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Logistics Transportation Cost Control of Hazardous Chemicals Based on Cost Control Method

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With the continuous expansion of industrial processes, the scale of logistics transportation in hazardous chemicals transportation industry has been expanding, and the increasing transportation costs have posed new challenges to the development of this industry. Based on the theory of cost control method, this paper studies the logistics transportation cost of hazardous chemicals and proposes relevant control measures. The research results show that the longer the transport distance, the higher the transportation cost and risk cost; under the condition of fixed transport distance, the rigid influencing factors are not controlled by the transport enterprises of hazardous chemicals. Both population density and free-flow speed have a greater impact on risk costs. With the cost as the core, the fixed cost, operating cost and transaction cost are combined organically according to the minimum cost requirement, so as to minimize the total logistics cost. This study has important guiding significance for reducing the transportation cost of hazardous chemicals and improving the profit and competitiveness of enterprises.

1. Introduction

Hazardous chemical is the general term for flammable, explosive, and corrosive materials (Cóccola & Méndez, 2015). Unlike ordinary goods, dangerous goods pose a threat to the safety of humans, animals, buildings, the environment, and property during its transportation or use, especially when dangerous goods are burned, exploded, or leaked, etc., it may cause serious safety accidents. Therefore, transportation of hazardous chemicals requires special transport vehicles, storage equipment and employees (Boulmakoul et al., 2016; Kirschstein 2018; Ozsakalli et al., 2014). According to incomplete statistics, at present, more than 90% of hazardous chemicals in China need to be transported over long distances for resource allocation. However, due to the factors such as transportation costs, transportation convenience, transportation facilities and safeguard measures, most hazardous chemicals rely on road transportation (Ji et al., 2018). In addition, the transportation industry of hazardous chemicals is also faced with the increasing number of dangerous varieties, the increasingly complex physical and chemical properties of dangerous goods, the difficulty of supervision and management, the lack of timely emergency assistance, and the rising cost of transportation (Venkatadri et al., 2016).

Cost control is the source of profit in the transportation industry. Compared with general goods, the transportation costs of hazardous chemicals are quite different, mainly focusing on risk and route optimization (Xu et al., 2015). The determination of the influencing factors on costs is the premise of effective cost control, and the control of transportation cost means the improvement of profit and the promotion of enterprise competitiveness. Therefore, the control of transportation risk cost is more realistic than the simple production cost control (Eckhardt & Rantala, 2012; Veisten, 2014). Dangerous species, vehicle running time, highway status and surrounding conditions of transportation routes are all the main reasons affecting the safety of hazardous chemicals transportation. For the factors affecting the transportation risk of hazardous chemicals, there have been different researches such as qualitative research, quantitative research, risk probability, risk measurement, risk equilibrium, and risk control (Andersson et al., 2017; Jane, 2011). Based on the cost control method, this paper focuses on the transportation risk cost of hazardous chemicals, and proposes countermeasures and suggestions for controlling the transportation cost of hazardous chemicals.

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2. Production costs of hazardous chemicals transportation

2.1 Main components and influencing factors of cost

The explicit costs of hazardous chemical logistics enterprises include operating costs and non-operating costs: the operating costs include direct labour and operating overheads, and non-operating costs include marketing, administrative, and other expenses (Havenga et al., 2016; Marasova et al., 2017). Factors affecting the logistics transportation costs of hazardous chemicals include hardware facilities, management tools, organizational systems, information systems, security awareness, optimization paths/routes, and personnel development etc. The transport distance is surely one important factor affecting the transportation cost of dangerous goods. The longer the transportation distance, the higher the transportation cost and the risk cost. When the transportation distance is fixed, the rigid influencing factors are not controlled by the transportation enterprises of hazardous chemicals (Lu et al., 2017). Figure 1 shows the ratio of logistics costs to GDP in China and the United States. It can be seen that China's logistics costs are about twice than the United States.

