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An Empirical Study on Sustainable Innovation Academic Entrepreneurship Process Model

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Received: 15 May 2018; Accepted: 4 June 2018; Published: 12 June 2018



Abstract: As academic entrepreneurs, university faculty members and researchers with rich knowledge resources play an important role in the technology commercialization process, and in the creation and development of university spinoff enterprises. In this paper, we used a case study method to construct a sustainable innovative academic entrepreneurship process model from the perspective of entrepreneurial behavior. Then, we used this model to provide a deeper understanding of the activities and roles of academic entrepreneurs. This paper also expounded the process of value creation that is a result of sustainable innovative academic entrepreneurship, and compared and analyzed three types of university technology commercialization models. Our results showed that in the sustainable innovative academic entrepreneurship process model, the motivation of academic entrepreneurs leads them to play multiple roles as academic researchers, enterprise founders, and enterprise managers. In creating enterprises as the founders, and establishing and developing their enterprises, academic entrepreneurs realize the commercial value of the technology, while also incrementing their personal value. The sustainable innovative academic entrepreneurship process model provides a new path for effective transfer of technological innovations from academic research to the commercial market, creates social as well as economic value, and promotes regional economic development.

Keywords: technology commercialization; academic entrepreneur; process model; technology transfer; sustainable innovation; innovation; sustainability

1. Introduction

Through their research, Jain et al. found that organized entrepreneurial activities have become an important catalyst for the transfer of university technology from laboratories to commercial markets, giving rise to the emergence of academic entrepreneurship [1]. As academic entrepreneurs, university faculty members and researchers play an important role in the creation and development of university spinoff enterprises [2]. However, Chrisman et al. found that academic entrepreneurs rarely serve as the founders of the university spinoff companies they help to create [3], and they usually do not participate in the technology commercialization activities after the university spinoffs have been established [4]. By contrast, Fritsch and Krabel found that the entrepreneurial motivations of some university researchers do lead them to suspend their duty at universities and become founders of enterprises [5–8]. However, to the best of our knowledge, none of the existing literature explores an academic entrepreneurship model in which academic entrepreneurs are committed to technology commercialization, and lead the creation as well as the development of their enterprises.

Enterprises started up through academic entrepreneurship are a new type of enterprise emerging in recent decades. They are created by scientists or academic organizations by acquiring various resources and identifying opportunities to commercialize their research results. Academic organizations, including universities and research institutes, are important sources of scientific and technological achievements. Therefore, scientists or academic organizations play to their advantages in knowledge management and scientific and technological innovation, and make full use of various resources to establish technology companies supported by high-tech, and make the companies continue to grow and develop, which becomes an important way to improve the conversion rate of scientific and technological achievements and realize the industrialization of scientific and technological achievements.

To address this gap, we constructed the sustainable innovative academic entrepreneurship model, which describes an extension of academic entrepreneurial behavior [9]. In this model, university researchers are committed to realizing the commercialization of technology held by their universities, and to leading the creation and development of the related companies. Researchers secure the business value of the technology, achieve their personal goals, and create social and economic value that promotes regional economic development in the long run.

In the process of sustainable innovative academic entrepreneurship, university faculty members play multiple roles as academic researchers, company founders, and managers. Their decisions are based on the interaction between the academic environment and commercial or industrial environments, which makes this model more complicated than other university technology commercialization models. This approach to university technology commercialization reflects a model of academic entrepreneurship in which university faculty are the behavioral subjects who lead academic entrepreneurship and are the key to success [10]. This paper aims to answer the following key questions. What behavioral activities are carried out by university researchers in the process of sustainable innovative academic entrepreneurship? How do university researchers lead the creation and the development of enterprises? The answers to these questions can provide important theoretical support for the study of technology transfer from academic research to commercialization. However, the existing literature has not provided a full exploration of these matters.

To examine the process of sustainable innovative academic entrepreneurship from the microcosmic level, first, we constructed the model from a behavioral perspective by reviewing the related literature on university technology commercialization and academic entrepreneurship. Second, we explored the behavioral activities and roles of academic entrepreneurs using a case study method. Finally, we conducted a comparative analysis of the features, value realization, and the behavioral activities and roles of academic entrepreneurs in three types of technology commercialization models: the sustainable innovative academic entrepreneurship model, technology licensing model, and university spinoff company model. The findings of this paper enrich the theories of university technology transfer and academic entrepreneurship.

The remainder of this paper is structured as follows. Section 2 provides the theoretical basis for our work, and constructs the model. Section 3 details our research methods, and Section 4 describes and examines the case study used in this work. In Section 5, we offer a discussion of our findings. Section 6 concludes the paper with an examination of the significance of this work, discussion of the limitations, and suggestions for future studies.

2. Theoretical Basis and Model Construction

2.1. Theoretical Basis

To understand the theoretical basis of the work presented here, this section explores existing research regarding the nature of the university technology commercialization process. Then, we present the investigations focused on academic entrepreneurship.

2.1.1. University Technology Commercialization

Louis (1989) described academic entrepreneurship as a commercialized activity involving technology developed in a university. As academic entrepreneurs, scholars develop research-oriented ideas or products, and bring them to market to promote the profit, influence, or reputation of individuals or institutions [11]. The commercialization of university technology is the beginning of technological innovation [3]. It is a process committed to achieving the market value [12] of technical know-how, technical knowledge, or technology developed within the university [13].

The process of commercializing university technology has been the focus of scholarly research. Roessner (1994) believed that university technology commercialization is a process in which technical knowledge, technical theory, or technical principles move from one organization to another [13]. Friedman (2002) divided commercialization of university technology into six stages based on a behavioral perspective: conducting basic research, generating a prototype, protecting intellectual property, deciding to commercialize, participating in commercialization or establishing an enterprise, and profit-making [14]. This process includes transforming technology into marketable products, as well as moving the technology from the laboratory to market. Steps must also be taken to protect intellectual property. In the sustainable innovative academic entrepreneurship model, academic researchers are involved in the whole process, from independent research to technology commercialization. The protection of intellectual property is not a necessary process in this process model. However, the existing literature does not provide in-depth discussion of university technology commercialization under the sustainable innovative academic entrepreneurship model.

