sustainability

MDPI

Article

Original Innovation through Inter-Organizational Collaboration: Empirical Evidence from University-Focused Alliance Portfolio in China

Jia Zhou [1], Aifang Guo [1], Yutao Chen [2,*] and Jin Chen [3]

[1] School of Economics and Management, Zhejiang Sci-Tech University, Hangzhou 310018, China; zhoujiazstu@zstu.edu.cn (J.Z.); gaifang@163.com (A.G.)
[2] School of Marxism, Zhejiang College of Construction, Hangzhou 311231, China
[3] School of Economics and Management, Tsinghua University, Beijing 100084, China; chenjin@sem.tsinghua.edu.cn
* Correspondence: chenytjy@foxmail.com

Abstract: A university-focused alliance portfolio is a manifestation of industry–university–research cooperation and has become an important path to realize original innovation in science and technology. Unlike traditional technological innovation, original innovation particularly emphasizes new ideas and research areas never covered before. This paper integrates resource-based theory, alliance portfolio theory, and innovation theory, and aims to scientifically establish an evaluation index system of original innovation performance from the three dimensions of initiate research, technology breakthrough, and research breakthrough. The work explores how a university can select partners to realize collaborative innovation in the context of inter-organizational scientific research cooperation with multiple innovation subjects for nationwide research institutes and universities in mainland China. The empirical results show that resource complementarity has a significant positive effect on innovation performance. Three typical universities in the "2011 project" are selected as post-interview cases for enriching empirical evidence. This study contributes to original innovation literature by introducing the concept of resource complementarity in a university-focused alliance portfolio, and further provides implications for original and science-driven innovation studies and suggests directions for university and research institutes.

Keywords: university-focused alliance portfolio; resource complementarity; original innovation; inter-organizational collaboration

Citation: Zhou, J.; Guo, A.; Chen, Y.; Chen, J. Original Innovation through Inter-Organizational Collaboration: Empirical Evidence from University-Focused Alliance Portfolio in China. *Sustainability* **2022**, *14*, 6162. https://doi.org/10.3390/su14106162

Academic Editors: João Carlos Correia Leitão and Dina Batista Pereira

Received: 14 April 2022
Accepted: 17 May 2022
Published: 19 May 2022

1. Introduction

Original innovation serves as the cornerstone of national core competencies. The sustained economic development of a country requires original theories and disruptive technologies in fundamental and high-tech research fields to reduce technological dependence on other countries, thereby adapting rapidly to the needs of a volatile global environment and advanced production systems. Innovations and technological changes are not only the result of scientific and technical discoveries, but also of a complex chain reaction triggered by the interplay between specific demands and solutions designed to overcome technology bottlenecks [1]. Previous studies have shown that national demand is a source of innovation, and public universities may also have a considerable economic impact on innovation via the demand side [2]. Universities have a higher propensity to introduce more radical product innovations, attributed to the special role played by academic scientists as knowledge brokers, bringing insights to other organizations about the evolution of technologies and needs that are not yet common in the marketplace.

Universities often play the role as key innovators of original innovation and have achieved a litany of original innovations in recent years through inter-organizational collaborations (i.e., the formation of loose collaborations through multi-partners, i.e., a dynamic alliance portfolio). For example, the latest resonance structure of the "tetraquark particle" Zc (3900), which was hailed by Physics magazine as one of the top 11 breakthroughs in physics in the world in 2013, was discovered through the collaborative efforts of several universities. Another major breakthrough in research in this field in 2017, the discovery of the "double-charm baryon", a new particle, was also based on a multi-university collaboration by 72 units and even a multinational collaboration by 16 countries.

So, is it possible to achieve original innovation with the creation and funding of an innovation platform for multiple actors, and what characteristics do partners need to have? This paper argues that the essence of collaborative innovation by multiple organizations is not to build a brick-and-mortar Research & Development platform or innovation center, but to generate new knowledge by seeking partners with complementary resources for knowledge interaction and exploratory learning based on existing research foundation, so that the organizational structure is more in line with the alliance portfolio model with the university and research institutions as the focal organizations. According to the definition of alliance portfolio in the enterprise context [3–5], we extend the enterprise context to all organizational contexts, such as universities and research institutes, and argue that the alliance portfolio connotes a collection of bilateral as well as multilateral collaborative relationships involving focal organizations and is manifested in the form of a virtual network of individual centers. The selection of partners by focal organizations and the governance of alliance portfolios have long been important issues in the field of alliance portfolio research. Established research has found that alliance portfolio diversity (organization diversity, industry diversity, function diversity, technology diversity) and alliance management capabilities are important factors for enhancing innovation performance to a certain extent [6,7], with a bias towards emphasizing partner heterogeneity [8,9], while not taking into account the complementary factor of partner organizations. However, for universities, which are knowledge-creating rather than just value-creating organizations, the complementary knowledge and resources provided by other organizations, such as other universities, external research institutes, enterprises, and government, are the main sources of innovation [10,11], and the collaboration between organizations and partners with complementary resources can enhance innovation performance [12]; therefore, we seek to explore the relationship between partner resource complementarities and innovation performance in an alliance portfolio organized with a focus on universities.

This study deconstructs the concept of original innovation into three dimensions according to the types of research and innovation. Initiate Research mainly focuses the original incremental innovation, which is major scientific discovery to the whole world and could spark a new research boom and even open up new industries with first public concepts or first public technologies. The other two constructs focus on the breakthrough innovation, which are Technology Breakthrough and Research Breakthrough, following the divisions of breakthrough innovation into technology and research breakthrough [13]. Accordingly, we contribute to the measurement of original innovation. The measurement of original innovation is developed by university-focused collaboration through integration with technology push- and science-based innovation. Unlike normal innovation driven by enterprises, original innovation generally cannot be separated from government support [14,15], and it is considered that the outcome of original innovation consists of three types, including major scientific discoveries, major theoretical breakthroughs, and major technological and methodological inventions, with the important characteristics of being initiate and groundbreaking.

Secondly, we contribute to the industry–academic conversation by considering the alliance portfolio lens to describe the inter-organizational collaboration relationship between universities and other partners. Most of the original innovation studies stay in the perspective of individual organizations of enterprises and universities [2]; there are fewer papers from the perspective of inter-organizational collaboration. Meanwhile, all alliance portfolios focus on enterprise organizations [6,16], with a lack of attention to university organizational contexts [17]. Existing studies have focused on the impacts of alliance portfolio diversity and interdisciplinary heterogeneity on original innovation performance and have not fully considered the importance of partner complementarity in research contexts. Current alliance portfolio studies are mainly in the corporate context, and do not consider the knowledge context of universities. Complementary knowledge provided by other organizations, such as other universities, off-campus research institutes, companies, and government, is the main source of innovation for universities, who are knowledge-creating rather than value-creating organizations [18].

2. Theory and Hypotheses

Wassmer (2008) defined an alliance portfolio as "the set of all bilateral strategic alliances in which the focal firm has been and is currently involved" [3]. Vapola et al. (2010) defined alliance as all types of inter-organizational partnerships that can create or protect competitive advantage, and alliances portfolios are alliances between the focal organization and external partners [5]. In this paper, the alliance portfolio is connoted as a collection of bilateral as well as multilateral partnerships in which the focal organization participates in, morphologically manifested as a virtual network of individual centers.

The organizational form of inter-organizational cooperation among the focal university, other universities, industrial enterprises, and research institutes is essentially a kind of alliance portfolio with a focal university as the core. How the focal organization conducts partner selection and alliance portfolio governance has been an important topic in the field of alliance portfolio research. Established studies have found that alliance portfolio diversity (organizational diversity, industrial diversity, functional diversity, and technological diversity) is significantly positively related to innovation performance to a certain extent [6,7].

