

Article

A Study on Sustaining Corporate Innovation with E-Commerce in China

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Abstract: Previous research indicates that information technology promotes innovation in general. The mechanisms of how information technology, such as e-commerce, can promote corporate innovation have not yet been fully recognized. The empirical results show that e-commerce promotes corporate innovation by improving the regional informatization level and the local commercial circulation system. The evidence from Chinese firms implies that it is necessary to strengthen the construction of information infrastructure, encourage the transformation and upgrading of traditional commercial circulation, and promote innovation of traditional business in combination with e-commerce.

Keywords: e-commerce; innovation; structural equation modelling; ict

1. Introduction

Since Schumpeter put forward the concept of innovation in his classic work “Economic Development Theory”, innovation has become a research topic of wide concern in academic society [1–3]. In the research on the mechanisms of innovation, the topic of the factors influencing corporate innovation has very important theoretical and practical significance [4,5]. Innovation is the core driving force for market growth and economic development [6]. Clearly understanding the influencing factors of innovation has great value in corporate management and incentive mechanisms. Identifying these influencing factors can help the academic community to deepen the understanding of the mechanism of innovation formation.

E-commerce is a new economic form that has emerged in recent years. Corporate innovation brought on by this new form has attracted the attention of some scholars [7,8]. Cloud computing, Internet of Things (IoT), VR/AR and other technologies based on e-commerce enable the rapid growth of data information [9]. The cost reduction and the rise of efficiency in the collection, processing and dissemination of data information have made it easier for companies to innovate more than ever before. However, the mechanism of e-commerce development to promote corporate innovation is still ambiguous.

The sustainable way for companies to develop is to keep promoting innovation through various means, including adopting e-commerce. Several studies focused on organizational innovation based on the e-marketplace, and provided a possible framework for corporate innovation with e-commerce. Inoue et al. (2019) taking the logistics industry as an example, developed an ecosystem strategy which can dramatically improve the performance of logistics firms [10]. Yun and Liu (2019) developed a conceptual framework for “open innovation” by examining the previous literature at both a micro and macro level [11]. Other studies also show that ICT and e-marketplaces may be a foundation for corporations to promote innovation [12–15]. The development of e-commerce in China provides a good opportunity for research in this field. With the rapid development of China’s e-commerce, it has become an indispensable market in the global Internet economy. Research on China’s e-commerce, especially its

impact on corporate innovation, is becoming more and more important. In Figure 1, there is a significant positive relationship between e-commerce development and corporate innovation in different Chinese provinces. At present, academics pay little attention to the relationship between China's e-commerce development and corporate innovation. Recently, some studies have presented various factors impacting on corporate innovation [16,17]. In this paper, we further establish the relationship between corporate innovation and e-commerce in China. Specifically, this study conducted an empirical study of e-commerce and its relationship with corporate innovation using China's Macroeconomic data, and set up a conceptual path model to illustrate the mechanism of the e-commerce impact on corporate innovation. This study can enrich the current research on e-commerce and increase our understanding of the relationship between e-commerce and innovation. Thus, the main goals of this research and the questions we are trying to answer are:

- What is the relationship between e-commerce and corporate innovation?
- How can e-commerce have a positive impact on corporate innovation?
- What are the influence mechanisms from e-commerce development on corporate innovation?

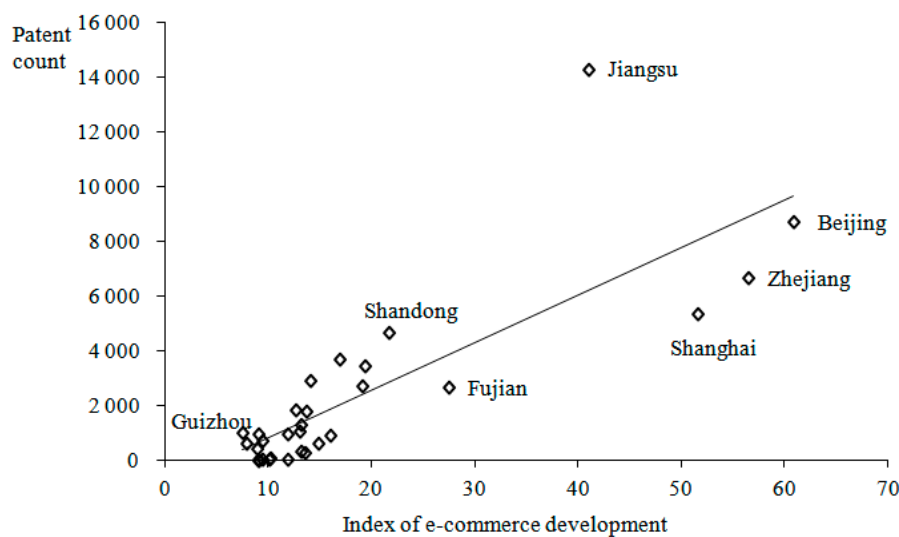


Figure 1. E-commerce Development and Enterprise Technological Innovation in Different Provinces of China. Data Source: The e-commerce index comes from the China E-Commerce Development Report (2017–2018), and the number of patents comes from the China Science and Technology Statistical Yearbook (2018).

2. Literature Review

2.1. Innovation Factors

The research on the factors influencing innovation focus on four aspects. The first is “human capital theory”. This theory holds that entrepreneurial spirit and the innovative labour of technicians themselves are the main factors driving the technological innovation of enterprises [18]. The second is “environmental inducement theory”. This theory insists the institutional environment in which enterprises are located, especially the market environment [19,20], the macroeconomic environment [21,22], and the regulatory policy environment [23] are the most important factors affecting the innovation of enterprises. The third is “financial stimulus theory”. This theory states that the level of financial development in the region has a significant impact on the innovation of companies in the region [24]. Empirical studies show that the more perfect the financial system is, the higher the incidence of innovation among enterprises in the region (especially small and medium-sized enterprises). This opinion is mainly based on the assumption that innovation activities require a large amount of venture capital investment [25,26]. Finally, the research may focus on the “business organization model theory”. Some scholars pointed out

that cooperation between different companies within the same supply chain and different departments within the same company are important sources of innovation. Organizational management and cooperation modes such as corporate culture and incentive mechanisms have a significant impact on the corporate business model and technological innovation [27,28].