2.1.2. Academic Entrepreneurship

Until recently, there has been little research regarding academic entrepreneurship at the microcosmic level. Prior literature focused instead on academic entrepreneurship concepts, process models, and influencing factors. Louis (1989), Shane (2004), and other scholars each defined academic entrepreneurship differently [15]. O'Shea (2004) believed that academic entrepreneurship is a broad concept, referring to a series of entrepreneurial activities undertaken by universities and industry partners to achieve technology commercialization [16].

Academic entrepreneurship is not a single event, but rather, a dynamic process consisting of a series of events [17]. The success of academic entrepreneurship is related significantly to the completion of milestone events [4]. At each stage of the process, academic entrepreneurs have the ability to obtain and reorganize resources, network, and complete tasks to ensure the sustainable development of their companies, thereby achieving successful commercialization.

At present, research on the academic entrepreneurship process at the microcosmic level has become an area of active interest. Vohora et al. (2004) believed that academic entrepreneurship is a non-linear iterative process that passes through a number of key nodes, including identification of an opportunity, establishing entrepreneurship, acquiring resources, and sustaining development [4]. Wai Fong Boh (2015) established a process model for the early stages of academic entrepreneurship that included the following steps: generating the idea, making the decision to commercialize, generating and establishing a prototype, forming a team, determining the commercialization strategy, and executing fundraising activities [18]. He also examined early-stage academic research led by academic entrepreneurs, along with the concrete behaviors involved in early-stage entrepreneurial activities. Friedman (2002) proposed that the later stages of academic technology transfer included making the decision to commercialize, participating in commercialization, and making a profit [14].

Nonetheless, scholarly investigations have continued to lack microlevel examination of the behavior of university faculty as founders who create enterprises and are dedicated to commercializing their own technology. Scholars have also failed to explore the whole process through which academic entrepreneurs lead the establishment and development of their enterprises, as well as the specific behaviors of the academic entrepreneurs during this process.

2.2. Proposed Model and Model Construction

The process model of sustainable innovative academic entrepreneurship integrates academic behavior and the conduct of entrepreneurship. Academic entrepreneurs, who are the main subjects of study, carry out academic research and entrepreneurial activities in a dynamic way that provides the path for transferring university technology to the commercial markets.

To build a process model of sustainable innovative academic entrepreneurship, in this paper, we cross-merged the work of Vohora et al. (2004), cited above with the six stages of behavior of early stage academic entrepreneurship proposed by Wai Fong Boh (2015) [18], and the later stages proposed by Friedman (2002) (see Section 2.1.2). Our proposed model includes a value-added process in which academic entrepreneurs establish new enterprises as the founders, and finance the research and commercialization of technology through technology capitalization and securitization. Our model explains how academic entrepreneurs realize technical and commercial value, while incrementing their personal value as well as the enterprise value, producing positive socioeconomic returns.

The proposed process model of sustainable innovative academic entrepreneurship (as shown in Figure 1) includes eight phases: idea generation, developing the experimental prototype, deciding to commercialize, creating the product prototypes, creating and developing the new venture, producing the product, and generating sales.

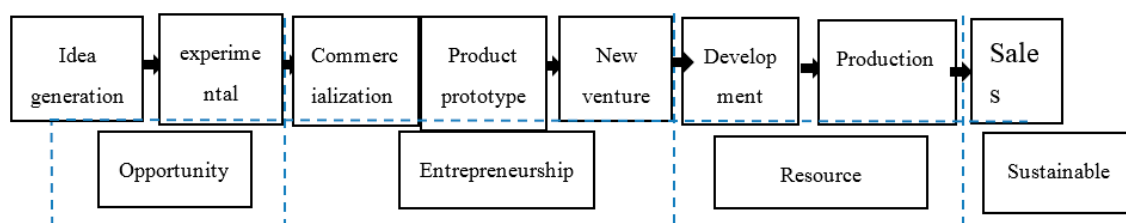


Figure 1. Process model of sustainable innovative academic entrepreneurship.

The process model of sustainable innovative academic entrepreneurship begins with the creative idea of an academic entrepreneur. After a series of laboratory studies and basic physical and social experiments, an experimental prototype is developed. If the prototype is superior to existing market products, it may be recognized widely and regarded as a product the market is ready to commercialize. At this point, the intention to attain sustainable innovation in academic entrepreneurship tends to motivate the researcher to create an enterprise as the founder [5–8]. In other words, at the stage when commercialization is determined, the academic entrepreneur's strategic decisions are focused on commercialization of the technology by creating a new enterprise with himself/herself as the founder.

When academic researchers have just created an idea, or are working on a technology that has not yet been fully successful in the laboratory, the decision to create an enterprise is premature. Often, academic researchers lack the funds to perform necessary research and development, or to test or validate their creative ideas [19]. However, for university technology with commercial prospects, researchers can fund verification of the experimental prototype by leveraging technology capitalization and securitization to attract incubator or seed money [20,21].

During the transition from the experimental prototype to the product prototype stage, academic researchers have a strong desire to commercialize the technology [22–24]. They develop the product prototype based on the experimental prototype, and can attract angel investors using the existing experimental prototype. Although the angel funds cannot provide enough money to fund the entire commercialization process, the rich experience of the investors can provide academic entrepreneurs with guidance regarding technology commercialization, and help them outline the blueprint for the future. The movement from idea creation to product prototype occurs during the so-called “seed period.” There is no sales revenue during this time. Cash only flows out, with no inflow. The main

goals of this phase are the success of product development, and the formation of a complete production and management plan.

