control variable. There are corresponding objective functions in different discrete cases.

$$J_S = \frac{1}{2}\sum_{k=0}^{N}\left[(\mathrm{X}_{1,k+1} - \mathrm{X}_1^0)^T Q_{11}(\mathrm{X}_{1,k+1} - \mathrm{X}_1^0) + \mathrm{U}_{1,K}^{\mathrm{T}} R_{11}\mathrm{U}_{1,k} + \mathrm{V}_{1,K}^{\mathrm{T}} R_{12}\mathrm{V}_{1,k}\right] \tag{9}$$

For the two equations (2a) and (2b) in the manufacturing phase, we take into account the stock status of the manufacturing phase $\mathbf{X_2}$, the tracking of the production output $\widehat{\mathbf{P}}$, the amount of material $\mathbf{V_1}$ provided by the supplier to the manufacturer and Vendor's target product $\mathbf{V_2}$ are used as a control variable. The objective function of its discrete case is

$$\mathrm{J_m} = \frac{1}{2}\sum_{k=0}^{N}\left[\mathrm{X}_{2,K+1}^{\mathrm{T}} Q_{12}\mathrm{X}_{2,k+1} + \left(\widehat{\mathrm{P}}_{k+1} - \mathrm{P}^0\right)^T Q_{13}\left(\widehat{\mathrm{P}}_{k+1} - \mathrm{P}^0\right) + \mathrm{V}_{1,K}^{\mathrm{T}} R_{12}\mathrm{V}_{1,k} + \mathrm{V}_{2,K}^{\mathrm{T}} R_{13}\mathrm{V}_{2,k}\right] \tag{10}$$

For the sales phase of equation (3), its objective function in discrete cases is

$$J_1 = \frac{1}{2}\sum_{k=0}^{N}[\mathrm{X}_{3,k}^{\mathrm{T}} Q_{13}\mathrm{X}_{3,k} + \mathrm{V}_{2,K}^{\mathrm{T}} R_{13}\mathrm{V}_{2,k}] \tag{11}$$

We assume that the supply chain system has the best results $\dot{\mathbf{X}}_1$ 、 $\dot{\mathbf{X}}_2$ 、 $\dot{\mathbf{X}}_3$ 、 $\dot{\mathbf{P}}$ 、 $\dot{\mathbf{U}}_1$ 、 $\dot{\mathbf{V}}_1$ 、 $\dot{\mathbf{V}}_2$. Then the total objective function of modeling optimization in the integrated case will be smaller than the result of the objective function in discrete cases, that is

$$(\mathrm{J}_1 + \mathrm{J}_2 + \mathrm{J}_3) - (\mathrm{J}_s + \mathrm{J}_m + \mathrm{J}_d) = -\frac{1}{2}\sum_{k=0}^{N}\left[\dot{\mathrm{V}}_{1,k}^{\ T} R_{12}\dot{\mathrm{V}}_{1,k} + \dot{\mathrm{V}}_{2,k}^{\ T} R_{13}\dot{\mathrm{V}}_{2,k}\right] \tag{12}$$

Therefore, the integrated modeling has the advantage of reducing costs than the discrete case.

The control problems of integrated model

Now we consider the control of supply chain integration model. The problems of supply chain models (1) - (4) and their objective functions (5) - (8) are actually quadratic objective control problems for a linear dynamic system and a neural network system. For an integrated model, one of the important steps is the predictive output of the system model. Linear dynamic systems (1), (2b), (3) are deterministic equations and obviously do not require predictive output. In this way, the output for the equation of direct determinism can be processed. That is, the leftmost term of equations (1), (2b) and (3) above is the output. For neural network system (2a), the result of learning with feed forward network is the predicted output. After the uniform output of the integrated model is processed in this way, the other steps of the neural network control are the same.

