Independent Innovation or Secondary Innovation: The Moderating of Network Embedded Innovation

Bing Cao, Zishu Han, Ling Liang, Yuanyuan Liu, Jialiang Wang and Jiaping Xie

1 College of Business, Guilin University of Electronic Technology, Guilin 541004, China
2 College of Business, Shanghai University of Finance and Economics, Shanghai 200433, China
3 School of Management, Shanghai University of International Business and Economics, Shanghai 201620, China
4 School of International Business, Shanghai University of International Business and Economics, Shanghai 201620, China
* Correspondence: liang-ling@suibe.edu.cn (L.L.); liuyuanyuan@tjfsu.edu.cn (Y.L.)

Abstract: Based on the provincial data of China’s high-tech industries from 2009 to 2019, this paper constructs a stepwise regression to analyze the effect of innovation inputs, independent and secondary innovation, and innovation value, while being mediated and moderated by innovation ability and innovation network, respectively. We found that in general, innovation inputs had a significant positive direct effect on innovation valuation: a one unit increase of independent innovation increased 0.60 units of innovation valuation, and a one unit increase of secondary innovation input increased 0.78 units of innovation valuation. Innovation ability was found to be a partial mediator for independent innovation (0.74), and a complete mediator for secondary innovation (0.90). Finally, the innovation network showed significant moderating effects in both innovation input methods. Empirical research indicates that China is entering an era shifting from secondary innovation to independent innovation, and Chinese high-tech companies should focus on independent innovation.

Keywords: independent innovation; secondary innovation; innovation network; innovation valuation

1. Introduction

The high-tech industry is highly dependent on innovation-driven development and is the most innovative industry. The high-tech industry is not only the growth pole of sustainable economic development, but also the vital force in breaking the mediocrity of economic development and achieving a “dual circulation” pattern in which the domestic and international economic cycles are mutually beneficial. It is crucial for high-tech companies’ survival and growth to continuously invest in innovation, acquire external knowledge, and apply the innovation outcomes to new products and services. The health of high-tech companies will ultimately affect the development of a country’s economy [1].

1.1. Background

Innovation theory originated in the early 20th century. Schumpeter put forward the concept of “innovation” and conducted representative pioneering research on innovation management in 1912. Since Hansen et al. (2007) proposed the “innovation value chain” based on knowledge transformation [2], Roper et al. (2008; 2012) supplemented and improved the theory of the innovation value chain based on a comparison of manufacturing innovation activity in Ireland and Sweden, and proposed that the firm innovation value chain includes three progressive links [3,4]. The first link is knowledge acquisition, which obtains the necessary knowledge for innovation via various methods; the second link is knowledge transformation, which transforms knowledge into innovation achievements, including new product or process innovation; the third link is the use of knowledge, where companies utilize innovation achievements to improve product sales and profits. Some
scholars divide the innovation process into three stages: knowledge innovation, R&D design innovation, and product innovation [5–7]. Technological innovation in China has experienced four development processes: technology introduction and imitation, open market to attract investment, secondary innovation and integrated innovation, and independent innovation and collaborative innovation [8]. Based on the innovation practice with Chinese characteristics, innovation theories such as closed independent innovation, open independent innovation, and sustainable enterprise innovation have gradually formed [9].

With the trend of globalization, China has continuously acquired knowledge, carried out knowledge transformation, and improved innovative abilities through innovation introduction and self-innovation. However, the applications of innovation achievements are not satisfactory and do not create much economic value [10]. How to obtain knowledge more efficiently through the introduction of innovation and independent innovation, form innovation output, and achieve the commercial transformation of innovation achievements, has become the focus of the current government, enterprises, and academia.

1.2. Literature Review

There are many studies on improving innovation efficiency in the literature. The research scope covers the relationship between independent and secondary innovation—the choice of innovation methods—and other influencing factors of innovation, etc. There are multiple paths for enterprises to pursue technological progress. They can choose independent innovation, technology introduction, or a combination of the two strategies. Which technological progress path an enterprise chooses, is related to its technical level [10], and also to the applicability and effectiveness of the long-term development strategy and technological progress of the enterprise. Combined with the solid development background of the enterprise, relevant research has incorporated factors such as environmental constraints, trade status, resource endowments, equity incentives, digital economy, and self-created zone policies into the category of influencing factors for the choice of innovation methods and examine innovation capabilities under the influence of different factors [11–16]. In addition, the improvement of innovation ability will eventually be transformed into the sustainable economic output of enterprises. Therefore, much literature has also explored the relationship between innovation ability and economic output from different perspectives and levels, such as technology spillover effect and enterprise absorptive capacity [8]. The above analysis shows that the discussion of innovation performance requires two parts: the formation efficiency of innovation capability and the transformation efficiency of innovation achievements. This paper argues that innovation performance embodies the continuous action mechanism of innovation mode selection—innovation capability formation—innovation economic output. It is a two-stage achievement process from the start of innovation to the profit of innovation. Therefore, the research design of this paper intends to use innovation capability as a mediating cohesive variable to examine its mediating effect in the innovation value chain.

