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"A Theory of Innovation: Market Transition, Property Rights and Innovation in China"

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A Theory of Innovation: Market Transition, Property Rights, and Innovative Activity in China

by

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The aim of this paper is to specify a theory to explain why transitions to a market economy cause a shift to a higher level of innovation. Marketization increases the power of economic actors relative to political actors, increases inter-firm competition, creates new opportunities for entrepreneurship, and subsequently motivates innovative activity. For our empirical application, we focus on China's transition economy, which offers a broad range of institutional environments to examine the relation between market transition and increasing innovative activity by entrepreneurs and firms. (JEL: O 31, P 31, P 3)

1 Introduction

The innovative process – SCHUMPETER's [1942] "perennial gale of creative destruction" – is the recognition of opportunities for profitable change and the pursuit of those opportunities all the way through until they are put into business practice. For Schumpeter, the entrepreneur – distinct from the capitalist and businessman – is the purveyor of innovations. For Marx, in contrast, innovation is a systemic feature of the underlying competitive dynamics of market capitalism. This view of innovation as an outgrowth of the ferocity of competitive pressures on capitalists has attracted new attention in the research on innovation. Insofar as innovation is a social process involving cooperation and competition within a larger institutional structure, incentives are matters not only of individual-level motives and decisions, but also of that institutional framework (SCHUMPETER [1912/1934], WILLIAMSON [2000], GREIF [2006]).

This paper builds on the supposition that institutions matter in explaining innovative activity. Its core argument extends NEE's [1989] market transition theory to explain the rise of innovative activity in China (Propositions 1, 2, 4) and refines BAUMOL's [1990] supposition that the most effective way to stimulate

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productive entrepreneurial activity is to diminish relative rewards to unproductive or destructive rent-seeking and increase payoffs to productive entrepreneurial activity (Propositions 3, 5). By linking a theory of endogenous emergence of markets and entrepreneurial activities with Baumol's ideas on competition and innovation, our approach shifts the focus towards specifying the features of the institutional framework that enable, motivate, and guide innovative activity. We assert that the innovation literature neglects the role of real markets when it comes to the analysis of motivation and capability to innovate.

Our theory specifies the effect of marketization in transition economies on the relative payoffs to unproductive and productive entrepreneurial activity, and derives testable hypotheses. It is in transition economies where one finds a wide range in variability in the extent and scope of markets, which allows us to examine the effect of property rights and markets on entrepreneurial action as measured by innovative activities. Hypotheses derived from our model underscore the capacity of private enterprise to innovate, explain innovation as outgrowth of the competitive pressures on firms, and highlight the role of networks in regional clustering of innovation linking universities and research institutes with firms. Our empirical application focuses on China's transition economy as a strategic research site.

The remainder of the paper is organized as follows: The next section develops the theoretical framework explaining the shift of the reward structure as a consequence of economic transition. Section 3 derives our hypotheses predicting a close linkage between market transition, property rights, and innovation. Section 4 provides a summary account of market transition in China as our strategic research site and section 5 specifies data and method. Section 6 confirms that a principal cause of China's shift to innovation as a source of economic growth is the emergence of competitive markets. The final section concludes.

2 Theoretical Framework

We proffer propositions that specify elementary mechanisms embedded in markets as social institutions explaining the propensity to innovate (1–3), and then we lay out propositions (4–5) that explain increasing rate of innovations arising from market transition:

In market economies, the rules of the game of private property rights and decentralized markets provide powerful incentives for economic actors to innovate. Whether innovative activity is for the sake of the fruits of success, or for success itself, in price-making markets rewards are based on the competitive sorting and matching of quality and price. It is thus the restoration of consumer and producer sovereignty in transition economies, which activates incentives to innovate.

For convenience, we apply ROSEN's [1974] theory of hedonic prices to justify our first three propositions. Rosen's model of product differentiation – based on the hedonic assumption that goods are valued for their utility bearing attributes – illustrates how buyer and seller choices determine competitive equilibrium in a multi-dimensional plane. In fact, market pressure and subsequent innovation processes are the causal processes behind the illustrated product differentiation.

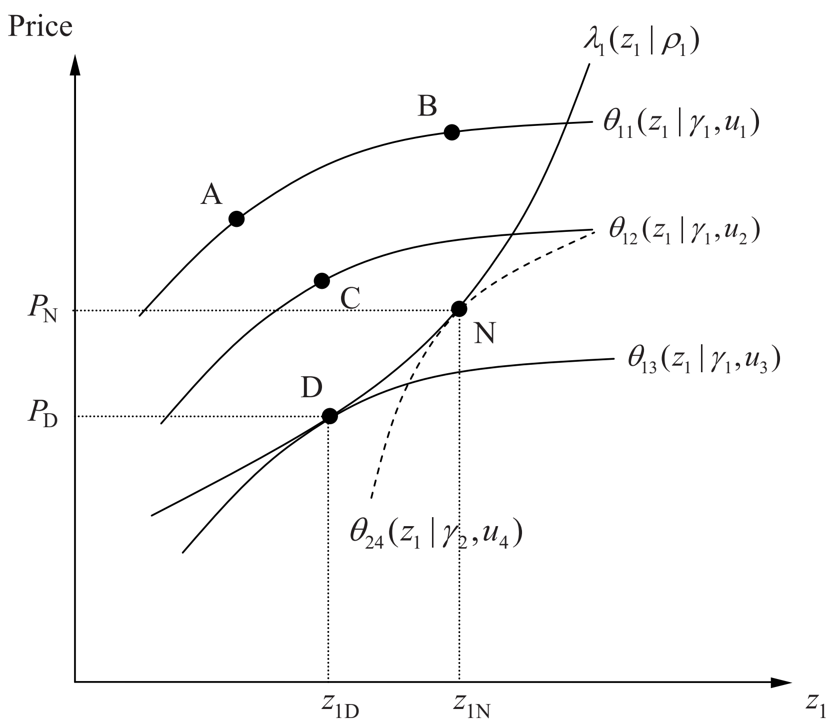
A class of goods is described by a vector of *n* measured characteristics $z = (z_1, z_2, \ldots, z_n)$, where z_i measures the quantity of the good's product quality *i*. Products of a given class are thus described by distinct packages of z. Typically a spectrum of differentiated products will be available to choose from. Each product is associated with a market price $p(z) = p(z_1, z_2, \ldots, z_n)$, which guides consumer and producer choices. $P(z)$ thus represents the minimum market price for a given package of product qualities.

To identify the consumption decision, assume that the expenditures a consumer is willing to pay at a given consumer's taste and utility index is given by the value function $\theta(z; \gamma, u)$. Figure 1 depicts $\theta(z; \gamma, u)$ in z_1 given specific consumers' taste γ_i and utility level u_k (i.e., $\theta = \theta_{ik}(z_1 \mid \gamma_i, u_k)$), holding constant other elements of vector z. θ_{11}, θ_{12}, and θ_{13} represent three utility levels $(u_1 < u_2 < u_3)$ assuming a consumer type with taste γ_1. Further, the producers' offer function given profit level ρ is $\lambda(z; \rho)$. Evidently utility is maximized in D, where $\theta(z; \gamma, u)$ and $\lambda(z, \rho)$ are tangent to each other. As customers prefer D's price-z_1-offer over the three alternatives, firms A, B, and C have incentives to innovate by either lowering costs or adjusting the quantity of z_1. Trivially, D will be in a short-term equilibrium at the tangential point of offer λ_1 and value function θ_{13} as long as consumer taste remains unchanged. In sum,

PROPOSITION 1 *Markets offer incentives to innovate insofar as rewards for performance depend on a match of quality and price or a match of cost and price.*

Figure 1

Incentives and Opportunity to Innovate



The entrepreneur-as-innovator is the person who pursues opportunities that others forgo. Suppose firms in a market sector, say cell-phones, face perfect competition so that the equilibrium prices of products provide only razor-thin margins. An entrepreneurial action in this setting would be to innovate by coming up with a new product based on the hunch that its novel features will break out of the standard mold and fetch a higher price. Our entrepreneur has accordingly purposively sought an opportunity that other firms in the industry have either implicitly forgone or have assessed as too costly to pursue. In this view the opportunity cost for forgoing investments in innovative activity is the *hidden cost* of firms pursuing the established business patterns and practices, which in our example locks them into a stable price structure. The market mechanism offers means to assess the potential costs and benefits from an innovation (HAYEK [1978]).