2.1. Original Innovation

For years, scholars in the economics of technical change held two alternative perspectives [18–21]. Some believed that economic development is brought about by technological change, and others embraced the demand–pull approach and believe economic development is driven by demand (Di Stefano et al., 2012). Although society in the 1970s witnessed the significance of science and technology in generating innovation, the debate still continued with insisting the roles of demand and the market as complementary [21]. However, demand–pull- and enterprise-initiated technology drives are generally based on already existing needs or improvements to existing technologies. For areas where no demand has emerged, once a new idea is generated, it may trigger original innovation, opening up a new field and creating a new industry [1,22].

Scholars came to a consensus on the interdependence of technology and demand, and previous research has found the interactive model between these two potential sources of innovation [23] (Kline and Rosenberg, 1986). Science and technology were the main sources of innovation and demand acts as the best companion to drive them. It is believed that demand–pull and technological change are inextricably linked, and university and government occupied significant roles in innovation, especially in original innovation. However, researchers seem to have focused their attention on firms from the perspective of technology, few studies pay attention to university- and science-based innovation. Sometimes radical technological shifts emerge from strategic government-sponsored mission-oriented policies [15,24], where radical and new technologies are developed for national defense or pride purposes [14].

Therefore, we cut through the university perspective in the context of original innovation in China, borrowing from the characteristics categorized by original innovation theory [25–28].

Compared to traditional innovation literature, which highlights the role of enterprises played in technological innovation and market demand, original innovation covers the less predictable innovations that may bring up brand new concepts and even open new areas of research. Original innovation, serving as a dynamic and unpredictable solution driven by internal factors, is simpler and more effective than ordinary solutions [22]; it is a fundamental innovation that uses new technology, including new products or processes [28]. Chinese scholars have developed and deepened the concept that original innovation represents a qualitative change in science and technology, different from quantity, which will overturn previous human perceptions and engender leaps in the development in productivity [29].

The concept of original innovation differs in priorities from similar concepts, such as technological innovation and breakthrough innovation. Technological innovation is a new combination of introducing production factors into the production system. There are five forms of technological innovation combinations—new products or new quality of products, new processes or new production methods, opening new markets, developing new sources of material supply, and new methods of organization [30]—that generally refer mostly to commercial success through development, production, and marketing tasks. Breakthrough innovations are major changes or innovations in products or services, as well as programs and markets, and can also be new significant products created or newly expanded market segments [31,32]. Original innovation places more emphasis on originality than breakthrough innovation, excludes significant integrated innovation components, and focuses more on originality in basic research. Table 1 shows the main connotation and spotlight of similar innovation concepts, such as original innovation, technological innovation, and breakthrough innovation.

Table 1. Comparison of similar innovation concepts.

Concepts	Connotation	Spotlight
Original Innovation	To make discoveries and inventions in the field of basic research and high-tech research that have not been made before and to launch innovations, it is not extending an innovation cycle, but opening new innovation cycles and setting off new waves of innovation.	Science-driven and technology-driven, Initiate performance
Technological Innovation	The process of seeking new opportunities or new markets for a technology-based invention and making that invention commercially successful through R&D, production, and marketing.	Technology-driven, Commercial performance
Breakthrough Innovation	Significant changes or innovations in products or services, as well as programs and markets, which can also be new significant products created or newly expanded market segments	Innovation in product or service, Commercial performance

The comparison was organized and summarized by authors based on previous literature.

Since previous studies did not have a clear and explicit understanding of the connotation of original innovation, this paper combines the recognized characteristics of original innovation to build a thorough and scientific innovation performance evaluation dimension and index system. This study deconstructs the concept of original innovation into three dimensions according to the types of research and innovation. Initiate Research mainly focuses the original incremental innovation, which is major scientific discovery to the whole world and could spark a new research boom and even open up new industries with first public concepts or first public technologies. The other two constructs focus on the breakthrough innovation, and are Technology Breakthrough and Research Breakthrough, following the divisions of breakthrough innovation into technology and research breakthrough [13]. Innovation based on the national innovation context is proposed to focus on basic research and high technology fields [1]. Innovative achievements include both basic research (pure basic research and applied basic research) and applied research [33], which are expressed as major scientific discoveries, major theoretical breakthroughs, and major technological and methodological inventions. Technology Breakthrough refers to technologies achieved breakthrough in the previous research area, and it could be measured by the level of patents and value of technology secrets. Research Breakthrough refers to breakthroughs in research from the previous area, including theory building, protocol choosing, improvements with new solutions. Based on the measurements of Huang (2019) that focus on inventiveness and novelty of innovation performance [34], we developed items to measure the performance of original innovation, which includes three main dimensions that contain scientific and technological progress while also emphasizing original innovation.

2.2. Resource Complementarity and Innovation Performance

Resource complementarity is the comparison of resource between focal organization and other cooperative partners and stresses the non-overlapping resources which have a complementary effect in inter-organizational collaboration [35]. Previous literature studies complementarity from various perspectives, including partner complementarity [36,37], knowledge complementarity [38] and the resource we mention in this paper covers knowledge, funding, and intelligence capital. What they have in common is that the existence of resource complementarity first requires different organizations to have homogeneous resources, i.e., cross resources, the basis of their cooperation, and second, the resources that are not the same between organizations partly belong to the organization's own superior resources, which leads to cooperation with organizations with complementary resources and can achieve the cooperation effect of 1 + 1 > 2 [39].

Several studies have demonstrated that resource complementarity has a direct impact on organizational innovation performance [40]. From the perspective of resource-based theory, complementary resources are crucial for alliances; therefore, in inter-organizational collaboration, the selection of partners with complementary resources by universities is an important driving force for the formation of collaboration. Resource complementarity is critical to synergistic success [41–43]. Resource complementarity encompasses both uniqueness and symmetry [44]. On the one hand, complementarity determines the mix of unique and valuable resources available to obtain strategic objectives [45], thus enhancing the competitive viability of the alliance. On the other hand, complementarity encompasses strategic symmetry in a balanced sharing of unique strengths that can create partner dependence [42]. Johnson et al. conceptualize resource complementarity as "the extent to which each partner brings unique strengths and resources into the synergy" [44].

For universities, which are knowledge-creating rather than value-creating organizations, resources including knowledge provided by other organizations such as other university research institutions, off-campus research institutes, enterprises, and government are also important sources of information for the innovation process, as has been well illustrated by previous industry–university–research collaboration research. Dornbusch and Neuhäusler (2015) found that university and industry collaboration contribute to scientific and technological progress, and by analyzing how direct academic engagement influences the output of creative activities of research teams in different organizational contexts [46], using a German database, concluded that cross-boundary knowledge production by universities and firms can enhance innovation performance. However, the relationship between the intensity of collaboration in heterogeneous organizations and knowledge creation performance is not simply a positive one. "Healthy" egocentric networks are a mix of strong and weak ties that balance exploration and exploitation. The authors suggest that the reason for this is the imposition of relational strength, which on the one hand facilitates synergistic knowledge creation processes and on the other hand reduces cognitive diversity [47]. At the level of resource complementarity research, it is possible that reduced cognitive diversity leads to diminished resource complementarity, thereby lowering performance [35].

