Factor Decomposition on Energy Cost Change of Freight Hub Based on SDA

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Abstract. The paper construct the factor decomposition model based on SDA, with the idea of jointly created and equally distributed. The model is used to analysis the energy cost change of freight hub for example. Through the analysis and calculation of the energy consumption data of freight hub, the conclusion is shown: The unit cost decline is the common contribution by cost effectiveness and energy structure. In the cost effectiveness, natural gas played a positive role for two years. In the energy structure, gasoline makes the most change. For the energy consumption cost control of freight hub, extensive promotion of natural gas vehicle and large vehicle are very effective measures.

Introduction

With the rapid development of economic in China, highway freight transport growth fast. By the end of 2015, 31.5 billion tons of freight was completed by commercial vehicles, highway freight turnover was 5.795572 trillion ton-km. Growth of 1.2% and 1.2% respectively over the previous year. Along with the increasing of the freight transport demand, the role of freight hub become more and more important. But now, it still has the problem with high energy consumption, high cost and low energy efficiency. Energy consumption cost is an important part of cost control in. Hao Ruibin analysis the spatial and temporal variations of energy consumption intensity based on the SDA [1]. Xu Ting analysis the cost control about the number of devices in cargo terminal [2]. Linda K put forward the influence of cost control about transportation in freight hub [3]. But the analyzation on energy consumption cost is still imperfection.

Factor Decomposition Model

SDA (Structure Decomposition Analysis) is a mainstream analysis model in input and output field. This decomposes the variable in economic system into the sum of each independent factor. It can be used to test the contribution of each independent variable. The paper constructs the factor decomposition model based on the SDA.

The calculation of the unit energy consumption cost is shown in formula (1):

$$e = \frac{G}{E} \tag{1}$$

In formula (1), e is the unit energy consumption cost; G is the energy consumption cost; E is the total energy consumption.

Energy consumption of freight hub mainly includes electricity, gas, coal, gasoline and diesel. Kinds of energy consumption decomposition model are shown in formula (2):

$$e = \frac{G}{E} = \sum_i^n G_i / E = \sum_i^n G_i / E_i \times E_i / E = \sum_i^n e_i s_i \tag{2}$$

In formula (2), G_i is the consumption cost of energy i; E_i is the consumption of energy i; e_i is the unit consumption cost of energy i; s_i is consumption accounted of energy i.

As shown in formula (2), the influence factors about energy cost can be decomposed into two parts: one is cost effectiveness, the other is energy structure. Changes in the cost of energy from 0 to period are shown in formula (3):

$$\Delta e=\sum_{i}^{n}(e_{it}s_{it}-e_{i0}s_{i0})=\sum_{i}^{n}\left[e_{i0}(s_{it}-s_{i0})+s_{i0}(e_{it}-e_{i0})+(e_{it}-e_{i0})(s_{it}-s_{i0})\right] \tag{3}$$

In formula (3) , Δe is the variation of energy consumption; $(e_{it}-e_{i0})(s_{it}-s_{i0})$ describes the joint action of the cost effectiveness and energy structure. J.W.Sun puts forward the idea of jointly created and equally distributed [4][5]. Based on the methods, The factor decomposition model is shown in formula (4):

$$\begin{aligned}\Delta e_{str}&=\sum_{i}^{n}(s_{it}-s_{i0})e_{i0}+0.5\sum_{i}^{n}(e_{it}-e_{i0})(s_{it}-s_{i0})\\ \Delta e_{eff}&=\sum_{i}^{n}(e_{it}-e_{i0})s_{i0}+0.5\sum_{i}^{n}(e_{it}-e_{i0})(s_{it}-s_{i0})\\ \Delta e&=\Delta e_{str}+\Delta e_{eff}i\end{aligned} \tag{4}$$

In formula(4), Δe_{str} is the variation of energy structure; Δe_{eff} is the variation of cost effectiveness; the calculation of the energy structure and the cost effectiveness in period t of energy i was shown in formula (5):

$$\begin{aligned}\Delta e_{istr}&=(s_{it}-s_{i0})e_{i0}+0.5(e_{it}-e_{i0})(s_{it}-s_{i0})\\ \Delta e_{ieff}&=(e_{it}-e_{i0})s_{i0}+0.5(e_{it}-e_{i0})(s_{it}-s_{i0})\end{aligned} \tag{5}$$

Energy Consumption of Freight Hub

Energy consumption of freight hub mainly includes electricity, gas, coal, gasoline and diesel. Purpose of all kinds energy is shown in Figure 1.