After developing the product prototype, academic entrepreneurs enter the stage of finding a partner to establish the new enterprise. The biggest obstacle at this juncture is that outsiders and organizations are not familiar with the technology and its potential for commercialization. However, academic entrepreneurs' own academic backgrounds [25] and professional networks [10,26,27] can help them recruit the right collaborators and get advice from experienced entrepreneurs. At this point, as the founders of new enterprises, academic entrepreneurs are the decision makers. They must consider the interests of the collaborators and the whole organization, instead of considering only their own interests. After the new enterprise has been established, they need to find resources, carry out market research and development, arrange for large-scale production, develop the market, implement market activities, develop a sales network, and establish sales channels.

In the later stages of entrepreneurship, the focus of academic entrepreneurs shifts from academic research to commercialization of the technology. Additional areas of business concern, such as suppliers, employees, and customers, become the direct or indirect concern of the academic entrepreneurs. Decisions at each stage are critical, because they affect the probability of successful commercialization [28]. If the academic entrepreneurs are in close contact with the market, they can obtain funding and have a successful commercialization experience. As a result, it will be easier for them to create future enterprises because they will have gained skills and a positive track record as successful founders of an enterprise [25,29–32].

The transition from establishing a new enterprise to production occurs during the creation period, at which time the demand for funds is enormous. To realize the economic value of the product, academic entrepreneurs need to build the plant, purchase machinery and office equipment, and generally create the means of production, while at the same time carrying out the follow-up research and development (R&D) and initial sales work. However, entrepreneurs often do not have the funds to support these activities. The possibility of securing loans from banks is very small because academic entrepreneurs generally lack a record of previous business successes and an ample credit record. Therefore, during this stage, academic entrepreneurs need to raise equity financing from venture capital sources to complete the technology commercialization, obtain sales profits, and increment the enterprise value.

3. Research Methods

3.1. Method Selection

This paper adopted a case study method that is used commonly in qualitative research, and is suitable for deep study of detailed and complex real-world problems. Through case studies, researchers can either establish new theories or demonstrate and modify the existing ones. They can also describe and explore various phenomena and theories [33]. Case studies can provide rich and detailed information that allows for in-depth analysis, argumentation, and application of a deductive approach. Case studies tend to be more focused [34]. The method we adopted in this paper uses an identified theory to verify a single case. First, this paper studied the key activities, participants, and pivotal roles in the development of university spinoff enterprises. Since enterprise development is a dynamic interactive process, use of a case study method is appropriate [35]. Second, we chose a case study that illustrates the new model. This work required rich and detailed case materials and data as a support for systematic and in-depth exploration and analysis. Using the single case study method [35] helped to elucidate the dynamic and complex mechanism behind this particular process [36], and extract the theory or law that can explain complex phenomena [37]. Third, we used the single case study to expand our thinking to other representative cases, an approach employed to guarantee the depth of case studies. The conclusions drawn from this case contribute to the analysis and understanding of

similar events [38]. Finally, we applied deductive logic to validate the proposition through case study to make the theory more accurate [39].

3.2. Case Selection

For this study, we chose Shanghai Fudan Forward Science and Technology Co., Ltd. (No. 525 Guoquan road, Shanghai, China). (hereinafter referred to as Fudan Forward) as the sample case study. This company offered a successful representative case that was accessible for the purposes of this research, and company data was readily available.

Fudan Forward as a representative case. Fudan Forward is engaged in the research, development, and production of computer numerical control (CNC) systems and related equipment. Its growth and development process has been closely linked to the numerical control research carried out by Huazhong University of Science and Technology. Fudan Forward's founder was the core technology inventor, who established the enterprise as an academic entrepreneur and achieved the commercialization of the technology. The founding and development process of Fudan Forward is an example of a successful sustainable innovative academic entrepreneurship process that serves well as a representative case for the study of the proposed model.

Accessibility of the case study. Fudan Forward was listed on the Shanghai Stock Exchange in 1993. The availability of the company's prospectus and other information from the official Fudan Forward website and the Shanghai Stock Exchange made it easy to secure the needed materials for this study. In addition, Fudan Forward is often noticed and reported by news media, which facilitated various aspects of data acquisition, validation, and comparison.

Availability of data. Fudan Forward, was founded in 1992 by professors of Fudan University. Their research and technological achievements were developed into products through Fudan Forward. The company became the first national "innovative enterprise" and won the national, provincial, and ministerial level Science and Technology Progress Award several times. In 1993, Fudan Forward was listed on the Shanghai Stock Exchange. Through the company's official website, annual reports, corporate magazine, database, news media interviews, newspapers, magazines, and other channels, we collected available information on how the enterprise conducted academic entrepreneurship and its unique approach to achieving success.

3.3. Case Study Data Collection and Analysis

3.3.1. Data Sources and Collection Methods

To enhance the accuracy of our research results, this paper adopted a data collection method that used a substantial number of diversified and multilevel data sources to form triangular verification [40]. Our work included data collected from three main sources: the official website of Fudan Forward, the prospectus of Fudan Forward on the Shanghai Stock Exchange, and reports by news media.

3.3.2. Data Analysis

To provide a more accurate and reliable analysis of the research subject, and to improve the overall reliability of the research, the data were analyzed and sorted by different researchers using different sources of evidence according to the method proposed by Patton (2002) [41]. The specific data analysis process was as follows. First, we analyzed the course of development of Fudan Forward, extracted milestone events, put forward preliminary conclusions, and listed evidence sources, as well as references, to support these conclusions. Second, the other two researchers studied and analyzed the materials and data, and presented their own results, which were then validated and compared with the preliminary conclusions. Finally, our research team discussed and analyzed any inconsistent conclusions, and adopted the consensus views and conclusions agreed by our entire team.

4. Case Study

4.1. Background Information for the Case Enterprise

Shanghai Fudan Forward Science and Technology Co., Ltd. is a listed company controlled by Fudan University, and was the first listed joint-stock company in mainland China. As the well-known spinoff enterprise of Fudan University, Fudan Forward has not only had enormous influence and popularity in domestic education and academic research, but also has taken a lead among China's university spinoff science and technology enterprises in terms of development history, scale, and maturity. For these and other reasons mentioned above, Fudan Forward was selected for this research as a representative case.

