SYNERGY PUBLISHING PTE. LTD.

Journal of Finance Research

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ARTICLE

Empirical Research on the Influence of Marine High-end Human Resources on Marine Knowledge Innovation——With Organizational Incentive and Technological Innovation as Mediating Variable

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ARTICLE INFO

Article history
Received: 27 March 2020
Revised: 7 April 2020
Accepted: 9 April 2020
Published Online: 16 April 2020

Keywords:
Marine high-end human capital
Policy incentives
Marine technology innovation
Marine knowledge innovation

ABSTRACT

The main purpose of this paper is to explore the intermediary role of policy incentives and marine technological innovation in marine high-end human capital promoting marine knowledge innovation. Previous studies on the impact of marine high-end human capital on marine knowledge innovation mainly focused on the direct impact of marine high-end human capital on marine knowledge innovation, while ignoring the role of intermediary variables. Based on 512 sample survey data from 138 organizations in 16 coastal cities of China, this paper uses structural equation model to examine the relationship between high-end human capital and policy incentives, technological innovation and marine knowledge innovation. The research shows that marine high-end human capital has an impact on marine knowledge innovation through policy incentives and marine technology innovation. Policy incentives and marine technology innovation play a full intermediary role in the relationship between marine high-end human capital and marine knowledge innovation.

1. Introduction

This paper analyses the impact of Marine High-end Human Resources on Marine Knowledge Innovation, and then identifies how Organizational Incentive and Technological Innovation affect the relationship between Marine High-end Human Resources and Marine Knowledge Innovation. Marine high-end human resources include marine scientific research and education personnel, marine related industries and professional technicians, marine economic management service personnel (Qianbin Di et al., 2018)[1]. National marine departments should participate more in the training of marine talents and the popularization of marine education nationwide, so as to raise marine education to the height of space education (Pew Oceans Commission,2005). Marine knowledge innovation is the primary driving force for the development of marine economy, the endogenous factor for the survival and competitiveness of marine economy. Marine knowledge innovation can't be separated from marine high-end

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Fund Project:
This paper was supported by National Social Science Fund Project ——Research on the Identification, Control and Emergency Treatment of Major Ecological Security Risks (Project No.:14BJY022).

marine talents. Marine human capital is the key element of marine knowledge innovation. Human capital plays an important role in economic growth, and successively puts forward the endogenous role model of economic growth (Sollow, 1957; Arrow, 1962; Romer, 1986)[2-4]. The cooperation consciousness and interdependence behavior of high-end talents can improve the effectiveness of innovation strategy implementation (Schuler, 1989)[5]. The value of marine high-end human capital in marine knowledge innovation and in promoting marine economic development are increasing day by day. Marine high-end human capital becomes the promoter of marine knowledge innovation. Therefore, it is of great significance to study the impact of marine high-end human capital on marine knowledge innovation.

Through in-depth analysis and empirical research, this paper deeply explores the impact of marine high-end human capital on knowledge innovation on the basis of summarizing the literature. The research on the relationship between marine high-end human capital and marine knowledge innovation by scholars at home and abroad is basically based on theoretical analysis, with few empirical studies. It is not clear which path marine high-end human capital will take to promote marine knowledge innovation. It is necessary to further explore whether marine high-end human capital directly affects marine knowledge innovation or mediates marine knowledge innovation.

2. Relevant Theoretical Basis and Research Hypothesis

2.1 Marine High-End Human Capital and Technological Innovation

The definition of human capital is given in terms of human quality, economics, access to ability and practical value (Schultz, 1960)[6]. The concept of technological innovation can be traced back to the definition of technological innovation by Austrian economist Schumpeter in The Theory of Economic Development (Schumpeter, 1912). The role of human capital in technological innovation and diffusion is studied by means of "technological potential" and "technological potential difference" (Jinying Wang, 2000). The investment expenditure of human capital is directly proportional to the dynamic innovation ability of the organization (Yong Yang Di et al., 2007). In the final analysis, the competition of marine economy is the competition of marine high-end marine human capital. Marine high-end human capital gains value appreciation through education and training. If the investment of marine high-end human capital is insufficient, the bottleneck of marine knowledge innovation will be formed (Pew Oceans Commission, 2003; Maica Garriga, 2010; Natalie K. Bown, 2013)[7]. By analyzing the role of entrepreneurs and core technicians in technological innovation, it is concluded that human capital is the key element of technological innovation (Xiaobin Wang, 2000)[8]. Marine core technicians are not only the source of marine technological innovation, but also the carrier of marine technological innovation. The enthusiasm and effective allocation of marine technological R&D personnel are the premise and guarantee of improving marine technological innovation (Meihua Qiao, 2018). Based on the above theories, the first hypothesis of this paper is proposed.

