Open Innovation and New Mechanism of Market-Based Technology Diffusion from MNCs

Zheng Feihu (郑飞虎), Cai Hongbo (蔡宏波), Zhong Xin (仲鑫)*
School of Economics and Business Administration, Beijing Normal University, Beijing, China

Abstract: *The international community has blamed developing countries for the lack of intellectual property rights (IPR) protection - not least the "forced technology transfers" - in attracting foreign direct investment (FDI). This paper employs the large-sample contract data of multinational companies' (MNCs) IT R&D transactions in China to discuss this controversy from a unique perspective of MNCs in the role of contractors. Our findings suggest that MNCs initially guarded their know-how before the 2000s under closed innovation, but have started to take the initiative to transfer technology to local partners as open innovation held sway. China's structured market entities and huge demand for technology transactions have served as key drivers for MNCs to transfer technology, which has been further boosted by the new business model of open innovation. This paper's empirical analysis not only helps unravel the "black box" of technology transfers by MNCs, but reveals how late-moving developing countries may make better use of FDI referencing China's experience on the three dimensions of market opportunities, structured entities, and economies of scale.*

Keywords: *open innovation, foreign direct investment (FDI), market-based technology diffusion, initiative to match between supply and demand*
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1. Introduction

Over the past four decades, opening-up and FDI inflows have transformed China's economic growth. Today, China has become a leading trading nation with the largest foreign exchange reserves in the world. Yet controversies over China's opening-up experience and model remain. Chinese academics hold different views on the effects of market-based technology diffusion, which vary across industrial sectors[1] (Ping, 2007; Gao et al., 2007; Xia and Zhao, 2012; Li, 2014). Research on the relevant literature found that the topic of market-based technology diffusion drew attention from numerous academics since McDougal (1960) first developed a theory on the technology spillover

* Corresponding author: Zhong Xin, email: z_xiny@sina.com
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[1] According to Chesbrough (2003), technology itself does not contain value, and value is derived only from market-based technology applications. In this paper, "market-based technology diffusion" is defined by whether host-country firms generate new value through technology spillover or transfer. This concept is related to the policy principle to "acquire foreign technology in exchange of market access" (taking into account the influence of host country government), but focuses more on entities' intent of transaction and motivations of behavior at the microscopic level.

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effect. According to Zheng's (2006) review of empirical studies on FDI's technology spillover effects by Chinese academics (1994-2005), the prevalent view in the academia was that "despite the existence of FDI's technology spillover effect recognized in theoretical analysis, empirical studies have led to inconsistent results." A multitude of studies have employed China's industrial sector data to verify the models in the Western classical economics literature, but are subject to limitations with respect to model application and research methodology, and thus led to poor empirical results. On the basis of existing studies, Chinese academics have made further progress concerning the objects of research, the measurement of technology progress, and the determinants of technology assimilation, thus advancing research in this field (Chen and Liu, 2006; Zhang, 2008; Mao and Sheng, 2012; Zhang and Zhang, 2011; Yu, 2012).

Despite numerous studies on the technology spillover effect, academics have conducted much fewer studies on technology transfer as another avenue of market-based technology diffusion. For one thing, Chinese and international academics have yet to agree on the definition of technology transfer.[2] For another, technology transfers between multinational companies (MNCs) and their affiliates are hard to measure directly, and technology transfers between Chinese and foreign-funded companies are relatively few and not a key FDI dividend for Chinese companies. While the limited studies by Chinese academics include the deductions of theoretical models (Zhou and Chen, 2004; Ni and Zhang, 2009), empirical studies at the level of industrial enterprises did not appear until in recent years (Shen and Fu, 2010; Luo and Ge, 2015; Mao and Xu, 2016; Sheng and Mao, 2017; Mao, 2019).

In reviewing Japan's and South Korea's experiences, this paper finds that Japanese and Korean firms purchased numerous basic patents from Western countries for secondary development and re-innovation. This approach of technology ascent is apparently different from what many Chinese academics previously focused on, i.e. technology spillover via FDI, espcially through joint ventures (Li, 2004; Xie, 2007). As can be learned from Japanese and Korean experiences, an open market of intermediate inputs offers fundamental incentives to FDI-related technology transfers. Since China's development contexts are different from those of Japan and South Korea, the question is: What conditions are required for investigating market-based technology diffusion in China? What empirical explanations can be learned from MNCs' technology diffusion via transaction in intermediate inputs?

To answer the above questions, this paper proceeds from a unique perspective of R&D contracts and technology transactions by MNCs in China, i.e. how the intermediate input market encouraged technology diffusion. By creating an analytical framework for R&D contracts transaction matching, this paper elaborates on the proactive transactions of Chinese and foreign companies in the R&D technology market at a microscopic level and the underlying motivations behind such transactions under given contexts of changing domestic and international policy and institutional environments. In this manner, we create a link between changing institutional contexts and firms' innovations, which allows us to trace the policy differences in various stages of FDI attraction and characterize interactions between various stakeholders for an in-depth analysis of market-based technology diffusion arising from FDI inflows.

This paper offers the following contributions: First, most studies on FDI attraction are focused on the effects of relevant factors at macro and micro levels without analyzing how the parties of technology transactions take the initiative to match with each other. By examining the links between changing domestic policy contexts and innovations by MNCs, this paper discusses transaction matching behaviors

[2] International academics regard technology transfer as an alternative to outward direct investment, and thus pay more attention to technology transfer at the national level and the choice of MNCs from developed countries between the two options. In contrast, Chinese academics proceed from the benefit of the host country and local firms, and focus more on the economic effects of technology transfer between MNCs and their affiliates, or those between FDI entities and domestic enterprises. In essence, these studies are still intended to investigate FDI's effects on domestic enterprises' technology progress.