With the increasingly complex innovation environment, it is difficult for enterprises to survive and stand out in the fierce market competition by themselves. More and more enterprises are promoting collaborative innovation through cooperation [17]. During this process, a market-led and government-led innovation network has gradually formed and broadly impacted corporate innovation [15]. Freeman (1991) first proposed the concept of a scientific and technological innovation network, which is a network relationship based on orderly interaction between participating subjects [18], an organizational collective formed for innovation. Min et al. (2020) defined the concept of enterprise innovation network, and pointed out that enterprise innovation network is a network formed in the process of enterprise innovation activities, that is, the process of technological innovation includes formal and informal cooperative relations with enterprises as the core [19]. The innovation network is accompanied by the creation, flow, transfer, and spillover of knowledge [20]. It is dynamic, open, complex, and focuses on collaborative innovation [21]. The connection between multiple subjects is conducive to the accumulation of innovation resources, further
forming network externalities [8]. Moreover, joining the innovation network can stimulate enterprises to acquire, integrate and utilize essential innovation resources [22]. The network structure governance and network relationship governance of the innovation network can solve the current constraints of innovation development to a certain extent, thereby improving the innovation performance of enterprises [15]. Therefore, more and more enterprises formulate and spread technical standards by forming alliances, and obtaining innovation resources by means of network embedding, so as to improve their technological innovation performance [23]. From the above analysis, it can be seen that the innovation network brings together innovation subjects such as enterprises, scientific research institutions, intermediaries, and financial institutions. The flow of knowledge between different subjects in the innovation network creates favorable conditions for enterprise innovation. However, the existing research has not revealed the influence of an innovation network on the links of the enterprise innovation value chain. This paper argues that a firm’s innovation value chain activities are affected by the innovation network in which it is embedded, especially in knowledge acquisition. Therefore, the research design of this paper intends to use the innovation network as an embedded moderator variable to examine its moderating effect in the innovation value chain.

In contrast, some scholars believe that independent innovation capability is crucial to acquire sustainable competitive advantages for an enterprise [24]. Wu et al. (2012) constructed the double helix model of TC and TM for independent innovation, and found that both technology management and technological capabilities have a significant impact on the success of independent innovation [25]. Perks et al. (2012) found that independent innovative behavior from network partners of enterprises can foster sharing and visualization of innovation advances [26]. Therefore, independent innovation can also enhance the competitiveness of enterprises, and it is affected by the technology management and technological capabilities of enterprises.

The original definition of open innovation stressed that valuable ideas could originate from inside or outside the company and could go to market from inside or outside the company [27]. The analysis of Obradović et al. (2021) showed that research into sustainability, commitment-based HR practices, and Industry 4.0 (I40) represent important research streams for the future of OI in manufacturing [28]. Yun et al. (2020) proposed a cultural conceptual model of the dynamics of open innovation and found that culture can have different impacts on open innovation dynamics [29]. Chesbrough et al. (2018) argued that open innovation requires collaboration among distributed but interdependent actors who rely on each other’s capabilities to create and capture value [30]. Xia et al. (2020) found that when innovative talent input exceeds a specific value, the open innovation environment can alleviate the positive marginal effect of its decline [8]. To sum up, open innovation requires cooperation among enterprises, is widely applied and effective in modern enterprise management, and is influenced by culture.

1.3. Motivation and Contribution

As the micro-subject of technological innovation, the Chinese high-tech industry is a vital force to promote China’s innovation-driven development strategy and promote high-quality economic development. In the innovation process, innovation valuation is a vital index to evaluate the promotion of economic development. When studying the factors that influence innovation valuation, we should not only focus on the investment in R&D and the purchase of patents. The choice of innovation method is also important. This paper selects high-tech industries as the research object, focuses on different ways of acquiring innovative knowledge based on the theory of innovation value chain, and takes innovation ability and innovation network as the mediating variables of knowledge transformation. The main research contribution of this paper is to innovatively compare the mechanism of independent innovation and secondary innovation on the innovation valuation of the Chinese high-tech industry, and taking innovation ability and innovation network as mediating and moderating variables, respectively, further discusses how the
Chinese high-tech industry can rid itself of the status of global OEM and overcome “technical breakpoint” and “stranglehold technology”. Another research contribution of our paper is that we find that the innovation network can not only free the Chinese high-tech industry from the current innovation constraints and improve the innovation valuation of enterprises, but can also be used as an adjustment mechanism to positively mediate the impact of independent innovation and secondary innovation of enterprises on the innovation valuation of enterprises.

2. Research Design
2.1. Model Establishment

The rapidly changing high-tech industry urges high-tech firms to carry out internal research and development while acquiring new knowledge through collaboration and assimilation. Companies acquire knowledge mainly through internal research and external knowledge acquisition. Based on the differences in the sources of knowledge, resources, and capabilities, innovations can be categorized as independent innovation and secondary innovation [31]. Independent innovation refers to companies developing new products or technologies and independently conducting innovative studies [32,33]. Secondary innovation means that firms adopt strategies such as technology import to acquire resources, capabilities, and knowledge for innovation activities from external organizations, which is a concept that emphasizes the externality of the innovation knowledge source [34].

Different sources of knowledge can affect innovation output in various ways. From the perspective of internal knowledge development, greater internal R&D investment can lead to a more innovative company that produces better product or service innovation [35–37]. From the external knowledge acquisition perspective, participants with complementary knowledge resources can improve knowledge transformation efficiency by proposing and verifying ideas through cooperation [38]. Knowledge acquisition can improve the possibility of combining existing knowledge resources with external knowledge to improve knowledge transformation and innovation output. Furthermore, through independent or secondary innovation, the firm can transform the acquired new knowledge into the core technology in the form of intellectual property rights, which is reflected in the type and quantity of patents obtained [39]. As a result, we set our model to test the effectiveness of independent and secondary innovation.

The ultimate goal of firm innovation is not to acquire new knowledge nor to obtain patents but to apply the innovation output to improve corporate performance [40]. Whether innovation output from the knowledge transformation can promote corporate performance depends on the effectiveness of the firm’s knowledge transformation and its ability to obtain market share from innovation [3,41–43]. Therefore, the one purpose of high-tech companies in implementing innovation is to improve competitiveness and corporate performance, which is affected by the knowledge resources and knowledge transformation efficiency in the innovation process. Therefore, we use innovation valuation to measure the outcome of company innovation and innovation ability as a mediator that affects company innovation output.