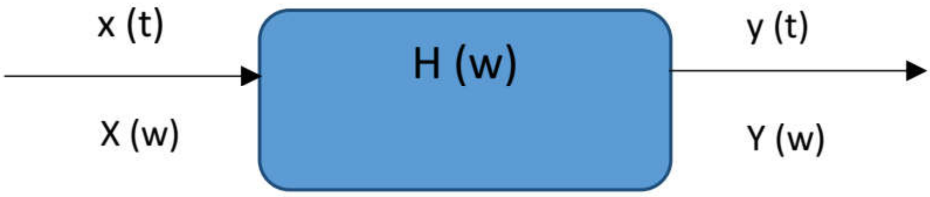

Figure 6. Linear system diagram

Neural network control

Supply chain integration model using direct adaptive neural network controller. It consists of two parts, one part is the feed forward neural network model. Its weight is corrected by the actual system output and model output error. The other part is the gradient optimizer. The correction of the state output and control input set by the gradient algorithm error processing. Among them, we should pay special attention to the status output and setting processing. Status output is expressed as a one-step prediction output. Supply, manufacturing, sales phase of the inventory status are deterministic output. That is the formula (1), (2b), (3). The manufacturing phase of the production process using neural network (2a) shows that the nonlinear system can also be expressed as predictive output.