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in the technology market under the interplay between factors at the macro and micro levels.

Second, data analysis at the microscopic project level is almost absent from existing empirical studies on market-based technology diffusion, most of which employed macroeconomic data with respect to the technology spillover effect and industry- and firm-level data (Zheng and Chang, 2016). Judging by international experience, successful market-based technology diffusion in countries like Japan and South Korea largely stemmed from project contract transactions involving patented technologies. Hence, empirical studies on project contract transactions are the key to revealing market-based technology diffusion at the microscopic level. With large sample data of R&D contract transactions between MNCs and local companies in China, this paper carries out an in-depth study on relevant issues at a more detailed level.

Third, most existing studies focus more on the technology spillovers from foreign-funded companies under the assumption of closed innovation. In the context of open innovation, however, technology transactions should become a focus of attention in the research on market-based technology diffusion (Zheng and Tang, 2017), which should analyze key factors for achieving market-based technology diffusion. The conclusions of this paper's empirical study reveal the important role of such factors as market opportunities, structural entities, and economies of scale. Our findings offer a new summary of FDI's technology-driving effects in China's context, which also serves as an important supplement to relevant frontier economics literature.

Section 2 reviews relevant studies on MNCs' technology transfer in the context of open innovation, and puts forward relevant assumptions accordingly; Section 3 elaborates research data and methodologies; Section 4 discusses research results; the final section offers conclusions and future research methodologies.

2. Literature Review and Research Hypothesis

2.1 Proactive Technology Transfer under Open Innovation

American scholar Chesbrough's (2003, 2006) open innovation theory drew wide attention from academics and policymakers after the dawn of the 21st century. According to Chesbrough, closed innovation had been the dominant form of innovation for MNCs since the first half of the 20th century. Under closed innovation, firms keep their know-how within their corporate boundary, regarding the territories outside the firm's in-house research agencies as a technological wasteland. Under closed innovation, firms must strictly protect their proprietary technologies and build up a solid technological barrier to stay competitive against their rivals. Under this approach of innovation, MNCs will not take the initiative to transfer technology, and as a result, external companies may only gain from passive technology spillovers. Yet with the mobility of core R&D employees and the rise of venture capital, closed innovation has eroded, and is giving way to open innovation. Open innovation means that firms may expedite innovation through access to internal and external knowledge that creates value, and broaden the market by means of external innovations. The biggest strength of open innovation is that it encourages firms' initiative to transfer knowledge and technology.[3] According to Chesbrough, since not all proprietary technologies can be commercialized within the firm, around 40% of the technologies developed by leading MNCs are left unused. Many of such wasted technologies can otherwise be commercialized outside the firm. Under open innovation, MNCs take the initiative to participate in the technology market to transfer their proprietary technologies outside their corporate boundary through licensing, transfer, joint venture, or other means. Meanwhile, open innovation

[3] This paper argues that in open innovation, the parties of technology transactions take the initiative to transfer or acquire technology.

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facilitates transferees' technology assimilation and re-innovation to yield higher market returns. Open innovation may bring the following changes in the policy effects of market-based technology diffusion through FDI attraction:

First, closed innovation limits domestic companies to benefit from technology spillovers by learning from a foreign partner in a joint venture. This method is retained and takes a much richer form under open innovation. As open innovation takes hold, MNCs have started to establish R&D centers in China in search of know-how outside the firm boundary instead of relocating only the manufacturing activity (Quan and Chesbrough, 2010). According to Du's (2007) questionnaire survey, R&D institutions run by MNCs in China to seek access to global technology are more inclined to partner with local firms. Based on the panel data of 28 sectors, he found that investments from foreign-funded R&D institutions generated technology spillovers that benefited domestic companies.

Second, foreign-funded companies will also take part in domestic technology transactions, thus making advanced technologies available to local companies via the intermediate input market. Such "inside-outbound" open innovation in the technology market has become an important avenue for market-based technology diffusion (Gao and Ma, 2014). Foreign investors are also interested in the lucrative business of technical consulting and services to help host-country companies assimilate and apply the transferred technologies. In this manner, profit-driven MNCs share knowledge and technology with host-country companies. Yet under traditional closed innovation, MNCs refrain from entering the intermediate input market and impose strict control over technology diffusion.

2.2 MNCs' Considerations on the Two Types of Technology Transfer in China

According to the outbound open innovation theory, MNCs take the initiative to sell technologies in a host-country market to reduce the loss of sunk cost and maximize the marginal return on technology outside the firm boundary. Notably, firms carefully protect their core technologies in order to stay competitive against their rivals (Mahoney and Pandian, 1992). That is why domestic companies cannot directly access the core technologies of MNCs even under the open innovation model. According to the open innovation theory, MNCs may transfer the following two types of technology outside the firm boundary:

First, the transfer of mature technologies. According to the product lifecycle theory, MNCs cease to rely on mature technologies as the cornerstone of their global competitiveness, but mature technologies are still advanced in relative terms for developing countries. Standardization also makes it easy for host-country companies to deploy mature technologies. Based on mature technologies, MNCs develop technical platforms for Chinese companies, provide technical services and solutions, and even transfer technologies. Hence, this paper puts forth the following hypothesis:

Hypothesis 1: Under open innovation, MNCs prefer to transfer mature technologies to domestic companies.