Hypothesis H1: Marine high-end human capital is positively correlated with marine technological innovation.

2.2 Marine High-end Human Capital and Policy Incentives

Studies at home and abroad show that marine high-end human capital is closely related to policy incentives. Demand Hierarchy Theory (Maslow, 1943), Two-Factor Theory (Herzberg, 1958) And Expectation Theory (Vroom, 1964) have demonstrated from different perspectives that people play a positive role in promoting policy incentives in the process of realizing their own values. Accumulation of marine high-end human capital is conducive to policy incentives. According to different needs of marine high-end human capital, different policy incentives can be adopted to realize "the potential of marine high-end human capital"(Hongliang Qi, 2003; Chaminade et al.,2008; Xiaowei Chen, 2013)[9]. Marine high-end human capital is the core resource that can’t be imitated to promote the development of marine economy. Different policy incentives should be adopted to fulfill the desire of self-realization of marine high-end human capital. Appropriate policy incentives can improve the personal quality of personnel and the ability of marine knowledge innovation (Robert Blasiak et al., 2015; Kostadinov Ivaylo et al., 2011; Nicole Schaefer, 2011). Policy incentive should adopt different incentive modes according to the demand level of marine high-end talents and different stages of marine economic development, and adopt different policy incentive modes with different environments, so as to achieve the best incentive effect (Ping Liu et al., 2003). To improve the enthusiasm and initiative of marine high-end innovators, a scientific and rational human capital incentive system should be established (Xianxiang Kong, 2007). Based on the above theories, the second hypothesis of this paper is proposed.

Hypothesis H2: Marine high-end human capital is positively correlated with policy incentives.

DOI: https://doi.org/10.26549/jfr.v4i1.3514

2.3 Marine High-end Human Capital and Marine Knowledge Innovation

Regional concentration and industrial cluster can promote the reserve and accumulation of human capital stock. Through formal and informal learning and communication, high-level personnel can make knowledge flow and spread freely, which is conducive to knowledge spillover and knowledge innovation (Hirschman, 1958; Myrdal, 1957; Milton Friedman, 1999 Maria,2010 et al.)[10]. Concentration of marine high-end human capital can accelerate knowledge diffusion. When marine high-end human capital is completely dispersed, the cost of marine knowledge acquisition increases, which is not conducive to marine knowledge innovation (Ning Hui, 2007; Chunsheng Zhao, 2017)[11]. Marine high-end human capital is the carrier of marine knowledge. The competition of marine knowledge is essentially the competition of marine high-end human capital. Technical talents with rich marine knowledge are the main force of marine knowledge innovation and marine knowledge reconstruction (Bing Wang et al., 1999). The marine knowledge consortium composed of marine knowledge workers is the carrier of marine knowledge innovation. The quality and quantity of marine knowledge innovation depend on the stock of marine high-end human capital (Liangrong Song et al., 2001). In the marine high-end human capital, the marine knowledge previously mastered by the individual is conducive to absorbing similar new knowledge. The knowledge mastered by the individual reaches a certain level, which can quickly complete the exchange, absorption and integration of new and old knowledge, and improve the ability of marine knowledge innovation (Jin Tian, 2003). Based on the above theories, the third hypothesis of this paper is proposed.

Hypothesis H3: Marine high-end human capital is positively correlated with marine knowledge innovation.