The application of new technologies (including e-commerce) has attracted the attention of scholars [29,30]. These studies are based on the impact of new technologies on the internal organization and the external environment of the enterprise, which, in turn, affects the adoption and diffusion of innovation [31]. Some researchers have used questionnaires to show that the application of some new technologies, such as e-commerce, can increase the trust between traditional business partners and promote innovation [32]. Compared to the traditional business environment, this Technology Organization-Environment (TOE) promotes innovation adoption and diffusion with lower costs [33,34]. Although there are many studies on innovation factors, scholars do not agree on the mechanism of innovation. Among them, the change in business operation mode and technological innovation brought by e-commerce have not been fully recognized. Research in this area is still fragmented and needs to be further explored.

2.2. E-Commerce and Innovation

The impact of new technologies such as e-commerce on corporate innovation has not yet been fully recognized. Based on the existing literature, it is generally believed that e-commerce promotes corporate innovation by ameliorating the internal organizational structure of the enterprise, optimizing the industry's supply chain operations and improving the efficiency of the external economic environment.

First, e-commerce adoption ameliorates the internal organization of the company. The emergence of e-commerce enables companies to communicate more effectively with business partners, and has an important impact on marketing [35] and procurement [36], which in turn stimulates corporate innovation activities [31,37]. For example, some scholars believe that e-commerce has had a profound impact on corporate marketing activities and proposed the concept of e-marketing and e-CRM, which make it necessary for companies to establish an organizational structure which is closer to the market [38], to absorb market information more efficiently [39,40], and to make changes and innovations that are compatible with the market (e-marketplace).

Secondly, the use of e-commerce optimizes the industry supply chain operations. As an online trading activity, e-commerce can effectively aggregate and process massive transaction data. The use of these data resources can enhance the competitiveness and effectiveness of the industry, which provides a low-cost industry environment for the occurrence, adoption and diffusion of innovation [41]. In addition, companies increase the availability of data through online transactions, and this allows them to manage their own business, including the management of suppliers and customers, more effectively, and gradually transform the industry environment [42]. In such an environment, innovation is more likely to occur [43].

Finally, e-commerce improves the efficiency of the external economic environment. The application of e-commerce and other Internet technologies enables companies to rearrange business processes and other forms of corporate cooperation based on market information at a low cost [44], promoting the sharing of economic information, the maintenance of business relationships and social specialization [45]. In turn, the application of e-commerce provides an economic environment for the adoption and diffusion of innovation. Some studies have shown that economic environments shape innovation assimilation [34]. The current research on e-commerce to promote corporate innovation is shown in Table 1.

Table 1. Current studies on e-commerce and corporate innovation.

	Scenes	Mechanisms/Factors	Representative Literature
1	Internal organization	e-procurement e-marketing/e-CRM Organizational innovation	[34,46,47]
2	Industry supply chain	Big Data Supply Chain Suppliers and Customers	[41–43,48]
3	External environment	Collaboration, Communication, Connection and Computation	[49–51]

Some studies focus on China's e-commerce and point out the impact of e-commerce on corporate innovation. For example, Li (2015) believes that e-commerce has caused a considerable impact on the traditional enterprise supply chain system. Traditional enterprises need to adapt to the development trend of e-commerce, and actively carry out technological innovation, thus, forming a new relationship between traditional business and electrical business [52]. Shao and Hu (2016) discussed the driving forces, critical factors and impact of e-commerce in business model innovation from the perspective of platform economy, and considered self-organization as the key to e-commerce-driven technological innovation, taking Alibaba as a case to verify this [53].

2.3. Literature Comments

Although research on innovation factors has expanded greatly, we find two gaps in the research:

1. Most tests are based on theoretical hypotheses put forward by predecessors and collecting relevant data to verify this opinion. If a factor is directly related to corporate innovation, it can be considered as one of the factors affecting the innovation of companies. Since corporate innovation activities are a systematic project in which multiple factors work together, the conclusions verified by the current empirical methods are actually correlation relationships rather than a causal relationship. The conclusions do not deal well with multiple dependent variable interactions, so this causes the endogenous problem;
2. Since e-commerce is a new type of economic format that has emerged in recent years, the research on the relationship between e-commerce and corporate innovation is rare, and it stays at the level of qualitative discussion based on qualitative analysis and case analysis. Although the impact of management concepts, organizational models, and marketing strategies brought about by e-commerce will inevitably lead to the continuous adoption of corporate innovations, how does e-commerce affect corporate innovation? What is its exact path or mechanism? These questions require more systematic research.

Based on the research gaps above, the contributions of this study are as follows. On the one hand, this study uses China's data to examine the relationship between regional e-commerce development and innovation systematically, which helps to deepen the perception of the factors influencing innovation. On the other hand, this paper uses the SEM method to establish a path model for e-commerce development to promote corporate innovation, and empirically examines the specific impact mechanism, integrating regional informatization level, commercial circulation system and economic development level in the model. This effectively avoids the endogenous problem of the traditional model and reveals the relationship between e-commerce development and corporate innovation more clearly.

The remainder of this research is structured as follows. Section 3 presents the research hypotheses, that possible mechanisms of e-commerce promote innovation in China's commercial environment. Section 4 reports research methods and data description. Section 5 summarizes the results of the empirical study. Section 6 concludes with a discussion of its limitations and implications.

3. Hypotheses

Based on our own experience and previous research, we believe that regional e-commerce development may influence corporate innovation through the following hypothetical path.

First of all, some studies have pointed out that e-commerce and economic development have mutually reinforcing relationships [38,54], and a higher level of economic development actually provides a better innovation environment for companies. Secondly, the development of e-commerce has a high correlation with the construction of a regional commercial circulation system [55]. On the one hand, the regional commercial circulation system is the basis for the development of e-commerce. The more mature the commercial circulation system in a certain location, the better the development e-commerce can have. On the other hand, e-commerce also promotes the transformation and upgrading of the traditional trade circulation industry [56]. The improvement of the commercial circulation system provides a foundation for companies to engage in technological innovation. Finally, e-commerce promotes the improvement of regional informatization level, and the improvement of informatization can effectively promote the diffusion of knowledge, thus improving the level of regional technological innovation.

Although we can assume that e-commerce development promotes technological innovation through the above three paths, the five elements in the real business world are interrelated. Based on this, we further propose the following four sets of assumptions.