The second type is the transfer of unused technologies. According to the open innovation theory, unused technologies originate from MNCs' know-how and may remain in the first or second stage of an R&D cycle but are left unused due to lack of business relevance. This category also includes idle technologies for which MNCs have acquired patents. Obviously, unused and idle technologies have driven up companies' R&D costs. MNCs will sell unused and idle technologies to compensate for the losses of sunk capital and offset R&D costs. As far as the Chinese market is concerned, a desirable option for MNCs is to sell such technologies to other foreign-funded companies in China. Technology partnerships allow MNCs to work with foreign-funded companies in China to further develop and wring value from unused technologies. Hence, this paper puts forward the following hypothesis:

Hypothesis 2: Under open innovation, MNCs tend to transfer unused technologies to foreign-funded companies in China.

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For MNCs, the above technology transactions involve two types of domestic entities: First, technology transactions between foreign-funded R&D institutions and domestic enterprises, including government-affiliated institutions; second, technology transactions between foreign-funded R&D institutions and other foreign-funded companies in China. Obviously, as the two types of domestic entities are increasingly active, MNCs will be attracted to participate more in technology market trade in the host country. Yet foreign-funded R&D institutions selling technology may face various asset specificity, technology exclusivity, and behavioral uncertainty. These institutions themselves may also vary in terms of R&D capabilities and organizational form. Such differences, if significant, will affect the actual value of technologies on offer and the degree of technology transfer. In analyzing the technology transactions made by foreign-funded R&D institutions and other foreign-funded companies in China, we may identify the position of domestic companies in such proactive technology transactions and the extent to which they may benefit from market-based technology diffusion. Hence, this paper puts forward the following hypothesis:

Hypothesis 3: Under open innovation, technology demand from domestic entities attracts more technology transfers from MNCs.

2.3 Structural Rationale of Market-based Technology Diffusion

In the above section, we have explained open innovation and defined scenarios in which MNCs transfer technologies in China. As can be learned from the above discussions, market-based technology diffusion may achieve better effects in this new institutional context. The question is: Will the above theoretical assumptions be supported in the empirical analysis? To what extent will foreign companies' initiative to trade technology induce technological progress in domestic companies? What are the applicable conditions? These questions have yet to draw attention from domestic academics (Zheng et al., 2018).

This paper argues that the extent to which the above mechanism contribute to market-based technology diffusion is subject to not only MNCs' intentions, but domestic entities' (domestic firms and foreign-funded companies in China) initiative to search for technologies and the host-country government's influence on market structure (Fransman, 1995). While the first two involve transaction

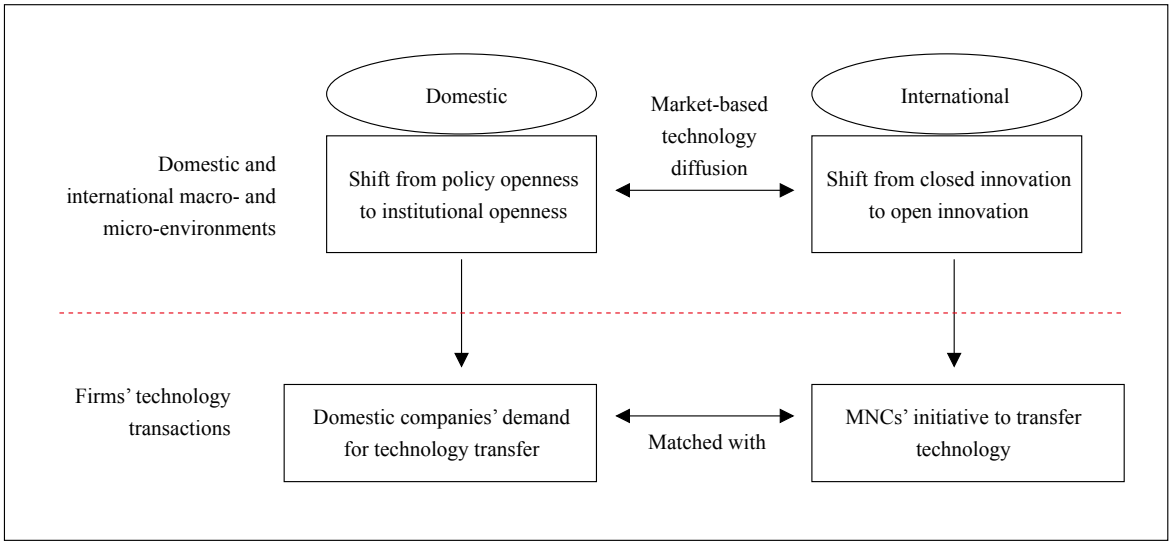

Figure 1: Analytical Framework for Interactions in Market-based Technology Diffusion

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motivations and the strategic behaviors at the microscopic level, the third aspect involves institutional and policy design at the macro level. Based on the above rationale, this paper creates a theoretical analytical framework that integrates macro and micro aspects (Figure 1). With given changes in the domestic policy environment and the transition of innovation modes for MNCs, we test the above theoretical hypothesis based on the transactions of Chinese and foreign-funded companies at the microscopic level as a new perspective and dimension for evaluating market-based technology diffusion.

3. Data, Variables and Econometric Model

3.1 Data Sources

This paper selects the IT sector as the most representative sector of open innovation for an empirical study. In the IT sector, all the selected foreign-funded R&D institutions are influenced by the open innovation mindset, and have changed their previous behaviors under closed innovation. On the other hand, China's IT market has been growing rapidly over recent years thanks to rising penetration of IT terminals, a thriving internet economy, and policy preferences introduced since the early 2000s. With IT market growth came domestic companies' robust demand for IT technology. In this context, the IT sector has become an ideal sample for research.