2.4 Policy Incentives and Marine Knowledge Innovation

Policy incentives can be divided into individual incentives and group incentives. Through potential incentive, institutional incentive, psychological incentive and benefit incentive strategies to stimulate the enthusiasm and initiative of marine high-end talent work. Policy incentive can optimize the incentive structure of marine knowledge innovation and improve the ability of marine knowledge innovation (Liqun Sun, 2010; Sheng Xu et al., 2018)[12]. In the process of realizing marine knowledge innovation, policy incentives can effectively stimulate the potential of marine high-end talents, stimulate the enthusiasm of knowledge workers through incentive mechanisms such as salary, knowledge capitalization and career development, and ensure the continuity of marine knowledge innovation activities (Le Yu, 2016). Policies can give innovative vigor and rights to the subjects of marine knowledge innovation, enhance their motivation of knowledge innovation and enhance their ability of knowledge innovation through four aspects: interest incentive, ability incentive, right incentive and responsibility incentive (Zhe Wu, 2003). By establishing interest-driven incentive mechanism, administrative order-driven incentive mechanism, corporate culture-sharing incentive mechanism, knowledge alliance incentive mechanism and benchmark management incentive mechanism, knowledge innovation ability of marine high-end talents can be stimulated (Ailin Wang, 2001). Based on the above theories, the fourth hypothesis of this paper is proposed.

Hypothesis H4: Policy incentive is positively correlated with marine knowledge innovation.

2.5 Marine Technological Innovation and Marine Knowledge Innovation

Knowledge is divided into expressive knowledge and concealed knowledge (Polanyi, 1962)[13]. Because of its complexity, specificity, ambiguity and difficulty to express, marine knowledge has become the core competitiveness of marine economic innovation (Xingwu Cui, 2018). It is technology that knowledge is systematically applied to production and meets market demand through production process and service process (Holsapple C W and Singh M., 2001)[14]. Any marine technology is the manifestation of marine knowledge. Marine technological innovation is conducive to marine knowledge innovation. Marine knowledge innovation pays attention to the progress of marine economy, while marine technology innovation pays more attention to the commercial benefits brought to the marine economy (Jitao Guo, 2018). Marine technological innovation is the carrier, concretization and core content of marine knowledge innovation. Marine knowledge innovation depends on marine technological innovation (Lizhen Liu, 2018). Marine knowledge innovation not only exists in the source of marine technology innovation, but also runs through every link in the process of marine technology innovation. Marine technology innovation provides a new tool for marine knowledge innovation, opens up a new scope for the development of marine knowledge innovation, influences the development and direction of marine knowledge innovation, and provides support for marine knowledge innovation (Hongmei Hao, 2015)[15]. Based on the above theories, the fifth hypothesis of this paper is proposed.

Hypothesis H5: There is a positive correlation between marine technological innovation and marine knowledge innovation.

2.6 The Mediating Role of Policy Incentives and Marine Technological Innovation

On the one hand, marine high-end human capital has a positive correlation with marine knowledge innovation, which indicates that marine high-end human capital has a direct effect on marine knowledge innovation. On the other hand, marine high-end human capital is positively correlated with policy incentives and marine technological innovation, while policy incentives and marine technological innovation are positively correlated with marine knowledge innovation. Policy incentives and marine technological innovation can improve the stock and accumulation of marine high-end human capital, thus conducive to marine knowledge innovation. It shows that marine high-end human capital has an indirect impact on marine knowledge innovation through policy incentives and marine technological innovation. Policy incentives and marine technological innovation play an intermediary role. Based on the above analysis, the following hypothesis are put forward.

Hypothesis H6: Policy incentive plays an intermediary role in the relationship between marine high-end human capital and marine knowledge innovation.

Hypothesis H7: Marine technological innovation plays an intermediary role in the relationship between marine high-end human capital and marine knowledge innovation.

Based on previous research theories, the conceptual model and hypothesis of this study are established (Figure 1).