Companies obtain knowledge through continuous internal R&D investment as well as the importing and assimilation of external technology. Through constant internal R&D investment and assimilation of advanced external technology, enterprises can obtain the knowledge resources needed for innovation. Among all kinds of knowledge, explicit knowledge becomes patents and other innovative achievements via the transformation process; tacit knowledge is applied to developing new products and services to improve corporate performance. When companies are embedded in the innovation network and carry out trusty and reciprocating activities with other companies, it encourages the transformation of tacit knowledge to explicit knowledge, causing the spillover of new knowledge and new ideas [44]. The transfer of tacit knowledge can narrow the gap between the principal role of innovation in the innovation network, and help companies to promote, participate and cooperate. Innovation network embeddedness can enable firms to obtain knowledge and information sources in the alliance, promoting company performance [45]. The innovation
collaboration in the innovation network can reduce not only the cost and risk of companies, but also enable the efficient transformation of tacit knowledge, which can help the companies to be competitive [46]. Thus, an innovation network is not only a vital channel for companies to obtain the resources for innovation, but also encourages tacit knowledge spillover and direct knowledge application to improve innovation valuation [47]. We introduce the innovation network as a moderating variable in company innovation process.

Based on the previous analysis, we constructed the model demonstrated in Figure 1.

Figure 1. Model concept.

2.2. Data

The data used in this paper were provincial data sets from the China Statistical Yearbook on High Technology Industry (2010–2020) and the China Statistical Yearbook on Science and Technology (2010–2020) published by the Chinese National Bureau of Statistics. Both yearbooks include the total value of innovation investment, valuation, and knowledge sharing data from 32 administrative divisions in mainland China, and represent the overall performance of high-tech companies across 22 provinces, 5 autonomous regions, and 4 centrally-administered municipalities. According to the definition from the National Bureau of Statistics, the high-tech industry refers to industry that has high innovation investment intensity (http://www.stats.gov.cn/tjsj/tjbz/gjtjbz/201310/P0202-006125 82959783957.PDF accessed on 1 October 2022). The expenditure for acquisition of foreign technology, the expenditure for assimilation of technology, the number of patents in force, and the sales revenue of new products were collected from the China Statistical Yearbook on High Technology Industry (2010–2020). From the China Statistical Yearbook on Science and Technology (2010–2020), we captured contract exportation from domestic technical markets by region and the value of contract exportation from domestic technical markets by region. Due to the lack of data in some provinces and years, we excluded data that contained missing values.

2.3. Variables

This paper used internal R&D investment and foreign advanced technology investment as the innovation method of high-tech companies. Since companies can use both internal and external knowledge to improve innovation output, it is not enough to measure the innovation input of companies merely by internal R&D investment. The measurement should also include technology import and assimilation fees. Therefore, we used R&D expenditure (RDEX) and investment intensity of independent innovation (IIINDE) to measure the input of independent innovation. To measure the input of secondary innovation, we used the expenditure for the assimilation of technology (AEX) and the investment intensity of secondary innovation (IISEC).

This paper used the number of authorized patents (M) to measure the innovation ability of companies. Existing literature mainly uses the number of invention patent applications or authorized patents [48]. However, patent invention and innovation ability are usually highly correlated, which makes the number of patents the best reflection of innovation output. Moreover, patent statistics are easy to obtain and are often used as a standard to evaluate a firm’s innovation ability [49].
We chose the sales revenue of new product from high-tech companies® to measure the firm innovation valuation. From the perspective of innovation knowledge application, the existing literature primarily uses new product sales to measure innovation valuation [50,51]. Company innovation valuation significantly improves product performance or expands product functionality by adopting new technology, design, structure, material, and process improvement while obtaining market recognition. The increasing income from new products can reflect such improvement.

In order to evaluate the influence of the innovation network in the innovation process, we used contract exportation from domestic technical markets by region as the index (W). This index counts the total number of high-tech authorization or purchase contracts initiated in the given administrative divisions, representing knowledge flow. Since the basic activity of an innovation network is knowledge flow [52], we used this index as the measurement variable of the innovation network.

Table 1 is the summary of the index variables.

### Table 1. Index variables.

| Index Description                                | Variable Name |
|-------------------------------------------------|---------------|
| R&D expenditure                                 | RDEX          |
| Investment intensity of independent innovation   | IIINDE        |
| Expenditure for assimilation of technology       | AEX           |
| Investment intensity of secondary innovation     | IISEC         |
| Number of authorized patents in force            | M             |
| Contract exportation from domestic technical markets by region | W |
| Income from new products                         | R             |

3. Empirical Test

3.1. Descriptive Analysis

Table 2 shows the mean, standard deviation, minimum, and maximum values for all variables and indicators.

### Table 2. Descriptive analysis.

| Variable | Mean Value | Standard Deviation | Minimum Value | Maximum Value |
|----------|------------|--------------------|---------------|---------------|
| RDEX     | 1,068,657.036 | 1,787,483.530     | 12,117        | 12,040,270    |
| IIINDE   | 0.105      | 0.088              | 0.013         | 0.730         |
| AEX      | 5874.501   | 9480.962           | 0             | 73,868        |
| IISEC    | 0.003      | 0.008              | 0             | 0.092         |
| M        | 10,266.571 | 29,051.864         | 21            | 230,537       |
| W        | 13,438.643 | 14,204.416         | 650           | 81,311        |
| R        | 17,065,292.656 | 31,657,249.352  | 92,087        | 220,050,838   |

As shown in Table 2, the development of high-tech industries in Chinese provinces is uneven. There is considerable difference between investment for independent innovation and expenditure on the import of foreign technology, which leads to significant differences in the number of authorized patents in force, the number of contract exportations from domestic technical markets by region, and income from new products.