4.2. Case Enterprise: History and Development

The predecessor of Shanghai Fudan Forward Science and Technology Co., Ltd. was the Fudan University Science and Technology Development Company. The company was founded in November 1984 when a few young professors from Fudan University registered the enterprise as a non-independent accounting company. The managers of the company were the administrative cadre from Fudan University. Yang Fujia, the president of Fudan University, became the first chairman to lead the university joint scientific research team of teachers and students to undertake the marketization of their technology achievements. Before June 1992, as Fudan University's school-run science and technology enterprise, the company was encouraged and supported by both China's national policies and the Shanghai municipal government's policies. Technical innovation leaders and teams were actively engaged in the research and development of Chinese medicine, chemical drugs, as well as genetic engineering drugs, achieving great breakthroughs. In succession, they developed a series of biotechnology products that could meet the market demand.

In June 1992, the company was restructured as Shanghai Fuhua Industrial Co., Ltd (No. 525 Guoquan road, Shanghai, China), which became the first listed university spinoff company in China (securities code: 600624). In January 1993, the company's stock was officially listed on the Shanghai Stock Exchange. For the first time, the company issued shares to the public for public fundraising, issuing a total of 433.909 million shares with a face value of 10 yuan each, among which 1.5 million shares were issued to the public at the price of 52 yuan per share. The company raised capital amounting to 78 million yuan.

In June 2001, the company took its current name: Shanghai Fudan Forward Science and Technology Co., Ltd (No. 525 Guoquan road, Shanghai, China). Relying on the strong scientific research, technology, and talent advantages of Fudan University, Fudan Forward established a successful science and technology system centered on software development, biomedicine, and real estate. It excelled in the exploration and practice of "developing high technology and realizing industrialization" after start-up development and listing, adjustment and reform, and comprehensive development. At present, it has China's important software export platform to Japan. Fudan Forward also has the technology and innovation capability for pharmaceutical R&D, handles its own production and marketing, and owns a nationally known hi-tech development park that attracts a wide range of high-tech enterprises from China and abroad. Its management demonstrates a good approach for creating sustained, stable, and healthy development.

Fudan Forward continues to rely on the strong scientific research, technology, and talent advantages of Fudan University to adjust, transform, and achieve comprehensive development. During nearly 20 years of development under its current identity, Fudan Forward has continued to forge its entrepreneurial spirit: "pursue the first-class; dare to be first; work hard and make contributions to the society." It has also united a large number of Fudan Forward scholars who have had the courage to undertake innovation and entrepreneurship. This successful academic entrepreneurship model has given Fudan University an effective example of commercialization of scientific and technological achievements.

4.3. Case Study and the Proposed Model of Sustainable Innovative Academic Entrepreneurship

In this section, we demonstrate how the founding and development of Fudan Forward reflects the phases of our proposed Sustainable Innovative Academic Entrepreneurship model.

Phase 1: Creative idea generation

In November 1984, several young researchers from Fudan University worked part-time to generate the ideas and means to establish a technology consulting and service enterprise.

Phase 2: Experimental prototype

Technical innovation leaders and teams from Fudan University actively engaged in the research and development of Chinese medicine, chemical drugs, and genetic engineering drugs. They also developed a successful uninterruptible power supply, and a fully sealed maintenance-free battery.

Phase 3: Commercialization decisions

Fudan University Science and Technology Development Corporation purchased a workshop of 2600 square meters in Caohejing Hi-Tech Park. This move laid the foundation for the restructuring and listing of the company.

Phase 4: Product prototype

Before June 1992, as Fudan University's school-run science and technology enterprise, the company was encouraged and supported by China's national policies and the Shanghai municipal government's policies. The company made a great breakthrough on the research and development of Chinese medicine, chemical drugs, as well as genetic engineering drugs, and developed biotechnology products that could meet the market demand.

Phase 5: Establishment of new enterprises

Fudan University Science and Technology Development Corporation was restructured into Shanghai Fuhua Industrial Co., Ltd (No. 525 Guoquan road Shanghai City, Country). in 1992. The company issued shares to the public in the form of public fund-raising for the first time, and became the first listed university spinoff company in China. The company issued a total of 433.909 million shares with a face value of 10 yuan each, among which 1.5 million shares were issued to the public at the price of 52 yuan per share. In so doing, the company raised 78 million yuan. The manager of the company was the administrative cadre from Fudan University. Yang Fujia, the president of Fudan University, became the first chairman to lead the university scientific research team, teachers and students jointly to undertake the marketization work of the technology achievements.

Phase 6: Development

Fudan Forward relied on the strong scientific research, technology, and talent advantages of Fudan University to adjust, transform, and achieve comprehensive development. By 1998, Fudan Forward Pharmaceutical Co. took the national lead in the innovation of new drugs and gene research, and developed a series of medicines for specialty areas such as geriatrics, cardio-cerebrovascular medicine, antitumor drugs, and modern Chinese medicine.

Phase 7: Production

By 2003, Fudan Forward relied on the strong advantages and abundant talent resources of Fudan University's School of Pharmacy, Medical College, and School of Life Science, and made full use of China's natural and unique plant and animal resources. The company's biomedical division invested actively in several special pharmaceutical and health products projects, and achieved great success.

Phase 8. Sales

The POWERSON uninterruptible power supply system, and the FDDS high sensitivity human sex identification PCR kit produced by Fuhua Industrial Co., Ltd. were recognized as designated products by the first East Asian Games. Fuhua Industrial Co., Ltd. implemented a profit distribution and allotment plan in 1992. The company's total equity increased to 58,756,840 shares, and raised 44.11 million yuan.

4.4. Background Information for the Case Enterprise

Neusoft provides innovative information technology-enabled solutions and services to meet the demands arising from social transformation, to shape new lifestyles for individuals, and to create values for the society. Neusoft was established at Northeastern University, China in 1991. Today, Neusoft has about 20,000 employees worldwide, and it has 10 software R&D bases, 8 regional headquarters and a comprehensive marketing and service network covering 60+ cities across China, as well as subsidiaries in the United States, Japan, Europe, the Middle East, and South America. It was the first listed software company in China, also the country's first one in the industry that had received both CMM Level 5 and CMMI V1.2 Level 5 certifications.