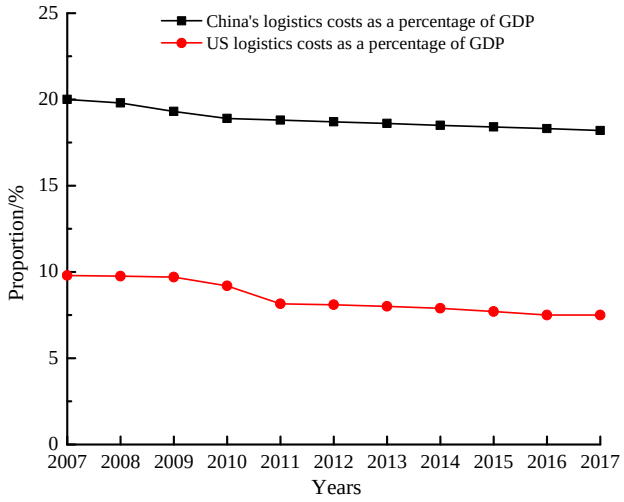


Figure 1: China and the US logistics costs as a share of GDP

2.2 Transaction costs for the hazardous chemical transportation

Special funds will be set up during the transportation of hazardous chemicals. It includes site asset specificity, material asset specificity, human assets specificity and special assets. There are many participants in the hazardous chemicals transportation industry, and they often adopt self-operating or outsourcing operations. Enterprises or companies with hazardous chemicals transportation have certain asset specificity.

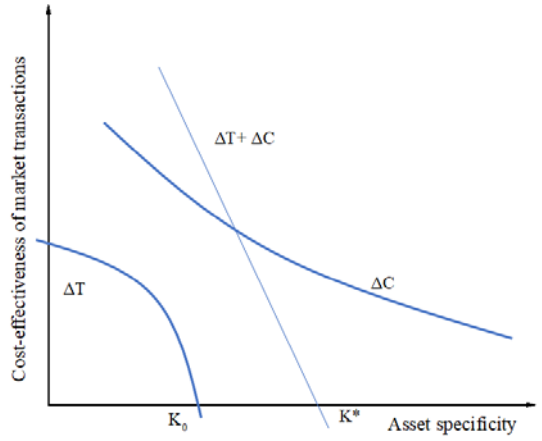


Figure 2: Cost-effectiveness of market transactions and vertical boundaries of enterprises

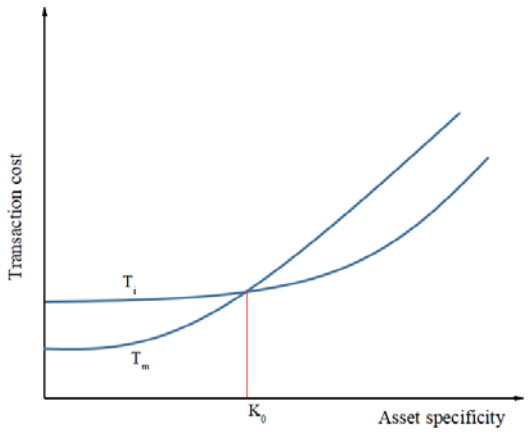


Figure 3: Transaction cost and asset specificity

Figure 2 shows the cost-benefit of market transactions and the vertical boundary of the enterprise. For hazardous chemicals manufacturers, the transportation function is not its core capability, and there is a large gap from the enterprises specializing in the transportation of hazardous chemicals. In Figure 2, ΔC is the minimum cost difference between self-operation and outsourcing operation, and it is generally ΔC≥0. Figure 3 shows the transaction cost and asset specificity, where T_i is the internal proprietary transaction cost, and T_m is the outsourcing transaction cost. When the asset specificity level is low, the enterprise can obtain the service of hazardous chemical transportation enterprise by paying lower transaction cost; when the asset specificity level is high, the transaction cost will be higher than the internal self-operation.

3. Cost measurement for hazardous chemical transportation

3.1 Measurement model for transportation costs of hazardous chemicals

Figure 4 shows the risk analysis framework for hazardous chemicals transportation. It can be seen that transportation costs include production costs and transaction costs; operating costs only include the cost of vehicle transportation; fixed costs are those controlled by non-transportation enterprises; the risk costs in transaction costs are subject to the employed personnel and environmental risks. Traffic density, traffic flow, traffic flow speed, road conditions and weather conditions are all influence conditions of environmental risk. Table 1 lists the impact of road grade on the probability of accidents. It can be clearly seen that the higher the road grade, the accident probability the lower.