Beijing is a leading IT technology market in China. According to Beijing S&T Indicators released by the Beijing municipal government in 2000, the IT sector was ahead of other sectors in terms of R&D workforce and spending. As China's largest IT R&D center, Beijing took the lead in attracting multinational IT firms to establish R&D centers. According to the Beijing Technology and Market Office (BTMO), IT transactions represented 28.9% of R&D technology transactions in Beijing in 2012, totaling 10.98 billion yuan - the largest trading volume among all sectors. According to the 2015 China Internet Recruitment Report released by the Internet Society of China (ISC), Lagou.com and Analysys Think-tank, Beijing employed 35.5% of internet professionals in China - an indication of the representativeness of technology contract transactions executed by MNCs in Beijing chosen as samples for analysis in this paper.

In the BTMO database, we have found 2,071 technology contracts executed from 2001 to June 2011 that meet our criteria. Data analysis finds that most technology transactions conducted by MNCs' research agencies in China are related to technology outsourcing. Based on client attributes,[4] we define outsourcing by domestic firms as "onshore reverse outsourcing," which primarily involves mature technologies and includes 1,843 contracts. Outsourcing by foreign-funded companies in China is referred to as "normal outsourcing," and such deals primarily involve unused technologies with a total of 228 contracts. Sample distribution by year is shown in the following table:

3.2 Variable Explanation

3.2.1 Variables of MNCs' initiative to transfer technology

(i) Asset specificity: Asset specificity can be measured by sunk cost, dedicated technology, experienced workforce, and diversity (Stanko and Calantone, 2011). In this paper, asset specificity is expressed as the contractual input of technology costs. Logmoney is the contractual value in the logarithmic form. We assume that MNCs face different technology needs from domestic clients and

[4] We refer to outsourcing by MNCs from developed countries as "normal outsourcing" and outsourcing by firms from developing countries as "reverse outsourcing." Outsourcing in the client's home country is referred to as "onshore outsourcing." Outsourcing outside the client's home country is referred to as "offshore outsourcing."

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Table 1: Sample Distribution

Outsourcing[5]	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Normal outsourcing	0	17	10	4	21	53	32	14	28	32	17	228
Onshore reverse outsourcing	22	50	42	74	52	129	124	306	352	485	207	1,843
Total	22	67	52	78	73	182	156	320	380	517	224	2,071

Source: BTMO.

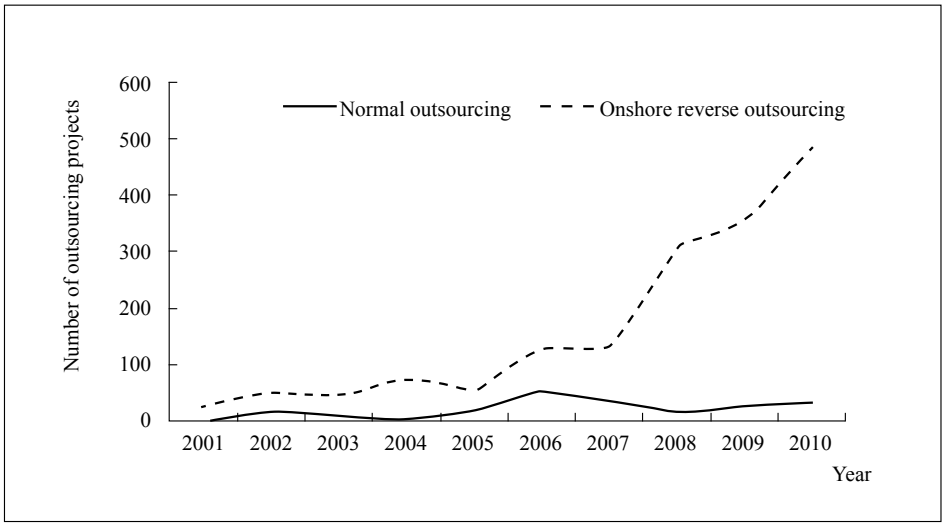

Figure 2: Trends in Normal Outsourcing and Onshore Reverse Outsourcing

Note: Data source: BTMO

invest more in asset specificity for the further development of unused technologies than for mature technologies. Hence, normal outsourcing entails more investments on asset specificity compared with onshore reverse outsourcing;

(ii) Control over organizational form: MNCs tend to have greater control over solely-funded overseas affiliates compared with joint ventures. Sellerform is a two-value dummy variable denoting MNCs' control over the organizational form of their overseas affiliates, i.e. 1 stands for sole investment, and 0 stands for joint venture. Obviously, solely-invested multinational research institutions have a greater initiative with respect to technology transfer;

(iii) Possession of ambidexterity: If MNCs are driven by maximal marginal return, they may achieve this goal by accepting more contracts from domestic clients, which is reflected in multinational research institutions' exploitative capacity. Variable abilitiyg denotes the total number of projects undertaken by MNCs in the R&D stage. On the other hand, MNCs need to develop new technologies and solutions to meet

[5] There are two types of outsourcing transactions between MNCs and domestic entities: "Onshore reverse outsourcing" refers to outsourcing in which the domestic firm is the client and the multinational R&D institution is the contractor. "Normal outsourcing" refers to outsourcing in which the foreign-funded company in China is the client and the multinational R&D institution is the contractor.

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complex client requirements such as those regarding unused technologies, which require explorative capacity, expressed as prebig; prebig's value is the share of contracts worth more than 10 million yuan in total contracts executed. Ambidexterity measures MNCs' initiative from different aspects (March, 1991).