Consider the price–z_1 combination N in Figure 1. Given consumer taste γ_1, the price–quality combination of good D would be preferred over N, but N in turn promises higher utility to a new latent customer class with taste $\gamma_2\left[\neq \gamma_1\right]$, here illustrated by a value curve $\theta_{24}(z_1 \mid \gamma_2, u_4)$. A firm's ability to realize N rests on the identification of new consumer preferences (i.e., consumer-differentiation). In our illustration, the new consumer class can be reached by offering a package of characteristics z, which includes a higher quantity of z_1.

PROPOSITION 2 *The emergence of markets endogenously expands the opportunities for entrepreneurs and firms to identify new markets and prospects for profit-making.*

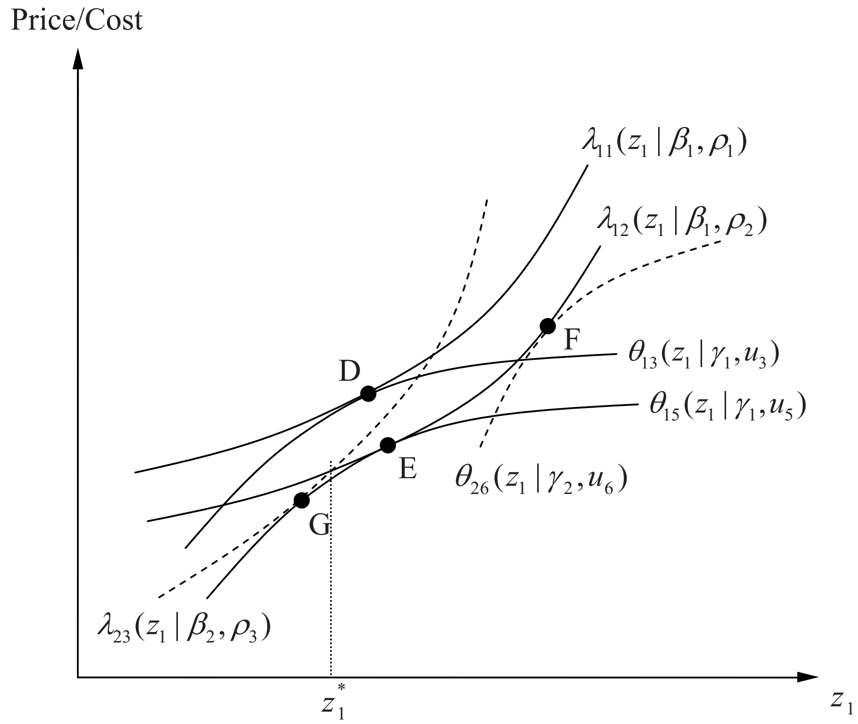
Market capitalism provides powerful incentives for innovation through the ferocity of competitive pressures (BAUMOL [2002]). The competition effect can be conveniently illustrated by incorporating multiple offer curves into the value map (Figure 2). A key consideration here is the differentiation of suppliers by introducing parameter β to offer curves (i.e., $\lambda = \lambda_{jt}(z_1 \mid \beta_j, \rho_t)$). β reflects inter-firm differences in factor prices and, more importantly, in "technology" and "R&D expenditure" (ROSEN [1974, p. 43]).

Given an offer curve $\lambda_{11}(z_1 \mid \beta_1, \rho_1)$ and a value curve $\theta_{13}(z_1 \mid \gamma_1, u_3)$ with an equilibrium offer D, market entry of new producers with the same price–quality offer will intensify competition. Subsequently, profit erodes and the offer curve shifts downward to $\lambda_{12}(z_1 \mid \beta_1, \rho_2)$ with $\rho_2\left[< \rho_1\right]$ whereas consumer utility increases to $u_5\left[> u_3\right]$. Eventually, competition will drive the offer curve down to the cost curve, which signals the technological frontier for producing a good with a given amount of product characteristic z_1. To escape the competitive pricing situation, producers have to innovate: (1) By means of cost-saving innovations, firms at E may be able to shift the offer curve further down, and enjoy the higher profit margin until rival firms discover a similar or even better technology. (2) Alternatively, firms can move to F to reach a new customer class which prefers a different quantity of product feature z_1 (as explained in Proposition 2). (3)

Finally, firms can extend existing customers' choice options by reshaping the firms' cost structure (i.e., different β) without necessarily reducing overall costs. In Figure 2, a shift of the cost condition parameter β_1 to β_2 would shift the offer curve from $\lambda_{12}(z_1 \mid \beta_1, \rho_2)$ to $\lambda_{23}(z_1 \mid \beta_2, \rho_3)$. λ_{23} now has a cost advantage over λ_{12} as long as z_1 does not exceed z_1^* and the offer curve λ_{23} and value curve $[=\theta_{15}]$ yield a new equilibrium G. The second and the third types of innovation respectively represent the process of consumer-differentiation and producer-differentiation. In sum,

PROPOSITION 3 *Irrespective of the distinct innovation type, the greater the market competition, the more firms are compelled to innovate.*

Figure 2
Innovation and New Combinations



The more both buyers and sellers differentiate and the more innovations made in accordance to the differentiation, the more equilibrium points are emerging crossing E, F, and G in Figure 2. Those points or an "envelope" signals as implicit prices or "hedonic" prices against which both buyers and sellers adjust their offer or value curves. It is the implicit prices or the "market" that intermediate between buyers and sellers (ROSEN [1974, p. 36]). In our terms, marketization is an effective mechanism to enhance innovation by realizing various Schumpeterian "new combinations" of γ, β, and z = (z_1, z_2, …, z_n).

2.1 *The Power Proposition*

In state socialist economies, the political actors – party officials and bureaucrats – held monopoly power over the allocation of scarce resources. The emergence and growth of a decentralized market economy necessarily involves reducing the scope of state controls over resource allocation, hence diminishing the redistributive power of political actors, while economic actors – firms and entrepreneurs – gain power insofar as market transactions are based on voluntary agreement between buyers and sellers (NEE [1989]). Moreover, the shift to market allocation causes changes in relative rewards that reduce the payoffs for unproductive rent-seeking and offers incentives and opportunities for economic actors to engage in productivity-enhancing innovative activity.

PROPOSITION 4 *Market transition diminishes the relative power of political actors and empowers economic actors – firms and entrepreneurs.*

Assume that a firm can generate additional revenue through economic or political sources:

(1) $$T_j = C\pi_j + P\phi_j ,$$

where T_j is firm *j*'s total expected payoff, C expected revenue from competitive advantage through innovation (formalized in Figures 1 and 2), P expected rents from political sources, π_j (with $0 \leq \pi_j \leq 1$) firm *j*'s probability to realize additional revenue from innovation, and finally ϕ_j (with $0 \leq \phi_j \leq 1$) firm *j*'s probability to generate rents from political sources. In this model, a firm's expected pay-off T_j is determined as a linear combination between given structural parameters of the market (i.e., C and P) and firm-level parameters (i.e., π_j and ϕ_j). Note that we do not specify distinct market structures and resulting prices and costs, as our aim is not to model the market. For simplification we assume only one period and assume that failed efforts to pursue either innovation or political advantages yield no pay-off.

Further, the power proposition implies that expected innovation gains (C) and political rents (P) are functions of market transition with

(2) $$C'(m) > 0 \quad \text{and} \quad P'(m) < 0 ,$$

where m is the degree of marketization. In other words, the firm's income generation moves away from resources controlled by the state – political funds P – to income generated by innovative activities C as market transition changes the relative payoffs of unproductive and productive entrepreneurship. Expanding market transition opens up opportunities for productive entrepreneurial activities (NEE [1989]).

We further assume that firm's probability to generate income from innovation (i.e., π_j) or political funds (i.e., ϕ_j) is a positive function of investment (including capital, time, skills, and efforts) in innovation I_{ji} (R&D activities) or politics I_{jp} (rent-seeking activities) by firm *j*:

(3) $\partial_{I_{ji}} \pi_j > 0$ with $\pi_j \big|_{I_{ji}=0} = \pi_0$ and $\partial_{I_{jp}} \phi_j > 0$ with $\phi_j \big|_{I_{jp}=0} = \phi_0$,

where I_{ji} and I_{jp} are constrained by the investment budget B_j:

(4) $$I_{ji} + I_{jp} = B_j .$$

Note in condition (3) that with no investment in innovation or politics (i.e., with $I_{ji} = 0$ or $I_{jp} = 0$), a firm's probability to generate income from innovation or political funds is assumed to reach a lower bound (i.e., π_0 or ϕ_0) which is independent of any firm characteristic *j*. Those lower bounds may be regarded zero for convenience. Also note that for convenience there are no financing costs.