First, as mentioned above, the level of e-commerce development in the region will have an impact on economic development, commercial circulation system and the level of regional informatization. We set up the first group of hypotheses (H1) as follows:

Hypotheses H1a (H1a). *E-commerce Development (ECD)→Level of Economic Development (LED)*

Hypotheses H1b (H1b). *E-commerce Development (ECD)→Commercial Circulation System (TCS)*

Hypotheses H1c (H1c). *E-commerce Development (ECD)→Regional Informatization (RI)*

Secondly, the level of economic development has an impact on the regional commercial circulation system, the level of regional informatization and corporate technological innovation.

(a) There is a positive correlation between the level of economic development and the regional commercial circulation system. The higher the level of regional economic development, the higher the requirements for the commercial circulation system that adapts to it, so the demand for economic development will stimulate the construction of the local commercial circulation system;

(b) The level of economic development is positively related to the level of informatization [57]. The main mechanism is that economic development provides the basis for the construction and application of information technology;

(c) The level of regional economic development is directly proportional to the technological innovation of their enterprises. The higher the level of regional economic development, the better the foundation and conditions for technological innovation.

We establish the second set of hypotheses (H2) as follows:

Hypotheses H2a (H2a). *Level of Economic Development (LED)→Commercial Circulation System (TCS)*

Hypotheses H2b (H2b). *Level of Economic Development (LED)→Regional Informatization (RI)*

Hypotheses H2c (H2c). *Level of Economic Development (LED)→Corporate Technological Innovation (CTI)*

Thirdly, the situation of the regional commercial circulation system affects the level of economic development in the region, the development of e-commerce and corporate technological innovation.

(a) The commercial circulation system will promote economic development. The more sound the commercial circulation system is, the higher production efficiency the enterprises can have, so the higher the level of economic development would be [58];

(b) The degree of perfection of the commercial circulation system affects the development of e-commerce in the area. Only with a sound commercial circulation system as support can e-commerce achieve good performance;

(c) The improvement of the commercial circulation system reduces the operational costs of the enterprise, allowing them more resources to invest in technological innovation [59].

We set up the third group of hypotheses (H3):

Hypotheses H3a (H3a). *Commercial Circulation System (TCS)→Level of Economic Development (LED)*

Hypotheses H3b (H3b). *Commercial Circulation System (TCS)→E-commerce Development (ECD)*

Hypotheses H3c (H3c). *Commercial Circulation System (TCS)→Corporate Technological Innovation (CTI)*

The level of informatization promotes the economic development of the region, the construction of commercial circulation systems and corporate technological innovations.

(a) There have been lots of academic works on the relationship between informatization and economic development. Most of them believe that informatization has a positive effect on economic development. The mechanism is that informatization promotes economic development by improving the efficiency of traditional industries [60];

(b) Informatization will promote the development of regional commercial circulation systems. Generally speaking, the higher the level of informatization in the region, the higher the efficiency of the commercial circulation system is, and the higher the level of specialization of commerce and trade industry [61];

(c) The level of informatization in the region is positively related to corporate innovation. In general, most studies show that the higher the level of informatization is, the lower the cost of corporate innovation can have [62].

We construct the fourth group of hypotheses (H4) as follows:

Hypotheses H4a (H4a). *Regional Informatization (RI)→Level of Economic Development (LED)*

Hypotheses H4b (H4b). *Regional Informatization (RI)→Commercial Circulation System (TCS)*

Hypotheses H4c (H4c). *Regional Informatization (RI)→Corporate Technological Innovation (CTI)*

Based on all the hypotheses, we can establish a conceptual model of corporate technological innovation and its influencing factors, as shown in Figure 2.

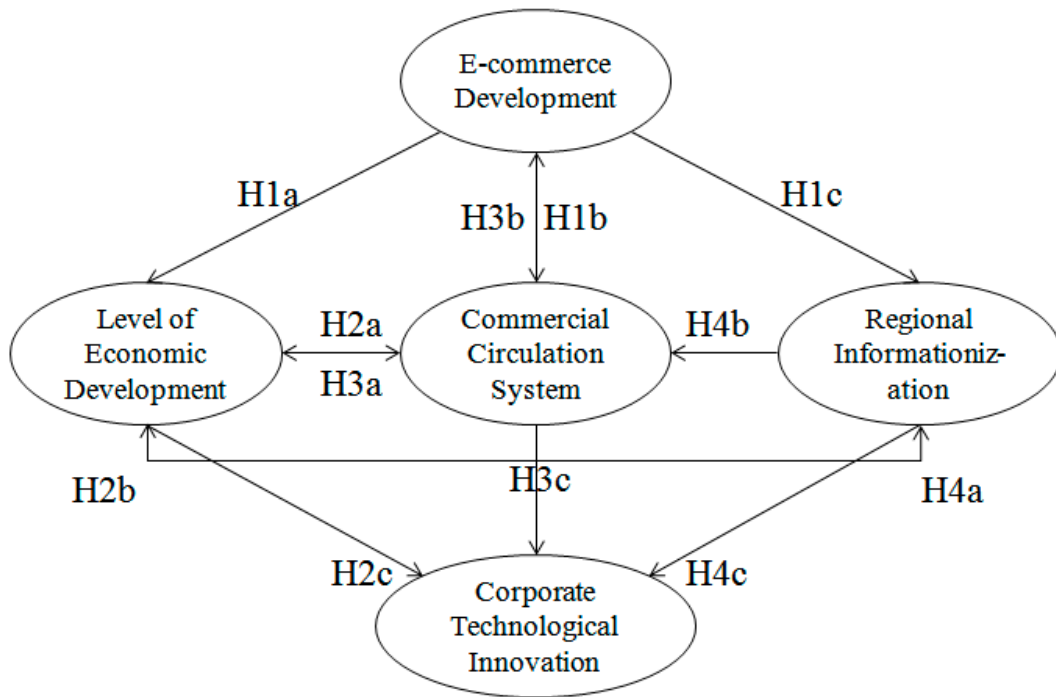


Figure 2. Conceptual Model.

4. Research Methods and Data

4.1. Methods

The above hypotheses examine the possible paths by which e-commerce may have an impact on corporate innovation. This paper applies the Structural Equation Modelling to evaluate the relationship between the path of e-commerce development and corporate technological innovation.

