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Challenges to the Green Marine Economy in China: Case Study of Qianhe Environmental Terminal's Bankruptcy

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Abstract

The expansion of the world fleet has increased consequently discharge of oily sewage and garbage, which has become a threat to the marine ecology environment. Qianhe Terminal for Oily Wastewater and Garbage (Qianhe) was the first professional terminal to receive and dispose of oily sewage and garbage from ships in Ningbo-Zhoushan Port which was the largest port in the world. However, this terminal bankrupted after only two years of operation. In this study, the Interpretative Structural Model (ISM) is used to investigate why the bankruptcy of Qianhe happened as it was and find out the causes from different perspectives. The ISM-based model analyzed the interrelationships among those causes and their positions in the structural hierarchy from high- to low-level. The contributions provide lessons learning from the bankruptcy for ecology environment economy and offer managerial insight for the port policy.

Keywords: Port environment; Interpretative Structural Model (ISM); Bankruptcy; Policy

1. Introduction

With the development of the world economy, trade and global influence is expanding rapidly. China is the world's largest country in goods trade since 2001. Among the top 10 world ports, 7 ports are in China. However, the increasing number of the ship brought an increase in illegal discharge of garbage and sewage from ships, which threatened the marine ecology environment in China. According to the international conventions, oily sewage and garbage should be received and treated in the ports. Therefore, the ports must build an oil sewage and ship garbage receiving facilities, which contributes to the development of the green environmental protection industry.

Ningbo-Zhoushan Port is the largest port in the world. In 2019, this port handled 1.12 billion tons of cargo and welcomed more than 3500 ships each day on average. The vast ship traffic has brought a considerable demand for receiving the garbage and sewage from the ships. That's why Qianhe Environmental Protection Terminal was built. Qianhe is the first comprehensive environmental protection terminal in China to dispose of abandoned oil-polluted water and ship garbage. However, the terminal was in operation for only two years and was shut down by June 2020. This was a shocking event in the green marine industry of China. It would be a valuable issue arousing our concerns.

Nowadays, whether a port is good or not depends not only on its economic condition but also on its ecological environment. Good and well-planned environmental practices contribute to enhancing the competitive position of ports (Wakeman, 2009). Because of the complexity of the port-construction, the analysis of the ecological and environmental protection system of the port must be carried out from several levels (Bekovnik and Bajec, 2015):

investment of the environmental protection construction by the port infrastructure, advantages of the national policy to the environmental protection system, the development and implementation of the coastal environmental protection system and the support services of relevant departments. Roso (2007) evaluated the concept of dry ports from an ecological perspective. China's listed port environment efficiency is evaluated and analyzed with the DEA model (Sun *et al.,* 2017) and FAHP method (Tseng and Pilcher, 2019). Kegalj *et al.* (2018) used a container terminal in Croatia to study the port environment. Ya-juan *et al.* (2017) investigated port environmental protection from a technical perspective. Analyzing factors that affect port environmental protection is a difficult task because the factors at all levels involve many policymakers. Therefore, this paper is limited to some specific aspects of port business operation.

This study contributes to the failure cases studying of Qianhe, the first professional terminal to dispose of the abandoned oil-polluted water and garbage from ships. The results reveal the importance of the government intervention mechanism to enterprises in the Chinese market. Preferential policy plays a decisive role in the survival of the private enterprises without a direct relationship with market law and economic situation, aiming to protect port resources and the global environment better and accelerate the construction of green harbor.

2. Materials and methods

2.1 Methodology

The ISM is an interpretive technique to effectively investigate the relationships among the factors in a complex system. ISM divides the system to analyze the sub-systems (factors, elements) by combing the characteristics and the direct binary relationship between different aspects. It's presented in the form of a map and maps this conceptual model into a directed graph through Boolean logic operation. Finally, it reveals the structure of the system by giving the simplest hierarchical directed extension without losing the overall function of the system. This method analyzed problems associated with complex socio-economic systems (Sharma and Singh, 2015). ISM-based model is efficient to clarify the structure of complex pattern and is widely applied currently globally, e.g., environmental policy (Tseng and Lin, 2011), industry (Pitchaimuthu *et al.,* 2019) and transportation (Kumar *et al.,* 2019). The framework of this contribution is following (see Figure 1);

1. Identifying the factors causing the bankruptcy;
2. Identifying the representative factors affecting bankruptcy;
3. Depicting how a factor may affect others;
4. Establishing the ISM model;
5. Hierarchical analysis of the primary and minor causes leading to the bankruptcy of Qianhe and the relationship between these factors.