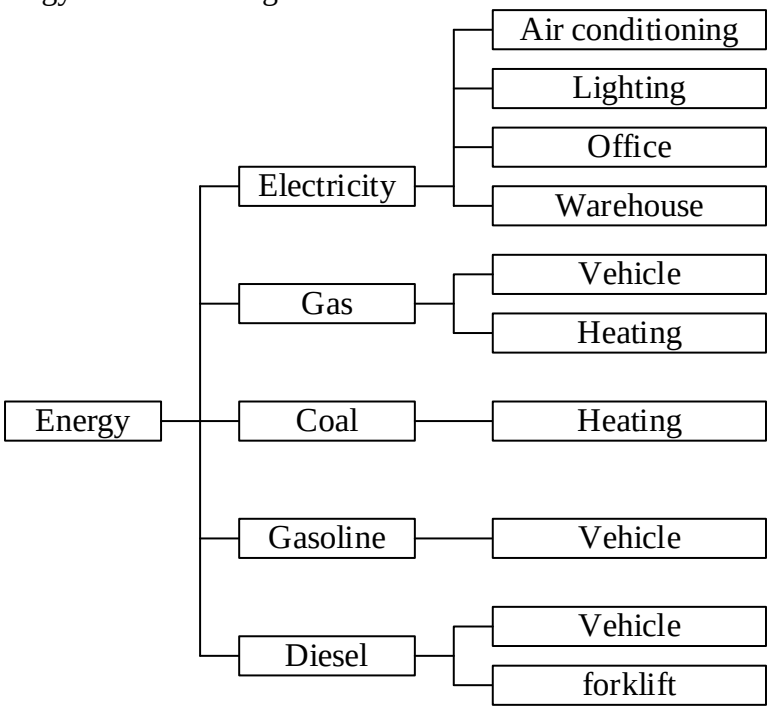


Figure 1 Purpose of all kinds energy

The paper takes a freight hub for example. The energy consumption from 2013 to 2015 is shown in Table 1.

Table 1 The energy consumption from 2013 to 2015

Year	Energy category	Unit	actual consumption	Standard coal[tce]	Accounted for energy	Cost[Ten thousand yuan]
2013	Electricity	Kwh	5559026.7	683.2	15.16%	455.62
	Gas	m^3	230837.6	307.01	6.81%	50.11
	Coal	GJ	1826.18	62.27	1.38%	12.68
	Gasoline	T	503.91	741.46	16.45%	398.67
	Diesel	T	1861.33	2712.15	60.19%	1117.47
	Sum	tce	—	**4506.09**	**100%**	**2034.55**
2014	Electricity	Kwh	5949052.5	731.14	17.85%	473.08
	Gas	m^3	296936.8	394.93	9.64%	63.28
	Coal	GJ	1993.38	67.97	1.66%	16.61
	Gasoline	T	370.85	545.66	13.32%	255.62
	Diesel	T	1617.9	2357.44	57.54%	949.92
	Sum	tce	—	**4097.14**	**100%**	**1758.51**
2015	Electricity	Kwh	4472368	549.65	11.66%	364.07
	Gas	m^3	379300.65	460.58	9.77%	68.89
	Coal	GJ	2119.06	72.26	1.53%	11.77
	Gasoline	T	407.5	599.59	12.72%	320.42
	Diesel	T	2081.41	3032.83	64.32%	1085.06
	Sum	tce	—	**4714.91**	**100%**	**1850.21**

As shown in Table 1, In terms of total energy consumption, 2014 is the lowest energy consumption and the cost. The reason is freight hub slumped in 2014. The unit cost decline year by year, the reason is more and more efficient energy-using products and energy saving technology is used widely. The variation of energy consumption and the cost is shown in Figure 2.