2.2 The Politics Proposition

Whether through informal or formal arrangements, the reward structure for political actors is skewed to encourage the pursuit of innovative rent-seeking rather than productivity enhancing innovations (BAUMOL [1993]). In state socialist economies, the structure of incentives did not reward managers for innovating (SHLEIFER AND VISHNY [1994]). Given annual assignments of production quotas, managers bargained for more appropriations and lower production quotas. In other words, the payoff matrix rewarded managers with positional advantage and connections with politicians. Government bureaucracies lack the commitment to hard budget constraints, and hence the capacity for effective *ex post* screening required for divesting from innovation projects that are not viable (QIAN AND XU [1998]). For this reason, bureaucrats tend to rely on *ex ante* screening, which results in rejecting promising projects and funding fewer numbers of projects, especially those involving higher uncertainties and less research in the initial stages of development.

Our previous proposition assumed for convenience fixed firm-level probabilities of achieving innovation (π_j) or political advantages (ϕ_j), given an investment allocation between innovation (I_i) and politics (I_p). This simplification overlooks the critical role reward structures play in shaping economic activities and subsequent effectiveness for realizing innovation. Particularly the difference between economic actors, as profit maximizers, and political actors, who typically pursue multiple goals (such as employment generation and realization of social stability) may have a critical impact on the incentive to innovate. In line with earlier studies (HART, SHLEIFER, AND VISHNY [1997]), we claim that involvement of political actors may dilute both incentives and opportunities for productive entrepreneurship because it tends to skew the structure of rewards towards unproductive rent-seeking (WAN [2003]). We predict that firms respond to variability in the involvement of political actors by either strengthening competitive position through innovative activity or political advantage.

PROPOSITION 5 *When political actors are empowered to allocate resources in firms there are fewer innovations and more delays in bringing innovation projects to new products.*

The politics proposition implies that the marginal increase in the probability of successful innovation by a unit increase in investment (i.e., $\partial_{I_i}\pi$) depends on the extent of involvement by political actors in the governance of the firm. While political control and involvement is usually hard to measure, state interference typically builds on the extent of government ownership of the firm. SHLEIFER AND VISHNY [1994], for instance, develop a formal model, where privatization limits the involvement of political actors in a firm's decisions. Based on the close connection between ownership form and involvement of politicians in the firm's governance, we introduce *a* as the proportion of private ownership in the politics proposition:

(5) $$\partial_{a I_i}\pi > 0 .$$

Condition (3) specifies a positive effect of investment in innovative activity on the probability of successful innovation (i.e., $\partial_{I_i}\pi > 0$). The politics proposition (condition (5)) further implies that this investment effect will be the stronger the larger the private ownership share *a,* and the less vulnerable the firm to political intervention. In addition, the politics proposition implies that the marginal increase in the probability of achieving political advantage by a unit increase in investment to politics (i.e., $\partial_{I_p}\phi\left[=\partial_{-I_i}\phi\right]$) will decrease with the extent of private ownership of the firm, *a*:

(5a) $$\partial_{a I_p}\phi < 0 \quad \text{or} \quad \partial_{a I_i}\phi > 0 .$$

Essentially we hold that gains from innovative efforts are on average greater in private firms than in public enterprise.

Notwithstanding, this is not a claim that state-owned enterprises may not play a critical role in innovation. Given ready access to government funding for capital investment, for instance, state-owned enterprises enjoy advantages in sectors, where scale and scope effects lead to lower unit costs. In steel-production, for instance, the two state-owned enterprises Posco (Korea) and Shanghai Baosteel Group (China) rank among the top five steel producers globally. Similarly, China's state-owned enterprises out compete private companies in industries such as ship-building, aircraft, and mobile telephone.

3 Derived Hypotheses

Given the payoff structure in conditions (1) to (5a) and abstracting from financing costs, a firm will choose an optimal allocation of the budget B between two investment types I_i and I_p so that it maximizes the expected payoff *T*:

(6) $$\partial_{I_i}T = 0 \quad \text{and} \quad \partial_{I_i I_i}T < 0 .$$

Let I_i^* denote I_i satisfying condition (6). In other words, I_i^* is the optimal level of investment to innovation, for a given level of marketization (*m*) and a given proportion of private property rights (*a*). Then, we can deduce

$$\partial_m I_i^* > 0 . \tag{7}$$

See Appendix, section A.1, for proof. Hence, for any firm, the optimal investment to innovation increases with market transition. Accordingly, the probability of successful innovation increases with market transition for *any* firm:

$$\partial_m \pi^* > 0 . \tag{8}$$

See Appendix, section A.1, for details. Hence we specify:

HYPOTHESIS 1 *The greater the extent of market transition, the more dependent are firms on innovative activity for survival and profits.*

It is the growth of wealth-maximizing opportunities in competitive markets outside of the state-directed sectors of the transition economy that triggers a shift towards innovation, regardless of ownership form. In this process, firms will increasingly rely on regional technical and research cooperation. The idea that geographical concentration generates positive externalities dates back to MARSHALL [1920]. Analyses of positive externalities either build on the assumed information exchange and knowledge spillovers due to facilitated conditions for cooperation and backward and forward linkages or refer to intensified local competition, which motivates innovation activities (PORTER [1990]). As an extension of Hypothesis 1 we specify:

HYPOTHESIS 2 *The greater the extent of market transition, the more developed markets for innovation, the more effective are R&D networks between firms and between firms and research universities and institutes.*

Hypotheses 1 and 2 are general properties independent of the firm's ownership structure. However, from our politics proposition (i.e., condition (5)) we derive that firms under tight political control will be less innovative than independent firms. Formally,

$$\partial_a \pi^* > 0 . \tag{9}$$

Thus

HYPOTHESIS 3 *The higher the proportion of private ownership of a firm, the more likely a firm's chances of success in innovation projects (see Appendix, section A.2, for its proof).*

Condition (9) implies that state-owned enterprises will not invest in innovation at a level so that its probability of innovation π^* can keep up with that of private firms. Further examination of condition (6) reveals the underlying reason. First, in order to satisfy the requirement of $\partial_{I_i I_i} T < 0$, we assume concavity of both π and

ϕ, that is if investments in innovation projects / political efforts increase the same degree, we expect a *decreasing marginal improvement* in the probability of successful innovation and in that of allocation of political funds:

$$(10) \qquad \partial_{I_i I_i}\pi < 0 \text{ and } \partial_{I_p I_p}\phi\left(= \partial_{I_i I_i}\phi\right) < 0 .$$

This concavity assumption implies an *increasing marginal degeneration* when investments are reduced. Second, $\partial_{I_i} T = 0$ in condition (6) is equivalent to

$$\frac{C(m)}{P(m)} = \frac{-\partial_{I_i}\phi}{\partial_{I_i}\pi}$$

Hence, with proceeding market transition income from innovative efforts $C(m)$ increases relative to income streams from political funds $P(m)$. A firm will rebalance its investment portfolio in favor of innovation projects, until $C(m)/P(m)$ equals the ratio between the marginal decrease in the probability of achieving political funds $\left(= -\partial_{I_i}\phi\right)$ and the marginal increase in the probability of successful innovation $\left(= \partial_{I_i}\pi\right)$. When $-\partial_{I_i}\phi / \partial_{I_i}\pi$ is smaller than $C(m)/P(m)$, the firm is under-investing in innovation and would benefit from a reduction of investments in political rents. If in contrast $-\partial_{I_i}\phi / \partial_{I_i}\pi$ is larger than $C(m)/P(m)$, the firm is over-investing in innovation as additional payoffs from innovation projects do not cover forgone income streams that could have been secured from political sources.

For a given investment I_i, the politics proposition (or conditions (5) and (5a)) implies that the marginal increase in the probability of successful innovation ($= \partial_{I_i}\pi$) for a government-owned firm is smaller than that of a private firm while its marginal decrease in the probability of achieving political advantages ($= -\partial_{I_i}\phi$) is larger than that of a private firm. As a result, $-\partial_{I_i}\phi / \partial_{I_i}\pi$ is larger for a government-owned firm than for a private firm. For government-owned firms, the probability of achieving political advantage decreases faster than that of private firms, relative to the probability that successful innovation increases. If the government-owned firm were to invest the same amount as the private firm at a certain level of marketization, the government firm would thus be over-investing in innovation. The lower levels of innovation for government-owned firms are therefore not only rooted in less effective innovative activity, but also attributable to smaller investments.