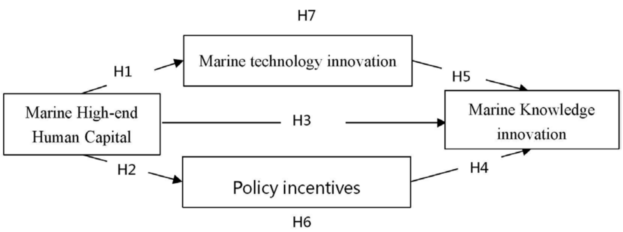

Figure 1. Conceptual model and research hypothesis

3. Research Methods

3.1 Sample Data

The survey data are from China's Coastal Cities of Dalian, Qinhuangdao, Tianjin, Yantai, Qingdao, Lianyungang, Nantong, Shanghai, Wenzhou, Fuzhou, Xiamen, Shantou, Shenzhen, Zhuhai, Zhanjiang and Beihai. The scope of the survey included traditional manufacturing industry, scientific research institutions, small and medium-sized innovation enterprises, large-scale science and technology enterprises, government, science and technology bureau. The respondents were mainly middle and senior managers and technological innovators. By means of target sample and random sampling, a total of 138 organizations were involved. 617 questionnaires were sent out and 530 questionnaires were recovered. After deducting 18 questionnaires with incomplete or incomplete answers, 512 valid questionnaires were received, with an effective recovery rate of 83%. The questionnaire was conducted by 5-Likert scale. The way of investigation is to let the respondents evaluate themselves. In order to avoid consistency errors in answering questions due to fixed thinking patterns, some items were set in reverse way during the survey (Salancik and Pfefer, 1977). Because all items of the questionnaire are filled by the same person, homologous deviation is easy to occur, so Haman single factor test is used (Podsakoff and Organ, 1996). Factor analysis of all items in the questionnaire shows that the load of the first principal component without rotation is 37.26%. The relatively low single factor explanatory scale shows that the homology deviation is not serious. At the same time, according to the descriptive statistics of variables and the correlation coefficient matrix (Table 1), the covariance is less than 0.80, indicating that there is no multiple collinearity among factors (Haman, 1995).

Table 1. Variable descriptive statistics and correlation matrix

	Mean	Variance	1	2	3
Marine High-end Human Capital	3.58	0.56			
Policy incentives	3.86	0.51	0.233**		
Marine technology innovation	3.80	0.65	0.391**	0.216*	
Marine Knowledge innovation	3.33	0.59	0.377**	0.425**	0.315**
Note: **to express P<0.01, *to express P<0.05(Two-Tailed Test), N=277					

3.2 Variable Measurement

This paper uses SPSS 22.0 to test the reliability of the internal consistency coefficient Cronbach's alpha of the total scale and sub-scale. Because the measurement items used in the research are from the previous research literature, and samples have been sampled for questionnaire testing before the formulation of the questionnaire, which deletes unreasonable options and adds reasonable options. After many times of "test-analysis-add-delete options" process, the total scale and the measurement items of each subscale

  DOI: https://doi.org/10.26549/jfr.v4i1.3514

are finally determined, so the questionnaire has a high content validity. Considering that regional economic and cultural differences may have an impact on the validity of the questionnaire structure, the validity of the scales was evaluated by structural equation model (SEM) confirmatory factor analysis (CFA) using LISREL 8.7 statistical tool.

Marine high-end human capital. The scale consists of 10 items (Adam Smith and Schultz, 1960; Yixue Huang 2015; Jinghuai Hou 2017)[16]. The scale includes three dimensions: marine knowledge capital (3 items), marine skills capital (3 items), learning ability and innovative spiritual capital (4 items). The Cronbach's alpha values of the three dimensions subscales are 0.81, 0.83 and 0.80, respectively. The Cronbach's alpha value of the total marine high-end human capital scale is 0.83. The reliability coefficients of the total scale and the subscale are all over the critical value of 0.70, which indicates that the scales have good reliability. The fitness indices of confirmatory factor analysis of marine high-end human capital scale are: $\frac{x^2}{df}=2.213$, $P < 0.05$, NFI=0.935, IFI=0.959, TLI=0.932, CFI=0.963, RMSEA=0.090. The results show that the marine high-end human capital scale has good structural validity.