3.2. Multicollinearity Test

In order to judge whether there is a collinearity issue, we conducted a correlation test on variables and calculated the correlation coefficient as well as the variance expansion factor VIF of each explanatory variable.

As shown in Table 3, except for the mediation variable, most correlation coefficients in the analysis were within 0.8. It indicated a weak correlation between variables, indicating no significant multicollinearity problem.
### Table 3. Correlation test results.

|        | RDEX   | IIINDE | AEX    | ISEC   | M       | W       | R       |
|--------|--------|--------|--------|--------|---------|---------|---------|
| RDEX   | 1      | -0.150* | 0.278** | 0.500** | 0.943** | 0.353** | 0.974** |
| IIINDE |        | 1      | -0.016 | 0.130  | -0.029  | 0.214** | 0.282** |
| AEX    | 0.278**| 1      | 0.520** | 0.130  | -0.026  | 0.247** | 0.934** |
| ISEC   | 0.049  | -0.016 | 1      | -0.029 | 1       | 0.247** | 0.282** |
| M      | 0.943**| 0.520** | 0.130  | 1      |         |         |         |
| W      | 0.353**| -0.016 | 0.214**| -0.026 | 1       |         |         |
| R      | 0.974**| 0.282**| 0.247**| 0.934**| 0.318** | 1       |         |

*, ** Significant correlation at the 95%, 99% levels, respectively (two-tailed).

#### 3.3. Variables Factor Test

Based on the variables in the model, we used SPSS 26.0 to process the data set. First, we conducted the Bartlett–KMO test on the raw data from two factors. The results in Table 4 illustrate that the KOM value was 0.5, and the significance was 0.000, less than 1%. The variables were suitable for factor analysis.

### Table 4. Result of variables factor test.

| Factor               | Measured Variables | Standard Communality | Results                                      |
|----------------------|--------------------|----------------------|----------------------------------------------|
| Independent innovation | RDEX   | 0.575                | KMO = 0.5, approx. chi-square: 5.025; p = 0.025, variance: 57.488. |
|                      | IIINDE | 0.575                |                                              |
| Secondary innovation  | AEX    | 0.565                | KMO = 0.5, approx. chi-square: 3.752; p = 0.053, variance: 56.48. |
|                      | AP     | 0.565                |                                              |

Firstly, we extracted common factors from internal R&D expenditure and investment intensity of independent innovation using the principal component analysis. As shown in Table 1, the “independent innovation” factor only contained one common factor (0.5), and the total variance was 57.488%, indicating that the extracted factor had a solid validity. With the same method, we used principal component analysis to extract common factors from two variables: expenditure for assimilation of technology and investment intensity of secondary innovation. Table 1 shows that the factor of “secondary innovation” only contained one common factor. The factor loading of the index was 0.565, and the total variance was 56.48% which verified its validity. Therefore, in the following empirical analysis, we used independent innovation (II) and secondary innovation (SI) as two of the independent variables in the model.

#### 3.4. Mediating Effect Regression Results

We used the stepwise regression method to run regression analysis. This section shows the results of the regression.

As presented in Table 5, we carried out four regression models to verify the influence of independent innovation on the dependent variable via innovation ability as a mediating variable. The first model only considered the effect of independent innovation on the income from independent innovation. The results showed that independent innovation positively impacted the revenue from new products ($\beta = 0.777, p < 0.01$). Models two, three, and four tested the mediating mechanism of knowledge transformation. The results showed that knowledge transformation plays a role of partial mediation. Therefore, investment in independent innovation can effectively improve the performance of companies, and innovation ability is a positive mediator that can increase the output of independent innovation.
Table 5. The mediating effect of innovation ability on independent innovation.

| Variables | R       | M       | R       |
|-----------|---------|---------|---------|
|           | Model 1 | Model 2 | Model 3 | Model 4 |
| II        | 0.777 *** | 0.678 *** | 0.275 *** |
|           | (18.194) | (13.515) | (9.527)  |
| M         | 0.929 *** | 0.741 *** |
|           | (36.605) | (25.506) |
| Year fixed effect | Yes | Yes | Yes | Yes |
| R²        | 0.641 | 0.874 | 0.505 | 0.912 |
| R² adjusted | 0.622 | 0.868 | 0.479 | 0.907 |
| F         | 34.190 | 133.536 | 19.570 | 182.042 |
| Number of obs. | 224 | 224 | 224 | 224 |

Note: *** indicate significance at 99% level, respectively; t value is in the parentheses.

As shown in Table 6, we carried out four regression models to verify the influence of secondary innovation on the dependent variable via innovation ability as a mediating variable. The first model only considered the effect of secondary innovation on innovation valuation. The results showed that secondary innovation positively impacted the income from new products ($\beta = 0.597, p < 0.01$). That is to say, companies can improve their performance by increasing the assimilation of technology or the proportion of foreign secondary technology.

Table 6. The mediating effect of innovation ability on secondary innovation.

| Variables | R       | M       | R       |
|-----------|---------|---------|---------|
|           | Model 1 | Model 2 | Model 3 | Model 4 |
| SI        | 0.597 *** | 0.613 *** | 0.044 |
|           | (11.003) | (11.488) | (1.371) |
| M         | 0.929 *** | 0.902 *** |
|           | (36.605) | (27.921) |
| Year fixed effect | Yes | Yes | Yes | Yes |
| R²        | 0.413 | 0.874 | 0.432 | 0.876 |
| R² adjusted | 0.383 | 0.868 | 0.402 | 0.868 |
| F         | 13.517 | 133.536 | 14.581 | 123.075 |
| Number of obs. | 224 | 224 | 224 | 224 |

Note: *** indicate significance at 99% level, respectively; t value is in the parentheses.