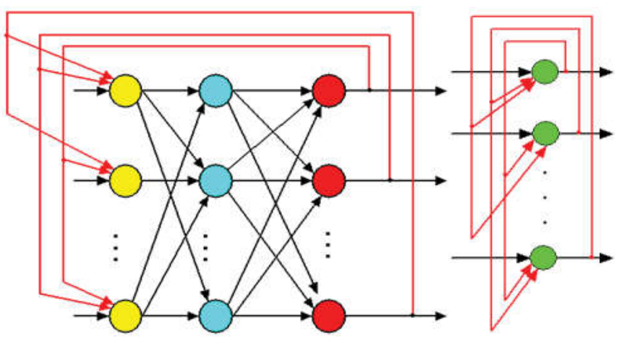

Figure 7. Structure of neural networks

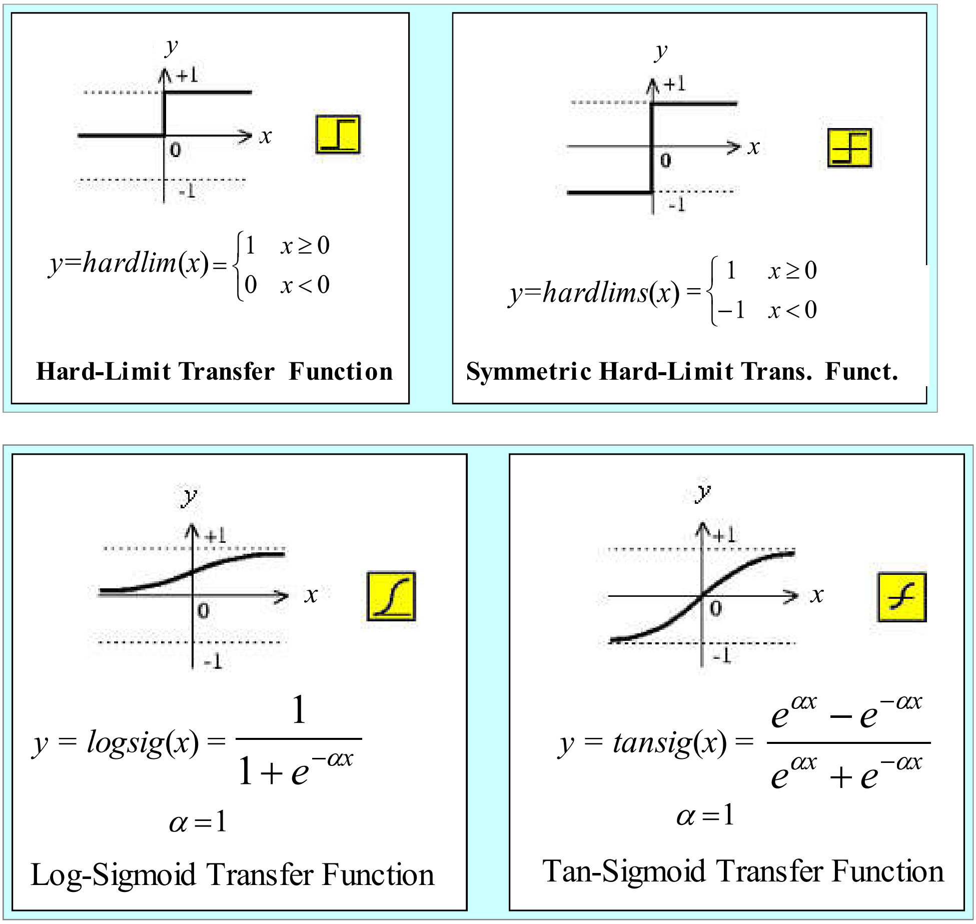

Figure 8. The function form of neural network

$$\widehat{P}_{k+1} = \widehat{f}(P_k, V_{1,k}) \quad (13)$$

In equation (9), the neural network adopts the intermediate hidden layer node as the hyperbolic tangent function. The output layer node is a linear function.

$$\hat{\mathbf{P}}_{\mathbf{k+1}} = \mathbf{W_2}\left[\tanh\left(\mathbf{W_1}\left(\mathbf{p_k^T}, \mathbf{V_{1,k}^T}\right)^{\mathbf{T}} + B_1\right)\right] + B_2 \quad (14)$$

In equation (10), tanh(.)$\tanh(.)$ is a hyperbolic tangent function. (P_k^T, $V_{1,k}^T$)^T is the augmented input of the system. W_1, W_2, W_3 $\mathbf{W_1}$、$\mathbf{W_2}$、$\mathbf{W_3}$ and B_2 are matrices, vectors corresponding to weights and offsets. The objective function of the supply chain system is an objective function (8) for four state vectors $X_{1,k}$,

$X_{2,k}$, $X_{3,k}$, P_{k+1}, X_1 tracking X_1^0, P_{k+1} tracking P^0) and three control vector U_{1k}, v_{1k}, v_{2k} quadratic form. We should pay special attention to the formula (3). d_3 is exogenous variables. In the supply chain integrated system, neural network control using gradient optimizer.

$$U_k^{s+1} = U_k^s - Z\frac{\partial J}{\partial U_k}\ U_k^{s+1} = U_k^s - Z\frac{\partial J}{\partial U_k} \tag{15}$$

Where U_k^s isU_k^T=$[u_1^T,V_1^T,V_2^T]=[u_{11}, u_{12},\cdots,u_{1n1};v_{11}, v_{12},\cdots,v_{1n1}; v_{21}, v_{22},\cdots,v_{2n2}]$ and the control vector of $2n_1+n_2$. The superscript s is the number of iterations of the gradient algorithm, Z is the step factor, Z ＞0.

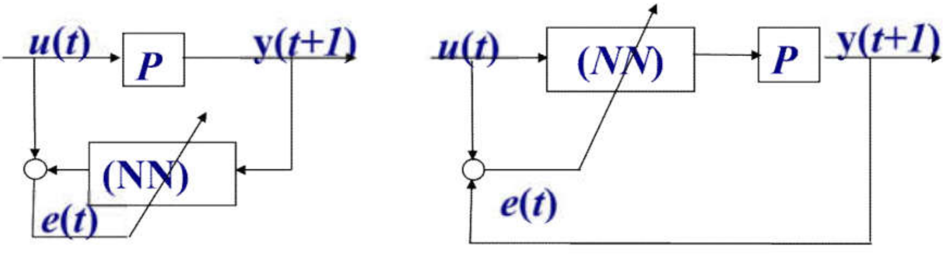

Figure 9. Two kinds of structures of neural network system inverse model identification

The gradient in the gradient optimizer is

$$\frac{\partial J}{\partial U_k} = \frac{\partial J_1}{\partial U_k} + \frac{\partial J_2}{\partial U_k} + \frac{\partial J_3}{\partial U_k} \tag{16}$$

$$\frac{\partial J_1}{\partial U_k} = \begin{bmatrix} Q_{11}(X_{1,k+1} - X_1^0) \\ -Q_{11}(X_{1,k+1} - X_1^0) \\ -Q_{12}X_{2,k+1} + Q_{13}X_{3,k+1} \end{bmatrix}(2n_1 + n_2) \times 1 \tag{17}$$

$$\frac{\partial J_2}{\partial U_k} = \begin{bmatrix} R_{11}U_{1,k} \\ R_{12}V_{1,k} \\ R_{13}V_{2,k} \end{bmatrix}(2n_1 + n_2) \times 1 \tag{18}$$

$$\frac{\partial J_3}{\partial U_k} = A^T Q_3 \left(\hat{P}_{k+1} - P^0\right) \tag{19}$$