4 The Transition to Market Economy in China

China as a strategic research site provides an ideal case to test our theory due to its enormous inter-provincial variance in the extent of market transition. While many hinterland provinces remain locked in state-directed transition economies, most coastal provinces have completed the transition to a market economy. A review of the reform process confirms a close link between market transition and innovation. China embarked on a "dual-track" approach to economic reform, which emphasized a gradual approach to the diversification of allocation mechanisms and property forms over the shock-therapy undertaken in Eastern and Central Europe and the Soviet Union. Central planning was not immediately abolished in 1978, but complemented by a "market-track" which operated parallel to the "plan-track". Under the dual-track system, producers enjoyed the right to sell their surplus production on free markets after fulfilling compulsory delivery obligations. By 1990 markets became the dominant allocation mechanism for most commodities. For industrial products, the share of economic transactions controlled by the state fell from near 100% prior to economic reform to 45% in 1990; while market sales in the retail market approached 70% of total sales by 1990 (LAU, QIAN, AND ROLAND [2000]).

Once free markets operated alongside planned production, market niches, particularly in light industries notoriously neglected under central planning attracted entrepreneurial talents. Regulatory market entry barriers were gradually lowered and only few areas, such as finance, telecommunications, tobacco, selected heavy industries, and high-technology sectors, remained off-limits for private enterprise. Competition further intensified in the 1990s when, after a decade of organizational reforms, wide-ranging ownership reforms of state-owned enterprises (SOE) were initiated. Small and medium-size SOEs were privatized through auctions and management buy-outs, while key firms in strategic industries were corporatized, and as public corporations the largest were listed on the domestic stock markets. Formally the corporatization strategy intended to depoliticize enterprise decision making and to limit the state's interference in firm management. However, with the state as majority shareholder of two third of the listed firms and complete state ownership in many of the non-listed companies, political intervention persisted (NEE, OPPER, AND WONG [2007]).

In the early period of economic reform, new market entrants were mainly rural non-state firms (collective and privately run township and village enterprises) and foreign firms. But by the mid-1980s, the fledgling private enterprise sector grew rapidly in the expanding consumer and light industrial sector. Confronted with fierce competition from these start-ups, the contribution of state-owned enterprises decreased from 78% to only 35% of gross industrial production between 1979 and 2005 (NATIONAL BUREAU OF STATISTICS OF CHINA [2006]). Private firms spear-headed the development of China's technology-based industries in electronic and computer appliances. With an unprecedented founding rate of non-state firms, China developed into one of the most competitive market economies, with comparatively low market concentration ratios.[1]

Between 1999 and 2003, national R&D-expenditures increased from 0.8% to 1.3% of GDP. The Ministry of Science and Technology projects that spending on R&D will increase to 2.5% of GDP by 2020 (CHONG [2006]). In parallel, the locus of research shifted from government institutions to the firm. With more than

[1] The five largest machinery builders in the US have a combined market share of 69%, in Japan the top five hold 42%, whereas the top five manufacturers in China have only 20% of the market (OECD [2002, p. 403]).

60% of R&D funds provided by firms, the expenditure structure resembles that of advanced market capitalist economies. Also inter-firm technological collaboration and regional innovation clusters developed rapidly.

5 Data and Method

To analyze the relationship between market transition and innovativeness at the firm level, we use data from the World Bank Investment Climate Surveys. The 2002 survey includes firms in five middle-size and large Chinese cities ($N = 1{,}548$) and the 2003 survey includes firms in 18 middle-size and large cities ($N = 2{,}400$). Both surveys share a set of core questions on innovation activities and firm characteristics. Participating firms were randomly selected in each city. The industry mix comprises both labor-intensive and technology-intensive sectors across a broad spectrum of different production technologies and levels of competition.[2] Importantly, the World Bank data enables quantitative institutional analysis of a diverse sample of organizational and ownership forms – private, hybrid and state-owned enterprises. A note of caution, however, should be added: there is currently no longitudinal data available that covers the type of in-depth organizational information ideally needed to test our theory. It is therefore technically not possible to fully rule out endogeneity concerns.

5.1 Model Specification

Our model tests for the impact of market forces and political influence on innovation. Formally, our model is

$$y_{ij} = \mathrm{X}_{ij}\beta + v_i + \varepsilon_{ij} \,,$$

where i denotes each city and j each firm. X_{ij} is a set of firm-level variables covering political control, research activities, competition and distinct firm characteristics and β is a vector of corresponding coefficients. v_i denotes regional level effects while ε_{ij} residuals.

5.2 Dependent Variable

To assess the broader concept of firm innovativeness, we employ three measures of innovation: (1) the introduction of new products, (2) the introduction of a new production process, and (3) the introduction of new quality-control measures. For all innovation measures the 2002-survey provides information for the years from

[2] The surveys used 16 different industry categories. The distribution of firms is: Apparel & leather goods (14.61%), electronic equipment (9.73%), electronic parts (12.34%), household electronics (1.6%), vehicles & vehicle parts (14.61%), information technology (8.64%), accounting & related services (6.81%), marketing (6.18%), business logistics (9.75%), food processing (1.80%), chemical products & medicine (1.67%), biotech & Chinese medicine (0.91%), metallurgical products (4.00%), transport equipment (1.27%), communication services (1.85%), and consumer products (4.23%).

1998 to 2000, while the 2003-survey provides information for the years from 1999 to 2002.

In addition, we follow earlier work (SCHMOOKLER [1966]) and construct a dummy variable, which indicates whether a firm received a patent in the last available survey year (i.e., in 2002 and 2000). The use of patent applications as a measure of innovativeness, however, is not unproblematic. First, only patented inventions that are actually brought to the market are true innovations (SCHUMPETER [1942]). In addition, firms do not generally decide to patent their inventions. We therefore include patents mainly for the sake of complete coverage of standard innovation measures.

5.3 Independent Variables

Marketization. Measuring progress in market transition is not an easy endeavor. We employ a measure of local "private sector development", as privatization is a close proxy of overall market transition and is also used to broadly classify capitalist systems (BRADA [1996]). The city level scores for private economic development are based on three components: (1) the proportion of private sector employees in total employment, (2) the proportion of private sector revenues to GDP, and (3) the contribution of private sector tax revenues to total revenues (CHINESE ACADEMY OF SOCIAL SCIENCES [2005]). The indicator is formulated as a relative measure, wherein 1 is assigned to the city with the most developed private sector in China. Due to missing information on five survey cities, our final sample is reduced to 18 cities, with private sector development ranging from 0.11 in Beijing to 0.56 in Shenzhen.[3] To allow a closer analysis of the impact of market transition on innovation processes we also construct two sub-samples and divide the sample at the mean value of private sector development [= 0.277]. Note that the sub-mean sample does not indicate absolutely low levels of market transition.[4] After more than 25 years of successful market reform, all survey cities have undergone extensive market reforms.

Research Activities. Whether a firm has invested in R&D over the last three years preceding the survey year is specified by a dummy variable (MAIRESSE AND MOHNEN [2002]). The average ratio of R&D expenditures to total sales over the last three years serves as an indicator of R&D intensity. Finally, we approximate the most recent stock of technological capital by noting whether a firm acquired patents over the preceding two years. This variable takes into account the path-dependent process of innovation wherein past experience and success has a positive impact on future innovation.

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[3] The following cities are included in our sample. Private sector development scores are indicated in brackets: Beijing (0.12), Xian (0.16), Kunming (0.16), Chengdu (0.18), Haerbin (0.20), Nanchang (0.21), Tianjin (0,27), Guangzhou (0.27), Wuhan (0.27), Zhengzhou (0.28), Chongqing (0.30), Changchun (0.34), Wenzhou (0.35), Hangzhou (0.35), Changsha (0.40), Dalian (0.41), Shanghai (0.43), Shenzhen (0.56).

[4] The sub-mean sample includes the cities from Beijing to Guangzhou whereas the above-mean sample includes the cities from Wuhan to Shenzhen.

Research Networks. The emergence of innovation markets is measured through variables indicating the existence of contractual agreements for R&D cooperation in the last three years between the firm and (1) research institutes, (2) universities, and (3) other firms. Membership in business associations and location in industrial parks are proxies of the potential diffusion of information and knowledge through networks. This source of regional advantage does not rely on formal contractual research agreement, but on reduced information costs due to propinquity and inter-firm networks (POWELL, KOPUT, AND SMITH-DOERR [1996], BURT [2005], ARROW [2007]).

Political Control. We first note whether a firm is legally registered as a state-owned enterprise. State-owned enterprises in general operate under softer budget constraints and are subject to political involvement and rent-seeking. Public ownership is not limited to firms legally registered as state-owned enterprises. Many firms listed in China's two stock exchanges and joint-stock firms registered as private enterprises are partly or even majority state-owned. In order to capture such ownership effects, we differentiate four mutually exclusive levels of state ownership: (1) up to 25%, (2) between 25% and 50%, (3) between 50% and 99%, and (4) 100%. Fully privately held firms serve as benchmark category.