Models two, three, and four tested the mediating mechanism of innovation ability. The results showed that knowledge transformation had a complete mediation effect on innovation valuation in terms of secondary innovation. Such result implies that secondary innovation has a different mechanism compared with independent innovation. Independent innovation has a direct effect on innovation valuation, but secondary innovation only affects innovation valuation through the mediator. Yet, there is no doubt about the positive influence of secondary innovation on innovation valuation.

3.5. Moderating Effect Regression Results

We further investigated whether innovation network activities can positively affect the relationship between knowledge acquisition and application. Based on our model, we added the number of contract exportations representing the influence of the innovation network into the regression as a moderating variable. The regression results are shown in Tables 7 and 8.
Table 7. The moderating effect of the innovation network on independent innovation.

| Variables | Model 1 | Model 2 | Model 3 |
|-----------|---------|---------|---------|
| II        | 0.777 *** | 0.759 *** | 0.734 *** |
|           | (18.194) | (17.112) | (24.685) |
| W         | 0.066   | −0.040  | −0.468 *** |
|           | (1.515) | (−1.316) | (16.083) |
| II × W    |         |         |         |
| Year fixed effect | Yes | Yes | Yes |
| R²        | 0.641   | 0.644   | 0.841   |
| R² adjusted | 0.622 | 0.624   | 0.831   |
| F value   | 34.190  | 31.725  | 85.113  |
| Number of obs. | 224 | 224 | 224 |

Note: *** indicate significance at 99% level, respectively; t value is in the parentheses.

Table 8. The moderating effect of the innovation network on secondary innovation.

| Variables | Model 1 | Model 2 | Model 3 |
|-----------|---------|---------|---------|
| SI        | 0.597 *** | 0.564 *** | 0.618 *** |
|           | (11.003) | (10.379) | (14.785) |
| W         | 0.161   | 0.066   | 0.502 *** |
|           | (2.992) | (1.569) | (12.261) |
| SI × W    |         |         |         |
| Year fixed effect | Yes | Yes | Yes |
| R²        | 0.413   | 0.437   | 0.673   |
| R² adjusted | 0.383 | 0.405   | 0.652   |
| F value   | 13.517  | 13.604  | 33.053  |
| Number of obs. | 224 | 224 | 224 |

Note: *** indicate significance at 99% level, respectively; t value is in the parentheses.

The regression result in Table 7 had three models to verify how the innovation network regulates direct effect and the impact of independent innovation on innovation valuation. Model 3 tested that the innovation network had a positive and significant moderating effect on the direct effect model ($\beta = 0.468, p < 0.01$), which implies that the innovation network is a powerful boosting effect in the independent innovation process.

The regression analysis in Table 8 had three models to verify how the innovation network regulates the direct effect and the impact of secondary innovation on innovation valuation. The result of model 3 indicated that the innovation network had a positive and significant moderating effect on the direct effect model ($\beta = 0.501, p < 0.01$).

For secondary innovation, innovation ability was a boosting moderator. Compared with independent innovation, the integration of secondary innovation activities and the innovation network played a more significant role in innovation valuation, indicating that high-tech companies heavily invested in secondary innovation activities should be actively embedded in the innovation network.

Apart from the previous analysis, we performed a robustness test that used an alternative index to measure the innovation network.

This index counts the total number of high-tech authorizations or contracts purchased in the given region ($W'$). As we can see in Tables 9 and 10, the number of contract inflows to domestic technical markets still played a positive role in the relationship between independent, secondary innovation and knowledge application ($\beta = 0.558, p < 0.01$, Table 8; $\beta = 0.458, p < 0.01$, Table 9). The result was similar to the results in the previous regression.
Table 9. The robustness test of the moderating effect of the innovation network (independent innovation).

| Variables | Model 1 | Model 2 | Model 3 |
|-----------|---------|---------|---------|
| II        | 0.777 *** (18.194) | 0.687 *** (14.889) | 0.559 *** (21.691) |
| W’        | 0.198 *** (4.264) | 0.029 (1.080) | 0.558 *** (22.344) |
| II × W’   |                     |                     |                    |

Year fixed effect: Yes
R²: 0.641
R² adjusted: 0.622
F value: 34.190
Number of obs.: 224

Note: *** indicate significance at 99% level, respectively; t value is in the parentheses.

Table 10. The robustness test of moderating effect of innovation network (secondary innovation).

| Variables | Model 1 | Model 2 | Model 3 |
|-----------|---------|---------|---------|
| SI        | 0.597 *** (11.003) | 0.481 *** (9.152) | 0.566 *** (13.335) |
| W’        | 0.351 *** (6.591) | 0.186 *** (4.153) | 0.458 *** (11.097) |
| SI × W’   |                     |                     |                    |

Year fixed effect: Yes
R²: 0.641
R² adjusted: 0.622
F value: 34.190
Number of obs.: 224

Note: *** indicate significance at 99% level, respectively; t value is in the parentheses.