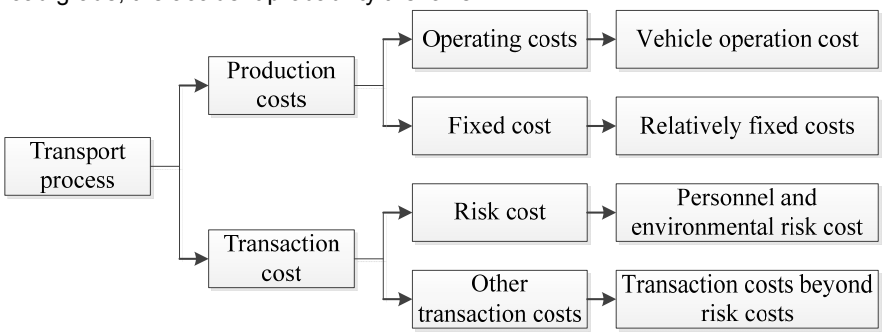


Figure 4: Hazardous chemicals transportation cost analysis framework

The total logistics transportation cost C of hazardous chemicals can be expressed as

$$C=C_{dl}+T_{rl} \quad (1)$$

where, C_{dl} is the production cost at the transport distance l; T_{rl} is the transaction cost at the transport distance l.

$$C_{dl}=(O_qP_o+F_m+F_h)L_l+C_f \quad (2)$$

$$T_{rl}=f^{\lambda l H l}\{[(N+N_p)C_{HLL}]\}^{\beta l}L_l+C_e+T' \quad (3)$$

where, O_qP_o is fuel cost; F_m is vehicle depreciation; F_h is the toll; L_l is the transportation distance; C_f is fixed cost; β_l is the traffic flow speed parameter; C_e is the environmental risk cost

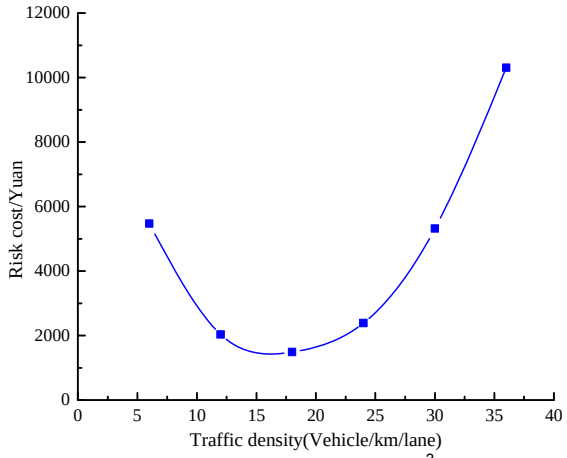
Table 1: The influence degree of road grade on the probability of accident

Road grade	Expressway	Grade I highway	Grade Ⅱ highway	Grade Ⅲ highway
Influence level	1.0	1.1	1.2	1.3

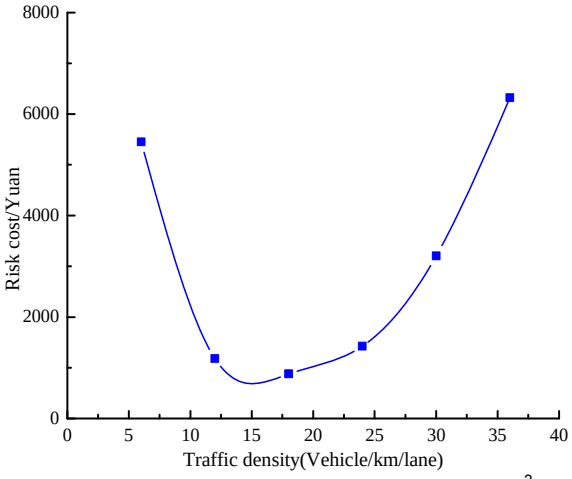
3.2 Example analysis

In this example, the parameters in the above formula were given a fixed value, and then the logistics transportation cost would be calculated. The diffusion radius of different hazardous chemicals is different. Taking ammonia chemicals as an example, its diffusion radius is 400m. The population density d_{pl} around the road segment l and the free flow velocity FV_l have a great impact on the risk cost. Table 2 lists the value range of factors in the example, and the data in the table is selected according to the actual situation in China. Figure 5 shows the relationship between traffic density and risk cost. In the four situations of population density and free flow speed, the relationship between traffic density and risk cost shows that with the increase