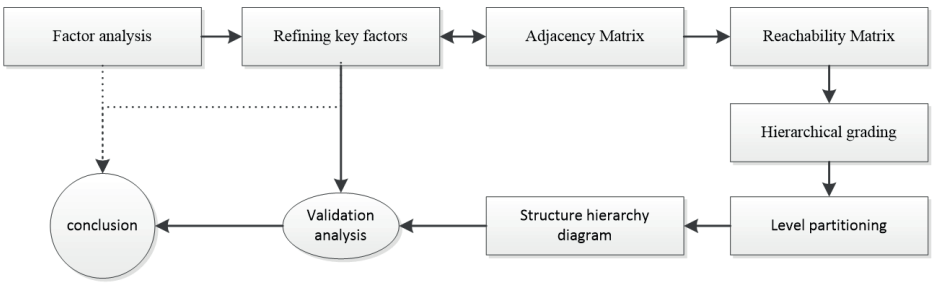

Figure 1. Process of the ISM modelling

The ISM modeling process is described as follows:

Step 1: To establish a correlation structure. In this step, elements of the complex system should be identified and the relationship among the identified elements should be explored in the self-interaction matrix with the symbols (i.e.; *V, X, A, O*). According to related research (Chander *et al.,* 2013), four symbols (i.e.; V, A, X, and O) are used to explore the relationships between the significations in ISM:

V – Dimension '*i*' contribute to the dimension '*j*';
A – Dimension '*j*' leads the dimension '*i*';
X – Dimension '*i*' and '*j*' result in each other;
O – Dimensions '*i*' and '*j*' are unrelated mutually.

Herein, *i* and *j* represent an arbitrary influence factor separately.

Step 2: To develop the reachability matrix. Two steps are followed to build the reachability matrix from the self-interaction matrix. Firstly, the initial reachability matrix is transformed according to (Shakerian *et al.,* 2019). Secondly, find their indirect relationships. The initial reachability matrix only illustrates the direct relationships among elements. the final reachability matrix should be transformed according to (Lin *et al.,* 2018):

$$(C+I)^{2n} \neq (C+I)^{2n+1} = (C+I)^{2n+2} \quad (1)$$

where n is an integer, and $n \geq 1$.

Step 3: Level partition. Reachability set, antecedent set and intersection set are identified for each element from the final reachability matrix. According to Tan *et al.* (2019), elements of which the Reachability set is identical to its intersection set would be regarded to rank in Level 1. After fixing and removing the elements in Level 1, a new cycle will repeat until all elements are partied into levels.

Step 4: To draw the directed graph according to the level and the connection of each element and produce the final ISM-based model.

2.2 Materials

2.2.1 Qianhe terminal

As mentioned above, Ningbo-Zhoushan Port (see Figure 2 (left)) is the largest port in the world. In 2019, the port handled 1.12 billion tons of cargo and welcomed more than 3500 ships each day. The oily water and the ship garbage increase with the increasing ship traffic, it's necessary to take emergency preventing measures of the oil spill for rush repair and ship garbage to serve the visiting ships and prevent the environment from pollution.

According to the master plan and layout of Ningbo-Zhoushan Port, Qianhe environmental protection terminal was built in the core area (see Figure 2 (right)) to meet the needs of ships to treat oily water and garbage from the ships. This terminal is the first environmental protection terminal in China to dispose of the abandoned oil-polluted water and garbage from the ships.