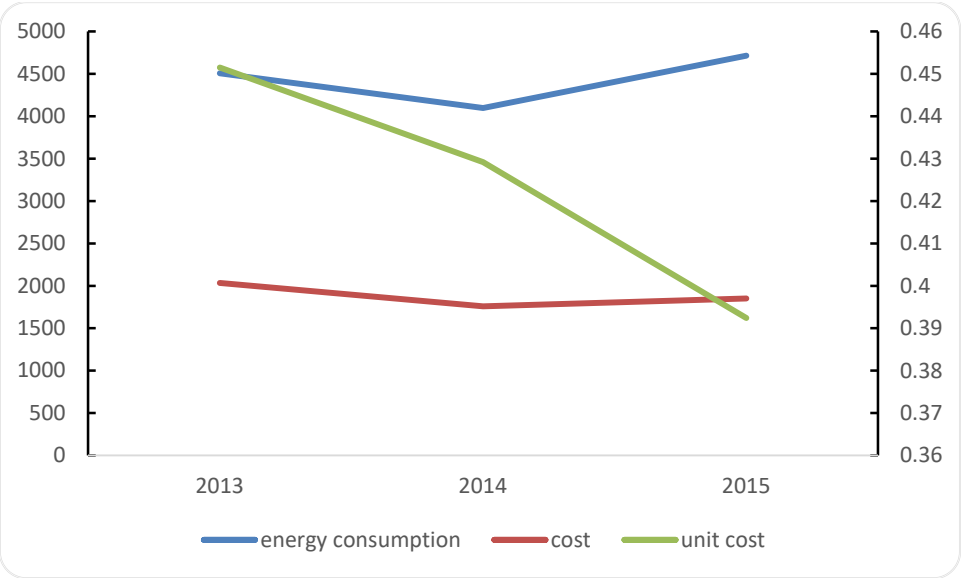
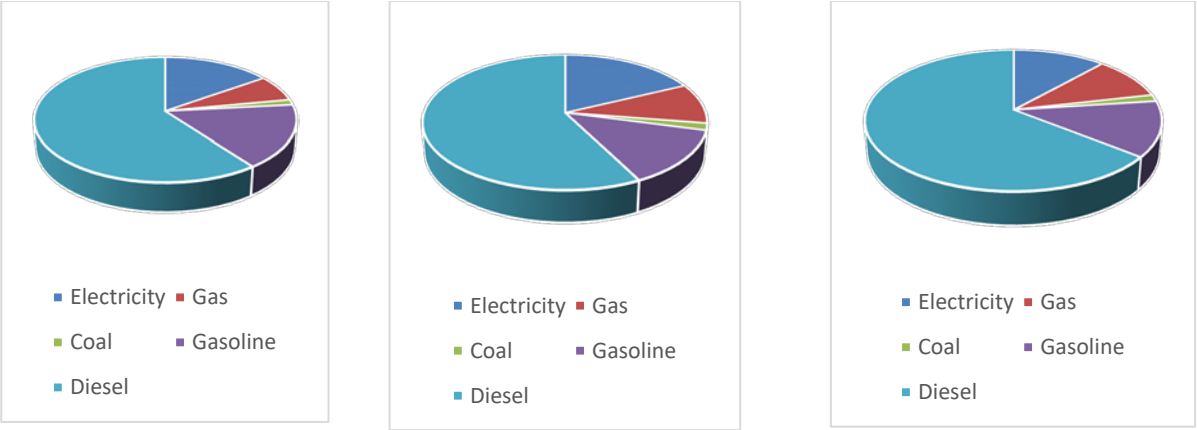


Figure 2 The variation of energy consumption and the cost

In terms of Energy category, the proportion of all kinds of energy remained stable basically. Because the freight and goods loading is the main business, diesel consumption used by vehicles and forklift occupy the largest proportion. From 2014, gas consumption increase rapidly, the reason is to response the emission reduction requirements of nation, more natural gas vehicle is used. The proportion of all kinds of energy is shown in Figure 3.