This paper proposes the hypothesis that "resource complementarity positively affects innovation performance", based on previous studies of resource complementarity and innovation performance (see Figure 1), including:

Hypothesis 1a (H1a). *Resource complementarity positively affects initiate research. The higher the resource complementarity, the higher the initiate research.*

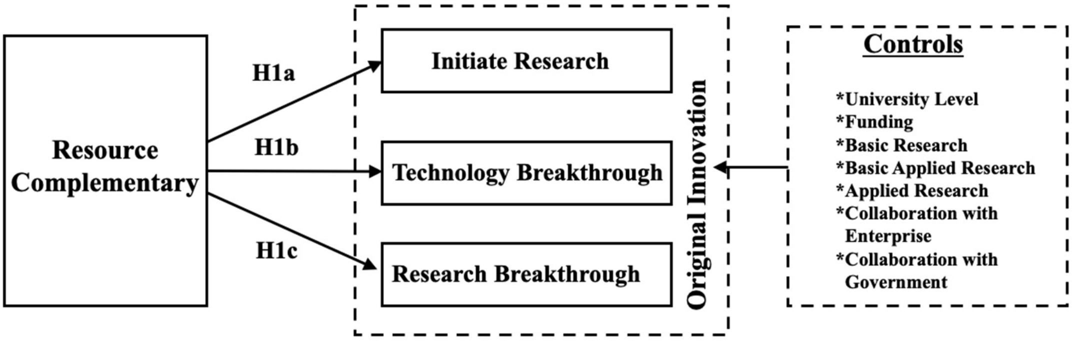

Figure 1. Research framework.

The key to the success of focal organizations stems from the willingness to find novel areas and explore scientific knowledge, and to coordinate partners to form alliance portfolios, thus obtaining value returns and competitive advantage gains in the positive impact of alliance portfolio strategies on original innovation. Scholars have studied the institutional arrangements for initiate research [48]; Hollingsworth concluded that "major discoveries tended to occur more frequently in organizational contexts that were relatively small and had high degrees of autonomy, flexibility, and the capacity to adapt rapidly to the fast pace of change in the global environment of science" [49], which fits the organizational context of flexible collaborative relationship in university-focused alliance portfolio.

The choice of diverse alliance partners and the intensive interaction with scientific staff in universities and researchers in companies can enhance knowledge [50,51]. Strategic alliances allow organizations to access external resources and maintain a competitive advantage [52]. External resources are considered as network resources [53], and access to and use of external resources are important thrusts of inter-organizational linkages and alliance formation in organizations. Empirical studies have shown that in addition to internal R&D activities, external knowledge acquisition is an extremely important means of resource complementarity for organizations, among which universities and research institutes are important sources of basic research, i.e., important sources of information for the innovation process [12].

Hypothesis 1b (H1b). *Resource complementarity positively affects technology breakthrough. The higher the resource complementarity, the higher the technology breakthrough.*

Scholars in the disruptive technology and breakthrough innovation field have found that universities and research institutes play important in technological changes and radical innovation through collaboration with enterprises, which creates demands beyond enterprises [1]. Heinze et al. found "that creative accomplishments are associated with small group size, organizational contexts with sufficient access to a complementary variety of technical skills, stable research sponsorship, timely access to extra-mural skills and resources, and facilitating leadership" [48,54], which revealed the positive effect of complementarity on technology breakthrough.

The properties of research content at the project level include general aspects of quality (originality, creativity or other 'breakthrough' characteristics, as well as validity and reliability of methods) and interdisciplinarity. Technology breakthrough could be achieved collaboration enterprises and universities, because universities would bring to enterprises insights into the evolution of technologies that were not yet common needs in the marketplace, playing the role of knowledge brokers for radical innovations [1].

Hypothesis 1c (H1c). *Resource complementarity positively affects research breakthrough. The higher the resource complementarity, the higher the research breakthrough.*

Heinze et al. found "that creative accomplishments are associated with small group size, organizational contexts with sufficient access to a complementary variety of technical skills, stable research sponsorship, timely access to extra-mural skills and resources, and facilitating leadership" [54].

Through organizational learning, the knowledge resources of the focal organization's embedded alliance network are transformed into its own "combinative capability" of unilateral and multilateral linkages, and the inter-organizational role changes and appropriate interactions across organizational boundaries [55]. As a result, the partner firms are willing to share complementary resources and create a favorable knowledge environment [56], and ultimately the knowledge resources are created. In general, universities engage in inter-organizational collaboration with multiple innovation subjects whose alliance portfolio is conducive to original innovation, while the resource complementarity of partners positively affects the research.

Based on a review of the literature above, this paper constructed a comprehensive research framework that demonstrated the relationship between partners' resource complementary and innovation performance.

3. Data and Methods

3.1. Data

We tested our hypotheses in the empirical context of universities in China. From the global experience, the role of universities as a new type of universities in the field of higher education has been highlighted as early as over a decade ago, and two-thirds of the top journals in academia are published by universities, which attach importance to scientific research and the transformation of scientific and technological achievements and play an important role in promoting economic and social progress. In recent years, Chinese universities have made some achievements on original innovation, with steady growth in the number of published papers and the three major awards of science and technology innovation. In 2011, under the guidance of national policies, universities, as the main innovation body, can build national key laboratories, declare scientific research projects, and participate in national scientific research programs. In addition, universities can also apply for the establishment of collaborative innovation centers by responding to the national research needs, acting as the leading unit, and integrating other scientific research institutions, industrial enterprises, local governments, and other advantageous resources to obtain large amounts of national financial support.

This paper adopts the questionnaire survey to count and collect data. Before the questionnaires were distributed, the authors selected the questionnaire samples and designed the channels for collection planning to ensure the acquisition of a large data sample, as well as to guarantee the quality of the data for more accurate research results. Since the research objects are the university research institutions, which are the focal organizations of the university alliance portfolio, the initial design of this paper is to distribute the questionnaires to all the university research institutions participating in the study nationwide in order to guarantee the harvesting of a large sample of data.

The questionnaires were sent to researchers in research institutions of universities recognized by the Ministry of Education, using simple random sampling. In total, 10,377 questionnaires were distributed to 45 research universities and more than 650 research institutions (including research institutes, research centers, key laboratories, etc.), and 211 valid questionnaires were collected. The 211 samples came from more than 20 provinces and municipalities in China, and 29.86% came from Zhejiang province due to the university of the authors. Among them, there were 173 samples of research institutes from top level universities. The questionnaire divided funding into several levels; we found that 84 research institutes (39.81% of samples) owned research funding above CNY 100 million, 13.74% had funding of CNY 50 million to 100 million, 19.91% had funding of CNY 10 million to 50 million, 9.48% had CNY 5 million to 10 million, 9.95% had CNY 1 million to 5 million, and the rest had below CNY 1 million, including 0.95% below CNY 100,000. Then, 55% of research institutes conducted basic research, 82% conducted basic applied research, and 48% conducted pure applied research. Finally, 71% research institutes had cooperation with enterprises, and 36% signed long-term strategic collaboration with local governments.

3.2. Dependent Variables and Estimation Method

We examined the relationship between the partners' characteristics and innovation performance in inter-organizational collaboration, which mainly refers to the measurement of innovation performance considering the initiative dimension and patent factors [57]. The measure of resource complementarity was assessed with five items and measured on a seven-point scale, ranging from 1 (strongly disagree) to 7 (strongly agree).

Items relating to innovation achieved by inter-organizational collaboration were constructed by three dimensions, Initiate Research, Technology Breakthrough and Research Breakthrough [34] (see Table A1 in Appendix A). Initiate Research includes the first public concept, the first public technology, the first public paper related to research [22]. Technology Breakthrough encompasses patent level and technology secrets [31]. Research Breakthrough contains brand new theory, brand new research approach, opening up a new field of research, initiating new research trends, overcoming the shortcomings of existing research, expanding the functions of existing research, improving the functional indices of existing research, overcoming long-standing research problems in the field, achieving unexpected results, overcoming research bias in the field, generating a high value for subsequent development, achieving commercial value, solving important social problems, and training highly qualified personnel [22,48].