Structural Equation Modelling is known as LISREL analysis and latent variable modelling [63]. SEM integrates two statistical methods, factor analysis and path analysis, which are suitable for analyzing coefficient estimates between multiple factors that cannot be directly measured. A SEM model consists of a measurement model and a conceptual model. The measurement model reflects the relationship between latent variables and measurable variables. The latent variables refer to variables which are not easy to measure directly, such as corporate technological innovation and regional informatization in this study. These variables generally need to be represented by measurable indicators. As is shown in Equations (1) and (2):

$$X = \Lambda_x \xi + \delta \tag{1}$$

$q \times 1$ $(q \times n)(n \times 1)$ $q \times 1$

$$Y = \Lambda_y \eta + \varepsilon \tag{2}$$

$p \times 1$ $(p \times m)(m \times 1)$ $p \times 1$

X and Y are the Observational indicators of ξ and η , δ and ε are the measurement error of X and Y, Λ_x is a $q \times n$ coefficient matrix, which is composed of X by the factors loaded on ξ . Λ_y is a $p \times n$ coefficient matrix which is composed of Y by the factors loaded on η . p is the number of endogenous measurable variables; q is the number of exogenous measurable variables.

The conceptual model reflects the relationship between latent variables as is shown in Equation (3):

$$\eta = B\eta + \Gamma\xi + \zeta \tag{3}$$

$m \times 1$ $(m \times m)(m \times 1)$ $(m \times n)(n \times 1)$ $m \times 1$

η is a vector composed by endogenous latent variables, ξ is a vector composed by exogenous latent variables, ζ is a vector composed by random bias. B is an endogenous latent variable coefficient matrix, Γ is an endogenous latent variable coefficient matrix. m and n represent the number of endogenous latent variables and exogenous latent variables, respectively.

The Maximum Likelihood Estimation (MLE) method provided by AMOS17 software is used to estimate Equation (3). The MLE method has excellent statistical properties such as unbiasedness, consistency and validity in large sample cases. The form of its estimate is Equation (4):

$$F_{ML} = \log \left| \sum (\theta) \right| + tr(S \sum^{-1} (\theta)) - \log |S| - (p + q) \quad (4)$$

$tr(S \sum^{-1} (\theta))$ is the trace of the matrix $S \sum^{-1} (\theta)$, $\log \left| \sum (\theta) \right|$ and $\log |S|$ represent the logarithm of determinant $\sum (\theta)$ and S , p and q are the number of endogenous measurable variables and exogenous measurable variables.

4.2. Data

The data used in this study come from various statistical yearbooks and research reports of China. Among them, the indicators for regional e-commerce development come from the China E-Commerce Development Report (2017/2018/2019). The indicators of regional informatization are from China Statistical Yearbook, China Internet Development Status Report (2017/2018/2019) and Tencent Internet + Index Report. The indicators of corporate technological innovation come from the China Science and Technology Statistical Yearbook (2017/2018/2019). The indicators of the commercial circulation system come from the Yearbook of Large and Medium-sized Wholesale, Retail and Accommodation Enterprises. The indicator of economic development level come from the China Statistical Yearbook (2017/2018/2019). SPSS is used to analyze 20 indicators to construct the database used in this study. The descriptive statistics of these indicators are shown in Table 2. Most of the data used in his study come from the yearbook published by the National Bureau of Statistics of China. These yearbooks are the most authoritative data in China and are continuously obtained by a uniform and comprehensive sampling statistical method. A small amount of data are mainly from China's industry research report. For example, the Internet+ Index is published by Tencent, a well-known Internet company in China. The index is a scientific measure of the level of Informatization in China and is authoritative in China.

The data is analyzed in three steps:

- Extract the data from the sources (yearbooks\reports) according to previous work and the theoretical assumptions;
- Download the data into SPSS software and standarize the data, then we perform reliability tests using SPSS;
- Use AMOS to estimate the conceptual model according to SEM method.

Table 2. Descriptive Statistics for Each Indicator.

Indicator	Variable Name	Latent Variable	Mean	Standard Deviation	Remarks
E-commerce scale	gm	E-commerce Development	16.34	25.55	The scale of development of the online market
E-commerce growth	cz		23.46	12.16	E-commerce development prospects
E-commerce penetration	st		25.65	22.26	The impact of e-commerce on economic development
E-commerce support	zc		10.31	19.42	Supporting environment for e-commerce development

Table 2. Cont.

Number of netizens	wms		2024.74	1619.76	Ten thousand
Internet penetration rate	pjl		51.3%	11.7%	-
Internet + index	hlwj	Regional Informatization	3.03	3.42	Index of Internet+ developed by Tencent Corporation
Number of computers	jsjs		22.69	9.68	Number of computers per 100 people
Number of websites	wzs		55.18	9.58	Number of websites owned by every 100 companies
Number of technical personnel	rysl	Corporate Technological Innovation	10.57	11.68	Number of R&D personnel (10,000)
R&D expenditure	jfzc		236.98	343.02	R&D internal expenditure of enterprises (100 million yuan)
Number of patents	zls		4238.48	12,641.34	High-tech industry patents
Total number of social retail	shls		10,184.12	18,467.21	100 million yuan
Number of online retail	wlls	Commercial Circulation System	1209.67	2162.75	100 million yuan
Corporation gross profit	mll		8.84%	3.9%	Main business gross profit of commercial and trading enterprises
Employed population	jjrs		35.71	29.33	Employment in the commerce and trade circulation industry (10,000 people)
Regional GDP	dqsc		23,021.53	18,196.76	100 million yuan
Income per capita	rjsr	Level of Economic Development	52,138.32	23,488.03	yuan
Household consumption index	jmxj		109.71	2.18	-
Revenue	czsr		2472.36	1841.43	Budgetary revenue (100 million yuan)

Notes: Due to the inconsistent investigation time of various investigation reports, this study mainly uses 2016\2017\2018 data, and a small amount of missing data is compiled by the data of the surrounding years. The sample size is 99 observations.

4.3. Reliability and Validity Test

To verify that the data set selected in this study can explain the conclusions of this paper, we need to test the reliability and validity of the data. The units of the selected indicators are different. This study first uses SPSS for standardized dimensionless processing, then conducts a reliability and validity test on the data.