And

$$A = \begin{bmatrix} 0 \cdots 0 \dfrac{\partial \hat{P}_{1,k+1}}{\partial V_{11,k}} \cdots \dfrac{\partial \hat{P}_{1,k+1}}{\partial V_{1n_1,k}} 0 \cdots 0 \\ 0 \cdots 0 \dfrac{\partial \hat{P}_{2,k+1}}{\partial V_{11,k}} \cdots \dfrac{\partial \hat{P}_{2,k+1}}{\partial V_{1n_1,k}} 0 \cdots 0 \\ 0 \cdots 0 \dfrac{\partial \hat{P}_{n_2,k+1}}{\partial V_{11,k}} \cdots \dfrac{\partial \hat{P}_{n_2,k+1}}{\partial V_{1n_1,k}} 0 \cdots 0 \end{bmatrix} n_2 \times (n_1 + n_1 + n_2) \tag{20}$$

Here:

$$0\ (\partial P^{*}_{1}(i,k+1))/(\partial V_{1}(1j,k)) = \sum_{(l=1)}^{h} [W_{2}(r,l)(\mathrm{sech}^{2}(W_{1}((p_{k}^{T},V_{(1,k)}^{T})^{T}+B_{1}))1W_{1}(l,n_{2}+j)] \quad (21)$$

In the formula, superscript h of the summation number Σ is the number of columns of W_2, which indicates the number of columns l = 1, 2,…, h.$W_2(r,l)$ is the element of row r and column l of W_2, $W_1(l,n_2+j)$ is the first row of W_1, n_2+j column elements. sech is a hyperbolic secant function and $(\mathrm{sech}^2(W_1((p_k^T,V_{1,k}^T)^T+B_1))$ is the first element of $\mathrm{sech}^2(W_1((p_k^T,V_{1,kT})^T+B_1)$. $(p_k^T,V_{1,k})^T)^T$ is the augmented input of neural network.

Algorithm

Supply chain integration model control algorithm is a neural network controller algorithm.

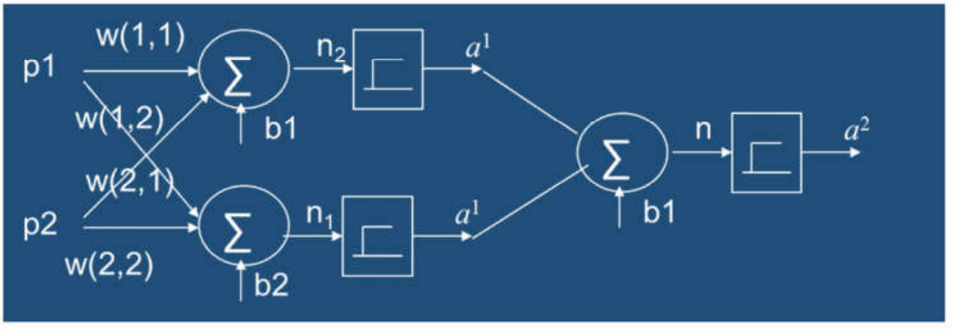

Figure 10. Introduction to neural network algorithm

It is summarized as follows:

I. Assume the initial value for each state equation, especially given the exogenous sales variables for the sales inventory equation;

II. The left-end deterministic state of state equations (1), (2b) and (3) in the integrated supply chain model can be directly used as the output. After the already-completed production model (2a) outputs the output and control the amount of augmented input substitutes can calculate the predicted output;

III. Neural network BP back propagation algorithm is applied to update weights and offsets. A production system neural network model of supply stage is established.