This paper first tested the validity of exploratory factor analysis for the question items included in the original innovation performance scale. The KMO value of the original innovation performance was 0.931, which was greater than 0.7, and the Bartlett's sphere test value was significantly different from 0, indicating that the dependent variable was suitable for factor analysis. After removing the question items that were not suitable for factor analysis and cross-loading, principal component analysis was used for the extraction of common factors, and three common factors were extracted according to the requirements of eigenvalues greater than 1 and maximum factor loadings greater than 0.5. The percentage of cumulative explained variance was 74.959%, which was enhanced more than the cumulative explained ability before the removal of the question items (see Table A2). Three factors were extracted according to the requirements of characteristic root greater than 1 and maximum factor loading greater than 0.5, and there was no cross-loading. It indicates that the factor loadings have good discrimination among all three dimensions. Table A3 shows the results of Harman's single test for the check of common method bias (CMB). Results show the first and most important factor explains 43% of the total variance, lower than the 50% threshold [58], indicating the absence of CMB.

3.3. Independent Variables

Resource complementarity: in the alliance portfolio with university-focused organizations, the goal of the inter-organizational collaboration is different from the performance of mere business-to-business cooperation, and more attention is paid to the national policy trends to obtain some support resources, such as the co-establishment of laboratories and the joint declaration of research projects. The resource complementarity questions of Sarkar (2001) are appropriately adapted in this paper [59]. Table 2 shows the constructs and measurements of resource complementarity.

Table 2. Constructs and measurements.

Variable	Items	Source
Resource Complementarity	➢ Partner's resources are needed to accomplish the declared goals of collaborating entities, such as centers, bases, laboratories, etc. ➢ Need resources from partners to file research projects together. ➢ Need the resources of partners to achieve their respective economic interests. ➢ Collaboration of partners is needed to achieve significant original innovation output. ➢ Each partner brings its most valuable and advantageous resources.	Sarkar; Echambadi; Cavusgil; Preet. [59]

We examine the internal consistency reliability for resource complementarity by calculating Cronbach's alpha coefficient. The Cronbach's alpha coefficient for all five question items of resource complementarity was 0.826 greater than the suggested 0.7 of prior literature [60], and the CITC values for each question item (corrected item–total correlation coefficients of 0.698, 0.698, 0.608, 0.59, and 0.521, respectively) were greater than 0.5, indicating that all five question items were acceptable. In addition to this, the result shows that the alpha values after excluding each observed variable would decrease (0.770, 0.769, 0.796, 0.8, and 0.818, all less than 0.826), indicating a good internal consistency among the various question items of resource complementarity. Therefore, it demonstrates that the measure of resource complementarity scale has high reliability.

In the validity test, using exploratory factor analysis, the factor loadings of the item that "partner's resources are needed to declare cooperative entities" of resource complementarity were 0.834, which was the largest among the five items, indicating the largest association with resource complementarity, and the factor loadings of the other four items were 0.833, 0.764, 0.737, and 0.669, all of which are greater than 0.5, indicating that they are closely related to the common factor and can jointly reflect the measurement of resource complementarity without deleting the items. The KMO value of resource complementarity was 0.764, which was greater than 0.7, and the Bartlett's sphere test value was significantly different from 0, indicating that the independent variable was suitable for factor analysis.

3.4. Control Variables

The omitted variable bias is minimized by including a large set of controls. We first controlled for the related factors to focal universities and its alliance portfolio, namely university level, and funding. University level reflects the research level of the university, and funding was regarded as an important resource aspect for scientific collaboration and original innovation [61]. Then, we controlled for research type to further master the results of original innovation, following the division from the OECD, we divide the study type area into three categories: basic research, basic applied research, and applied research. Given the innovation quality in cross-organizational collaboration is related to partner attributes, we added different cooperation method as control variable, including collaboration with government or enterprises, and whether governments play roles in the focal university's alliance portfolio.

Table 3 lists descriptive statistics and a correlation matrix for variables. In general, the correlation among the independent variables is low, and the maximum value is 0.781, which is less than 0.8. According to the rule-of-thumb that represents weak multicollinearity among variables, this is not a serious problem and can be disregarded [62].

Table 3. Descriptive statistics.

	1	2	3	4	5	6	7	8	9	10	11
University Level	1										
Funding	0.283 **	1									
Basic Research	0.047	0.010	1								
Basic Applied Research	0.173 *	0.177 *	−0.142 *	1							
Applied Research	0.079	0.148 *	0.181 **	0.118	1						
Collaboration with Enterprise	0.191 **	0.255 **	−0.136 *	0.256 **	0.360 **	1					
Collaboration with Government	0.043	0.061	−0.075	0.138 *	0.131	0.174 *	1				
Resource Complementarity	−0.012	0.072	−0.015	0.099	0.151 *	0.202 **	0.091	1			
Initiate Research	0.168 *	0.167 *	0.120	0.050	0.039	0.081	−0.034	0.243 **	1		
Technology Breakthrough	0.145 *	0.331 **	0.018	0.255 **	0.106	0.265 **	−0.092	0.351 **	0.388 **	1	
Research Breakthrough	0.125 *	0.197 **	0.087	0.056	−0.008	0.102	−0.109	0.418 **	0.552 **	0.595 **	1
Mean	0.820	7.340	0.550	0.820	0.480	0.710	0.360	4.683	3.910	4.256	4.575
SD	0.385	1.868	0.499	0.381	0.501	0.454	0.481	1.292	1.493	1.762	1.419

** Significant at 0.05; * significant at 0.1.

4. Results

4.1. Hypothesis Testing

Table 4 reports the empirical results, presenting the logit regression estimate for original innovation. Model 1, Model 3, and Model 5 are the baseline models including the set of all control variables only. Model 2, Model 4, and Model 6 further add the independent variable. The F-value of Model 2, Model 4, and Model 6 in Table 4 is significant ($p < 0.01$), and the R square and R square change in the models also indicate that the overall effect of the model is satisfactory.

Table 4. Empirical result for H1-3.

Dependent Variable	Initiate Research		Technology Breakthrough		Research Breakthrough	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
University Level	0.098	0.124	−0.18	0.013	0.003	0.045
Funding	0.124	0.123	0.281 ***	0.280 ***	0.168 **	0.168 **
Basic Research	0.162 *	0.150 *	0.090	0.074	0.132 *	0.110
Basic Applied Research	0.066	0.052	0.206 ***	0.190 ***	0.015	−0.007
Applied Research	−0.040	−0.055	−0.033	−0.051	−0.107	−0.132 *
Collaboration with Enterprise	0.058	0.018	0.221 ***	0.172 **	0.120	0.018
Collaboration with Government	−0.006	−0.007	−0.150 **	−0.151 **	−0.130	−0.132 *
Resource complementarity		0.261 ***		0.314 ***		0.428 ***
R Square Change	0.098	0.061 ***	0.222 ***	0.089 ***	1.385	43.835 ***
F	1.239	2.030 **	3.231 ***	4.813 ***	1.385	4.033 ***
df	17	18	17	18	17	18
Observations	211	211	211	211	211	211

*** Significant at 0.01; ** significant at 0.05; * significant at 0.1.

First, Model 1 shows that the type of research—Basic Research—is significantly positively correlated with Initiate Research in original innovation, in line with prior literature regarding it as valuable organizational resources for collaboration [12]. Model 2 shows that the Resource Complementarity of partners has a significant positive effect on the original innovation performance of the alliance portfolio in terms of Initiative Research (Beta = 0.261, $p < 0.001$); thus, hypothesis 1a is tested. Model 1 and Model 2 indicate that collaboration with other partners with resource complementarity in basic research area contribute to enhance knowledge for major research discoveries and coming up with initiate concepts and research fields.