4.5. Case Enterprise: History and Development

At the beginning of 1988, Dr. Liu Jiren from Northeastern University worked together with two other young teachers to set up a computer software and network engineering research lab with 30,000 RMB and only three computers. In 1991 OPENSOFT System Development Company was established. In 1992, OPENSOFT System Development Company went through an ownership restructuring and was renamed OPENSOFT System Co., Ltd. (Knaresborough, UK) of Northeast Institute of Technology. On 18th June, Neu-Alpine Software Co., Ltd. (Shenyang, China) went public on the Shanghai Stock Exchange, becoming the first listed software company in China. Philips, SAP, and Intel invested in Neusoft Group successively, and became strategic investors in Neusoft Group. Then, Neusoft started providing BPO (Business Process Outsourcing) services. In 2008, Neusoft Group released its new growth strategy upon its consolidated listing, announcing its dedication to becoming a leading global IT solutions and services provider. Neusoft's second software park in Dalian and first R&D base in Nanjing were built up and put into operation. In 2014, Neusoft Medical Systems launched a whole range of new products and solutions, including NeuViz 64 IN/EN 64-Slice CT Scanner. Neusoft also launched the latest version of SaCa v2 and UniEAP v4 products. In 2016, Neusoft launched "RealSight" big data analysis and application platform for enterprises; Neusoft's new generation of hospital core business platform "RealOne Suite" was officially launched; Neusoft Reach released a next generation intelligent battery management system.

4.6. Case Study and the Proposed Model of Sustainable Innovative Academic Entrepreneurship

Phase 1: Creative idea generation

At the beginning of 1988, Dr. Liu Jiren from Northeastern University worked together with two other young teachers to set up a computer software and network engineering research lab with 30,000 RMB and only three computers.

Phase 2: Experimental prototype

Dr. Liu Jiren engaged in research and development of software on the basis of the research lab.

Phase 3: Commercialization decisions

Dr. Liu Jiren released the slogan Bridging Software Research, dedicated to establishing the company to realize the commercialization of technology.

Phase 4: Product prototype

Dr. Liu Jiren and his team actively engaged in system software development.

Phase 5: Establishment of new enterprises

In 1992, OPENSOFT System Development Company went through an ownership restructuring and was renamed OPENSOFT System Co., Ltd. of Northeast Institute of Technology.

Phase 6: Development

Fudan Forward relied on the strong scientific research, technology, and talent advantages of Fudan University to adjust, transform, and achieve comprehensive development. By 1998, Fudan Forward Pharmaceutical Co. took the national lead in the innovation of new drugs and gene research, and developed a series of medicines for specialty areas, such as geriatrics, cardio-cerebrovascular medicine, antitumor drugs, and modern Chinese medicine.

Phase 7: Production

Neusoft Medical Systems launched a whole range of new products and solutions, including NeuViz 64 IN/EN 64-Slice CT Scanner. Neusoft also launched the latest version of SaCa v2 and UniEAP v4 products.

Phase 8: Sales

The POWERSON uninterruptible power supply system, and the FDDS high sensitivity human sex identification PCR kit produced by Fu Hua Industrial Co., Ltd. were recognized as designated products by the first East Asian Games. Fuhua Industrial Co., Ltd. implemented a profit distribution and allotment plan in 1992. The company's total equity increased to 58,756,840 shares, and raised 44.11 million yuan.

5. Discussion of Research Findings

Comparison of Three University Technology Commercialization Process Models

We compared the roles and activities of the academic researchers in the case study across the three kinds of university technology commercialization processes, as shown in Figure 2. In the process of technology licensing, university academic researchers participate in technology R&D and in developing intellectual property (IP), but do not participate in subsequent technical commercialization activities. In the process of the university spinning off an enterprise, academic entrepreneurs move from doing academic research to establishing the enterprise, but they are no longer the drivers in the subsequent technical commercialization. In the sustainable innovation model of academic entrepreneurship, academic entrepreneurs have a dual identity as academic researchers and entrepreneurs, and they are the drivers of academic research and commercialization of the technology.

From the perspective of the process of value realization, technology licensing realizes technical value. In the university spinoff enterprise model, academic entrepreneurs participate in technology commercialization as the technical support, a role that allows them to achieve personal values. In the sustainable innovative academic entrepreneurship model, academic entrepreneurs establish enterprises as the founders. While creation of an enterprise realizes the commercial value of the technology, the role of founder increments the value of the individual as well as the enterprise, generating social and economic value at the same time.

In summary, from the perspective of individual behavior and value realization, the comparison of the three kinds of university technology commercialization processes is shown in Figure 2.

In the three types of university technology commercialization process, the concrete behavior of the entrepreneurs during each stage is different. For technology licensing and spinning off an enterprise from the university, technology owners transfer technology [42] to external organizations

through the changeover of intellectual property rights, i.e., the creation and management of intellectual property in these two models is a necessary link. In the process of sustainable innovative academic entrepreneurship, academic entrepreneurs turn their creative ideas into a product or service. Intellectual property rights are formed based on the need for technology or product protection, and these rights will not be transferred to external organizations. Therefore, there is no IP link formed in academic entrepreneurship. During the stage when the decision to commercialize is made, because of the differences in entrepreneurial motivations and intentions [22–24], as well as technical characteristics [20,21], the technology commercialization decisions made by academic entrepreneurs vary.