IV. Apply (11) (17) to calculate new control variables;

V. Feed the new control into the actual supply chain system (1) (3);

VI. Stops if the terminal moment is reached, otherwise returns (II).

It should be pointed out that the convergence of the proposed control algorithm for supply chain neural networks needs to be further proved. However, in the following work on Liaohua Company's supply chain simulation; we have adopted a method of setting the terminal moment. That is, the simulation time is a given value and it will stop when it is cycled to a certain number of times. In the following simulation work, the terminal moment is about 100 simulation cycles.

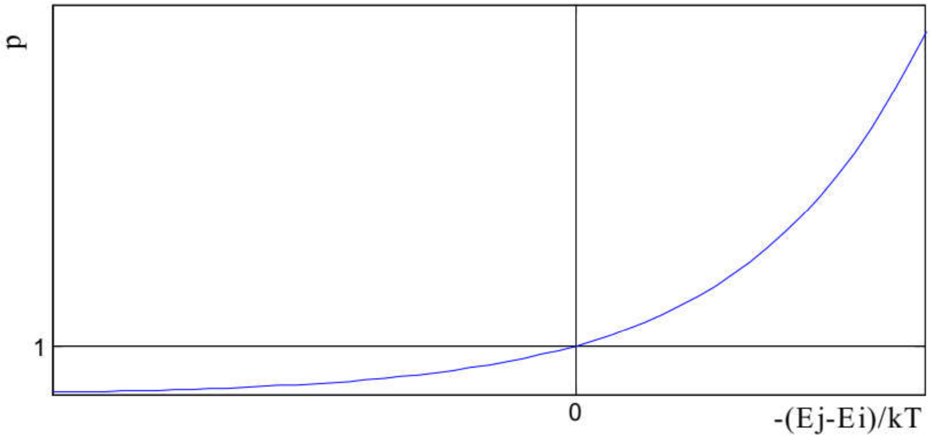

Figure 11. Metropolis guidelines

The simulated annealing algorithm is a non-numerical parallel optimization algorithm that uses the similarity of the solid annealing process and the combination optimization to introduce the Metropolis criterion into the optimization process. For supply chain management problems (1) (8), the basic steps are:

Step 1: Determining the initial decision variables $Y u_1, v_1, v_2, Y = (u_1^0, v_1^0, v_2^0)$, the initial state, the objective function J and the initial annealing temperature

Step 2: Randomly sample the decision variables of supply chain management to determine the new decision variables $Y u_1', v_1', v_2', Y$ that meet the constraints. We calculate the new state x_1', x_2', x_3', $\acute{p}$ and the new objective function J by using the equation of state and the neural network equations. Then we calculate the difference of the objective function

$$\Delta J = J Y u_1', v_1', v_2', x_1', x_2', x_3', \acute{p} Y - J Y u_1, v_1, v_2, x_1, x_2, x_3, p Y \quad (22)$$

Step 3: It generates uniformly distributed random numbers a∈[0,1). If min{ 1,exp(- ΔJ /T) }> a, then the decision variables are updated. Otherwise, the decision variables remain unchanged.

Step 4: If the annealing temperature has not yet reached the thermal equilibrium conditions, go to step 2, otherwise continue to the next step

Step 5: Determining the new annealing decay temperature, T is the attenuation coefficient

Step 6: If you do not meet the stop criterion, go to step 2, otherwise stop calculating and output the final result. In practical calculation, the thermal equilibrium conditions at a specific temperature during simulated annealing should be described as a fixed number of iterations, that is $L = n^2$. The attenuation coefficient of the simulated annealing temperature is taken as $T \in [0.2, 0.99]$ that is, the equivalent attenuation. The algorithm stops the criterion set to $T_f < (T^0 / n^2) * 10^{-5}$

The initial conditions of simulation of Company's supply chain system

Liaoyang Company is China's large petrochemical chemical fiber joint venture with eight main production plants and 25 sets of production facilities. The company research supply chain system for the purpose of ensuring supply, optimizing operation and oil, chemical, and benign production and sales.

Here we will simulate the initial conditions. The above equation dimensions are.