3.2.2 Variables of domestic firms' initiative to acquire technology

(i) Different technology requirements for MNCs: The types of requirements raised by domestic clients regarding technology transactions with MNCs reflect their initiative to acquire technology. Domestic clients requesting unused technology instead of mature technology are more proactive and keen on acquiring advanced technological capabilities. These two types of technical requirements can be differentiated by technology exclusivity. Specifically, we use LocalIP to denote domestic patents, know-how to denote technology secrets, and noIP to denote projects without intellectual property rights. We expect more intellectual properties (IP) to be involved in normal outsourcing, so that foreign-funded companies in China require more advanced technology transactions with MNCs.

(ii) Avoidance of uncertainties: Behavioral uncertainties in R&D outsourcing primarily stem from two sources of moral hazard, including contractors' negligence and leakage or unauthorized use of technologies developed on behalf of clients. These moral hazards are hard to identify and expose clients to the risk of behavioral uncertainties. Different payment methods reflect and may mitigate behavioral uncertainties facing the parties of transaction. Variable longpay is a dummy variable that stands for different payment methods: 1 stands for installment payment, and 0 for one-time payment. Compared with foreign-funded companies operating in China, domestic firms may face more asymmetric access to information when dealing with multinational R&D institutions. To avoid such uncertainty, domestic companies will opt for more flexible payment methods in reverse outsourcing.

(iii) Control variables: Control variables include the completion time of technology contracts

Table 2: Variable Names and Explanations

Variable	Category	Description	Meaning and value
FTLO	Explained variable	Outsourcing	Did the domestic firm contract a multinational company? Yes=1, No=0
Logmoney	Explanatory variable of MNCs' initiative to transfer technology	Contract value	Contract value
Sellorform		Organizational form	1=Sole investment, 0=Joint venture
prebig		Exploration	Contracts with over 10 million yuan as a share of all contracts
abilityq		Exploitation	Number of projects undertaken by MNCs
Longpay	Explanatory variable of domestic firms' initiative to acquire technology	Payment method	1=Installment payment, 0=One-time payment
LocalIP		Domestic patents	Dummy variable
Know-how		Technical secrets	Dummy variable
NoIP		No intellectual property	Dummy variable
Frequency	Control variable	Frequency of transaction	Number of repetitive transactions during contract parties' research period
logtime		Time of contract execution	Time span from contract execution to completion
logabilitym		Fixed effect of R&D firm	Total project value/number of projects
year		Time trend	Year

Source: BTMO

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Table 3: Correlation Coefficient Matrix of Key Variables

	FTLO	***Logmoney***	longpay	localIP	know-how
FTLO	1				
Logmoney	0.0704	1			
longpay	0.241	0.484	1		
localIP	-0.123	0.0158	0.0079	1	
know-how	-0.177	0.285	0.0847	-0.347	1
prebig	-0.0571	0.431	0.062	-0.0895	0.27
Sellerform	-0.285	0.11	-0.135	0.11	0.172
logtime	0.143	0.559	0.447	-0.0702	0.275
logabilitym	0.212	0.654	0.375	0.0308	0.194
noIP	0.232	-0.236	-0.0732	-0.687	-0.444
abilityq	0.385	-0.0265	0.258	-0.129	-0.489

	prebig	***Sellerform***	logtime	Logabilitym	noIP	abilityq
FTLO						
Logmoney						
longpay						
localIP						
know-how						
prebig	1					
Sellerform	0.136	1				
logtime	0.0959	0.14	1			
logabilitym	0.353	-0.0895	0.408	1		
noIP	-0.124	-0.238	-0.146	-0.18	1	
abilityq	-0.186	-0.525	0.0169	0.0678	0.503	1

Note: The list of variables is too long and written in two parts.

(Logtime: This variable stands for the time span from contract execution to completion for a specific technology transaction, and the asset specificity variable Logmoney is highly relevant to the contract time span. Second, for the "technical service and consulting" contracts that widely exist in our samples, a mere extension in the term of service contracts will increase the value of technical transactions without requiring additional dedicated assets. Moreover, payment method Longpay is also subject to Logtime: The longer the term of a contract, the more likely it requires contract parties to opt for installment payment or commissions to ease the buyer's economic burden and risk. Hence, this variable may control for the associated effects of asset specificity, payment method, and technical service and consulting contracts. The fixed effect of multinational R&D institutions logabilitym is the total value of all the R&D projects conducted by MNCs from 2001 to 2011 divided by the total number of their R&D projects to control for the impact of the IT industry's subsectors. Time trend year is based on

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mixed cross-section data and needs to consider the impact of different years on regressions. Given market internationalization, improving IPR protection and firms' growing IPR awareness, the effects of the time trend need to be taken into account for the two types of contract transactions. The frequency of contract transactions frequency measures the number of repetitive transactions between contract parties from 2000 to 2011. Among the explanatory variables, behavioral uncertainty may have an endogeneity problem, i.e. subject to the parties' experience of cooperation. Parties with prior experience of cooperation and mutual trust may opt for different payment methods. As a control variable, frequency may solve this endogeneity problem.

4. Econometric Model and Regression Results

4.1 Model Specification

This paper employs logit model for an empirical analysis to reveal the considerations and underlying factors behind market-based technology diffusion between MNCs and domestic entities. The dependent variable is a two-value dummy variable FTLO (foreign-to-local-outsourcing).

$$P(Y_i = 1) = \frac{e^{Z_i}}{1+e^{Z_i}} = \frac{1}{1+e^{-Z_i}} \quad (1)$$

$$\text{With} \quad Z_i = \beta_0 + \beta X_j + \gamma H_k + \mu \quad (2)$$

Here, X_j (j=1~8) is the vector of the explanatory variables (for MNCs and domestic entities), which involves asset specificity, organizational form, uncertainty and ambidexterity. H_k (k=9~12) stands for control variables, including time trend and the fixed effect of R&D firm. μ is stochastic disturbance term. When FTLO is 1, the transaction is "reverse outsourcing," in which the client is a domestic entity and the contractor is a multinational R&D institution. When FTLO's value is 0, the transaction is "normal outsourcing," in which the client is a foreign-funded enterprises in China and the contractor is a multinational R&D institution.