Reliability refers to the degree of data consistency or stability, mainly reflecting the proportion of the same “traits” between the indicators. This study uses the coefficient method proposed by Chronbach (1951) to measure the reliability level [64]. The calculation formula is as shown in Equation (5):

$$\alpha = \frac{K}{K-1} \left(1 - \frac{\sum_{i=1}^K \sigma_{Y_i}^2}{\sigma_X^2} \right) \quad (5)$$

K is the number of indicators. $\sigma_{Y_i}^2$ and σ_X^2 are the intra-group variance and population variance, respectively. It is generally believed that when the α coefficient is between 0.35 and 0.7, the data set has better reliability. Cronbach’s alpha is a measurement of how closely related a set of items as a group. It is generally considered as a measurement of reliability. However, Cronbach’s alpha is not a statistical test but rather a coefficient of reliability. Moreover, a high value of Cronbach’s alpha offers limited evidence of reliability. As shown in Table 3, we used SPSS to calculate the values of Cronbach’s alpha for the variables. Except for the low reliability value of the economic development level, the reliability values of other variables met the basic requirements, and the overall α coefficient was 0.641. Therefore, we can conclude that the data set in this study has a good reliability.

Table 3. Reliability Level of Each Latent Variable.

Latent Variable	Number of Observable Variables	Cronbach's α Value
E-Commerce Development	4	0.742
Corporate Technological Innovation	3	0.721
Commercial Circulation System	4	0.628
Regional Informatization	5	0.61
Level of Economic Development	4	0.451

Validity refers to the degree to which the measurement tool can accurately measure the target trait. It can be divided into content validity, criterion validity and structural validity according to the target traits. Factor analysis showed that the KMO estimate between the variables was 0.814, which was greater than the standard of 0.7, so the model's validity level is acceptable.

5. Results

The goodness of fit of the structural equation model in this study is based on the likelihood ratio chi-square test, GFI and RMR test, which is based on the results given by AMOS17. The test results show that the test values of the model are close to the saturation model, which indicates that the model has a good goodness-of-fit.

As shown in Table 4, except for H2b (the level of economic development→regional informatization) and H4b (regional informatization→commercial circulation system) are not significant, the other routes are shown to be significant at the level of 10%. This shows that the SEM established in this paper can roughly simulate the path structure and function level of e-commerce development (ECD) and corporate technological innovation (CTI). Based on this, we can sort out the two paths of e-commerce development to promote corporate technological innovation.

Table 4. Estimation Result of Conceptual Model.

Hypotheses	Path	Estimation Coefficient	Significant
H1a	ECD→LED	0.115	*
H1b	ECD→TCS	0.335	*
H1c	ECD→RI	1.834	**
H2a	LED→TCS	0.623	*
H2b	LED→RI	−0.127	Not Significant
H2c	LED→CTI	1	-
H3a	TCS→LED	1.361	*
H3b	TCS→RI	0.011	***
H3c	TCS→CTI	0.126	**
H4a	RI→LED	1.032	**
H4b	RI→TCS	−0.026	Not Significant
H4c	RI→CTI	1.57	***

Notes: (a) In order to facilitate comparison, based on previous research we assume that the promotion of Level of Economic Development (LED) to the Corporate technological innovation (CTI) is a significant unit impact. (b) *, **, *** indicate the significance at the levels of 10%, 5% and 1%, respectively.

Path 1: E-commerce Development→Regional Informatization→Corporate Technological Innovation

This path is the most obvious one in the empirical analysis of this paper. It has been well documented that there is a strong positive correlation between e-commerce development and the level of informatization in a region [4]. E-commerce is one of the main applications of informatization and basic information construction is the premise of e-commerce development. However, in recent years, we have observed that, in most of central and western China, the role of e-commerce in promotion of the development of regional informatization is becoming more and more obvious. The adoption of e-commerce has driven e-government and enterprise informatization that is profitable. E-commerce promotes other information projects, which have a relatively small profit. The improvement of regional

informatization levels can strongly stimulate corporate technological innovation. Its mechanism is that the improvement of the information level has accelerated the flow of information and knowledge in the region; thus providing an environment for the technological innovation of enterprises.

Path 2: E-commerce Development → Commercial circulation system → Corporate technological innovation

This is a relatively weak path. Although the empirical results show that the impact of regional e-commerce development on the commercial circulation system is significant at the level of 10%, in reality, we have observed that the two have different relationships in different regions of China. In general, the impact of e-commerce on the traditional commercial circulation system is obvious. The two are more likely to appear in the terminal market in a competitive relationship, but, in some areas which have a relatively mature business foundation, the integration of business channels (online and offline) has become a developing trend of the future commerce and circulation industry [65]. In this study, data from different regions are “offset”, but there is no doubt that regional e-commerce development and commercial circulation systems are closely linked. The maturity of the commercial circulation system is crucial to the corporate technological innovation, which provides a basic commerce infrastructure for corporate innovation diffusion [66].

Based on the above discussion, we can conclude that the paths of e-commerce development to corporate technological innovation are: (a) regional e-commerce development, regional information level, enterprise technological innovation, (b) regional e-commerce development, commercial circulation system, corporate technological innovation and (c) regional e-commerce development, economic development level, corporate technological innovation (as assumed); its intensity of action is $a > c > b$.

Table 5 and Figure 3 show the estimated results of the measurement model provided by Amos17. The absolute value of most indicators is greater than 0.5, which indicates that the observed data in the model is a good measure of latent variables. For variables with estimated coefficient signs that are negative (Number of netizens → RI), this is because there are other, “stronger” variables that have a positive effect on the latent variables.

Table 5. Estimation Result of Measurement Model.

Variable Name	Path	Estimation Coefficient	Variable Name	Path	Estimation Coefficient
Zrysl	Number of technical personnel →CTI	0.549	Zjyrs	Employed population →TCS	0.432
Zjfcz	R&D expenditure →CTI	0.621	Zdqsc	Regional GDP →LED	1.513
Zzls	Number of patents →CTI	0.849	Zrjsr	Income per capita →LED	1.092
Zgm	E-commerce scale →LED	0.974	Zjmxs	Household consumption index →LED	0.663
Zcz	E-commerce growth →LED	0.217	Zczsr	Revenue →LED	0.721
Zst	E-commerce penetration →LED	1.153	Zwms	Number of netizens →RI	-0.019
Zzc	E-commerce support →LED	0.824	Zpjl	Internet penetration rate →RI	1.212
Zshls	Total number of social retail →TCS	1.082	Zhlwj	Internet + index →RI	0.175
Zwlls	Number of online retail →TCS	0.429	Zjsjs	Number of computers →RI	0.037
Zml	Corporation gross profit →TCS	1.475	Zwzs	Number of websites →RI	0.132

Notes: The capital letter Z before the variable name indicates that the variable has been standardized.