Second, Model 3 shows that Funding, Basic Applied Research, and Collaboration with Enterprise, are significantly positively correlated with Technology Breakthrough in original innovation, in line with previous literature demonstrating that technology breakthrough could be achieved by collaboration enterprises and universities, because universities would bring to enterprises insights of the evolution of technologies that were not yet common needs in the marketplace, thereby playing the role of knowledge brokers for radical innovations [1]. It also corroborates the previous literature advocating that the lever function of funding to steer research [48]. Model 3 also indicates that Collaboration with Government is significantly negatively correlated with Technology Breakthrough. We tend to interpret this as technological breakthroughs are usually taken places in the collaborations between researchers and do not involve strategic cooperation with local governments. Model 4 shows that Resource Complementarity of partners has a significant positive effect on the Technology Breakthrough of the alliance portfolio (Beta = 0.314, $p < 0.001$); thus, H1b is verified.

Third, Model 5 shows that Funding and Basic Research are significantly positively correlated with Research Breakthrough in original innovation, in line with previous literature that insists enterprises that manage to pursue innovation based on science and complement such efforts with learning by doing and interacting with other economic actors innovate more [39]. Models show that there is a significant positive effect of resource complementarity of partners on research breakthrough of the alliance portfolio (Beta = 0.428, $p < 0.001$); thus, H1c is verified.

4.2. Post Interview

At the later stage of the study, we interviewed and verified the resource complementarity of the partners selected by the research institutions in university in the actual inter-organizational collaboration, and the original innovation performance generated.

Three typical universities and their alliance portfolio are chosen because of their first-class practice. Among them, the Thermal Energy Institute of Zhejiang University has been at the forefront of research universities in China in the field of clean energy utilization and environmental engineering, and it won the Grand Prize of the National Science and Technology Progress Award in 2017, which is a major original innovation achievement. In this study, the Thermal Energy Institute is considered as the focal organization, and the collection of dual cooperation and multiple alliances with other organizations is its alliance portfolio. The forms of cooperation within the alliance portfolio include formal organizational entities, cooperation agreements, strategic alliances, etc. The alliance portfolio consists of a multifaceted alliance of collaborative innovation centers led by Zhejiang University, and a number of dual alliances formed by Zhejiang University with Chinese Academy of Sciences, several enterprises, and overseas universities, respectively. It had achieved technology breakthrough and research breakthrough with remarkable achievements. It pioneered a new type of coal power generation, achieved ultra-low emission of coal-fired units for the first time, and signed cooperation agreements with coal-fired power plants in many provinces to promote the national coal-fired flue gas emission work. It achieved several top national awards and patents.

The Green Pharmaceutical Collaborative Innovation Center led by Zhejiang University of Technology is one of the first batch of collaborative innovation centers selected in the National “2011 Project”. The center collaborated with 6 core research institutes, 35 listed companies, and more than 300 pharmaceutical companies, which achieved original innovation by breakthroughs in key common technologies in drug manufacturing industry, creating commercial value more than CNY 6500 million, 240 patents, and adequate recognition from government. It constructed curcumin-conjugated nanocarrier drug delivery system, which is of great value for tumor therapy; obtained the world’s first light-driven new material; invented a new method of "excluding synthetic genomic defective targets"; and chemically reconstructed eukaryotic yeast long chromosomes.

Tianjin University has a particularly long history of cooperation with Nankai University, which both have strong strength in chemistry. The research theme of Tianjin Chemical and Chemical Collaborative Innovation Center is design and synthesis across molecules and processes, including the design and green synthesis of function-oriented substances, and the efficient and clean transformation and utilization of energy and resources. There are five research platforms in the center, including the platform of efficient catalytic conversion of syngas and carbon dioxide and the design and synthesis of high-energy fuels, the platform of theoretical innovation and application of new materials for efficient and clean transformation of energy resources, the platform of design, synthesis and application of artificial biological systems, the platform of structural effects of functional molecule construction and its application, and the platform of chiral substance creation and transformation.

All three universities are involved in the Collaborative Innovation Center funded by national government, and they are very prominent in partner selection and original innovation, so they fit well with the theme of this study and are very representative. Since we are involved in the research projects under the Ministry of Education, the centers are willing to allow us access to the data. We interviewed the heads of several university collaborative innovation centers and collected relevant documents. We found that they tend to choose "the first-class universities and research institutes in the same discipline" (head B1, B2 in Tianjin University) and "partners strong strength and complementarities for close and long-term cooperation" (head A1 in Zhejiang University), in line with the hypothesis above in the paper. They claimed, "strong combination of strength and complementary efficiency would be the internal motivation" (professor A2 in Zhejiang University), and it would "increase efficiency" (manager C1 in Zhejiang University of Technology). As shown in the Table 5, Zhejiang University, Tianjin University, and Zhejiang University of Technology have all adopted the principle of complementary strengths and developed diversified partnerships with partners who could be strong in the same field and achieved better original innovation performance. Three cases cover different research areas and achieved corresponding original innovation outcomes. Tianjin University focuses on basic science and its original innovation is mainly expressed in the discovery of new materials, the introduction of new concepts. Zhejiang University of Technology conducted applied research for manufacturing new medicine and the outcome refers to patents. Zhejiang University tries to the solve problem of clean energy, which belongs to basic and applied research, so it achieved original innovation mainly in research breakthrough.

Table 5. Alliance portfolio practice in three universities.

University	Alliance Portfolio	Resource Complementarity	Original Innovation Performance
Zhejiang University	Coal Collaborative Innovation Center (multiple alliance, three schools, and four enterprises) + University–Enterprise Cooperation, Inter-University Cooperation, Cooperation with CAS (dual alliance)	Formation of alliance portfolio based on the principle of "partners should have strong strength and complementarities for close and long-term cooperation (head A1)", insisting "strong combination of strength and complementary efficiency would be the internal motivation" (professor A2)	Pioneering a new type of coal power generation, achieving ultra-low emission of coal-fired units for the first time, and having signed cooperation agreements with coal-fired power plants in many provinces to promote the national coal-fired flue gas emission work; 2 National Natural Science Second Class Awards, 3 National Technical Invention Second Class Awards, 1 Third Class Award, 2 Fourth Class Awards, 4 National Science and Technology Progress Second Class Awards, 1 Third Class Award; 70 invention patents.

Table 5. *Cont.*

University	Alliance Portfolio	Resource Complementarity	Original Innovation Performance
Tianjin University	Tianjin Chemistry and Chemical Synergistic Innovation Center (dual alliance, two universities) + research projects between the center and Tianjin Bohai Chemical Industry Group (multiple alliance) + inter-university cooperation (dual alliance), cooperation with local government (dual alliance), cooperation with overseas research institutes (dual alliance)	"Considering the first-class research level in the same discipline, one university had strength in basic research in chemical industry, the other focused on technological innovation, which can complement each other" (head B1, B2)	Constructed curcumin conjugate nanocarrier drug delivery system, which is of great value for tumor therapy; obtained the world's first light-driven new material; invented a new method of "excluding synthetic genomic defective targets"; chemically reconstructed eukaryotic yeast long chromosomes; one first-class prize of National Natural Science, two second-class prizes, 96 patents granted.
Zhejiang University of Technology	Yangtze River Delta Green Pharmaceutical Collaborative Innovation Center (multiple alliance, core of six research institutions, foreign enterprises and overseas laboratories to join) + university–enterprise cooperation (dual alliance)	"Bringing together the most advantageous innovative resources in the pharmaceutical field to complement and increase efficiency" (manager C1), with emphasis on multi-university-industry cooperation aimed at serving the needs of the pharmaceutical industry.	4 National Scientific Progress Awards, Second Class, 3 National Technical Invention Awards, 8 Zhejiang Science and Technology Awards, First Class; 346 invention patents.