Knowledge innovation. In this paper, the scale of marine knowledge innovation adopts the process of continuous socialization, externalization, integration and internalization in the process of knowledge diffusion. Socialization refers to knowledge from recessive to recessive, sharing experience to achieve innovative knowledge. Externalization refers to knowledge from recessive to dominant, and combination refers to knowledge from dominant to dominant, forming systematic knowledge. Internalization refers to the change of knowledge from dominance to recessive (Nonaka I and Takecuchi H., 1995)[17]. There were 13 items in the scale, including 3 items of socialization, 3 items of externalization, 3 items of combination and 4 items of internalization. The Cronbach's alpha values of the four dimensions subscales are 0.72, 0.82, 0.85 and 0.76, respectively. The Cronbach's alpha values of the total scale of marine knowledge innovation is 0.81. The reliability coefficients of the total scale and the sub-scale both exceed the critical value of 0.70, which indicates that they have good reliability. The fitness indices of confirmatory factor analysis of the Marine Knowledge Innovation Scale are: $\frac{x^2}{df}=2.514$, $P < 0.05$, NFI=0.977, IFI=0.976, TLI=0.977, CFI=0.982, RMSEA=0.092, indicating that the Marine Knowledge Innovation Scale has good structural validity.

Policy incentives. Material incentives are more effective than other incentives (Holmstrom and Milgrom, 1991)[18]. Spiritual motivation is considered more effective by most people (Fama, 1980). Policy incentives play an important role in technological innovation (Zhiqiang Jia et al., 2003). The measurement items in this study come from the above results, and consist of 11 items, including material incentive (3 items), spiritual incentive (4 items) and institutional incentive (4 items). The Cronbach's alpha values of the three subscales are 0.82, 0.78 and 0.80, respectively, and the Cronbach's alpha value of the aggregate policy incentive scale is 0.82. The reliability coefficients of the total scale and the sub-scale both exceed the critical value of 0.70, which indicates that they have good reliability. The fitness indices of confirmatory factor analysis of the Policy Incentive Scale are: $\frac{x^2}{df}=1.966$, $P < 0.05$, NFI=0.953, IFI=0.961, TLI=0.971, CFI=0.975, RMSEA=0.091, indicating that the policy incentive scale has good structural validity.

Marine technology innovation. The index of marine technological innovation consists of 13 measurement items, including marine technological innovation input (4 items), marine technological innovation output (3 items), and marine technological innovation effect (6 items) (Jie Lan, 2018; Fu Lv, 2017; Xinying Liu, 2007). The Cronbach's alpha values of the three dimensions subscales are 0.75, 0.81 and 0.77, respectively. The Cronbach's alpha value of the total scale of marine technological innovation is 0.79. The reliability coefficients of the total scale and the sub-scale both exceed the critical value of 0.70, which indicates that they have good reliability. The fitness indices of confirmatory factor analysis of marine technological innovation scale are: $\frac{x^2}{df}=2.321$, $P < 0.05$, NFI=0.918, IFI=0.927, TLI=0.944, CFI=0.932, RMSEA=0.087, indicating that the scale has good structural validity.

4. Empirical Results and Analysis

In order to further confirm the conceptual relationship in the model, structural equation analysis software LISREL 8.7 is used to verify the hypothesis. The model is revised according to the path coefficient of the initial model, and the revised model is analyzed again to obtain the best data interpretation.

Initial model testing. According to the hypothesis in this paper, the path analysis of the initial model is carried out by using the analysis software, and the path coefficients of the model are obtained (Figure 2). According to the test results, the following conclusions can be drawn:

in the model hypothesis, Hypothesis H1 is supported, it shows that marine high-end human capital can promote marine technological innovation. Hypothesis H2 is supported, it shows that marine high-end human capital can promote the construction of policy incentive mechanism. hypothesis H3 is not supported, the direct effect of marine high-end human capital on marine knowledge innovation is not significant. Hypothesis H4 is supported, it shows that policy incentives can promote marine knowledge innovation. Hypothesis H5 is supported, it shows that marine technological innovation is beneficial to marine knowledge innovation. Hypothesis H6 is supported, it shows that policy incentives play a mediating role in marine high-end human capital and marine knowledge innovation. Hypothesis H7 is supported, it shows that marine technological innovation plays a mediating role in marine high-end human capital and marine knowledge innovation.