5.4 Control Variables

Competition. To separate effects of market transition from firm competition, we introduce five variables to measure competitive pressure: A binary variable indicates whether a firm controls more than 10% of the domestic market sales, in order to control for monopoly power (SCHUMPETER [1942], ARROW [1962]). Self-reported numbers of competitors in the relevant domestic market capture the perceived level of competition (we use a five-point scale with 1: 1–3, 2: 4–6, 3: 7–15, 4: 16–100, 5: more than 100). Because a certain threshold of competitive market pressure may be required to stimulate innovation, we allow for a non-linear relation (AGHION et al. [2005]) by specifying a square-term of the number of competitors. Whether firms participate in the export market is indicated by a dummy variable. Lastly, a set of dummy variables controls for 16 different industrial sectors, which serve as proxies of competitive pressure, technological opportunity conditions, and average innovativeness (MAIRESSE AND MOHNEN [2002]).

Additional Control Variables. Other firm characteristics – including age, size, financial leverage, and location – may correspond with a firm's innovativeness. A firm's age is believed to affect its adaptability and innovativeness. Older enterprises are encumbered by more structural inertia. A dummy variable for firms founded after the start of market reform in 1978 differentiates between new and older firms. To control for scale effects from firm size (SCHUMPETER [1942]), we include the natural logarithm of the average value of a firm's net assets over the last three years. The natural logarithm of the average debt–asset ratio over the

Table 1
Descriptive Statistics of Variables in Analysis

	Mean	Std. dev.	Min	Max
Product innovation	0.385	0.487	0	1
Process innovation	0.319	0.466	0	1
New quality control	0.490	0.500	0	1
Firm receives patent in 2002	0.116	0.320	0	1
Firm holds patents	0.114	0.318	0	1
Firm conducts R&D	0.353	0.478	0	1
Average R&D-to-sales ratio	0.020	0.604	0	32.370
Located in industrial park	0.240	0.427	0	1
Member of business association	0.568	0.495	0	1
R&D cooperation with firms	0.130	0.337	0	1
R&D cooperation with universities	0.140	0.347	0	1
R&D cooperation with research institutes	0.100	0.300	0	1
Legally registered as SOE	0.243	0.429	0	1
State holds up to 25% shares	0.020	0.138	0	1
State holds between 25% and 50%	0.020	0.138	0	1
State holds between 50% and 99%	0.023	0.150	0	1
State holds 100%	0.187	0.390	0	1
Market share > 10%	0.265	0.441	0	1
Number of competitors in main business*	3.561	1.393	1	5
Firm exports	0.235	0.424	0	1
Firm is founded after1978	0.810	0.393	0	1
Log of average firm assets	8.556	2.686	0	17.474
Log of average debt–asset ratio	1.013	0.869	0	7.291

Note: * 1: 1–3, 2: 4–6, 3: 7–15, 4: 16–100, 5: more than 100.

preceding two years indicates financial health. Finally we include a set of dummies for the northeast, coastal, central, southwest, and northwest region of China. Table 1 presents the descriptive statistics of variables in analysis.[5]

6 Results

To examine the impact of market forces on innovation, we provide estimates for the full sample of firms and for two subsamples representing firms in cities with below-mean and above-mean levels of market transition. We draw inferences on

[5] Correlation tables are available upon request from the authors.

the impact of market transition on our predictor variables from changes of coefficient estimates across the two subsamples.

6.1 Hypothesis 1: Increasing Rates of Innovation with Marketization

To begin with, we test whether we can confirm a positive correlation between the extent of market transition as measured by the regional development of the private economy and the probability of success in innovative activity. For each of the four dependent variables, our benchmark model in Table 2 only includes measures of city-level development of private economy and control variables for industries and regions. The estimation results for the full sample show significant and positive coefficients for private sector development for all outcome variables except for patents granted, which confirms Hypothesis 1, indicating that incentives and opportunities arising from the emergence of a market economy trigger innovation processes at the firm level (Propositions 1 and 2).

The negative effect of the extent of market transition on patenting activities is most likely a reflection of China's weak legal protection of intellectual property. Anecdotal evidence from our firm interviews suggests, that patenting activities are not only conducted to protect intellectual property rights but also to gain legitimacy within a government-controlled institutional environment. In this light it is not surprising that the results reported on patenting were driven by Beijing and Chengdu, both municipalities are tightly controlled by government bureaus.

Skeptics may raise the issue of reverse causality. One concern is that more innovative firms simply locate in more marketized cities, while the less innovation-prone firms choose cities with significantly lower marketization levels. To test selection effects at the firms' birth, we re-estimated the models in Table 2 for a subsample of firms, which were already founded before China's main liberalization drive in 1993. In all cases, the positive association between marketization and innovation is confirmed for the subsample of old firms. Even for patent acquisitions, the coefficient estimate is now positive, though insignificant. Reverse causality therefore seems not to be driving our results.

An intriguing pattern is revealed when we compare estimates between the two sub-samples sorted by marketization levels. Without exception, the strong positive effects of the extent of market transition in the sub-mean sample disappear in the above-mean sample to non-significant levels for the product, process, and quality control innovation. It implies that the system-level effect decreases with further marketization, which is consistent with the *decreasing marginal improvement* in the probability of successful innovation assumed in condition (10). Hence, after 25 years of market reform, China's most marketized cities no longer display direct system-level effects on innovation. Note that these findings are also confirmed under inclusion of the full set of control variables for process innovation (Table 4) and quality control innovation (Table 5). In contrast, significant system-level effects persist for product innovation (Table 3), which emphasizes the crucial role of markets for the placement of new products. While process innovation and quality control innovation may be essentially driven by cost competition, product innovation builds to a larger extent on the opportunity space that only markets with low entry barriers offer (see Table 3).

Table 2

Innovativeness and Market Transition

	All	Firms founded before 1993	Sample 1 (sub-mean private economy development)	Sample 2 (above-mean private economy development)
(1) Product Innovation				
Development level of	2.198^{***}	1.469^{***}	2.069^{***}	0.311
private economy	*(0.565)*	*(0.502)*	*(0.376)*	*(0.748)*
Industry	yes	yes	yes	yes
Region	yes	yes	yes	yes
Pseudo R^2	0.104	0.1004	0.098	0.112
N	3247	1363	1799	1444
(2) Process Innovation				
Development level of	1.034^{**}	0.874^{**}	5.450^{***}	–0.260
private economy	*(0.483)*	*(0.353)*	*(0.824)*	*(0.700)*
Industry	yes	yes	yes	yes
Region	yes	yes	yes	yes
Pseudo R^2	0.112	0.109	0.106	0.140
N	3243	1362	1798	1445
(3) Quality Control				
Development level of	1.006^{**}	0.821^{*}	2.138^{***}	–0.153
private economy	*(0.475)*	*(0.487)*	*(0.524)*	*(0.929)*
Industry	yes	yes	yes	yes
Region	yes	yes	yes	yes
Pseudo R^2	0.058	0.0758	0.057	0.066
N	3239	1362	1796	1443
(4) Patent Granted				
Development level of	-2.446^{***}	0.233	–7.036	–0.260
private economy	*(0.945)*	*(0.476)*	*(4.754)*	*(1.103)*
Industry	yes	yes	yes	yes
Region	yes	yes	yes	yes
Pseudo R^2	0.154	0.087	0.173	0.155
N	2017	1314	783	1188

Note: In parentheses are robust standard errors clustered on city; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3