5. Discussion

Compared with other more mature concepts of industry–academia–research innovation performance, academia has not yet developed a systematic dimensional classification standard for original innovation performance. Based on the understanding of the core connotation of innovation and the specific practice of original innovation, we propose three key dimensions to develop the findings of previous studies: Initiate Research, Technology Breakthrough, and Research Breakthrough. In order to verify the research presumptions proposed in this paper, we conducted an exploratory factor analysis in order to verify the research hypothesis proposed in this paper, we conducted exploratory factor analysis on the valid questionnaire sample data obtained from a large-scale survey, and after censoring the original innovation performance items, the principal component analysis yielded three factors with a cumulative explained variance of 75.325%, and the factor loadings were well differentiated among the three dimensions. Therefore, it indicates that the authors' definition and dimensional delineation of original innovation performance were validated.

Using correlation analysis and hierarchical regression analysis to examine the direct effect of resource complementarity of university research institution partners in alliance portfolios on original innovation performance, it was concluded that resource complementarity has a significant positive effect on initiate research, technology breakthrough, and research breakthrough, which is consistent with the findings of resource complementarity-related literature [63].

6. Conclusions

6.1. Theoretical Implications

Theoretically, we first contribute to the alliance portfolio literature on the players by introducing industry–academic collaboration. Universities are added to extend the focal organization of alliance portfolio. In prior literature, the concept of alliance portfolio as the set of all alliances that the focal enterprise has with its external partners is mainly adopted [5], and attention is paid to the dual and multiple relationship [3], alliance network [4], alliance portfolio diversity [64], and knowledge sharing [65]. In the context of focal university's alliance portfolio, the innovation achieved by research cooperation mainly highlights on knowledge creation characteristics, not only for commercial application. We take a step further and investigate the important factor of alliance partners for inter-organizational collaboration in scientific and technological research, and explore the relationship between resource complementarity between partners and focal university on the original innovation performance.

Second, we add to the original innovation literature. Studies on breakthrough innovation and demand–pull innovation have pointed out that universities usually introduce more "radical" product innovations [1]. Radical technological shifts have emerged from strategic government-sponsored mission-oriented policies, where radical and new technologies are developed for national defense or pride purposes [14]. Original innovation relies on university more specifically in the basic research area for opening up brand new research areas. We add original innovation to the innovation literature, the concept and measurement of original innovation are constructed by cutting through the university perspective in the context of original innovation in China, borrowing from the characteristics categorized by original innovation theory [25–27].

In the practice of university-focused alliance portfolios, which are often supported by government self-funding, and knowledge complementarity, as one of the sources of innovation, has a significant role in influencing innovation performance [50,51]. This paper investigated the positive role between resource complementarity and original innovation, expanding the research context of alliance portfolios and emphasizing the role of complementary assets.

6.2. Managerial Implications

From a practical perspective, the findings of this paper provide insights for universities and enterprises to realize original innovation. First, from the university perspective, this study, by revealing the mechanism of original innovation, helps motivate universities to realize the importance of partners with complementary resources for research exploration and socio-economic development, and stimulate them to continuously conduct inter-organizational research cooperation and establish dynamic and open organizational paths to achieve major theoretical and technological breakthroughs. Second, from the enterprise perspective, especially for high-tech industry, the research points out the importance of basic research and collaboration with knowledge brokers "universities" in line with previous industry–research studies that emphases the role of the university. Moreover, no matter for technology breakthrough or research breakthrough, funding is always an important factor, and enterprises should prepare an adequate budget for original innovation. Third, this paper provides a theoretical basis for the government to design policies to promote original innovation, pay more attention to the important causes of original innovation, formulate long-term innovation plans, increase research funding, encourage inter-organizational research cooperation among multiple innovation agents, and provide a cultural environment that is failure-tolerant and not eager for quick success, so as to lay the foundation for the country to achieve a strong state of science and technology innovation.

7. Limitations and Future Research

First, in terms of exploring the causes of original innovation, we only focused on the resource complementarity of partners, which is a rather single perspective. Due to the limitation of research effort and time, we selected two cases from Zhejiang Province and a case from Tianjin where we paid a visit, and the practice of original innovation is not among the strongest level in the country. In future research, more mature cases of domestic and foreign universities that are widely recognized by academia can be selected for fieldwork to uncover more causes of original innovation performance other than resource complementarity.

Second, data collection is more difficult because we use university research institutions as the target of investigation. Although this study expended a lot of time and effort to collect as many email addresses of researchers in research institutions of all research universities as possible. A total of 10,377 questionnaires were distributed, minus the number of email rejections totaling 9573, and the total number of questionnaires returned was only 211, indicating a low rate of response, and including 63 questionnaires from Zhejiang Province (Zhejiang University). Therefore, it is difficult to exclude the influence of regional cultural characteristics, which may affect the research results to some extent. In addition, the questionnaire data in this study are cross-sectional data, and longitudinal analysis through panel data can be considered in the future.

Author Contributions: The authors' contributions are as follows: conceptualization, J.Z. and J.C.; methodology, J.Z; analysis, J.Z. and A.G.; writing—original draft preparation, J.Z. and Y.C.; writing—review and editing, J.Z., A.G. and J.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Zhejiang Provincial Natural Science Foundation of China (Grant No. LQ20G030028; Grant No. LY18G020016) and Tsinghua University Humanities Building Project (Grant No. 2021TSG08302).

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

Appendix A

Table A1. Items of original innovation performance.

Variable	Items	Source
Initiate Research	We proposed the first public concept to the world (The concepts didn't exist in this field both domestically and internationally before) We put forward the first public technology to the world (The technology hasn't be developed before) We released the first public paper related to research (There was no public research related before)	Huang; Chen; Mei; Mo. [34] Goldenberg; Mazursky; Solomon. [22]
Technology Breakthrough	Compared to the most relevant patent from others, evaluate the level of our patents Compared to other technology secrets in the same field, evaluate the value of our technology secrets	Huang; Chen; Mei; Mo. [34] Capponi; Martinelli; Nuvolari. [31]
Research Breakthrough	We built brand new theory to explain the phenomena We used brand new research protocol to advance the research We opened up new field of research We initiated new research trends We overcame the shortcomings of existing research We expanded the functions of existing research We improved the functional indexes of existing research We overcame long-standing research problems in the field We have achieved unexpected results We overcame research bias in the field Our research would have high value for subsequent development Our research would be easy to achieve commercial value We solved important social problems We trained highly qualified talents	Huang; Chen; Mei; Mo. [34] Laudel & Gläser [48] Goldenberg; Mazursky; Solomon. [22]

Table A2. Total variance explained.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.321	59.586	59.586	11.321	59.586	59.586	8.289	43.627	43.627
2	1.661	8.740	68.327	1.661	8.740	68.327	3.076	16.190	59.817
3	1.260	6.632	74.959	1.260	6.632	74.959	2.877	15.142	74.959
4	0.795	4.185	79.143						
5	0.651	3.425	82.568						
6	0.533	2.805	85.373						
7	0.436	2.294	87.667						
8	0.339	1.786	89.453						
9	0.298	1.568	91.021						
10	0.254	1.338	92.359						
11	0.239	1.258	93.617						
12	0.237	1.245	94.862						
13	0.203	1.068	95.930						
14	0.185	0.972	96.902						
15	0.156	0.819	97.722						
16	0.135	0.710	98.431						
17	0.114	0.599	99.031						
18	0.102	0.539	99.570						
19	0.082	0.430	100.000						

Table A3. Total variance explained (Harman's single-factor test).