With 2006 as the boundary, this paper designs two basic models: Long-term model (Model 1) deals with the overall status from 2001 to 2011; short-term model (Model 2) examines the significance of model hypothesis from 2006 to 2011 after change in sample structure had occurred. The samples primarily include two types of contract, including 1,128 R&D contracts, or 54% of total samples and 848 technical consulting and service contracts, or 41% of total samples.[6] Differences between these types of contracts may affect econometric results. The rapid development of onshore reverse outsourcing is mainly attributable to growth in technical consulting and service contracts, 89% of which is onshore reverse outsourcing. It is therefore necessary to consider the two types of contract separately. For this purpose, we include Model 3 for a regression of R&D contracts. Model 4 is a regression of technical consulting and service contracts.[7]

$$\text{model 1 (2001—2011)} : Z_i = \beta_0 + \beta X_j + \gamma H_k + \mu X_j \text{ (j=1~8)} \quad (3)$$

[6] Compared with technical consulting and service contracts, R&D contracts require a higher frequency of transactions, more dedicated asset inputs and technology exclusivity, and the client facing greater behavioral uncertainties. R&D contractors thus need to possess stronger R&D capabilities.

[7] Since technical consulting and service contracts do not include contracts with "technical secrets" as objects of transaction, the comparison becomes one between domestic patent contracts and contracts involving no intellectual property rights. Hence, we introduce a binary dummy variable noIP, and when noIP's value is 1, the transaction does not involve any intellectual property rights; otherwise, it refers to transactions in which domestic patents have been applied for.

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$$\text{model 2 (2006─2011)} : Z_i = \beta_0 + \beta X_j + \gamma H_k + \mu X_j \ (\text{j=1~8}) \quad (4)$$

$$\text{model 3: } Z_i = \beta_0 + \beta X_j + \gamma H_k + \mu X_j \ (\text{j=1~8}) \quad (5)$$

$$\text{model 4: } Z_i = \beta_0 + \beta X_j + \gamma H_k + \mu X_j \ (\text{j=1、2、4、6、8}) \quad (6)$$

4.2 Multivariate Model Regression Results

Table 4 indicates that most variables reflecting initiative in the empirical results are significant

Table 4: Regression Results for Different Periods

	(1)	(2)
	Long-term	**Short-term**
Logmoney	-0.3107***	-0.2544**
	(-4.03)	(-2.49)
Longpay	0.8071***	1.3377***
	(3.36)	(4.21)
localIP	-2.9786***	-2.9799***
	(-7.75)	(-6.51)
Know-how	-4.1357***	-4.4646***
	(-9.26)	(-8.22)
Prebig	-3.1336***	-4.3039***
	(-3.79)	(-4.77)
Sellerform	-0.9713***	-1.9437***
	(-3.81)	(-5.62)
Logtime	0.3041***	0.1484
	(3.06)	(1.05)
Logabilitym	1.1155***	0.9378***
	(7.78)	(5.84)
Year	0.1102**	0.4700***
	(2.53)	(5.65)
Frequency	-0.0247***	-0.0140**
	(-5.18)	(-2.32)
cons	-2.3e+02***	-9.5e+02***
	(-2.61)	(-5.68)
N	2025	1737
r2		
r2_a		

Note: Numbers in parentheses are t statistics; *p< 0.05, **p< 0.01, ***p< 0.001

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at least at 1% level of significance. The effects of variables that stand for MNCs' initiative, i.e. asset specificity input, organizational form and explorative abilities, are highly consistent with expected directions. Between the long-term model 1 and the short-term model 2, there is no significant difference in the above variables. That is to say, IT outsourcing transactions in China are effectively supported by the two-way initiatives of MNCs and domestic entities. This result is also robust. Now for Hypothesis 3: Under open innovation mode, we have verified that domestic entities' initiative to introduce technology may attract more technology transfers from MNCs.

On a further look, the coefficient of the variable of MNCs' asset specificity input is negative and significant at 0.1% (***Logmoney***, β=-03107, p<0.001, Model 1; β=-0.2544, p<0.01, Model 2), and the coefficient of the variable of MNCs' explorative abilities is also negative and significant at 0.1% (Prebig, β=-3.1336, p<0.001, Model 1; β=-4.3039, p<0.001, Model 2). These results demonstrate that compared with onshore reverse outsourcing, normal outsourcing clients tend to put forward higher technical requirements, and MNCs as contractors need to develop more explorative abilities and invest more in asset specificity. Accordingly, the coefficient of the variable of domestic clients' avoidance of uncertainty (measured by different payment methods) is positive and significant at 0.1% (Longpay, β=08071, p<0.001, Model 1; β= 1.3377, p<0.001, Model 2). The coefficient of the variable of domestic clients' demand for different levels of technology (measured by IPR protection methods, i.e. technology secrets are Know-how and domestic patents are *LocalIP*) is negative, and significant at 0.1%. This conclusion suggests that in onshore reverse outsourcing, technology transfer involves much fewer IPR categories than in normal outsourcing. In addition, significant technology gaps between domestic firms and MNCs have increased behavioral uncertainties between the parties of transaction, giving rise to the option of installment payments. The above empirical results also suggest that although domestic entities' search for technologies is matched with MNCs' initiative to transfer technologies, there are structural differences behind the matching of quantitative trends, i.e. compared with domestic firms, foreign-funded companies' technology transactions and transfers with MNCs tend to deliver technical satisfaction through the transaction of unused technologies in more categories and at higher levels. This finding is consistent with Assumptions 1 and 2.