Probit Estimation: Product Innovation

	All	Sub-mean sample	Above-mean sample
Marketization			
Development level of private economy	1.357***	3.257***	0.656***
	(0.289)	(0.862)	(0.233)
Research Activity			
Firm holds patent	0.331***	0.183**	0.525***
	(0.097)	(0.077)	(0.189)
Firm conducts R&D	0.527***	0.400***	0.649***
	(0.067)	(0.082)	(0.081)
R&D-to-sales ratio	–1.436***	–1.445	–1.421**
	(0.512)	(1.162)	(0.650)
Network/Cooperation			
Located in industrial park	0.145**	0.230**	0.058
	(0.061)	(0.102)	(0.082)
Member of business association	0.334***	0.308***	0.305***
	(0.049)	(0.081)	(0.072)
R&D cooperation with firms	0.498***	0.312***	0.688***
	(0.070)	(0.066)	(0.078)
R&D cooperation with universities	0.238***	0.349***	0.092
	(0.058)	(0.083)	(0.070)
R&D cooperation with research institutes	0.372***	0.458***	0.325**
	(0.097)	(0.132)	(0.164)
Political Control			
Legally registered as SOE	0.007	0.157**	–0.137
	(0.111)	(0.062)	(0.194)
State holds up to 25% ownership	0.052	–0.187	0.432**
	(0.224)	(0.315)	(0.194)
State holds 25% to 50% ownership	–0.339***	–0.417***	–0.234
	(0.116)	(0.142)	(0.209)
State holds 51% to 99% ownership	–0.163	–0.041	–0.316*
	(0.111)	(0.140)	(0.178)
State holds 100% ownership	–0.051	–0.307***	0.275
	(0.106)	(0.089)	(0.172)
Competition			
Market share >10%	0.166*	0.047	0.355*
	(0.090)	(0.094)	(0.186)
# of competitors in main business	0.220	0.322	0.111
	(0.169)	(0.302)	(0.151)
# of competitors in main business (squared)	–0.044	–0.062	–0.025
	(0.027)	(0.049)	(0.024)
Firm exports goods	0.127**	0.075	0.237***
	(0.061)	(0.099)	(0.074)
Industry	yes	yes	yes
Firm Characteristics			
Founded after reform	0.025	–0.026	0.042
	(0.081)	(0.084)	(0.160)
Log value of assets	0.043**	0.051**	0.021
	(0.018)	(0.025)	(0.029)
Log of average debt-to-asset ratio	0.051	0.068	0.014
	(0.035)	(0.057)	(0.036)
Region	yes	yes	yes
Constant	–1.928***	–2.190***	–1.642***
	(0.310)	(0.581)	(0.320)
Pseudo R^2	0.218	0.200	0.253
N	2635	1361	1270

Note: In parentheses are robust standard errors clustered on city; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4

Probit Estimation: Process Innovation

	All	Sub-mean sample	Above-mean sample
Marketization			
Development level of private economy	0.134	7.745***	–0.354
	(0.391)	*(0.624)*	*(0.509)*
Research Activity			
Firm holds patent	0.451***	0.393***	0.504***
	(0.059)	*(0.065)*	*(0.114)*
Firm conducts R&D	0.328***	0.268**	0.346***
	(0.057)	*(0.112)*	*(0.073)*
R&D-to-sales ratio	–0.552	1.263	–0.723*
	(0.383)	*(1.795)*	*(0.424)*
Network/Cooperation			
Located in industrial park	0.066	0.090	0.028
	(0.041)	*(0.067)*	*(0.050)*
Member of business association	0.175***	0.244***	0.102
	(0.060)	*(0.091)*	*(0.079)*
R&D cooperation with firms	0.434***	0.263**	0.523***
	(0.111)	*(0.123)*	*(0.168)*
R&D cooperation with universities	0.224**	0.252***	0.147
	(0.092)	*(0.077)*	*(0.164)*
R&D cooperation with research institutes	0.403***	0.438***	0.383***
	(0.075)	*(0.099)*	*(0.115)*
Political Control			
Legally registered as SOE	0.011	0.109	–0.055
	(0.086)	*(0.113)*	*(0.127)*
State holds up to 25% ownership	0.215	0.445	–0.007
	(0.225)	*(0.298)*	*(0.322)*
State holds 25% to 50% ownership	–0.090	–0.122	–0.010
	(0.129)	*(0.139)*	*(0.290)*
State holds 51% to 99% ownership	–0.182	–0.331*	–0.003
	(0.175)	*(0.171)*	*(0.232)*
State holds 100% ownership	–0.010	–0.164	0.145*
	(0.092)	*(0.145)*	*(0.081)*
Competition			
Market share >10%	0.145*	0.131	0.244*
	(0.080)	*(0.121)*	*(0.129)*
# of competitors in main business	0.264**	0.280	0.306*
	(0.116)	*(0.195)*	*(0.159)*
# of competitors in main business (squared)	–0.044**	–0.046	–0.053**
	(0.020)	*(0.035)*	*(0.024)*
Firm exports goods	0.130	0.053	0.202
	(0.081)	*(0.096)*	*(0.132)*
Industry	yes	yes	yes
Firm Characteristics			
Founded after reform	0.096	0.048	0.139
	(0.063)	*(0.093)*	*(0.091)*
Log value of assets	0.063***	0.083***	0.043*
	(0.014)	*(0.023)*	*(0.022)*
Log of average debt-to-asset ratio	0.024	0.049	–0.011
	(0.040)	*(0.049)*	*(0.067)*
Region	yes	yes	yes
Constant	–1.632***	–2.911***	–1.409***
	(0.317)	*(0.357)*	*(0.360)*
Pseudo R^2	0.209	0.205	0.241
N	2632	1360	1272

Note: In parentheses are robust standard errors clustered on city; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 5

Probit Estimation: New Quality Control

	All	Sub-mean sample	Above-mean sample
Marketization			
Development level of private economy	0.119	2.931***	–0.321
	(0.348)	*(0.714)*	*(0.718)*
Research Activity			
Firm holds patent	0.148	0.128	0.219*
	(0.099)	*(0.145)*	*(0.121)*
Firm conducts R&D	0.230***	0.144*	0.315***
	(0.069)	*(0.075)*	*(0.110)*
R&D-to-sales ratio	1.602	2.638	1.096
	(1.011)	*(1.856)*	*(0.811)*
Network/Cooperation			
Located in industrial park	0.158***	0.158**	0.157
	(0.058)	*(0.075)*	*(0.097)*
Member of business association	0.220***	0.219***	0.235**
	(0.049)	*(0.040)*	*(0.096)*
R&D cooperation with firms	0.312***	0.287**	0.278**
	(0.081)	*(0.119)*	*(0.114)*
R&D cooperation with universities	0.224***	0.206*	0.224**
	(0.077)	*(0.119)*	*(0.098)*
R&D cooperation with research institutes	0.440***	0.429***	0.472***
	(0.099)	*(0.069)*	*(0.171)*
Political Control			
Legally registered as SOE	–0.132*	–0.080	–0.205*
	(0.077)	*(0.101)*	*(0.124)*
State holds up to 25% ownership	–0.113	–0.038	–0.191
	(0.162)	*(0.188)*	*(0.272)*
State holds 25% to 50% ownership	–0.193*	–0.225	–0.202
	(0.105)	*(0.145)*	*(0.195)*
State holds 51% to 99% ownership	0.102	0.166*	0.060
	(0.093)	*(0.094)*	*(0.192)*
State holds 100% ownership	–0.106	–0.245**	0.078
	(0.087)	*(0.107)*	*(0.134)*
Competition			
Market share >10%	0.115	0.148	0.116
	(0.084)	*(0.123)*	*(0.132)*
# of competitors in main business	0.139	0.354***	–0.137
	(0.109)	*(0.123)*	*(0.144)*
# of competitors in main business (squared)	–0.021	–0.053***	0.017
	(0.017)	*(0.019)*	*(0.025)*
Firm exports goods	0.172**	0.169	0.158
	(0.081)	*(0.130)*	*(0.116)*
Industry	yes	yes	yes
Firm Characteristics			
Founded after reform	0.289***	0.228***	0.366**
	(0.081)	*(0.076)*	*(0.160)*
Log value of assets	0.085***	0.096***	0.069*
	(0.018)	*(0.015)*	*(0.037)*
Log of average debt to asset ratio	0.026	0.033**	0.026
	(0.016)	*(0.017)*	*(0.036)*
Region	yes	yes	yes
Constant	–1.478***	–2.273***	–0.826***
	(0.312)	*(0.411)*	*(0.301)*
Pseudo R^2	0.144	0.138	0.167
N	2627	1359	1268

Note: In parentheses are robust standard errors clustered on city; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6