4. Conclusions

4.1. Research Findings

This paper discusses the innovation ability and innovation valuation of Chinese enterprises’ technological innovation in the past decade. Through the mediating effect of innovation ability and the moderating effect of the innovation network, the research discusses the impact of independent and secondary innovation on innovation valuation. The study found that both independent and secondary innovation has a positive effect on innovation valuation, and innovation ability plays a partial mediating role in the impact of independent innovation on innovation valuation, and plays a complete mediating role in the impact of secondary innovation on innovation valuation. Moreover, the innovation network positively mediates the impact of independent and secondary innovation on innovation performance. Compared with secondary innovation, although innovation ability still plays a part as an intermediary between independent innovation and innovation valuation, independent innovation itself also stimulates innovation valuation. Our finding indicates that the innovation mode of Chinese high-tech enterprises has shifted from secondary innovation to independent innovation, and China has now entered the era of independent innovation.

4.2. Research Implications

Our study provides research implications for the Chinese high-tech industry in the following aspects.
Independent innovation and secondary innovation are not only the primary sources of knowledge for Chinese high-tech companies, but also the essential driving forces for the development of the Chinese high-tech industry. Therefore, high-tech companies should further increase their investment in innovation. Such a leading effect in the industry can significantly improve the innovation ability and innovation valuation of high-tech companies. It should be emphasized that independent R&D is significant to mastering core technology, and is the main source of core competence of high-tech companies. With the rising knowledge intensity and innovation complexity, the need for knowledge resources for independent R&D in high-tech firms will increase. The rich stock of knowledge resources indicates a higher possibility for firms to acquire new knowledge through independent research. In the big picture, the rapid evolution of the Chinese high-tech industry has led to a rich stock of knowledge resources, laying a solid foundation for independent innovation.

For technological innovation-oriented enterprises, independent innovation can achieve competitive technological advantages, especially in strategic emerging industries. Secondary innovation aims mainly at achieving technological catch-up and surpassing competitors in existing industries. When the existing knowledge resources cannot satisfy the increasing R&D requirements, firms will seek to obtain knowledge externally [53]. When the company’s knowledge resources are scarce, it is more likely to acquire new knowledge from outside. Therefore, enterprises can also re-innovate after assimilating scientific and technological innovation technologies through secondary innovation.

How do Chinese enterprises balance independent innovation and secondary innovation? On one hand, enterprises can use independent innovation to promote subversive innovation and obtain a subversive technology advantage over competitors in the industry, and achieve technological leadership based on technological advantages. On the other hand, in the process of breakthrough innovation, enterprises attach great importance to the acquisition of innovation resources, especially the acquisition of external knowledge.

4.3. Policy Implications

In the process of supporting the Chinese high-tech industry, the Chinese government needs to consider building an innovation chain around the industrial chain. On the one hand, the Chinese government needs to improve the risk aversion mechanism for R&D development and continuously narrow the technological gap with developed countries to achieve technological catch-up. On the other hand, the Chinese government needs to improve the mechanism for acquiring innovative resources, stimulate the market potential of the domestic cycle, and expand the financing channels for innovative capital through technology finance and supply chain financing. The government should not only guide enterprises on how to avoid the technical risks of technology industrialization, but also remind enterprises to continuously increase their R&D technology investment capital and increase the intensity of investment.

The Chinese government also needs to strengthen the construction of the technological innovation network and improve the flow of knowledge. The first part of the latter statement means building a collaborative technological innovation network around the needs of the high-tech industry demand chain. The problem of the innovation value chain in the Chinese technological innovation network must be targeted. Based on the technology demand chain of the high-tech industry, building a technological innovation network with both upstream and downstream companies, research facilities, and institutions of higher education would take full advantage of knowledge resources from all parties, promoting knowledge flow and achieving the sustainable development of the high-tech industry. Regions with a lower level of high-tech industry development need to actively participate in the technological innovation network and explore different fields, eventually forming differentiated regional clusters.

A further policy implication is to complete the governance for technological innovation. Governance of technological innovation is not only via innovative policies but also interaction among different roles in the innovation system [54]. Although China has
issued many policies to encourage innovation and to shift the high-tech industry from “secondary innovation” to “independent innovation” in a timely manner, it is vital to promote governance for technological innovation. Therefore, there is an undoubtful necessity to establish specific rules of cross-platform information and data exchange [55]. Meanwhile, the improvement of policies on intellectual property rights, trading, patent licensing, and other institutional arrangements and the establishment of a solid foundation for knowledge-driven innovation, similarly is essential.

4.4. Research Limitation and Prospects

A limitation of this study is that the types of innovation networks are not discussed further. We believe that innovation networks can be built in various forms, and because of different participants, innovation cooperation methods are also different. For example, the government departments in China’s Yangtze River Delta region have promoted the use of technology innovation platforms to attract small and medium-sized enterprises to the platform and guide enterprises to carry out technological innovations. As such enterprises have very limited funds, it is difficult to commercialize the innovative patented technology of independent innovation. Another example is that the Chinese government has established 23 independent innovation parks since 2009, to encourage regional collaborative innovation to encourage independent innovation of enterprises. Therefore, the strength of the moderating effect of the innovation network based on different innovation cooperation methods is also different. Additionally, as one of the network governance mechanisms, the science and technology innovation platform is worthy of further research.