Table 1. Substitution rule

Self-interaction matrix	Initial reachability matrix	
(*i*, *j*)	(*i*, *j*)	(*j*, *i*)
V	1	0
A	0	1
X	1	1
O	0	0

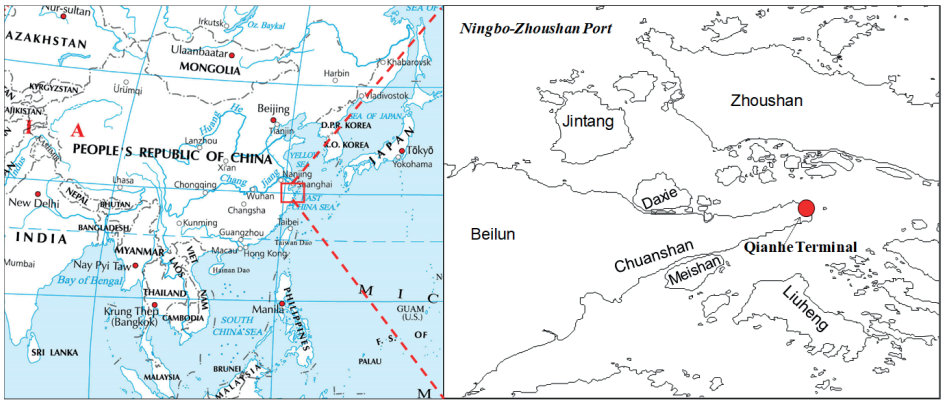

Figure 2. Location of Ningbo-Zhoushan Port (left) and Qianhe terminal (right)

According to the master plan and layout of Ningbo-Zhoushan Port, Qianhe environmental protection terminal was built in the core area (Figure 2 (right)) to meet the needs of ships to treat oily water and garbage from the ships. This terminal is the first environmental protection terminal in China to dispose of the abandoned oil-polluted water and garbage from the ships.

The terminal has an annual throughput of 729 thousand tons and has facilities for the recovery and disposal of oil sewage and garbage. The terminal's main structure was completed in October 2014 with the construction of a 5000-ton berth and a 1000-ton berth, six tanks with a total capacity of 42000 m³, and the establishment of an approximately 1755 m³ crude oil spill emergency warehouse and a marine garbage yard.

Paradoxically, the terminal was in operation for only two years and shut down due to debt problems. In June 2020, a local court auctioned the site's environmental waters, rights to use the terminal and refinery equipment.

2.2.2 Causes analysis of Qianhe's bankruptcy

The key factors that could be easily related to bankruptcy in the operation stage refer to some uncertain factors. A questionnaire survey is conducted on the old employees and the business partners of Qianhe, more than 20 possible reasons for its bankruptcy are collected. The top 10 factors are listed in Table 1.

The Qianhe terminal launched officially in 2015. However, in 2017, the Chinese government required each cargo terminal to be equipped with a garbage transfer station to receive the ship garbage and oily water. The market demand (C4) reduced significantly because of this policy (C1). The decline in business forced the company to fire its workers. The number of workers dropped down from 190 in 2016 to 28 in 2017, which means one staff, must simultaneously take on more than one post (C6). Furtherly, Qianhe had to operate a mortgage business to maintain its operations. To survive in the crisis, its owners bought large oil tankers to seek cooperation and tried to develop new business by cooperating with the new partners in oil spill emergency and oil wastewater treatment. However, since emergency handling of oil spills is a monopoly industry in China (C3) and China's market for oil sewage treatment was still in its infancy period (C2), customers' awareness of environmental protection was pretty weak (C5). The treatment of oil sewage and ship garbage has a high cost, but the customers are only willing to deal with that at lower prices (C9). The owner's arbitrariness and the improper strategy (C7) without involving the operational staff in decision-making (C10) made the debt of Qianhe even heavier. In 2018, Qianhe's total claims amounted to RMB 322.82million, with its mortgage guarantees exceeding 350million RMB (C8).