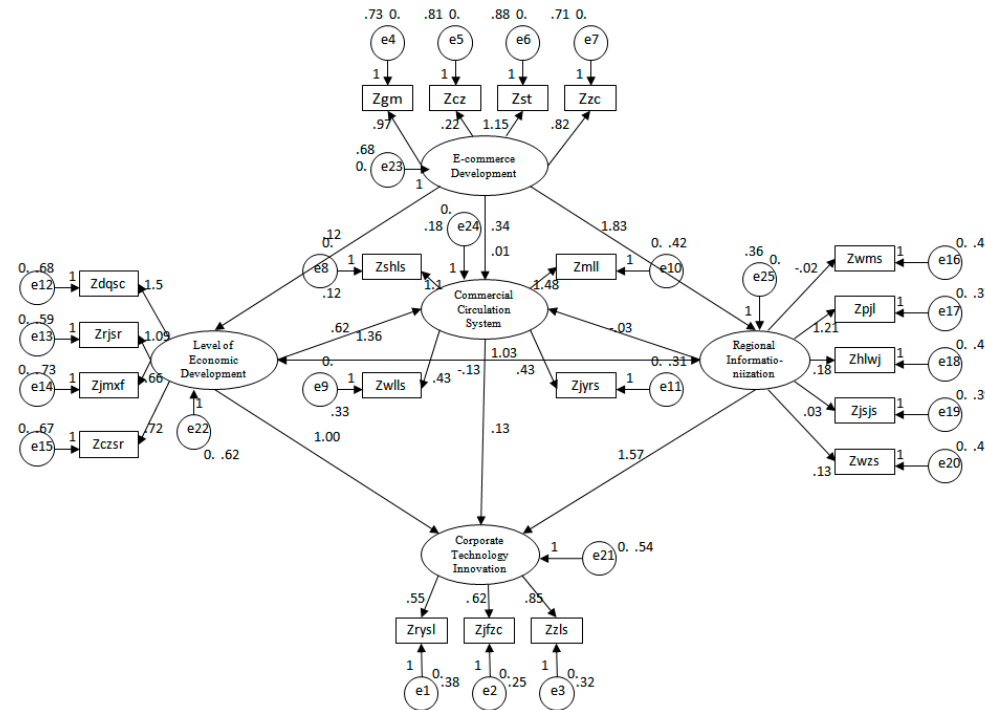


Figure 3. Empirical result given by AMOS17.

6. Conclusions and Discussion

This study has interesting conclusions in theory and practice. With respect to theory, from the empirical analysis results, it can be seen that the development of e-commerce in China stimulates corporate innovation by improving the level of regional informatization and promoting the upgrading of the regional commercial circulation system. Of these, the path of improving regional informatization level is more significant.

With respect to practice, this study has drawn the following conclusions:

First, the level of informatization is an important "bridge" which connects e-commerce and corporate innovation. Information infrastructure is an important embodiment of the regional informatization level. It can be seen that China's experience shows that behind the innovation of a company is not only the role of e-commerce, but also the level of local informatization.

Second, the convenient business circulation environment is a necessary environment for corporate innovation, and, in the future, the trade and circulation industry must realize its deep integration with e-commerce. This study indicates that, in the future, the trade circulation industry must rely on its local service capabilities, to build or undertake online trading channels, and provide convenient trade and circulation services for online and offline transactions, to realize the transformation of the traditional commerce and trade circulation industry. In fact, this transformation will significantly reduce the cost of corporate innovation in China.

Third, it may be necessary for companies to support both online and offline e-commerce operations in order to promote corporate innovation in future.

The main contributions of this paper are as follows:

- First, this study systematically examined the relationship between e-commerce and corporate innovation. Compared to previous research, this research has established the impact model of e-commerce in promoting corporate innovation while taking the e-commerce development factors, informatization level factors, commercial circulation system factors, and economic development factors into consideration, while other studies in this field were either a qualitative analysis or neglected the transmission mechanism between e-commerce and corporate innovation [30,44]. Hence, this study makes a step towards a systematic analysis of e-commerce to promote corporate innovation, which adds value to this research topic;
- Second, this study provides two possible path of e-commerce promoting corporate innovation. The implication of these possible paths is that they explain why, in China, there is a significant positive relationship between e-commerce development and corporate innovation. From these paths we can conclude that, in reality, the adoption of e-commerce does not necessarily promote corporate innovation; it has to cooperate with the construction of other information infrastructures, commercial circulation systems and economic developments;
- At last, this study provides a possible research perspective for the sustainable development of enterprises. A sustainable way for enterprises to develop is through innovation. As the mechanism of innovation caused by e-commerce or e-marketplaces has not been fully understood, this study uses Chinese data to empirically examine this phenomenon and provides two possible paths of e-commerce promoting corporate innovation. This can be a foundation for future research about sustainable development of enterprises in e-commerce environment.

The main limitation of this study is that possible system factors were not fully incorporated. These include invisible factors, such as the impact of e-commerce development on the internal organization and management structure of companies. Although in theory these factors may significantly affect corporate innovation, these factors cannot be included in the model of this study due to the lack of statistical data. Therefore, we have no way to judge whether or not there is such a path and its significance.

Another limitation of this study may be the sample size. Because this study was restricted to China within a short period, applying the findings to other countries may therefore require additional considerations of the conceptual modelling. The representativeness and generalisability

of this research only applies to the circumstances in China, and not necessarily to other countries or large-scale organisations.

Based on the results of this paper, we plan to further investigate two possible paths between e-commerce and corporate innovation in the future. These two paths, regional informatization and commercial circulation systems, may play important roles in e-commerce promoting corporate innovation. The detailed mechanism of how these two factors perform, and to what extent these factors feature in the two paths, still remains unclear. We will examine these factors from both micro and macro aspects. At the micro level, company-level data will be collected and analyzed to establish the relationship between e-commerce adoption and corporate innovation. At the macro level, cross-country data will be examined to establish a relationship between e-commerce development and diffusion of innovation.