2013 2014 2015

Figure 3 The proportion of all kinds of energy

Calculation of SDA Model

Based on the SDA model, Paper carry on the factor decomposition on energy cost change of freight hub. The calculation results of cost effectiveness and energy structure is shown in Table2.

Table 2 The calculation result of cost effectiveness and energy structure

Year	Electricity		Gas		Coal	
	cost	structure	cost	structure	cost	structure
2013	0.6669	0.15	0.1632	0.07	0.2036	0.01
2014	0.6470	0.18	0.1602	0.10	0.2444	0.02
2015	0.6624	0.12	0.1469	0.10	0.1629	0.01

year	Gasoline		Diesel	
	cost	structure	cost	structure
2013	0.5377	0.17	0.4120	0.60
2014	0.4685	0.12	0.4029	0.58
2015	0.5344	0.13	0.3578	0.64

Use the calculation results which is shown in Table 2. The variation of cost effectiveness and energy structure can be decomposed. The variation of cost effectiveness is shown in Table 3; The variation of energy structure is shown in Table 4.

Table 3 The variation of cost effectiveness

Year	Electricity	Gas	Coal	Gasoline	Diesel
2013-2014	-0.0033	-0.0003	0.0006	-0.0100	-0.0053
2014-2015	0.0023	-0.0013	-0.0012	0.0082	-0.0275
2013-2015	-0.0006	-0.0014	-0.0004	-0.0005	-0.0336

Table 4 The variation of energy structure

Year	Electricity	Gas	Coal	Gasoline	Diesel
2013-2014	0.0197	0.0049	0.0022	-0.0252	-0.0081
2014-2015	-0.0393	0.0000	-0.0020	0.0050	0.0228
2013-2015	-0.0199	0.0047	0.0000	-0.0214	0.0000

Based on the Table 3 and Table 4, The factor decomposition on energy cost change of freight hub is shown in Table 5.

Table 5 The factor decomposition on energy cost change of freight hub

Year	Cost effectiveness	Energy structure
2013-2014	-0.0183	-0.0065
2014-2015	-0.0195	-0.0135
2013-2015	-0.0365	-0.0367

As shown in table 3, table 4 and table 5, The unit cost decline is the common contribution by cost effectiveness and energy structure. In the cost effectiveness, diesel makes the most change, natural gas played a positive role for two years. It because the price of diesel has a sharp fall in 2015, and natural gas has a lower cost, because of more natural gas vehicle was used in 2014 and 2015, the overall energy cost decreased. In the energy structure, gasoline makes the most change, because of larger vehicles is used, the consumption of gasoline decreased, that plays a positive role about the unit energy cost.

Conclusion

The variation of energy cost of the freight hub has a characteristic of time regularity. the unit energy cost decline year by year. During 2013 to 2015, the proportion of unit energy cost decline 13%,from 4515 yuan/tce to 3924 yuan/tce. It means the adjustment of energy structure, choose low energy cost and the measures of energy-saving technology has obtained the obvious effect.

The unit cost decline is the common contribution by cost effectiveness and energy structure. Each of the contribution rate are 50%. It means the cost effectiveness and energy structure are equally important for the energy cost control of freight hub. Except the objective factors of diesel prices decrease, a large amount of natural gas vehicle applications played an important role. Natural gas is a kind of low cost, clean energy which can be used in vehicle. It should be promoted widely. In addition, large diesel vehicles are used to replace gasoline vehicle. It is a very effective measures to reduce the unit energy cost in the aspect of energy structure.

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