Table 2. Element identification

No.	Key factors	References	Author's opinions
C1	Lack of supportive policies	Jonathan and Lopez (2017)	French cosmetics competitiveness at risk is lack of policy support.
C2	An immature market	Gossum *et al.* (2011)	Thin markets and immature legal systems lead to the market failure.
C3	Lack of collaboration for the implementation	Bank (2012)	Implementation failure due to lack of adequate collaboration arrangements.
C4	Lack of market demand	Scheers (2016)	A positive correlation exists between marketing skills and business failure in South Africa.
C5	Lack of environmental awareness in the customer base	Khan *et al.* (2013)	Lack of people's support, green consumption development is slow.
C6	Lack of knowledge on development process	Tren *et al.* (2016)	Efficient communication and collaboration are core competencies of management.
C7	Inappropriate strategic positioning	Tomlinson and Cowling (2000)	Strategic failure lead to a long-term industrial decline in Japan
C8	High debt	Dinterman *et al.* (2018)	Financial debt lead to the bankruptcy of the American farms.
C9	Lack of understanding of customers' needs	Goffin and Lemke (2004)	Understanding the needs of the customers is a key factor in the promotion of products in the new environment.
C10	Operational staff not involved in major decisions	Krairiksh and Anthony (2001)	Staff nurses' participation in phases of the decision-making process had a small but significant positive effect.

2.3 Analyzing Qianhe's failure based on ISM model

2.3.1 Establishment of ISM

ISM model is established with the identified elements in Table 3, which aimed to clarify the relationships between the factors in the structural incidence matrix. According to related research (Jasiulewicz-Kaczmarek *et al.,* 2017), four symbols (i. e. V, A, X, and O) are used to explore the relationships between the significations in ISM, then the self-interaction matrix is obtained as Table 3.

2.3.2 Initial reachability matrix

Based on the principles mentioned in 2.3.1, Table 3 was translated to a binary reachability Matrix in Table 4, where V, A, X and O are replaced by the numbers 1 and 0 (Tseng and Lin, 2011). When *i* has a direct effect on *j*, the value is 1. Otherwise, the value is 0. Following this procedure, Table 4 is achieved.

2.3.3 Final reachability matrix

The initial reachability matrix displays the direct connection among the factors, while the final reachability matrix displays both direct and indirect relationships. According to Boolean Product, Table 5 is achieved by the Equation (1).

Table 3. Structural self-interaction matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1		V	O	O	O	O	O	O	O	O
C2			V	V	O	V	O	O	O	O
C3				O	O	O	O	O	O	V
C4					A	O	A	V	O	O
C5						O	O	O	V	O
C6							V	O	O	O
C7								O	O	A
C8									O	O
C9										A
C10										

Table 4. Initial reachability matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1	1	0	0	0	0	0	0	0	0
C2	0	1	1	1	0	1	0	0	0	0
C3	0	0	1	0	0	0	0	0	0	1
C4	0	0	0	1	0	0	0	1	0	0
C5	0	0	0	1	1	0	0	0	1	0
C6	0	0	0	0	0	1	1	0	0	0
C7	0	0	0	1	0	0	1	0	0	0
C8	0	0	0	0	0	0	0	1	0	0
C9	0	0	0	0	0	0	0	0	1	0
C10	0	0	0	0	0	0	1	0	1	1

Table 5. Final reachability matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1	1	1	1	0	1	1	1	1	1
C2	0	1	1	1	0	1	1	1	1	1
C3	0	0	1	1	0	0	1	1	1	1
C4	0	0	0	1	0	0	0	1	0	0
C5	0	0	0	1	1	0	0	1	1	0
C6	0	0	0	1	0	1	1	1	0	0
C7	0	0	0	1	0	0	1	1	0	0
C8	0	0	0	0	0	0	0	1	0	0
C9	0	0	0	0	0	0	0	0	1	0
C10	0	0	0	1	0	0	1	1	1	1

2.3.4 Level partitioning

Once the relationships between the factors are clarified, the hierarchical structure can be established based on level partitioning (Jadhav *et al.,* 2015). The processes for level partitioning are shown in Table 6. Then, these factors can be grouped into five levels.

3. Results and discussion

The reasons for Qianhe's failure are multi-level and multi-faceted. The ISM-based method provides a directed-graph approach for the in-depth understanding of interactive relationships among these causes. Accordingly, a directed-graph is obtained to explore the interrelationships between those influencing factors derived from the ISM method, as shown in Figure 3, to explain the factors about the bankruptcy of Qianhe.

Table 6. Level partitions for elements.