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References

1. Frankwick, G.L. Mastering the dynamics of innovation: How companies can seize opportunities in the face of technological change. *J. Acad. Mark. Sci.* **1996**, *24*, 379.
2. Pisano, G.P. *The Development Factory: Unlocking the Potential of Process Innovation*; Harvard Business Press: Boston, MA, USA, 1997.
3. Mueller, G.C.; Mone, M.A.; Barker, V.L. Formal strategic analyzes and organizational performance: Decomposing the rational model. *Organ. Stud.* **2007**, *28*, 853–883. [CrossRef]
4. Gallouj, F.; Weinstein, O. Innovation in services. *Res. Policy* **1997**, *26*, 537–556. [CrossRef]
5. Hsu, P.; Kraemer, K.L.; Dunkle, D. Determinants of e-business use in U.S. firms. *Int. J. Electron. Commer.* **2006**, *10*, 9–45. [CrossRef]
6. *Greenspan: A Testimony of Chairman Alan Greenspan: Federal Reserve Board's Semiannual Monetary Policy Report to the Congress before the Committee on Banking, Housing and Urban Affairs*; U.S. Senate: Washington, DC, USA, 2002. Available online: <http://www.federalreserve.gov/boarddocs/hh/2002/march/testimony.html> (accessed on 6 December 2018).
7. Geoffrion, A.M.; Krishnan, R. E-business and management science: Mutual impacts. *Manag. Sci.* **2003**, *49*, 1275–1286. [CrossRef]
8. Zhu, K.; Kraemer, K.L. Post-adoption variations in usage and value of e-business by organizations: Cross-country evidence from the retail industry. *Inf. Syst. Res.* **2005**, *16*, 61–84. [CrossRef]
9. Lynch, C. Big data: How do your data grow. *Nature* **2008**, *455*, 28–29. [CrossRef]
10. Inoue, Y.; Hashimoto, M.; Takenaka, T. Effectiveness of ecosystem strategies for the sustainability of marketplace platform ecosystems. *Sustainability* **2019**, *11*, 5866. [CrossRef]
11. Yun, J.J.; Liu, Z. Micro- and macro-dynamics of open innovation with a quadruple-helix model. *Sustainability* **2019**, *11*, 3301. [CrossRef]
12. Anttonen, M.; Lammi, M.; Mykkänen, J.; Repo, P. Circular economy in the triple helix of innovation systems. *Sustainability* **2018**, *10*, 2646. [CrossRef]
13. Inoue, Y.; Takenaka, T.; Kurumatani, K. Sustainability of service intermediary platform ecosystems: Analysis and simulation of Japanese hotel booking platform-based markets. *Sustainability* **2019**, *11*, 4563. [CrossRef]
14. Inoue, Y. Winner-takes-all or co-evolution among platform ecosystems: A look at the competitive and symbiotic actions of complementors. *Sustainability* **2019**, *11*, 726. [CrossRef]
15. Wan, X.; Cenamor, J.; Parker, G.; Van Alstyne, M. Unraveling platform strategies: A review from an organizational ambidexterity perspective. *Sustainability* **2017**, *9*, 734. [CrossRef]
16. Li, B.; Ho, C.-Y. Heterogeneous effects of internet channel on firm innovation. *Appl. Econ. Lett.* **2019**. [CrossRef]
17. Rodríguez-Ardura, I.; Meseguer-Artola, A. Toward a longitudinal model of e-commerce: Environmental, technological, and organizational drivers of B2C adoption. *Inf. Soc.* **2010**, *26*, 209–227. [CrossRef]

18. Rothaermel, F.T.; Hess, A.M. Building dynamic capabilities: Innovation driven by individual, firm, and network level effects. *Organ. Sci.* **2006**, *18*, 898–921. [[CrossRef](#)]
19. Jaffe, A.B.; Trajtenberg, M.; Henderson, R. Geographic localization of knowledge spillovers as evidenced by patent citations. *Q. J. Econ.* **1993**, *108*, 577–598. [[CrossRef](#)]
20. Breschi, S.; Lissoni, F. Knowledge spillovers and local innovation systems: A critical survey. *Ind. Corp. Chang.* **2001**, *10*, 975–1005. [[CrossRef](#)]
21. Hemlin, S. Creative knowledge environments in the innovation system, Copenhagen. *Cph. Bus. Sch. Work. Pap.* **2002**, *7*, 1–14.
22. Love, J.H.; Roper, S. Location and network effects on innovation success: Evidence for UK, German and Irish manufacturing plants. *Res. Policy* **2001**, *30*, 643–661. [[CrossRef](#)]
23. Ma, N.; Guan, J. Key factors affecting the technological innovation performance of China's industrial enterprises. *Sci. Sci. Technol. Manag.* **2000**, *3*, 16–20.
24. Fuerst, M.E. Technological Innovation and the Design of the Financial System. Ph.D. Thesis, University of Michigan, Ann Arbor, MI, USA, 1999.
25. Kortum, S.; Lerner, J. *Does Venture Capital Spur Innovation?* Working Paper; Harvard University: Cambridge, MA, USA, 1997.
26. Cesar, C.; Lin, L. The direction of causality between financial development and economic growth. *J. Dev. Econ.* **2003**, *72*, 321–330.
27. Moenaert, R.K.; Caeldries, F.; Lievents, A.; Wauters, E. Communication flows in international product innovation teams. *J. Prod. Innov. Manag.* **2000**, *6*, 178–196. [[CrossRef](#)]
28. Yang, J.; Kang, B. Research on the influence of communication between enterprise technology innovation decision-making subjects and investment subjects on innovation performance. *Sci. Manag. Res.* **2007**, *10*, 18–21.
29. Sila, I. Factors affecting the adoption of B2B e-commerce. *Electron. Commer. Res.* **2013**, *13*, 199–236. [[CrossRef](#)]
30. Chu, Y.; Chi, M.; Wang, W.; Luo, B. The impact of information technology capabilities of manufacturing enterprises on innovation performance: Evidences from SEM and fsQCA. *Sustainability* **2019**, *11*, 5946. [[CrossRef](#)]
31. Fichman, R.G. The role of aggregation in the measurement of IT-related organizational innovation. *MIS Q.* **2001**, *25*, 427–455. [[CrossRef](#)]
32. Alsaad, A.; Mohamad, R.; Ismail, N.A. The moderating role of trust in business to business electronic commerce (B2B EC) adoption. *Comput. Hum. Behav.* **2016**, *68*, 157–169. [[CrossRef](#)]
33. Soh, C.; Markus, M.L.; Goh, K.H. Electronics marketplaces and price transparency: Strategy, information technology and success. *MIS Q.* **2006**, *30*, 705–723. [[CrossRef](#)]
34. Zhu, K.; Kraemer, K.L.; Xu, S. The process of innovation assimilation by firms in different countries: A technology diffusion perspective on E-business. *Manag. Sci.* **2006**, *52*, 1557–1576. [[CrossRef](#)]
35. Dimoka, A.; Hong, Y.; Pavlou, P.A. On product uncertainty in online markets: Theory and evidence. *MIS Q.* **2012**, *36*, 395–426. [[CrossRef](#)]
36. Son, J.; Benbasat, I. Organizational buyers' adoption and use of B2B electronic marketplaces: Efficiency and legitimacy-oriented perspectives. *J. Manag. Inf. Syst.* **2007**, *24*, 55–99. [[CrossRef](#)]
37. Chong, W.K.; Bian, D.; Zhang, N. E-marketing services and e-marketing performance: The roles of innovation, knowledge complexity and environmental turbulence in influencing the relationship. *J. Mark. Manag.* **2016**, *32*, 149–178. [[CrossRef](#)]
38. Fan, Y.; Zhuo, D. An empirical study of the effect of China's e-commerce on economic growth. *Ind. Technol. Econ.* **2010**, *8*, 40–44.
39. Albrecht, C.C.; Dean, D.L.; Hansen, J.V. Marketplace and technology standards for B2B e-commerce: Progress, challenges and the state of the art. *Inf. Manag.* **2005**, *42*, 865–875. [[CrossRef](#)]
40. Bockstedt, J.; Goh, K.H. Seller strategies for differentiation in highly competitive online auction markets. *J. Manag. Inf. Syst.* **2011**, *28*, 235–268. [[CrossRef](#)]
41. Kauffman, R.J.; Srivastava, J.; Vayghan, J. Business and data analytics: New innovations for the management of e-commerce. *Electron. Commer. Res. Appl.* **2012**, *11*, 85–88. [[CrossRef](#)]
42. Lichtenthal, J.D.; Eliaz, S. Internet integration in business marketing tactics. *Ind. Mark. Manag.* **2003**, *32*, 3–13. [[CrossRef](#)]