Now we suppose that the initial value of dynamic inventory equation (1) of Liaoyuan Company in the supply phase is:

$X_{1,0}^T$= [crude oil, acetic acid, ethylene glycol, xylene, wax oil, coal] = [5,1,0 .8,1.5,0.7,3] （23）

The initial value of the dynamic model of production inventory (2) in manufacturing stage is

$X_{2,0}^T$=[residue,diesel,jetfuel,gasoline,o-xylene,benzene,dimerization-resin, polypropylene, hexacycan, refined adipic acid, long cotton, long FDY, long polyester DTY, polyester short] = [3,3,0.1,1,2,1,0.7,0.8,1,1,1.2,0.3,1,0.01,0.06,0 .05] （24）

The initial stage of dynamic equation (3) in sales stage is

$X_{3,0}^T$=[residue,diesel,jetuel,gasoline,o-xylene,benzene,thedimer,polyethylene,polypropylene,hexacyanhydride,refined adipic acid, long cotton, long FDY polyester, long polyester DTY, polyester short] = [2,1,0.2,0.8,0.9,1,0.9,0.9,1,0.2 ,0.8,0.03,0 .05,0.04,0.06,0 .06] （25）

The sizes of the various products are thousands of tons. The initial value of these products is based on the average Liaohua Company in recent years to determine.

For Liaohua Company's supply chain status tracking set, that is, the objective function (5) in the safety stock$X_1^0 = 1.2X_{1,0}$. Manufacturing phase neural network production state set $p^0 = 1.1X_{2,0}$. The exogenous sales variable $d_{3,k}$ is given as $d_{3,k} = 0.9X_{3,k}$ and the others are set as $u_{1,0} = v_{1,0} = X_{1,0}$. Supply chain objectives weight matrix Q_{11}, Q_{12}, Q_{13}, R_{11}, R_{12}, R_{13}, Q_3 are taken unit matrix.

Supply chain gradient optimizer step factor taken as Z = 0.1. It should be said above the initial value of several data set has a certain degree of arbitrariness. However, it can also reflect the stability of the control method designed in this paper.

The data used in neural network equation training at the manufacturing stage is based on the actual data of Liaoyuan Company from May 2017. The neural network uses a 3-layer BP network with $n_1 + n_2 = 22$ input nodes, 40 hidden nodes and $n_2 = 16$ output nodes. After calculation, it can be seen that the forecast error of output does not exceed 5%. The supply chain dynamic system time has taken June 1 to 30.

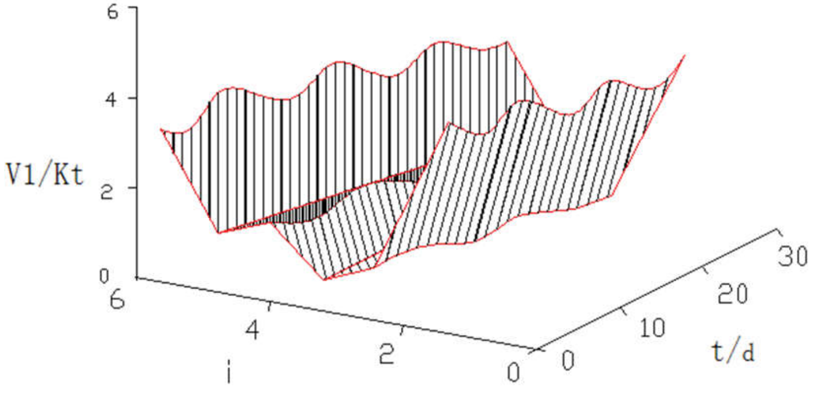

Figure 12. Stock products in the supply phase

The horizontal axis (t) is time. The vertical axis (i) is the inventory of the supply stage, and the coordinates i = 1, 2... 6 correspond to the products in the vector x 1 respectively. The vertical axis (X 1) is the number of products in stock during the supply phase in thousands of tons.