In Table 5, we conduct separate regression tests for the two types of contract. For R&D contracts, the test results of most variables in Model 3 meet expected assumptions. The coefficients of variables of asset specificity input, organizational form and explorative abilities that stand for MNCs' initiative are all negative and significant at 1%. The coefficients of technology demand variable that stands for the client's initiative and the variable of uncertainty avoidance and their significance levels are consistent with the conclusions in Table 4. Hence, the three hypotheses on the relationship between MNCs and domestic entities have been verified with respect to R&D contracts.

With respect to technical consulting and service contracts, in conducting the long-term model test for Model 4, the coefficients of the variables of MNCs' initiative (assets specificity Logmoney and exploitative abilities abilityq) and the variable of the client's initiative (variable of technology demand -noIP) meet expected assumptions are significant at 0.1%, but variables Longpay and Sellerform are statistically insignificant. There is no significant difference in the primary model assumptions between R&D contracts and technical consulting and service contracts. The following section discusses the reasons behind deviations of certain assumptions from the expectations.

(i) Explanations on variable Longpay

The transaction value of technical consulting and service contracts is far smaller than that of R&D contracts (the former's average transaction value is 520,000 yuan, and the latter's is 1.7 million yuan). Technical consulting and services are subject to fewer behavioral uncertainties compared with R&D contracts and focus more on economic factors. On the other hand, the small contract value also means that clients are free from excessive economic burden and risks. In the long run, therefore, both

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Table 5: Regression Results by Contract Types

	R&D contracts		Consulting and service contracts	
	Long-term	Short-term	Long-term	Short-term
Logmoney	-0.2854**	-0.2768*	-0.4912***	-0.2717
	(-2.46)	(-1.67)	(-2.99)	(-1.49)
longpay	1.3265***	1.4725***	0.6870	1.5190**
	(4.25)	(3.27)	(1.25)	(2.38)
localIP	-1.8166***	-1.5766**		
	(-3.30)	(-2.46)		
know-how	-2.0647***	-1.7199*		
	(-3.29)	(-1.95)		
prebig	-4.9802***	-7.4101***		
	(-5.12)	(-5.77)		
Sellerform	-0.9636***	-1.5377***	0.1679	.
	(-2.81)	(-3.21)	(0.07)	.
logtime	0.0439	0.2141	0.5911***	0.3117
	(0.29)	(0.83)	(2.65)	(1.23)
logabilitym	1.1749***	1.4480***	1.0203***	-0.3881
	(5.35)	(4.79)	(3.24)	(-0.92)
year	0.1489***	0.4301***	0.5993***	1.0508***
	(2.69)	(3.31)	(5.75)	(5.65)
frequency	-0.0110	-0.0053	-0.0685***	-0.0257
	(-1.59)	(-0.56)	(-4.91)	(-1.59)
noIP			2.5962***	0.3000
			(2.94)	(0.24)
abilityq			0.0051***	0.0052**
			(3.24)	(2.52)
_cons	-3.1e+02***	-8.8e+02***	-1.2e+03***	-2.1e+03***
	(-2.74)	(-3.34)	(-5.78)	(-5.66)
N	1125	958	807	715
r2				
r2_a				

Notes: *, ** and *** denote passing the test with 10%, 5% and 1% significance levels, respectively, and numbers in parentheses are t statistic.

outsourcing modes will tend to adopt one-time payment instead of installment payment, thus causing this variable to be insignificant.

(ii) Explanations on variable Sellerform

Differences in organizational form primarily exist between R&D contracts and technical consulting

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and service contracts (more than 72% of transactions undertaken by solely foreign-funded institutions are R&D contracts). The uneven distribution of these two types of contracts between normal outsourcing and onshore reverse of outsourcing modes significantly influences the organizational form of contract parties. After controlling for contract type, therefore, the correlation between the degree of control over organizational form and the choice of technology transaction contracts becomes insignificant.

4.3 Robustness Test

Chinese clients have to some extent entered a new economic stage since renminbi started to appreciate in 2005, which presented significant changes in international economic environment. To test the robustness of this paper's results in various economic cycles, we have tested the subsamples of 2006-2011 according to the method stated in this paper in addition to the test of a long timeframe (2001-2011), and the results suggest that this paper's main conclusions remain robust under the long-term and short-term models. In the context of open innovation, domestic entities take the initiative to search for technologies, thus inducing MNCs to engage in more contract transactions and technology transfers. While entering China's technology market, MNCs tend to transfer more mature technologies to Chinese domestic companies and unused technologies to foreign-funded companies in China.

5. Conclusions and Policy Implications

5.1 Research Conclusions

With this paper's theoretical framework and empirical results, we not only discussed the initiative taken by MNCs to transfer technology, but verified the argument that opening up the intermediate input market is another important way to achieve market-based technology diffusion while introducing FDI. We have also discussed how this approach is put to work under the open innovation framework. In conclusion, this paper argues that first, open innovation brings new transaction opportunities as reflected in MNCs taking the initiative to transfer technology to others (pushing force); second, there is a growing demand in the host-country market for technology transfer that drives MNCs to transfer their mature and unused technologies to host-country companies (pulling force). These conclusions based on empirical analysis adequately explain the manifestations and causes of market-based technology diffusion amid FDI inflows to China since the 1980s.