Causes	Reachability set	Antecedent set	Intersection set	Level
C1	1,2,3,4,6,7,8,9,10	1	1	5
C2	2,3,4,6,7,8,9,10	1,2	2	4
C3	3,4,7,8,9,10	1,2,3	3	3
C4	4,8	1,2,3,4,5,6,7,9,10	4	2
C5	4,5,8,9	5	5	5
C6	4,6,7,8	1,2,6	6	3
C7	4,7,8	1,2,3,6,7,10	7	2
C8	8	1,2,3,4,5,6,7,8,10	8	1
C9	9	1,2,3,5,9,10	9	1
C10	4,7,8,9,10	1,2,3,10	10	2

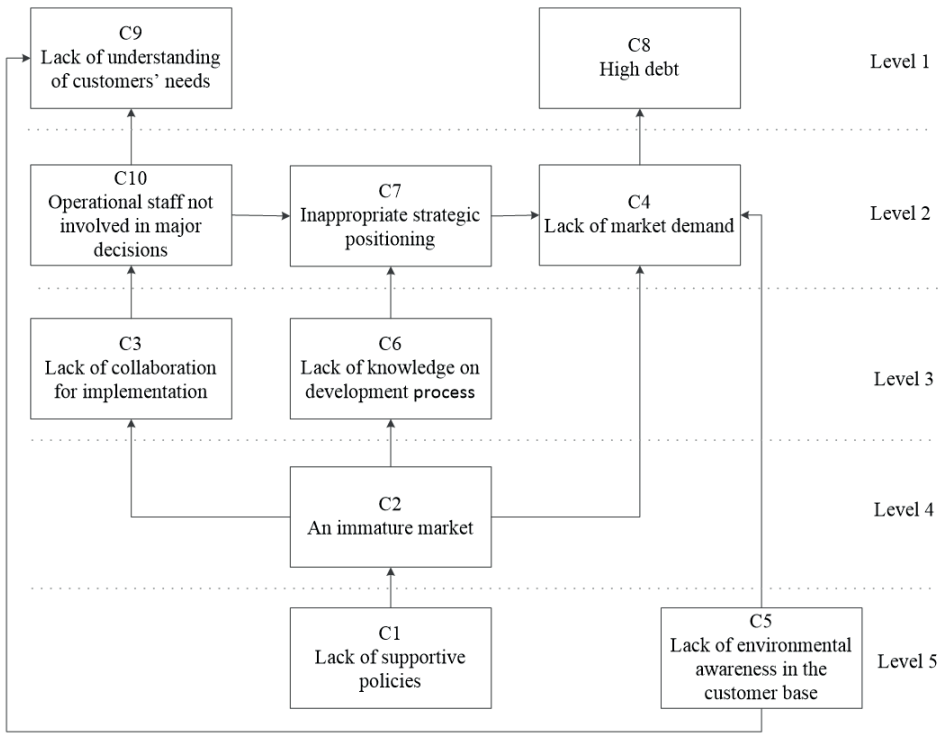

Figure 3. Interrelationships between ten causes

The ten elements are grouped into five levels. The topmost Level indicates C8 (High debt) and C9 (Lack of understanding of customers' needs) are with the equal reachability and intersection set. In contrast, "Lack of market demand" (C4), "Inappropriate strategic positioning" (C7) and "Operational staff not involved in major decisions" (C10) are the most critical factors. "Lack of collaboration for implementation" (C3) and "Lack of knowledge on development process" (C6) are the top-three objective indicators. Moreover, "An immature market" (C2) is in the second position of the last layer, Lack of supportive policies (C1) and Lack of environmental awareness in the customer base(C5) position at the bottom of the ISM model.

The high debt is a common cause in the context of China's reform and opening-up (Levy, 2000), which directly led to fierce competition and rapid updates. The highly indebted development pattern of Qianhe couldn't be maintained for a long time. It's only a matter of time before its bubble bursts. Product positioning must be based on customer requirements (Yu *et al.,* 1999). Without a fundamental understanding of customers' demands and the specific market, Qianhe did not formulate efficient strategies to attract the ships with long berthing time to choose the dedicated garbage collection station as the basic terminal in China. No targeted products and marketing strategies lead Qianhe to a weak competitiveness position in the monopoly market in China. Figure 3 indicated the two elements, i.e., C8 and C9, did not compose a closed coil and rather independent of each other. However, under certain conditions, their joint action further aggravated the situation, leading directly to the collapse of Qianhe.