Probit Estimation: Patent Granted in 2002

	All	Sub-mean sample	Above-mean sample
Marketization			
Development level of private economy	–2.706***	–6.190***	–0.740
	(0.687)	*(1.876)*	*(1.306)*
Research Activities			
Patents were granted in both preceding years	2.209***	1.713***	2.999***
	(0.381)	*(0.419)*	*(0.501)*
Conducts R&D	0.126	0.293**	0.010
	(0.099)	*(0.147)*	*(0.165)*
R&D-to-sales ratio	1.037	1.580	0.877
	(0.693)	*(1.182)*	*(0.807)*
Network/Cooperation			
Located in industrial park	0.173*	0.152	0.294*
	(0.105)	*(0.151)*	*(0.158)*
Member of business association	0.214**	0.292	0.169
	(0.090)	*(0.211)*	*(0.110)*
R&D cooperation with firms	0.075	0.176	0.069
	(0.152)	*(0.286)*	*(0.226)*
R&D cooperation with universities	0.335*	0.164	0.471
	(0.187)	*(0.228)*	*(0.329)*
R&D cooperation with research institutes	0.024	0.014	0.144
	(0.166)	*(0.302)*	*(0.126)*
Political Control			
Legally registered as SOE	–0.079	–0.034	–0.153
	(0.151)	*(0.174)*	*(0.232)*
State holds up to 25% ownership	–0.252	–0.124	–0.443
	(0.249)	*(0.461)*	*(0.445)*
State holds 25% to 50% ownership	0.179	0.620***	–0.946***
	(0.338)	*(0.196)*	*(0.113)*
State holds 51% to 99% ownership	–0.232	0.004	–0.539**
	(0.174)	*(0.346)*	*(0.231)*
State holds 100% ownership	–0.241**	–0.134	–0.445**
	(0.099)	*(0.157)*	*(0.192)*
Competition			
Market share >10%	0.169	0.179	0.105
	(0.116)	*(0.152)*	*(0.197)*
# of competitors in main business	0.220*	0.059	0.485**
	(0.131)	*(0.208)*	*(0.212)*
# of competitors in main business (squared)	–0.054***	–0.035	–0.087***
	(0.019)	*(0.034)*	*(0.027)*
Firm exports goods	–0.069	–0.061	–0.134
	(0.111)	*(0.189)*	*(0.165)*
Industry	yes	yes	yes
Company Characteristics			
Founded after reform	0.206	0.250	0.220
	(0.136)	*(0.158)*	*(0.284)*
Log value of assets	0.082**	0.081*	0.102***
	(0.033)	*(0.049)*	*(0.035)*
Log of average debt-to-asset ratio	0.134**	0.164***	0.101
	(0.056)	*(0.057)*	*(0.104)*
Region	yes	yes	yes
Constant	–2.145***	–1.346*	–3.699***
	(0.597)	*(0.764)*	*(0.648)*
Pseudo R^2	0.411	0.392	0.466
N	1804	664	1030

Note: In parentheses are robust standard errors clustered on city; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6.2 *Hypothesis 2: Increasing Effectiveness of Research Activities and R&D Networks with Marketization*

Progress in market transition (as measured by private sector development) has not only direct effects on firm innovativeness. Growing market incentives and opportunities to pursue productive rather than unproductive entrepreneurial activities also increase the effectiveness of ongoing research efforts (Propositions 1 and 2). Markets help entrepreneurs to distinguish between good and bad research initiatives, they increase incentives to monitor and guide research initiatives. These effects can be readily inferred from a comparative analysis of innovation effects of research activities on firm innovativeness (see Tables 3 to 6). To begin with, a firm's history of patenting activities (firm holds patents / patents were granted in both preceding years) is a strong and statistically significant predictor for most of the dependent variables.[6] A cross-sample comparison consistently confirms stronger effects for the above-mean sample for all innovation measures. Similarly, R&D efforts (firm conducts R&D) increasingly determine innovation rates. Estimated effects are stronger in the above-mean sample than in sub-mean sample, except for patenting activities (Table 6) where the R&D effect in the above-mean sample seems weakened by the overwhelming effect of the lagged patent variable. Finally, the R&D-to-sales ratio has either statistically insignificant positive effects or significant negative effects. We suspect that this is due to a skewed distribution of the variable, as about 72% of the sample firms do not conduct R&D.

In sum, both innovation capacity (measured by patent-holding) and R&D efforts (measured by a dummy for R&D activity) determine innovation and increasingly so the greater the extent of market transition. The growing effectiveness of R&D is consistent with stronger incentive to invest in innovation projects in a market economy and our assumption that political involvement in the economic sphere declines with market transition (*power proposition,* Proposition 4).

Also the five dummy variables for R&D cooperation or networks, in general, show strong effects for product, process, and quality control innovation (see Tables 3 through 5) and moderate effects for patenting activities (see Table 6). A comparison of coefficient estimates across the sub-mean and above-mean samples indicates that network ties with other firms and research institutes show robust effects across different levels of market transition. Most notably for product innovation, R&D networks with other *firms* are exceptionally effective in the above mean sample (see Table 3). Its coefficient [= 0.688] is more than doubled compared to the sub-mean sample [= 0.312] and at least twice as large as those for other R&D network dummies in the above-mean sample. For process innovation, our results show a similar pattern with doubled coefficient estimates at advanced levels of market transition indicating a general and increasing superiority of firm-to-firm collaboration (see Table 4). This indicates that particularly inter-firm collaborations become more effective with the emergence and growth of free

[6] The only exceptions are for quality control, in the sub-mean sample and consequently in the total sample.

markets. The underlying causal effect may well be a closer incentive alignment with firms. Other research partners such as universities and research institutes are to a lesser extent motivated by market forces.

Another reverse causality concern refers to the impact of research activities and research networks on firm innovativeness. In order to rule out a sorting effect in the way that only innovative firms enter into research activities and network collaboration, we have focused on a subsample of firms, which have not yet proven their ability to innovate by formal patent-holdings. Our substantial results, however, remained unaffected further supporting Hypothesis 2.[7]

6.3 Hypothesis 3: Positive Effects of Private Ownership on Innovation

Our final hypothesis argues that private ownership limits political involvement and unproductive entrepreneurship and thereby increases innovation rates (*power and politics propositions*, Propositions 4 and 5). The innovation advantage of private firms is widely confirmed as most of the coefficient values for state-owned enterprises and state ownership shares are negative though not all significant. In a straight forward interpretation, however, Hypothesis 3 calls for increasingly negative coefficient values the larger the representation of the state as a shareholder.

All three innovation types (Table 3 to Table 5) share two common patterns. First, our estimation results show stronger support for Hypothesis 3 in the sub-mean sample than in the above-mean sample. Across product, process, and quality control innovations, the state ownership share dummies tend to form negative slopes at large in the sub-mean sample. Second, there is a U-shaped pattern in the above-mean sample. Coefficient estimates even turn positive for the 100% state-share (0.275, 0.145, and 0.078 respectively in reference to zero state-share). We suspect, that these estimates most likely reflect a selection effect. Local governments typically divest less competitive state-owned enterprises, while profitable firms in key sectors remain under government control and enjoy various forms of government protection. If the firm sample is to some extent affected by such a selection effect, which might have been particularly pronounced during the survey years (due to the ongoing privatization wave), this might help explain the unexpected result for wholly state-owned firms. As the concept of market transition itself also reflects progress in enterprise reforms, the most marketized regions may be characterized by stronger performance of state-owned firms simply because the less successful firms have already been divested. This is consistent with the fact, that the proportion of 100% state-owned firms is 14.9% in the above-mean sample in comparison to 20.3% in the sub-mean sample.

For patenting activities, Hypothesis 3 is mainly confirmed for the above-mean sample. Coefficients for the three largest state ownership share dummies (i.e, larger than 25%) are negative and significant in the model (–0.946, –0.539, and –0.445 respectively). The above-mean sample, however, shows a slightly U-shaped pattern because the lowest innovation rate is found in the middle range of state ownership shares in 25 to 50% [= –0.946].

[7] Regression results are available upon request from the authors.

6.4 Other Control Variables

Most of our control variables for competition show the expected signs though coefficient estimates are not statistically significant in all models. Large market shares tend to increase innovativeness in the case of product and process innovations (Tables 3 and 4). Further, in line with AGHION et al. [2005] we identify an inverted U-shape relation between number of competitors and innovativeness, with statistically significant coefficients in the case of process innovation (Table 4) and patenting (Table 6). It is worth noting, that competition (as measured by the number of competitors) is not simply a proxy of progress in market transition. The correlation coefficients with marketization are –0.4 for the full sample and –0.17 for the above-mean sample, which confirms the distinctiveness of competition and the broader concept of market transition. Overall, firms in more marketized cities report almost the same number of competitors as firms in less marketized cities.

Among variables for firm characteristics, firm size measured by the natural logarithm of firm assets yields consistently strong effects on innovativeness. Larger firms seem to benefit from scale effects, which help them to succeed in a wide range of innovative activities. Also, new firms founded after the reform seem more successful in quality control. The debt-to-asset ratio reveals that more financially leveraged firms are more successful in patent acquisition and quality control.