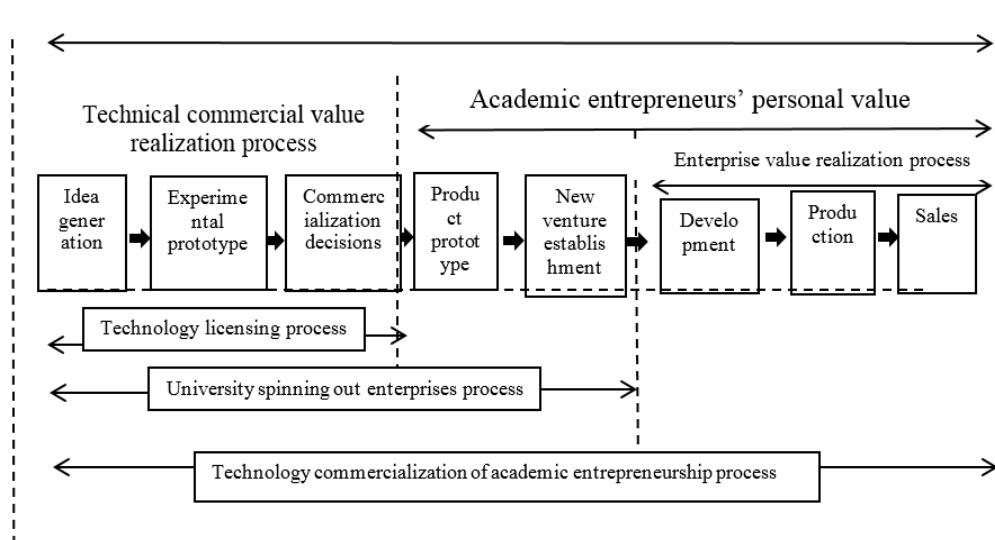


Figure 2. Comparison of three types of university technology commercialization process.

In each of the three university technology commercialization models, the behavior of the subjects involved in later technical commercialization differs. In the process of technology licensing, external organizations dominate the commercialization. When universities spin off enterprises, the development, production, and sales are led by the universities or university research centers. The participation of academic entrepreneurs is reduced gradually. In the sustainable innovative academic entrepreneurship model, academic entrepreneurs still dominate technology commercialization.

The income distribution model also differs in the three university technology commercialization models. In the technical commercialization model, academic researchers only participate in technical research, and gain the income of technology transfer. The income of technical commercialization is obtained by the technology commercialization organization; in the university derivative enterprise model, academic researchers not only participate in technical research, but also take parts in technical commercialization. They thus obtain the income of technical research and technical commercialization. Their universities receive full dividends; in the sustainable innovative academic entrepreneurship model, academic entrepreneurs not only obtain the technical research income, they also own the enterprise equity as the founders, and obtain the technical commercial dividend.

6. Conclusions and Limitations

6.1. Conclusions

This paper offers three key contributions. First, we proposed a sustainable innovative academic entrepreneurship process model. Second, we examined the value creation that results from sustainable innovative academic entrepreneurship. Last, we compared and analyzed three types of university technology commercialization models. We will comment on each in turn.

(1) Regarding the sustainable innovative academic entrepreneurship process model, we note that prior literature on academic entrepreneurship paid little attention to academic entrepreneurs who founded new enterprises. In this paper, we defined a clear model of the sustainable innovative academic entrepreneurship carried out by these individuals. By comparing our proposed model with the technology licensing and university spinoff enterprise models, we found that the sustainable innovative academic entrepreneurship model has unique characteristics and advantages in terms of the degree of participation of academic entrepreneurs, concrete behavior activities, value realization, and dominant right of the enterprises. It is important to note that the classification of university technology commercialization proposed by Maria Abreu, Vadim Grinevich (2013) did not include a sustainable innovative academic entrepreneurship model. Consequently, this paper supplements the construction of university technology commercialization classification by providing a more complete theoretical framework for future scholars to study the concept of university technology commercialization and academic entrepreneurship.

Prior research on the concept of academic entrepreneurship presented either the significance of academic research or entrepreneurship, but not a combination of the two. However, the sustainable innovative academic entrepreneurship model integrates the roles and behaviors of individuals in the academy and as entrepreneurs. Academic entrepreneurs carry out academic research and entrepreneurial activities dynamically, which serves as the means for building the path for transferring technology to the marketplace. At present, there are few studies on the activities, roles, and impact of sustainable innovative academic entrepreneurship. This paper studied the process of sustainable innovative academic entrepreneurship from the holistic perspective, developed the process model by utilizing a case study, expounded entrepreneurial behavior and value creation, and probed the behavioral activities and roles of academic entrepreneurs under this model. As a result, this work provides a theoretical reference for scholars to study academic entrepreneurship, and a theoretical basis for academic researchers and organizations dedicated to sustainable innovative academic entrepreneurship to improve their performance.

(2) This paper expounded the process of value creation that is a result of sustainable innovative academic entrepreneurship. This focus was lacking in prior research. By analyzing the process of sustainable innovative academic entrepreneurship, we demonstrated that academic entrepreneurs establish new enterprises as the founders, and finance the research and commercialization of technology through technology capitalization and securitization. Capitalization and securitization involve the use of technology as the basis for financing. The funds raised and the profits from sales of technology or products are distributed to team members in the form of equity incentives and compensation. Thus, academic entrepreneurs obtain financial gains. At the same time, when academic entrepreneurs achieve successes related to sustainable innovative academic entrepreneurship, they earn good reputations and prestige, which enables them to obtain more research funding. Overall, these activities realize the commercial value of the technology, increment the value of the individuals, and promote the enterprise as well, which, in turn, produces socioeconomic value. In other words, sustainable innovative academic entrepreneurship is a process of value creation.

Furthermore, sustainable and innovative academic entrepreneurship enables academic entrepreneurs to be linked more closely to more industry and corporate product development resources. This study showed that close industrial partnerships guide academic researchers in the direction of future research. Academic entrepreneurs can generate more new ideas, acquire business opportunities, start a new round of academic entrepreneurship, and produce technology or products that meet market demand, while bringing benefits and reputation to themselves and promoting socioeconomic development [43].