In the late 1980s and 1990s when China's market was more regulated and domestic resource allocation was subject to policy-based openness, MNCs that entered the Chinese market were still confined to closed innovation and shied away from China's intermediate input (technology) market. They took no initiative to transfer technology to local companies. As a result, FDI inflows did not lead to technology diffusion to China as policymakers had expected. In early 21st century, China finally established an open economy, adopted an innovation-driven national strategy, and brought about a transition towards institutional innovation in the domestic market and institutional openness in domestic resource allocation.,[8] As open innovation takes hold, MNCs increasingly put a premium on China's intermediate input (technology) market and take the initiative to transfer technology. This new institutional context presents new pathways and opportunities for the goal of market-based technology diffusion.

5.2 Policy Implications

With the basic views and rationale of the above theoretical research in this paper, we put forth the

[8] As the transition period for China's WTO entry ended in 2006, China's open economy officially embarked upon the path of institutionalization. In the same year, the Chinese government announced the strategy to build an innovative country.

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following policy advice in relation to a few case studies on market-based technology diffusion:

(i) In the context of open innovation, it is important to closely follow and seize opportunities for technology transactions while attracting FDI. A few sectors in China have successfully put this approach into practice. Examples include the hydropower generation unit for the Three Gorges Project and the manufacturing technology for high-speed railway. These instances of "market-based technology diffusion" all took place from the end of the 20th century and early 21st century - the period when MNCs started to embrace open innovation. MNCs' intent to externalize the cost of internal technology allowed Chinese companies to acquire foreign technology through the intermediate technology market and foster homegrown innovations through resource integration, technology assimilation, and technical consulting and services, which was hard to achieve in the previous closed innovation stage. In the early 1980s, China's automotive industry struggled to acquire foreign technology. In the first two decades of Sino-foreign joint ventures when closed innovation held sway, Chinese companies negotiated strenuously with their foreign counterparts over issues ranging from the establishment of R&D matching facilities to the local content of parts and components, and had little say in their joint ventures with foreign partners. With China's WTO entry at the end of 2001, rising consumer market and deepening globalization, Chinese companies developed in-house capabilities, and MNCs also embraced open innovations. In Sino-foreign joint ventures, Chinese parties began to have more say in the choice of new products, localized development, and interior and exterior designs. They were able to launch homegrown brands backed by their joint ventures with foreign companies. Chinese companies even had opportunities to acquire IP from leading multinational carmakers. In the wake of the global financial crisis in 2008, many loss-making Western companies had to sell assets and technologies, presenting Chinese companies with open innovation opportunities. Successful international M&As include Wanxiang's acquisition of the world's largest transmission system manufacturer DANA, LiuGong Machinery's acquisition of Poland's HSW (Huta Stalowa Wola), and Geely's acquisition of Volvo.

(ii) Under open innovation, host countries should develop a more structured market to benefit from market-based technology diffusion. As discussed before, MNCs' technologies available for transfer include both mature and unused technologies. Driven by profit maximization, MNCs will give more consideration to the market value and opportunities of technology commercialization. As open innovations become more common, MNCs will profit more from the intermediate technology market. In addition to their technology market sophistication, the attraction of host-country markets is also reflected in the diversification of technology transactions - and not least in the level of integration between host-country enterprises and MNCs with respect to technology management, IPR protection and corporate culture, as well as local companies' abilities to assimilate acquired technology (Cohen and Levinthal, 1990). Domestic partners more assimilative of foreign technology will be able to acquire more unused technologies from MNCs, thus lowering the latter's internal R&D cost. The ability to assimilate foreign technology also allows local companies to boost business performance through technology acquisition (Huang and Rice, 2009). In drafting industrial policy and fostering the technology market, the Chinese government should strive to promote open innovation.

(iii) Theoretically, the pushing force from the transaction opportunities and the pulling force of market structure are necessary and sufficient conditions for market-based technology diffusion to pull off in the host country. Yet in reality, host-country companies are way behind MNCs in terms of technological sophistication to the extent that not enough commercial value can be exploited from the latter's technologies. Take China for instance, significant institutional differences exist across its various regions, and technological and institutional gaps with developed countries remain (Wei, et al., 2014). A scattered and unstructured domestic market discourages MNCs from transferring technologies at a higher level. The third thing the host-country governments can do to achieve market-based technology diffusion is to unify the scattered domestic market. A large, unified domestic market will generate significant commercial value in acquiring unused and even core technologies from MNCs. Experiences gained

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from technology applications in a large market will also benefit homegrown innovations. An example is the rags-to-riches story of China's railway sector. Leveraging China's huge railway market, the then Ministry of Railway took the initiative to import high-speed rail technologies, avoiding reinventing the wheel (Lu, 2013) to economize time span of overtaking. Meanwhile, by issuing the Joint Action Plan for Indigenous Innovations, the Chinese government also played an important role in strategic coordination and technological autonomy. With these efforts, China's high-speed railway sector has developed indigenous IP rights and core technologies. A similar example is China's jumbo jet program over the past decade. In parallel to homegrown innovations by the Aviation Industry Corporation of China (AVIC), the Chinese government set out to integrate China's massive domestic civil aviation market by improving the policy environment and building infrastructure. Lucrative business opportunities drew a swathe of global aviation component suppliers to the Chinese market for partnership with local companies, helping form a complete civil aviation industry chain. Finally, international aircraft engine makers also decided to enter the Chinese market. Open innovation, market integration, and economies of scale allowed China's jumbo jet program to take off.

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