Author Contributions: Conceptualization, J.X. and B.C.; validation, L.L.; data curation, Z.H. and J.W.; methodology and writing—review and editing, L.L., Z.H. and J.W.; resources, B.C. and L.L.; software, Z.H., J.W. and Y.L.; formal analysis and writing—original draft preparation, B.C, L.L. and Y.L. The authors contributed equally to the paper and author names are in alphabetical order. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Major Program of National Social Science Foundation of China (Grant No. 20&ZD060), the National Social Foundation of China (Grant No. 21BGL129) and the Fundamental Research Funds for the Central Universities, Shanghai University of Finance and Economics (Grant No. 2021110837).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding authors, Ling Liang and Yuanyuan Liu, upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Ganotakis, P.; Love, J.H. The innovation value chain in new technology-based firms: Evidence from the UK. J. Prod. Innov. Manag. 2012, 29, 839–860. [CrossRef]
2. Hansen, M.T.; Birkinshaw, J. The innovation value chain. Harv. Bus. Rev. 2007, 85, 121. [PubMed]
3. Roper, S.; Arvanitis, S. From knowledge to added value: A comparative, panel-data analysis of the innovation value chain in Irish and Swiss manufacturing firms. Res. Pol. 2012, 41, 1093–1106. [CrossRef]
4. Roper, S.; Du, J.; Love, J.H. Modelling the innovation value chain. Res. Pol. 2008, 37, 961–977. [CrossRef]
5. Suttmeier, R.P.; Cao, C.; Simon, D.F. “Knowledge Innovation” and the Chinese Academy of Sciences. Science 2006, 312, 58–59. [CrossRef]
6. Paolillo, J.G.; Brown, W.B. How organizational factors affect R&D innovation. Res. Manag. 1978, 21, 12–15.
7. Danneels, E. The dynamics of product innovation and firm competences. Strateg. Manag. J. 2002, 23, 1095–1121. [CrossRef]
8. Xie, J.; Kong, H.; Liang, L.; Wang, H. Governance Factor Mechanism of Independent Innovation S&T Platforms: A Qualitative Study of the Grounded Theory. J. Shanghai Univ. Financ. Econ. 2019, 21, 64–80.
9. Lianto, B.; Dachyar, M.; Soemardi, T.P. Continuous innovation: A literature review and future perspective. Int. J. Adv. Sci. Eng. Inf. Technol. 2018, 8, 771–779. [CrossRef]
10. Ahlstrom, D.; Yang, X.; Wang, L.; Wu, C. A global perspective of entrepreneurship and innovation in China. Multinatl. Bus. Rev. 2018, 26, 302–318. [CrossRef]

11. Lv, C.; Shao, C.; Lee, C.-C. Green technology innovation and financial development: Do environmental regulation and innovation output matter? Energy Econ. 2021, 98, 105237. [CrossRef]

12. Song, Y.; Yang, T.; Zhang, M. Research on the impact of environmental regulation on enterprise technology innovation—an empirical analysis based on Chinese provincial panel data. Environ. Sci. Pollut. Res. 2019, 26, 21835–21848. [CrossRef] [PubMed]

13. Ma, J.; Hu, Q.; Shen, W.; Wei, X. Does the low-carbon city pilot policy promote green technology innovation? Based on green patent data of Chinese A-share listed companies. Int. J. Environ. Res. Public Health 2021, 18, 3695. [CrossRef] [PubMed]

14. Du, J.-A.; Liu, Y.; Diao, W.-X. Assessing regional differences in green innovation efficiency of industrial enterprises in China. Int. J. Environ. Res. Public Health 2019, 16, 940. [CrossRef] [PubMed]

15. Xie, J.; Jia, H.; Dong, Q.; Aisaiti, G. Research on the Governance Mechanism of Independent Innovation Network in the Core Area of Silk Road Economic Belt. Sustainability 2022, 14, 7589. [CrossRef]

16. Aisaiti, G.; Xie, J.; Zhang, T. National Innovation Demonstration Zone policy and city innovation capability—A quasi-natural experimental analysis. Ind. Manag. Data Syst. 2022, ahead-of-print. [CrossRef]

17. Cowan, R.; Jonard, N. Knowledge portfolios and the organization of innovation networks. Acad. Manag. Rev. 2009, 34, 320–342. [CrossRef]

18. Hurmelinna-Laukkanen, P.; Nätti, S.; Pikkarainen, M. Orchestrating for lead user involvement in innovation networks. Technovation 2021, 108, 102526. [CrossRef]

19. Min, S.; Kim, J.; Sawing, Y.-W. The effect of innovation network size and public R&D investment on regional innovation efficiency. Technol. Forecast. Soc. Change 2020, 155, 119998. [CrossRef]

20. Liu, Y.; Shao, X.; Tang, M.; Lan, H. Spatio-temporal evolution of green innovation network and its multidimensional proximity analysis: Empirical evidence from China. J. Clean. Prod. 2021, 283, 124649. [CrossRef]

21. Funk, R.J. Making the most of where you are: Geography, networks, and innovation in organizations. Acad. Manag. J. 2014, 57, 193–222. [CrossRef]

22. Kumar, P.; Zaheer, A. Ego-network stability and innovation in alliances. Acad. Manag. J. 2019, 62, 691–716. [CrossRef]

23. Yang, X.; Wang, H.; Gu, X. Impact of Enterprise Innovation Network Characteristics on Relationship Learning: Mediating Effect of Absorptive Capacity. In Proceedings of the International Conference on Management Science and Engineering Management, Chisinau, Moldova, 30 July–2 August 2020; pp. 687–703. [CrossRef]

24. Shan, W.; Zhang, Q. Extension theory and its application in evaluation of independent innovation capability. Kybernetes 2009, 38, 457–467. [CrossRef]

25. Wu, W.W.; Yu, B.; Wu, C. How China’s equipment manufacturing firms achieve successful independent innovation: The double helix mode of technological capability and technology management. Chin. Manag. Stud. 2012, 6, 160–183. [CrossRef]

26. Perks, H.; Gruber, T.; Edvardsson, B. Co-creation in radical service innovation: A systematic analysis of microlevel processes. J. Prod. Innov. Manag. 2012, 29, 935–951. [CrossRef]