The ISM model is a complex directed-graph in five levels; which can be broken down into two smaller units from the top levels of C8 and C9. Influencing factors related to the operation are shown in Figure 4. The human resource is the foundation of an enterprise (Yuan *et al.,* 2008). For strengthening public participation in marine ecological environment protection, it is necessary to popularize marine environmental protection education and raise public awareness of environmental protection (Liu, 2019). Lack of environmental knowledge and weak environmental consciousness make customers unwilling to pay extra fees for garbage disposal (H'Mida, 2009). C5 is a direct reason for the lack of market demand for Qianhe's paid garbage disposal business. C4 has forced Qianhe to take out loans to stay afloat. Simultaneously, Chinese government's policy of dedicating garbage collection stations at every freight terminal made less chance for Qianhe (Feng, 2007). The lack of environmental supervision and clear functional departments of anchored ships made potential users use loopholes in the law (Shi, 1995), and throw away garbage secretly becoming one reasons for the lack of market demand C1 lead to C2 and C4. As Smithian (López, 2008) said, the role of government is to break up monopolies, the monopoly markets and the immaturity of free markets make it difficult for the company to find partners to open up the market. C3 causes no implementation involvement, no awareness from the operational staff, and no opportunity for the ordinary staff to participate in the company's development plan, C10 and C2 lead to no success stories to refer to. Consequently, C6 and C7 must have acted in the wrong strategic direction leading to the lack of market demand.

The influencing factors focus on the strategic direction of this enterprise and the logical relationship between nodes C1 to C10, as shown in Figure 5. Grass-roots employees are the ones in direct contact with the customers (Lipman, 2007). And the customers' needs are diversified, so it is very unlikely that the products can be popular without understanding the customers' demands deeply (Shankar *et al.,* 2010). On the other hand, the lack of ecological concepts made potential users use loopholes of the law and secretly throw away garbage, meet customer needs and create consumers, which is the embodiment of enterprise competitiveness. It's not surprising that Qianhe failed.