43. Wright, L.T.; Robin, R.; Stone, M.; Aravopoulou, D.E. Adoption of big data technology for innovation in B2B marketing. *J. Bus. Bus. Mark.* **2019**, *34*, 1–13. [CrossRef]
44. Vladimir, Z. Electronic commerce and organizational innovation: Aspects and opportunities. *Int. J. Electron. Commer.* **2003**, *7*, 7–37.
45. Zeng, S.X.; Xie, X.M.; Tam, C.M. Relationship between cooperation networks and innovation performance of SME. *Technovation* **2010**, *30*, 181–194. [CrossRef]
46. Chakraborty, G.; Lala, V.; Warren, D. What do customers consider important in B2B websites? *J. Advert. Res.* **2003**, *43*, 50–61. [CrossRef]
47. Evangelista, R.; Vezzani, A. The economic impact of technological and organizational innovations. A firm-level analysis. *Res. Policy* **2010**, *39*, 1253–1263. [CrossRef]
48. Kraemer, K.L.; Gibbs, J.; Dedrick, J. Impacts of globalization on e-commerce use and firm performance: A cross-country investigation. *Inf. Soc.* **2005**, *21*, 323–363. [CrossRef]
49. El Sawy, O.A.; Malhorta, A.; Goasin, S.; Young, K.M. IT-intensive value innovation in the electronic economy: Insights from Marshall industries. *MIS Q.* **1999**, *23*, 305–335. [CrossRef]
50. Fretwell, L.; Strandquest, B. Online collaboration: The next wave of internet innovation. In *Perspectives on Business Innovation*; no.8.Cap; GeminiErnst & Young Center for Business Innovation: London, UK, 2002; Available online: www.cbi.cgey.com/journal/Issue8/Online_Collab.html (accessed on 19 December 2018).
51. Cui, T.; Ye, H.J.; Teo, H.H.; Li, J. Information technology and open innovation: A strategic alignment perspective. *Inf. Manag.* **2015**, *52*, 348–358. [CrossRef]
52. Li, H. Research on the innovation and development of traditional industry under the background of e-commerce. *Macroecon. Manag.* **2015**, *2*, 79–82.
53. Shao, P.; Hu, P. Case study on business model innovation and evolution of e-commerce platform. *Res. Manag.* **2016**, *7*, 81–88.
54. Yang, J.; Zhou, T.; Li, Q. An empirical study on the role of electronic commerce in economic growth. *World Econ. Study* **2011**, *10*, 40–43.
55. Fang, F.; Xing, W. Research on U-shaped relationship between household consumption and e-commerce market size. *Financ. Trade* **2015**, *11*, 131–147.
56. Fang, W. Transformation and upgrading of China's commerce and trade circulation industry under the background of urban and rural trade and economic planning. *Commer. Econ. Res.* **2016**, *7*, 11–19.
57. Li, J.; Yu, L. Research on the relationship between informatization and economic development based on simultaneous equation model. *J. Inf.* **2011**, *11*, 192–195.
58. Melitz, M.J. The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica* **2003**, *6*, 1695–1725. [CrossRef]
59. Zhang, H. Enhancement of circulation industry competitiveness and technological innovation. *Bus. Times* **2007**, *18*, 12–17.
60. Castells, M.; Ipola, E. Epistemological practice and the social science. *Econ. Soc.* **1976**, *5*, 111–144. [CrossRef]
61. Zhang, H. Informatization and China's circulation innovation. *Financ. Trade Econ.* **2003**, *10*, 58–62.
62. Ye, M.; Li, J. Informatization and enterprise innovation development. *J. Beijing Technol. Bus. Univ.* **2003**, *6*, 29–31.
63. Hair, J.F., Jr.; Anderson, R.E.; Tatham, R.L.; Black, W.C. *Multivariate Data Analysis*; Prentice Hall: Upper Saddle River, NJ, USA, 1998.
64. Chronbach, L.J. Coefficient alpha and the internal structure of tests. *Psychometrika* **1951**, *16*, 297–334. [CrossRef]
65. Wang, X. *Transformation and Upgrading of Traditional Commerce and Trade and Rural e-Commerce Development—Research Report of Huaiyuan Model*; BanTang Business School Research Report: HeFei, China, 2016.
66. Atkeson, A.; Burstein, A.T. Innovation, firm dynamics, and international trade. *J. Political Econ.* **2010**, *118*, 433–484. [CrossRef]



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