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.643	43.123	43.123	11.643	43.123	43.123
2	2.248	8.326	51.449	2.248	8.326	51.449
3	1.753	6.493	57.943	1.753	6.493	57.943
4	1.280	4.742	62.685	1.280	4.742	62.685
5	1.174	4.347	67.032	1.174	4.347	67.032
6	1.149	4.255	71.288	1.149	4.255	71.288
7	0.903	3.344	74.631			
8	0.855	3.165	77.796			
9	0.747	2.767	80.563			
10	0.639	2.366	82.930			
11	0.590	2.185	85.115			
12	0.534	1.979	87.094			
13	0.458	1.697	88.791			
14	0.437	1.618	90.409			
15	0.393	1.456	91.864			
16	0.306	1.134	92.998			
17	0.284	1.050	94.048			
18	0.244	0.905	94.953			
19	0.230	0.851	95.804			
20	0.214	0.791	96.595			
21	0.182	0.672	97.267			
22	0.177	0.657	97.925			
23	0.151	0.561	98.486			
24	0.125	0.462	98.948			
25	0.110	0.406	99.354			
26	0.099	0.367	99.721			
27	0.075	0.279	100.000			

References

1. Bianchini, S.; Llerena, P.; Patsali, S. Demand-pull innovation in science: Empirical evidence from a research university's suppliers. *Res. Policy* **2019**, *48*, 100005. [CrossRef]
2. Di Stefano, G.; Gambardella, A.; Verona, G. Technology push and demand pull perspectives in innovation studies: Current findings and future research directions. *Res. Policy* **2012**, *41*, 1283–1295. [CrossRef]
3. Wassmer, U. Alliance portfolios: A review and research agenda. *J. Manag.* **2010**, *36*, 141–171. [CrossRef]
4. Ozcan, P.; Eisenhardt, K.M. Origin of alliance portfolios: Entrepreneurs, network strategies, and firm performance. *Acad. Manag. J.* **2009**, *52*, 246–279. [CrossRef]
5. Vapola, T.J.; Paukku, M.; Gabrielsson, M. Portfolio management of strategic alliances: An international business perspective. *Int. Bus. Rev.* **2010**, *19*, 247–260. [CrossRef]
6. Oerlemans, L.A.G.; Knoben, J.; Pretorius, M.W. Alliance portfolio diversity, radical and incremental innovation: The moderating role of technology management. *Technovation* **2013**, *33*, 234–246. [CrossRef]
7. Wuyts, S.; Dutta, S. Benefiting from Alliance Portfolio Diversity the Role of Past Internal Knowledge Creation Strategy. *J. Manag.* **2014**, *40*, 1653–1674.
8. Baum, J.A.C.; Calabrese, T.; Silverman, B.S. Don't go it alone: Alliance network composition and startups' performance in Canadian biotechnology. *Strateg. Manag. J.* **2000**, *21*, 267–294. [CrossRef]
9. Eisenhardt, K.M.; Schoonhoven, C.B. Resource-based view of strategic alliance formation: Strategic and social effects in entrepreneurial firms. *Organ. Sci.* **1996**, *7*, 136–150. [CrossRef]
10. Makri, M.; Hitt, M.A.; Lane, P.J. Complementary technologies, knowledge relatedness, and invention outcomes in high technology mergers and acquisitions. *Strateg. Manag. J.* **2010**, *31*, 602–628. [CrossRef]
11. Mei, L.; Zhang, T.; Chen, J. Exploring the effects of inter-firm linkages on SMEs' open innovation from an ecosystem perspective: An empirical study of Chinese manufacturing SMEs. *Technol. Forecast. Soc. Chang.* **2019**, *144*, 118–128. [CrossRef]
12. Cassiman, B.; Veugelers, R. In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. *Manag. Sci.* **2006**, *52*, 68–82.
13. Carre, F. Research and technology breakthroughs in nuclear power for shaping a sustainable low-carbon energy future. *Energy Procedia* **2011**, *7*, 60–63. [CrossRef]
14. Gilbert, B.A.; Campbell, J.T. The geographic origins of radical technological paradigms: A configurational study. *Res. Policy* **2015**, *44*, 311–327. [CrossRef]
15. Mei, L.; Zhang, N. Transformer in navigation: Diverse government roles for open innovation in China's high-speed rail. *Long Range Plan.* **2022**, *55*, 102069. [CrossRef]
16. De Leeuw, T.; Lokshin, B.; Duysters, G. Returns to alliance portfolio diversity: The relative effects of partner diversity on firm's innovative performance and productivity. *J. Bus. Res.* **2014**, *67*, 1839–1849. [CrossRef]
17. Zhou, J.; Mei, L.; Chen, J. Leveraging University Competitiveness: Evidence from Alliance Portfolio Practices at Zhejiang University. *Emerg. Mark. Financ. Trade* **2019**, *55*, 827–842. [CrossRef]
18. Schmookler, J. *Invention and Economic Growth*; Harvard University Press: Cambridge, MA, USA, 1966.
19. von Hippel, E. The dominant role of users in the scientific instrument innovation process. *Res. Policy* **1976**, *5*, 212–239. [CrossRef]
20. Rosenberg, N. *Inside the Black Box: Technology and Economics*; Cambridge University Press: New York, NY, USA, 1982.
21. Dosi, G. Technological paradigms and technological trajectories. A suggested interpretation of the determinants and directions of technical change. *Res. Policy* **1982**, *11*, 147–162. [CrossRef]
22. Goldenberg, J.; Mazursky, D.; Solomon, S. Templates of original innovation: Projecting original incremental innovations from intrinsic information. *Technol. Forecast. Soc. Chang.* **1999**, *61*, 1–12. [CrossRef]
23. Kline, S.J.; Rosenberg, N. An Overview of Innovation. In *The Positive Sum Strategy: Harnessing Technology for Economic Growth*; Landau, R., Rosen-Berg, N., Eds.; National Academy Press: Washington, DC, USA, 1986; pp. 275–305.
24. Chesbrough, H.; Heaton, S.; Mei, L. Open innovation with Chinese characteristics: A dynamic capabilities perspective. *RD Manag.* **2021**, *51*, 247–259. [CrossRef]
25. Abernathy, W.J.; Rosenbloom, R. Parallel Strategies in Development Projects. *Manag. Sci.* **2011**, *15*, 486–505. [CrossRef]
26. Rosenbloom, R.S.; Abernathy, W.J. The climate for innovation in industry: The role of management attitudes and practices in consumer electronics. *Res. Policy* **1982**, *11*, 209–225. [CrossRef]
27. Tushman, M.; Nadler, D. Organizing for innovation. *Calif. Manag. Rev.* **1986**, *28*, 74–92. [CrossRef]
28. Peters, M.A. *Poststructuralism, Marxism, and Neoliberalism: Between Theory and Politics*; Rowman & Littlefield: Lanham, MD, USA, 2001.
29. Guanhua, X. Put great efforts to establish cultural environment favorable to innovation. *China Soft Sci.* **2001**, *3*, 1–7.
30. Schumpeter, J.A. *The Theory of Economic Development*; Transaction Publishers: Piscataway, NJ, USA, 1911.
31. Capponi, G.; Martinelli, A.; Nuvolari, A. Breakthrough innovations and where to find them. *Res. Policy* **2022**, *51*, 104376. [CrossRef]
32. Detienne, D.R.; Koberg, C.S. The impact of environmental and organizational factors on discontinuous innovation within high-technology industries. *Eng. Manag. IEEE Trans.* **2002**, *49*, 352–364. [CrossRef]
33. National Science Foundation. *Federal R&D Funding by Budget Function: Fiscal Years 1999–2001*; National Science Foundation: Arlington, VA, USA, 2000.