(3) In this research, we compared and analyzed three types of university technology commercialization models. Prior literature discussed the questions of motivation, behavior, and influence of academic entrepreneurs based on their degree of participation in the commercialization process. However, few researchers have compared and analyzed the characteristics, process, specific

behaviors, and roles in the sustainable innovative academic entrepreneurship model with other university technology commercialization models. Our work demonstrated that in the mode of the sustainable innovative academic entrepreneurship model, academic entrepreneurs play multiple roles as academic researchers, enterprise founders, and enterprise managers. They are committed to the integration of entrepreneurial resources, technology commercialization, and enterprise value creation. In addition, they hold primary control over the development of the technology and approach to the market. Academic entrepreneurs may control the shares of their enterprises, and they are able to obtain profit from the growing returns brought by the increasing value of the enterprises. This model not only realizes the commercial value of the technology and the academic entrepreneur's personal value, but also creates social economic value and promotes the regional economic development.

6.2. Theoretical and Practical Significance

With the rise of entrepreneurial activities in universities, research regarding the concept, mode, process, and influencing factors of academic entrepreneurship have become the focus of scholars' attention. This paper constructed a sustainable innovative academic entrepreneurship process model from the microscopic behavioral perspective. By exploring the behavioral activities and roles of academic entrepreneurs using a case study approach, this paper enriches the understanding of academic entrepreneurship, expands the thinking of academic entrepreneurship research, and enriches traditional research. In practical application, this work can provide a reference for financing policies for science and technology projects, and can contribute to the transformation and management of the commercialization of newly emerged science.

The sustainable innovative academic entrepreneurship model offers a new way to transform university technology and bring it to market in a manner that allows academic entrepreneurs to control the technology development and market approach. This model realizes the business value of the technology and the personal value of academic entrepreneurs, and creates social and economic value that promotes regional economic growth. It provides new ideas and experiences that promote the rate of university technology transfer. Furthermore, this research constructs a sustainable, innovative academic entrepreneurship process model that can help academic entrepreneurs choose a technology commercialization path according to each researcher's academic background, ability, and social network. The model guides academic entrepreneurs toward the completion of technology commercialization through milestone events. It also helps analyze the key role of sustainable innovative academic entrepreneurship in each stage, and realize the enterprises' sustainable development, as well as the social and economic development.

6.3. Limitations and Future Research

In the research process, we took validity and reliability into consideration, and followed the accepted methodology for case studies strictly. Nonetheless, this study has some limitations. First, the selected sample is a highly successful case, and we did not construct a comparison with less successful or failed cases. Second, in this paper, we analyzed and discussed only the behavioral activities and roles of academic entrepreneurs in the process of sustainable innovation. However, there is a need to explore further the factors that influence the process, and the factors that are key to success. In addition, this paper used a single case to analyze the problem deeply and thoroughly. It is difficult to put forward a universally applicable theoretical proposition with certainty because of the lack of samples for comparison [44]. In the future, multiple case studies can be used to explore further the process of sustainable innovative academic entrepreneurship.

Author Contributions: Writing: X.-D.Q., W.L.; Providing case and idea: X.-D.Q., W.L.; Providing revised advice: S.-B.T. and J.X.

Acknowledgments: This paper is supported by National Natural Science Foundation of China (71372139) and Zhongshan City Science and Technology Bureau Project (No. 2017B1015). I would like to express my gratitude to my daughter for your support and love. Without you, I cannot accomplish such a high quality article published in

the Sustainability Journal retrieved by SCI and SSCI. This is a gift for your graduation from high school. May all your dreams and plans turn to fulfillment and success!

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

References

1. Jain, S.; George, G.; Maltarich, M. Academics or entrepreneurs? Investigating role identity modification of university scientists involved in commercialization activity. *Res. Policy* **2009**, *38*, 922–935. [[CrossRef](#)]
2. Shane, S. *Academic Entrepreneurship: University Spinoffs and Wealth Creation*; Edward Elgar: Cheltenham, UK, 2004.
3. Chrisman, J. Faculty entrepreneurship and economic development: The case of the University of Calgary. *J. Bus. Ventur.* **1995**, *10*, 267–281. [[CrossRef](#)]
4. Vohora, A.; Wright, M.; Lockett, A. Critical junctures in the development of university high-tech spin-out companies. *Res. Policy* **2004**, *33*, 147–175. [[CrossRef](#)]
5. Berggren, E. The entrepreneurial university's influence on commercialisation of academic research: The illustrative case of Chalmers University of Technology. *Int. J. Entrep. Small Bus.* **2011**, *12*, 429–444. [[CrossRef](#)]
6. Duberley, J.; Cohen, L.; Leeson, E. Entrepreneurial academics: Developing scientific careers in changing university settings. *High. Educ. Q.* **2007**, *61*, 479–497. [[CrossRef](#)]
7. Stern, S. Do scientists pay to be scientists? *Manag. Sci.* **2004**, *50*, 835–853. [[CrossRef](#)]
8. Fritsch, M.; Krabel, S. Ready to leave the ivory tower? Academic scientists' appeal to work in the private sector. *J. Technol. Transf.* **2012**, *37*, 271–296. [[CrossRef](#)]
9. Yi, C.; Xia, Q. Research on relationship between entrepreneurial orientation and university spin-off performance: From the respective of academic entrepreneur's resource support. *Stud. Sci. Sci.* **2011**, *29*, 735–744.
10. Hayter, C.S. Harnessing university entrepreneurship for economic growth: Factors of success among university spin-offs. *Econ. Dev. Q.* **2013**, *27*, 17–27. [[CrossRef](#)]
11. Louis, K.S.; Blumenthal, D.; Gluck, M.E.; Stoto, M.A. Entrepreneurs in academe: An exploration of behaviors among life scientists. *Adm. Sci. Q.* **1989**, *34*, 110–131. [[CrossRef](#)]
12. Zhang, Y. Analysis of the Dual Interaction Process of University Technology Transfer. *Sci. Sci. Manag. S T* **2004**, *25*, 27–29.
13. Roessner, J.D.; Wise, A. Public Policy and Emerging Sources of Technology and Technical Information Available to Industry. *Policy Stud. J.* **1994**, *22*, 349–358. [[CrossRef](#)]
14. Feldman, M.; Feller, I.; Bercovitz, J. Equity and the technology transfer strategies of American research universities. *Manag. Sci.* **2002**, *48*, 105–121. [[CrossRef](#)]
15. Li, H. Scholar, Academic Organization and Environment: A Review of the Research on Academic Entrepreneurship. *Sci. Sci. Manag. S T* **2009**, *30*, 51–53.
16. O'Shea, R.; Allen, T.; O'Gorman, C.; Roche, F. Universities and technology transfer: A review of academic entrepreneurship literature. *Iran. J. Manag.* **2004**, *25*, 11–29.
17. Friedman, J.; Silberman, J. University technology transfer: Do Incentives, Management, and Location Matter? *J. Technol. Transf.* **2003**, *28*, 17–30. [[CrossRef](#)]
18. Boh, W.F.; De-Haan, U.; Strom, R. University technology transfer through entrepreneurship: Faculty and students in spinoffs. *SSRN Electron. J.* **2012**. [[CrossRef](#)]
19. Nicolaou, N.; Birley, S. Academic networks in a trichotomous categorisation of university spinouts. *J. Bus. Ventur.* **2003**, *18*, 333–359. [[CrossRef](#)]
20. Bradley, S.; Hayter, C.S.; Link, A.N. Methods and models of university technology transfer. *Found. Trends Entrep.* **2013**, *9*, 571–650. [[CrossRef](#)]
21. Link, A.N.; Siegel, D.S.; Bozeman, B. An empirical analysis of the propensity of academics to engage in informal university technology transfer. *Ind. Corp. Chang.* **2007**, *16*, 641–655. [[CrossRef](#)]
22. Hayter, C.S. In search of the profit-maximizing actor: Motivations and definitions of success from nascent academic entrepreneurs. *J. Technol. Transf.* **2011**, *36*, 340–352. [[CrossRef](#)]
23. Lam, A. What motivates academic scientists to engage in research commercialization: 'Gold', 'ribbon' or 'puzzle'? *Res. Policy* **2011**, *40*, 1354–1368. [[CrossRef](#)]
24. Hayter, C.S. Public or private entrepreneurship? Revisiting motivations and definitions of success among academic entrepreneurs. *J. Technol. Transf.* **2015**, *40*, 1003–1015.