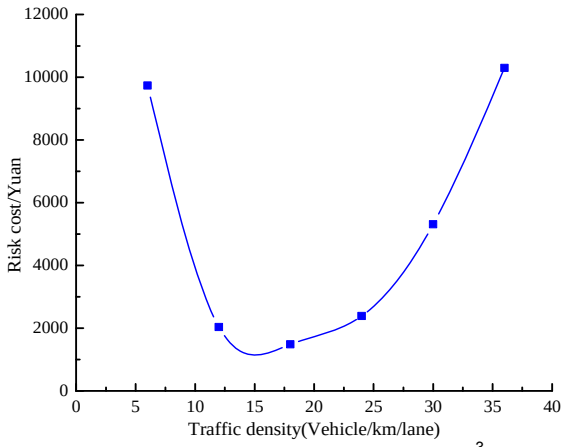
of traffic density, the risk cost first decreases and then increases, and the lowest point of risk cost appears at a traffic density of 15 vehicles/km/lane.



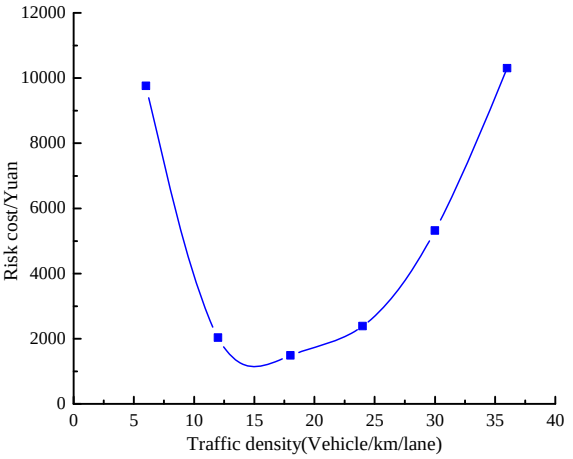
(a) Population density d_{pl}=40 people/km^3;Free flow speed FV_l=100km/h



(b) Population density d_{pl}=40 people/km^3; Free flow speed FV_l=70km/h



(c) Population density d_{pl}=250 people/km^3;Free flow speed FV_l=70km/h



(d) Population density d_{pl}=250 people/km^3;Free flow speed FV_l=100km/h

Figure 5: Relationship between traffic density and risk cost

Table 2: Example factor value range

Factor	Value range
Population density d_{pl} (people/km^2)	(50,300)
Traffic density dl(Vehicle/km/lane)	(5N; N=1, 2, 3, 4, 5……)
Free flow speed FVl (km/h)	(80,100)
Average traffic flow speed AVl(km/h)	60
Probability of dangerous goods transport accidents f	9.6×10^-6
Average vehicle load	2-3
Lanes number Nln	8
Road l length/km	150

4. Methods and measures to control the logistics cost of hazardous chemicals

4.1 Distribution route optimization and logistics cost control of hazardous chemicals

For hazardous chemicals, the complexity, ambiguity of the transportation cost, and the alternating profit and loss of cost make the transportation cost control more complicated. Figure 6 shows the relationship between transportation costs and inventory costs. It can be seen that with the increase of inventory points, inventory costs increase, transportation costs decrease, and there is a trade-off relationship between transportation

costs and inventory costs. The distribution route optimization and logistics cost control of hazardous chemicals can promote the realization and value-added of enterprise value. It is necessary to control the various costs incurred in the transportation process, and help the hazardous chemical enterprises to scientifically and rationally integrate various transportation functions through cost control methods. Thus, logistics channels are optimized, and transportation costs are reduced, thereby achieving the balance between transportation costs and transportation services. Figure 7 shows the logistics transportation cost control index system. The entire cost control system can be carried out from three aspects: market management, operation and decision-making mechanism. The reasonable arrangement of transportation tools, time, cost and distance can also greatly reduce transportation costs.