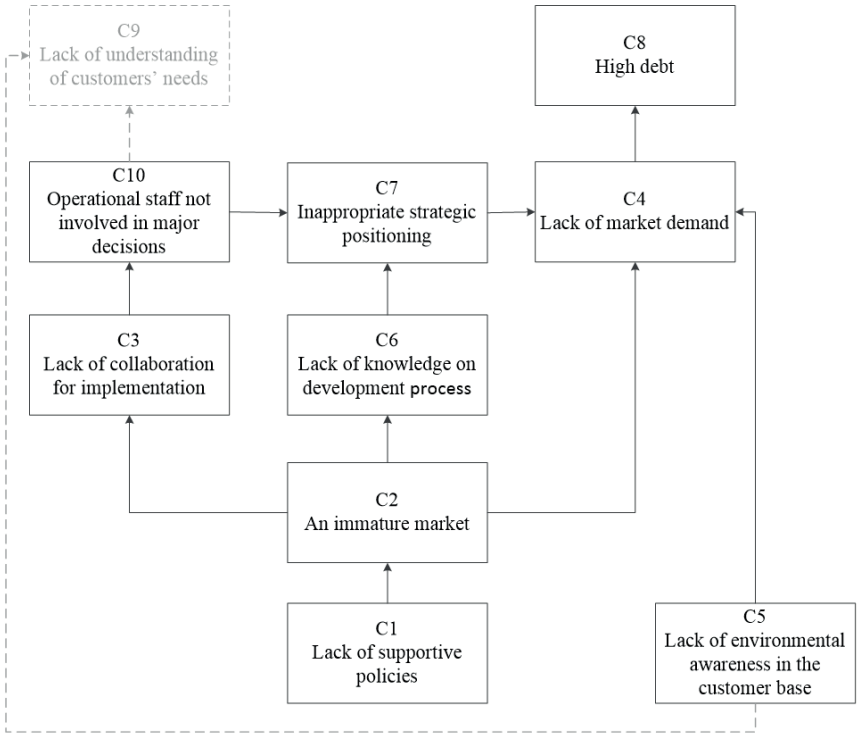

Figure 4. Directed-graph with vertex C8

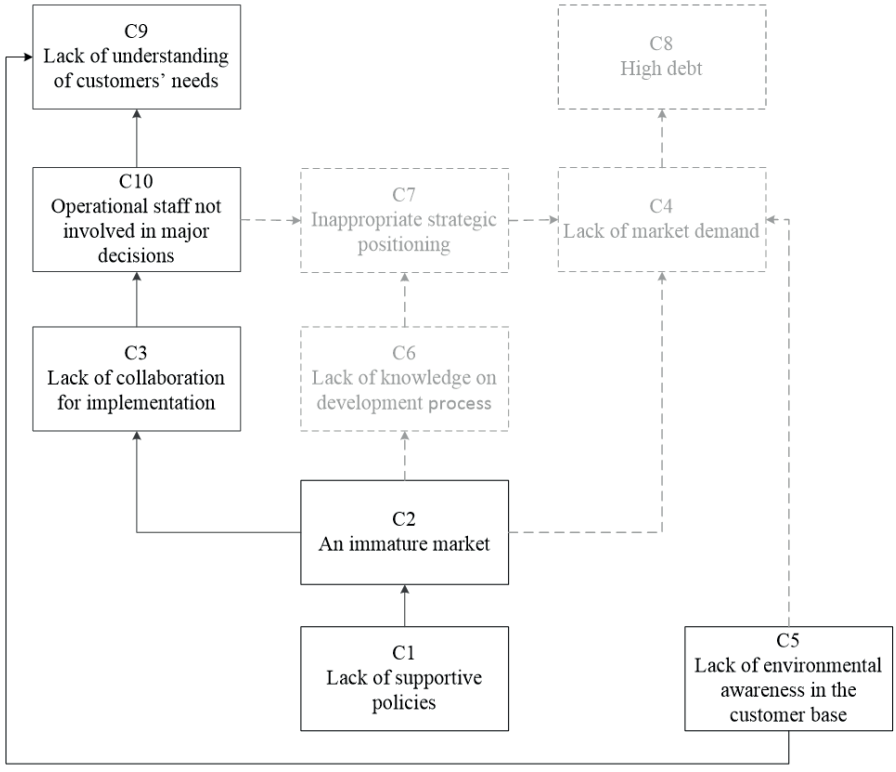

Figure 5. Directed-graph with vertex C9

It can be found that almost all the reasons of Qianhe's bankruptcy could be found by studying the previous researches in the related field. As a result, regardless of strategy or operation issues, Qianhe's bankruptcy is the absence of policy support and the lack of willingness of potential customer groups to consume the products they developed actively, similar to marsh gas industry in Europe (Xu and Zhu, 2011). The results indicate that the government intervention mechanism is essential for developing the enterprises under the socialist market economy system. (Tambunan, 2008). To sum up, the root cause of Qianhe's failure are C1 and C5, which lead to the outbreak of other levels of reasons in different intervals and dimensions, and finally leads to its bankruptcy. Therefore, the collapse of Qianhe seems to be occasional but inevitable.

4. Conclusion

It is a significant trend of global economic development to promote economic restructuring with environmental protection (Vaninsky, 2019). The rise and fall of environmental protection industry directly determines the speed of this process. In this research, the ISM-based modeling is used to analyze the collapse of Qianhe. Our contributions indicate that preferential policies play a decisive role in the survival of private enterprises without a direct relationship with the market law and economic environment. Meanwhile, preferential policies help to strengthen public consciousness of ecological protection, increase market demand, and change the current situation of marine garbage disposal.

Policy is the critical measure for marine environmental protection. Policies should support the development of enterprises, break monopolies, establish an open, competitive, and orderly market system, as well as establish a long-term mechanism for the marine environmental industry.

The government should establish the supervision and punishment mechanism help people to develop the environmental consciousness, and change the habit of obtaining the economic benefits at the expense of the environmental resource.

The case of Qianhe, to some extent, indicates the current situation of China's marine environmental protection industry. In addition to the practical implications of the research mentioned above, this paper also has some limitations. Besides analysis with the specific model, there is no dynamic verification, no actual calculation of Qianhe bankruptcy-related factors, but a calculation process needs a large number of accurate data, which will be the author's follow-up research direction.

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