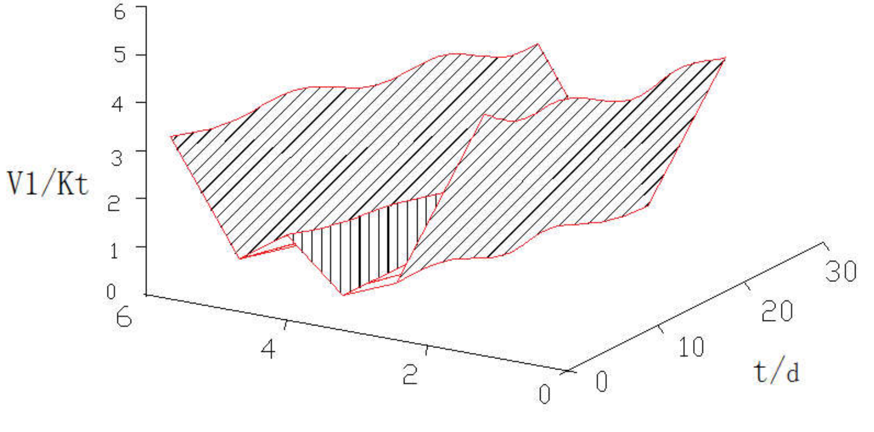

Figure 13. Supply products during the supply phase

The horizontal axis (t) is time. The vertical axis (i) is the product supplied in the supply phase, and the coordinates i = 1, 2... 6 correspond to the respective products in the vector x 1. The vertical axis (U1) is the number of inventory products in the supply phase, in thousands of tons.

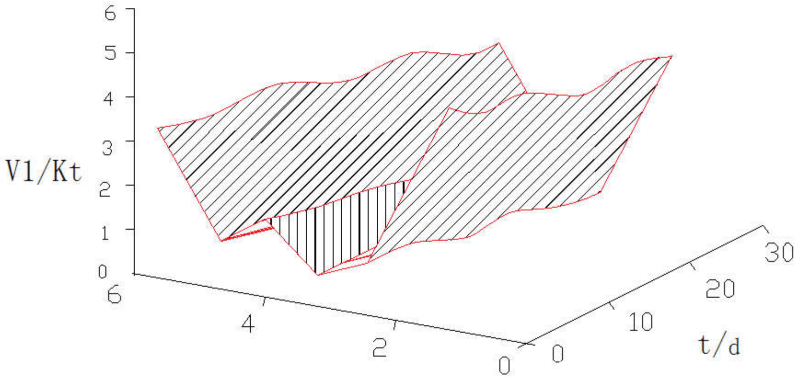

Figure 14. Surface diagram supplied by the supplier to the manufacturer

The horizontal axis (t) is time. The vertical axis (i) is the product supplied to the manufacturer by the supplier in the supply phase. The coordinates i = 1, 2... 6 correspond to the products in the vector x1, respectively. The vertical axis (V1) is the number of inventory products in the supply phase, in thousands of tons.

Through the simulation results, we take advantage of the control measures given in the article and quickly bring the inventory and production status in the supply chain to a steady state. Typical petrochemical enterprises calculated results J_1= 2 147.7 shows that the supply chain in all aspects of inventory is in a suitable state. J_2 = 2 122.9 shows the best case of supply costs, the actual situation J_2 is much larger. This shows that in practical work, an optimized supply chain will bring greater economic benefits. J_3= 518.1 indicates the best manufacturing stage of production.

Conclusion

Supply chain integration management provides the opportunity to integrate and manage functions and resources among enterprises. It is a conceptual model formed from the perspective of channel regulation. Successful supply chain management requires cross-functional areas and cross-value chain integration. Therefore, the study of supply chain management has certain practical significance. The main research focuses mainly on supply chain integration model. This study established a supply chain integrated dynamic equation, which is the result of a preliminary work. New research must be gradually perfected in theory and practice. Further work should be to study the dynamic model of supply chain mechanism, so that supply, manufacturing and sales to better link.

This article on the supply chain integration model is still in a more preliminary stage, there are many aspects that can be improved and continue to work: (1) The integrated model itself needs improvement; (2) The integrated model of empirical research needs continuous improvement. Under the background of rapid economic development in China and supply-side reform, the integrated supply chain management model will be the most widely used with the support of information technology, and gradually realize coalition and globalization. Supply chain integration management will play a very positive role in the production and operation of the enterprise.

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