25. O’Gorman, C.; Byrne, O.; Pandya, D. How scientists commercialise newknowledge via entrepreneurship. *J. Technol. Transf.* **2008**, *33*, 23–43. [[CrossRef](#)]
26. Hayter, C.S. Constraining entrepreneurial development: A knowledge-based view of social networks among academic entrepreneurs. *Res. Policy* **2016**, *45*, 475–490. [[CrossRef](#)]
27. Rasmussen, E.; Mosey, S.; Wright, M. The transformation of network ties to develop entrepreneurial competencies for spin-offs. *Entrep. Reg. Dev.* **2015**, *27*, 430–457. [[CrossRef](#)]
28. Wright, M.; Clarysse, B.; Mustar, P.; Lockett, A. *Academic Entrepreneurship in Europe*; Edward Elgar: Northampton, MA, USA, 2007.
29. Audretsch, D.B.; Lehmann, E.E.; Warning, S. University spillovers and newfirm location. *Res. Policy* **2005**, *34*, 1113–1122. [[CrossRef](#)]
30. Dietz, J.; Bozeman, B. Academic careers, patents, and productivity: Industryexperience as scientific and technical human capital. *Res. Policy* **2005**, *34*, 349–367. [[CrossRef](#)]
31. Gulbrandsen, M.; Smeby, J. Industry funding and university professors’ research performance. *Res. Policy* **2005**, *34*, 932–950. [[CrossRef](#)]
32. Roberts, E.B. *Entrepreneurs in High Technology*; Oxford University Press: New York, NY, USA, 1991.
33. Yan, S.; Wang, C. Control strategy on Human Resource Integration during the M & A Intrapreneurship: Case study. *Manag. World* **2006**, *28*, 13–29.
34. Berg, B.L. *Qualitative Research Methods for the Social Sciences*, 4th ed.; A Pearson Education Company: London, UK, 2001.
35. Yin, R.K. *Case Study Research: Design and Methods*, 4th ed.; Sage: London, UK, 2002.
36. Eisenhardt, K.M. Building Theories from Case Study Research. *Acad. Manag. Rev.* **1989**, *14*, 532–550. [[CrossRef](#)]
37. Eisenhardt, K.M.; Graebner, M.E. Theory Building from Cases: Opportunities and Challenges. *Acad. Manag. J.* **2007**, *50*, 25–32. [[CrossRef](#)]
38. Yin, R.K. *Applications of Case Study Research*, 2nd ed.; Sage: Thousand Oaks, CA, USA, 2003.
39. Eisenhardt, K.M. Better Stories and Better Constructs: The Case for Rigor and Comparative Logic. *Acad. Manag. Rev.* **1991**, *16*, 620–627. [[CrossRef](#)]
40. Jick, T.D. Mixing Qualitativeand Quantitative Methods: Triangulation in Action. *Adm. Sci. Q.* **1979**, *24*, 602–611. [[CrossRef](#)]
41. Patton, M.Q. *Qualitative Research and Evaluation Methods*, 3rd ed.; Sage Publications: Thousand Oaks, CA, USA, 2002.
42. Yusof, M.; Jain, K. Categories of university-level entrepreneurship: A literature survey. *Int. Entrep. Manag. J.* **2010**, *6*, 81–96. [[CrossRef](#)]
43. Colyvas, C.; Crow, M.; Gelijns, A.; Mazzoleni, R.; Nelson, R.; Rosenberg, N.; Sampat, B.N. How do university inventions get into practice? *Manag. Sci.* **2001**, *48*, 61–72. [[CrossRef](#)]
44. Wu, C.; Cao, Y.; Zhou, C. A Case Study on the Evolution of Leadership Style in the Growth of Enterprises. *Manag. World* **2009**, *42*, 25–32.