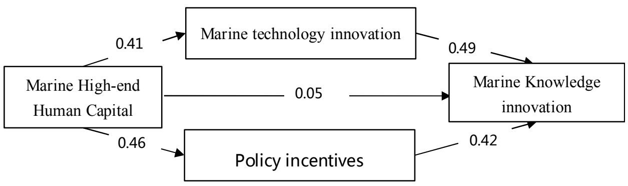

Figure 2. Intermediary model of marine high-end human capital and marine knowledge innovation

Initial model updating and path analysis. If the direct role of independent variable and dependent variable changes to zero after the intermediate variable is added, the intermediate variable plays the role of complete mediation (Baron and Kenny, 1996). In this study, the path coefficients of dependent variables and independent variables are 0.05, close to 0, and the P value is not significant when the intermediate variables are added to the model. Therefore, we can consider the full mediating role of policy incentives and marine technological innovation to modify the model. The revised model is shown in Figure 3. Through path analysis and comparison with model 2, it is found that the fitting effect of complete mediation model is slightly better than that of partial mediation model (Table 2). In order to further analyze the importance of policy incentives and marine technological innovation in marine high-end human capital and marine knowledge innovation, we can compare the path coefficients of marine high-end human capital and policy incentives, policy incentives and marine knowledge innovation with those of marine high-end human capital and marine technology innovation, marine technology innovation and marine knowledge innovation. The coefficient of influence with marine technology innovation as intermediary variable (0.41 x 0.50) is slightly larger than that with policy incentive as intermediary variable (0.46 x 0.43). This shows that marine high-end human capital is more likely to realize marine knowledge innovation through marine technology innovation as intermediary variable.

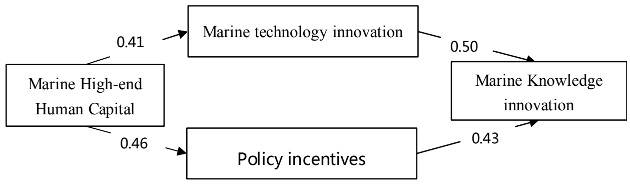

Figure 3. Complete mediation model of high-end human capital and marine knowledge innovation

Table 2. Comparison of fitting degree using structural equation model

Model	x^2/df	NFI	IFI	TLI	CFI	RMSEA
Model I	2.225	0.933	0.935	0.929	0.933	0.092
Model II	2.217	0.931	0.936	0.928	0.931	0.091
Critical value	3	0.9	0.9	0.9	0.9	0.1

5. Research Conclusions and Future Research Directions

This paper uses empirical research methods to test the mediating role of policy incentives and marine technology innovation in marine high-end human capital and marine knowledge innovation. Through factor analysis and path analysis, the following conclusions are drawn. First, marine high-end human capital has a positive impact on policy incentives. At the same time, policy incentives have a positive impact on marine knowledge innovation. Marine high-end human capital has a positive impact on marine knowledge innovation through the intermediary role of policy incentives. The direct impact of marine high-end human capital on marine knowledge innovation is not significant, and Marine high-end human capital has a positive impact on marine knowledge innovation through the intermediary role of policy incentives. Secondly, marine high-end human capital has a positive impact on marine technological innovation. At the same time, marine technological innovation has a positive impact on marine knowledge innovation. Marine high-end human capital has a positive impact on marine knowledge innovation through the intermediary role of marine technological innovation. Thirdly, policy incentives and marine technological innovation play a full intermediary role between marine high-end human capital and marine knowledge innovation. Marine high-end human capital can promote

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marine knowledge innovation through two ways. One way is that the government can adopt the combination of material incentive, spiritual incentive and institutional incentive to promote marine knowledge innovation. Another way is to increase investment in marine technological innovation and promote marine knowledge innovation through the intermediary role of marine technological innovation.

Although some new viewpoints put forward in this paper, there are still some limitations. Firstly, because the research data come from the respondents, the validity of the research is affected to some extent by the way of overall sampling and single-question answer. Future research can collect data from multiple levels and multiple channels. Secondly, due to the difficulty of data collection and the influence of time, the data come from cross-sectional data in the same period. Future research can try to use time series data to study the interaction between variables.

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