27. Chesbrough, H. The Era of Open Innovation. MIT Sloan Management Review, 15 April 2003; 35–36.

28. Obradović, T.; Vlačić, B.; Dabić, M. Open innovation in the manufacturing industry: A review and research agenda. Technovation 2021, 102, 102221. [CrossRef]

29. Yun, J.J.; Zhao, X.; Jung, K.; Yigitcanlar, T. The culture for open innovation dynamics. Sustainability 2020, 12, 5076. [CrossRef]

30. Chesbrough, H.; Lettl, C.; Ritter, T. Value creation and value capture in open innovation. J. Prod. Innov. Manag. 2018, 35, 930–938. [CrossRef]

31. Mol, M.J. Does being R&D intensive still discourage outsourcing?: Evidence from Dutch manufacturing. Res. Pol. 2005, 34, 571–582. [CrossRef]

32. Grossman, G.M.; Helpman, E. Endogenous innovation in the theory of growth. J. Econ. Perspect. 1994, 8, 23–44. [CrossRef]

33. Li, Y.; Li, X.; Liu, Y.; Barnes, B.R. Knowledge communication, exploitation and endogenous innovation: The moderating effects of internal controls in SMEs. RD Manag. 2011, 41, 156–172. [CrossRef]

34. Cassiman, B.; Veugels, R. In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. Manag. Sci. 2006, 52, 68–82.

35. Thu, T.P.M.; Knoben, J.; Vermeulen, P.; Tran, D.T. Made in Vietnam: Internal, collaborative, and regional knowledge sources and product innovation in Vietnamese firms. Eur. J. Innov. Manag. 2018, 21, 581–600. [CrossRef]

36. Baumann, J.; Kritikos, A.S. The link between R&D, innovation and productivity: Are micro firms different? Res. Pol. 2016, 45, 1263–1274. [CrossRef]

37. Barasa, L.; Knoben, J.; Vermeulen, P.; Kimuyu, P.; Kinyanjui, B. Institutions, resources and innovation in East Africa: A firm level approach. Res. Pol. 2017, 46, 280–291. [CrossRef]

38. Laursen, K.; Salter, A. Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. Strateg. Manag. J. 2006, 27, 131–150. [CrossRef]

39. Yli-Renko, H.; Autio, E.; Sapienza, H.J. Social capital, knowledge acquisition, and knowledge exploitation in young technology-based firms. Strateg. Manag. J. 2001, 22, 587–613. [CrossRef]

40. Geroski, P.; Machin, S.; Van Reenen, J. The profitability of innovating firms. RAND J. Econ. 1993, 24, 198–211. [CrossRef]

41. Troilo, G.; De Luca, L.M.; Atuahene-Gima, K. More innovation with less? A strategic contingency view of slack resources, information search, and radical innovation. J. Prod. Innov. Manag. 2014, 31, 259–277. [CrossRef]

Sustainability 2022, 14, 14796
42. Mitrega, M.; Forkmann, S.; Zaefarian, G.; Henneberg, S.C. Networking capability in supplier relationships and its impact on product innovation and firm performance. *Int. J. Oper. Prod. Manag.* 2017, 37, 577–606. [CrossRef]

43. Visnjic, I.; Wengarten, F.; Neely, A. Only the brave: Product innovation, service business model innovation, and their impact on performance. *J. Prod. Innov. Manag.* 2016, 33, 36–52. [CrossRef]

44. Isaksson, O.H.; Simeth, M.; Seifert, R.W. Knowledge spillovers in the supply chain: Evidence from the high tech sectors. *Res. Pol.* 2016, 45, 699–706. [CrossRef]

45. Capaldo, A. Network structure and innovation: The leveraging of a dual network as a distinctive relational capability. *Strateg. Manag. J.* 2007, 28, 585–608. [CrossRef]

46. Nonaka, I.; Takeuchi, H. The knowledge-creating company. *Harv. Bus. Rev.* 2007, 85, 162.

47. Paruchuri, S.; Awate, S. Organizational knowledge networks and local search: The role of intra-organizational inventor networks. *Strateg. Manag. J.* 2017, 38, 657–675. [CrossRef]

48. Kim, S.; Park, H. Effects of various characteristics of social commerce (s-commerce) on consumers’ trust and trust performance. *Int. J. Inf. Manag.* 2013, 33, 318–332. [CrossRef]

49. Bode, E. The spatial pattern of localized R&D spillovers: An empirical investigation for Germany. *J. Econ. Geogr.* 2004, 4, 43–64.

50. Liu, X.; Buck, T. Innovation performance and channels for international technology spillovers: Evidence from Chinese high-tech industries. *Res. Pol.* 2007, 36, 355–366. [CrossRef]

51. Guan, J.C.; Gao, X. Exploring the h-index at patent level. *J. Am. Soc. Inf. Sci. Technol.* 2009, 60, 35–40. [CrossRef]

52. Xie, X.; Fang, L.; Zeng, S. Collaborative innovation network and knowledge transfer performance: A fsQCA approach. *J. Bus. Res.* 2016, 69, 5210–5215. [CrossRef]

53. Hottenrott, H.; Lopes-Bento, C. (International) R&D collaboration and SMEs: The effectiveness of targeted public R&D support schemes. *Res. Pol.* 2014, 43, 1055–1066.

54. Boekholt, P.; Arnold, E.; Deiaco, E.; McKibbin, S.; Simmonds, P.; Stroya, J.; de la Mothe, J. *The Governance of Research and Innovation; An International Comparative Study Country Reports;* Technopolis: Amsterdam, The Netherlands, 2002.

55. Anderson, R.; Moore, T. The economics of information security. *Science* 2006, 314, 610–613. [CrossRef] [PubMed]