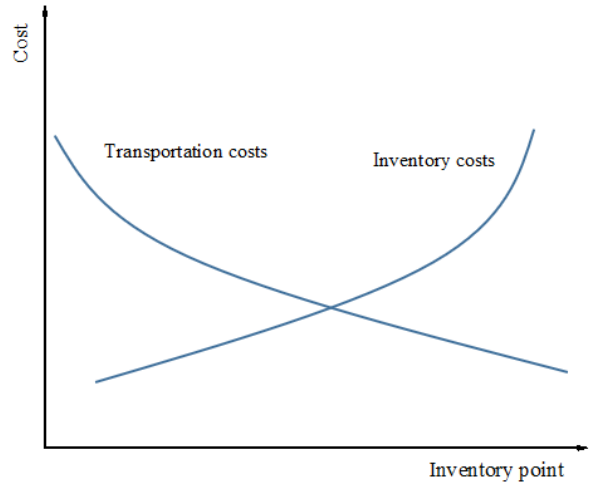


Figure 6: Relationship between transportation costs and inventory expenses

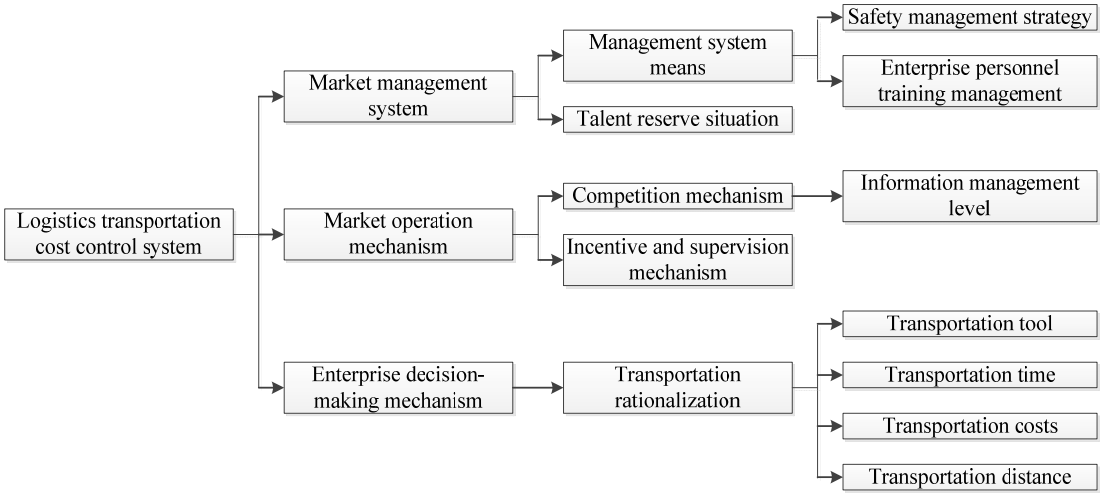


Figure 7: Logistics transportation cost control index system

4.2 Cost control method for hazardous chemical transportation

The logistics transportation cost of hazardous chemicals depends largely on the control of transportation risk, which starts from various items of transportation costs. The first is to improve asset utilization and reduce fixed costs, including scientific planning of fleet size to reduce unnecessary investment; increasing vehicle utilization rate to reduce asset sunk costs; undertaking external transportation services to avoid vehicle idle costs. The second is to seek external cooperation for reducing operating costs, including seeking price concessions through cooperation; reducing operating costs through service outsourcing; and shortening transportation distance through resource sharing. The third is the control of transportation risks to reduce transaction costs, including rational planning of travel time and routes; improvement of specialized operational capabilities; monitoring of hazardous chemicals transport vehicles operating conditions, etc.

5. Conclusions

Based on the cost control method, this paper focuses on the transportation cost risk of hazardous chemicals, and proposes countermeasures and suggestions for controlling the transportation cost of hazardous chemicals. The specific conclusions are as follows:

(1) When the asset specificity level is low, the enterprise can obtain the service of the hazardous chemicals transportation enterprise by paying a lower transaction cost; when the asset specificity level is higher, the transaction cost will be higher than the internal self-operation.

(2) The relationship between traffic density and risk cost shows that the risk cost decreases first and then increases with the increase of traffic density. The point with the lowest risk cost is roughly at the traffic density of 15 vehicles/km/lane, and there exists the trade-off relationship between the transportation cost and inventory cost.

(3) The transportation cost control of hazardous chemicals is realized by improving asset utilization, reducing fixed costs, seeking external cooperation to reduce operating costs, controlling transportation risks, and reducing transaction costs.

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