34. Huang, S.; Chen, J.; Mei, L.; Mo, W. The Effect of Heterogeneity and Leadership on Innovation Performance: Evidence from University Research Teams in China. *Sustainability* **2019**, *11*, 4441. [CrossRef]
35. Cobeña, M.; Gallego, Á.; Casanueva, C. Diversity in airline alliance portfolio configuration. *J. Air Transp. Manag.* **2019**, *75*, 16–26. [CrossRef]
36. Abuzaid, A.N.A. The impact of strategic alliance partner characteristics on firms' innovation: Evidence from Jordan. *Int. J. Bus. Manag.* **2014**, *9*, 77. [CrossRef]
37. Kale, P.; Singh, H.; Raman, A.P. Don't integrate your acquisitions, partner with them. *Harv. Bus. Rev.* **2009**, *87*, 109–115.
38. Zahra, S.A.; George, G. Absorptive capacity: A review, reconceptualization, and extension. *Acad. Manag. Rev.* **2002**, *27*, 185–203. [CrossRef]
39. Haus-Reve, S.; Fitjar, R.D.; Rodríguez-Pose, A. Does combining different types of collaboration always benefit firms? *Res. Policy* **2019**, *48*, 1476–1486. [CrossRef]
40. Salazar, A.; Jose, M.H.G.; Duysters, G.; Sabidussi, A.; Allen, M. "The value for innovation of inter-firm networks and forming alliances: A meta-analytic model of indirect effects": Corrigendum. *Comput. Human Behav.* **2017**, *76*, 603. [CrossRef]
41. Bleeke, J.; Ernst, D. The way to win in cross-border alliances. *Harv. Bus. Rev.* **1991**, *69*, 127–135.
42. Harrigan, K. *Strategies for Joint Ventures*; Lexington Books: Lanham, MD, USA, 1985.
43. Mei, L.; Zhang, N. Catch up of complex products and systems: Lessons from China's high-speed rail sectoral system. *Ind. Corp. Chang.* **2021**, *30*, 1108–1130. [CrossRef]
44. Jean, L.J.; John, B.C.; Tomoaki, S.; Hideyuk, T. Setting the stage for trust and strategic integration in Japanese-US cooperative alliances. *J. Int. Bus. Stud.* **1996**, *27*, 981–1004.
45. Killing, J. *Strategies for Joint Venture Success*; Praeger: New York, NY, USA, 1983.
46. Dornbusch, F.; Neuhäusler, P. Composition of inventor teams and technological progress–The role of collaboration between academia and industry. *Res. Policy* **2015**, *44*, 1360–1375. [CrossRef]
47. Wang, Z.; Wang, N.; Liang, H. Knowledge sharing, intellectual capital and firm performance. *Manag. Decis.* **2014**, *52*, 0025–1747. [CrossRef]
48. Laudel, G.; Gläser, J. Beyond breakthrough research: Epistemic properties of research and their consequences for research funding. *Res. Policy* **2014**, *43*, 1204–1216. [CrossRef]
49. Hollingsworth, J.R. *Scientific Discoveries: An Institutionalist and Path-Dependent Perspective*; Biomedical and Health Research-Commission of the European Communities; IOS Press: Amsterdam, The Netherlands, 2008; Volume 72, p. 317.
50. Jiang, L.; Tan, J.; Thursby, M. Incumbent firm invention in emerging fields: Evidence from the semiconductor industry. *Strateg. Manag. J.* **2011**, *32*, 55–75. [CrossRef]
51. Van de Vrande, V.; Vanhaverbeke, W.; Duysters, G. Technology in-sourcing and the creation of pioneering technologies. *J. Prod. Innov. Manag.* **2011**, *28*, 974–987. [CrossRef]
52. Mu, J.; Peng, G.; Love, E. Interfirm networks, social capital, and knowledge flow. *J. Knowl. Manag.* **2008**, *12*, 86–100. [CrossRef]
53. Gulati, R. *Managing Network Resources: Alliances, Affiliations, and Other Relational Assets*; Oxford University Press on Demand: Oxford, UK, 2007.
54. Heinze, T.; Shapira, P.; Rogers, J.D.; Senker, J.M. Organizational and institutional influences on creativity in scientific research. *Res. Policy* **2009**, *38*, 610–623. [CrossRef]
55. Kogut, B.; Zander, U. Knowledge of the firm, combinative capabilities, and the replication of technology. *Organ. Sci.* **1992**, *3*, 383–397. [CrossRef]
56. Lorenzoni, G.; Lipparini, A. The leveraging of interfirm relationships as a distinctive organizational capability: A longitudinal study. *Strateg. Manag. J.* **1999**, *20*, 317–338. [CrossRef]
57. She, L.H.; Chen, J. Review of Original Innovation. *Sci. Sci. Manag. ST* **2004**, *2*, 23–26.
58. Podsakoff, P.M.; MacKenzie, S.B.; Lee, J.Y.; Podsakoff, N.P. Common method biases in behavioral research: A critical review of the literature and recommended remedies. *J. Appl. Psychol.* **2003**, *88*, 879–903. [CrossRef]
59. Sarkar, M.B.; Echambadi, R.; Cavusgil, S.T.; Preet, S.A. The influence of complementarity, compatibility, and relationship capital on alliance performance. *J. Acad. Mark. Sci.* **2001**, *29*, 358–373. [CrossRef]
60. Mei, L.; Rentocchini, F.; Chen, J. Antecedents of strategic ambidexterity in firms' product innovation: External knowledge and internal information sharing. *J. Small Bus. Manag.* **2021**, 1–30. [CrossRef]
61. Zhang, N.; Mei, L. Sustainable Development in the Service Industry: Managerial Learning and Management Improvement of Chinese Retailers. *Sustainability* **2020**, *12*, 1430. [CrossRef]
62. Hair, E.; Halle, T.; Terry-Humen, E.; Bridget, L. Children's school readiness in the ECLS-K: Predictions to academic, health, and social outcomes in first grade. *Early Child. Res. Q.* **2006**, *21*, 431–454. [CrossRef]
63. Kim, K.K.; Umanath, N.S.; Kim, J.Y.; Ahrens, F.; Beomsoo, K. Knowledge complementarity and knowledge exchange in supply channel relationships. *Int. J. Inf. Manag.* **2012**, *32*, 35–49. [CrossRef]
64. Duysters, G.; Heimeriks, K.H.; Lokshin, B.; Maijer, E.; Sabidussi, A. Do firms learn to manage alliance portfolio diversity? The diversity-performance relationship and the moderating effects of experience and capability. *Eur. Manag. Rev.* **2012**, *9*, 139–152. [CrossRef]
65. Arora, A.; Belenzon, S.; Patacconi, A. Knowledge sharing in alliances and alliance portfolios. *Manag. Sci.* **2021**, *67*, 1569–1585. [CrossRef]