Finally, we note some concerns: First, there is limited availability of survey data on firm innovativeness. Due to the survey design, our econometric tests are confined to non-linear estimation techniques. The survey for instance contains no information on the number of implemented innovation projects or their economic value. Given the reasonable assumption, that firms in less marketized regions and state-owned firms perform fewer innovation projects, the survey design creates a statistical convergence which may not accurately reflect the current situation. It is likely that cross-ownership differences in firm innovativeness are downplayed in our firm sample.

Secondly, the lack of availability of city-level measures of market transition for Guiyang, Lanzhou, Nanning, Benxi, and Jiangmen has led to the exclusion of these five cities covered in the Investment Climate Survey. With the exception of Jiangmen, all of these cities belong to the less marketized cities with weak private sector development. We therefore assume that a broader sample covering the complete range of market transition would most likely show even stronger system level effects on firm behavior and innovativeness.

To sum up, we understand our empirical application as a first approximation. In spite of all limitations, we hope that these findings inspire future research exploring the distinct impact of the nature of the institutional environment on firm innovativeness.

7 Conclusion

We proposed a theory of innovation and applied it to explain why market transition caused a shift to a higher level of innovation in China's manufacturing economy. We proffered five propositions asserting that the endogenous emergence of markets increases the power of economic actors relative to political actors, increases inter-firm competition and creates new opportunities for entrepreneurship, and subsequently motivates endogenously innovative activity. The mechanisms explain that firms will become more inclined to invest in innovative activity and by doing so link marketization, economic power, and innovation into one theoretical framework. By linking Nee's ideas of endogenous emergence of decentralized markets and entrepreneurial activities with Baumol's ideas on innovation, our theory highlights how market forces that shape motivation are embedded in institutions.

This paper also makes methodological and empirical contributions to understanding the workings of institutions: First, we use a quantitative approach to comparative institutional analysis explaining variations in innovativeness by the level of market orientation. Significant advances have been made in recent decades in understanding of institutions through historical case studies. For example, Avner GREIF's [2006] applications of game theory to explain institutional change in late medieval Europe utilizes context-bound models and analyses to shed explanatory light on the endogenous emergence and decline of economic institutions. This advance in explaining endogenous institutional change notwithstanding, general propositions from which predictive hypotheses can be derived and confirmed with quantitative measures of institutions drawn from a randomized sample can contribute to further advances in understanding why institutions matter in economic performance. The variability of regional transition economies in China, from the highly marketized southeastern coastal provinces to the less marketized hinterland provinces, makes for a large canvas to test hypotheses linking institutions to rates of innovative activity.

Second, our empirical results confirm that the individual rate of innovation increases with the level of local marketization as measured by private firm activities. We find evidence consistent with the view that markets do not just generate competitive pressure on individual firms, but sustain self-reinforcing institutional change that enable and motivate innovative activities. We also confirm an increasing effectiveness of research activities and R&D networks in the transition to a market economy. Further, we provide empirical evidence for the hypothesized negative effects of political involvement on the innovativeness of firms.

Our quantitative institutional analysis yields results in line with HAYEK's [2002, p. 19] contention that "lack in entrepreneurial spirit […] is not an unchangeable attribute of individuals, but the consequence of limitations placed on individuals." The crucial role of the market economy as an institutional system driving innovation seems close to the Hayekian notion of "competition as a discovery procedure". While we emphasize the central role of competition as a mechanism to exploit undiscovered opportunities, our theory of innovation goes beyond the instrumental character of competition as a means for decentralized problem solving. Competition in the Hayekian sense is mainly a tool that responds to two observations: First, knowledge is dispersed and decentralized across society; secondly, rewards for knowledge generation are *ex ante* unpredictable as only consumer demand decides about success and failure. As a consequence, knowledge creation naturally relies on competition as a process of experimentation by a large number of entrepreneurs and the informational processing capability of free markets. In contrast, our concept capturing the market orientation of economic systems, attempts to reach down to the motivational foundations of human behavior.

While our empirical application focuses on the link between progress in market transition at the city-level and firm innovativeness in China's transition economy, we see scope for further development and applications: Our quantitative institutional approach can be applied to study cross-national variance of innovation. Another field for future application is the cross-national comparison of innovativeness in distinct industrial sectors which underlie greatly varying regulatory regimes, which may balance firm interests either in the direction of active R&D or rent-seeking activities.

Appendix

A.1 Proof of $\partial_m I_i^* > 0$ and $\partial_m \pi^* > 0$

Condition (6) is equivalent to

(A1) $$C \cdot \partial_{I_i} \pi + P \cdot \partial_{I_i} \phi = 0$$

and

(A2) $$C \cdot \partial_{I_i I_i} \pi + P \cdot \partial_{I_i I_i} \phi < 0$$

because *C* and *P* are functions of marketization *m* while π and ϕ are functions of investment $I_i \left(= -I_p\right)$ and privatization *a*. We can solve (A1) for I_i as a function of *m* and *a*. In other words, the optimal investment level given *a* and *m* $\left[I_i^* = I_i(a,m)\right]$ is implicit in (A1).

Plugging $I_i^* = I_i(a,m)$ into (A1) and differentiating both sides with *m*,

$$\partial_m \left(C(m) \cdot \partial_{I_i} \pi\left(a, I_i(a,m)\right) + P(m) \cdot \partial_{I_i} \phi\left(a, I_i(a,m)\right)\right) = 0 .$$

After some algebra we obtain

(A3) $$\underbrace{C'(m) \cdot \partial_{I_i} \pi}_{(+)\times(+)} + \underbrace{P'(m) \cdot \partial_{I_i} \phi}_{(-)\times(-)} + \underbrace{\left(C \cdot \partial_{I_i I_i} \pi + P \cdot \partial_{I_i I_i} \phi\right)}_{(-)\text{ by (A2)}} \partial_m I_i(a,m) = 0 .$$

In (A3), the first two terms are positive by (2) and (3). At the same time, $C \cdot \partial_{I_i I_i} \pi + P \cdot \partial_{I_i I_i} \phi$ is negative by (A2). In order to make the total sum zero, $\partial_m I_i(a,m)$ should be positive. Therefore, condition (7) is proved.

Let us denote innovation capacity at the optimal investment by π^*:

$$\pi^* = \pi\left(a, I_i^*\right) = \pi\left(a, I_i(a,m)\right).$$

Then,

$$\partial_m \pi^* = \partial_m \pi\left(a, I_i(a,m)\right) = \partial_{I_i} \pi \cdot \partial_m I_i^* > 0$$

by (3) and (7). Therefore, condition (8) is proved. *Q.E.D.*

A.2 Proof of $\partial_a \pi^* > 0$

First, we show $\partial_a \pi > 0$.

From (5),

(A4) $$\partial_{a I_i} \pi = \partial_{I_i a} \pi > 0$$

if $\pi(a, I_i)$ has continuous second partial derivatives. Let $\partial_a \pi(a, I_i) \equiv f(a, I_i)$. Then, (A4) can be re-written such that

(A4a) $$\partial_{I_i} f(a, I_i) > 0 .$$

Recall from condition (3) that π_0 is the lower bound of innovation capacity, when no investment into innovation is made at all. Namely,

(A5) $$\pi(a, 0) = \pi_0$$

for all *a*. From (A5),

(A6) $$\partial_a \pi(a,0) = f(a,0) = 0 .$$

From (A4a), $f(a, I_i)$ is an increasing function with I_i wit an initial value zero at $I_i = 0$ by (A6). It holds for any given *a*. Therefore,

(A7) $$f(a, I_i) = \partial_a \pi(a, I_i) > 0 \quad \text{for any } a \text{ and } I_i$$

which completes the proof of $\partial_a \pi > 0$.

Second, we show:

(A8) $$\partial_a I_i^* > 0 .$$

By plugging $I_i^* = I_i(a,m)$ into (A1) and differentiating both sides with *a*,

$$\partial_a \left(C(m) \cdot \partial_{I_i} \pi\left(a, I_i(a,m)\right) + P(m) \cdot \partial_{I_i} \phi\left(a, I_i(a,m)\right) \right) = 0 .$$

After some algebra we obtain

(A9) $$C \underbrace{\partial_{aI_i}\pi}_{(+)\text{ by }(5)} + P \underbrace{\partial_{aI_i}\phi}_{(+)\text{ by }(5)'} + \underbrace{\left(C \cdot \partial_{I_iI_i}\pi + P \cdot \partial_{I_iI_i}\phi\right)}_{(-)\text{ by (A2)}} \partial_a I_i(a,m) = 0 .$$

In order to make the total sum equal to zero on the left side of (A9), $\partial_a I_i(a,m) = \partial_a I_i^*$ should be positive and condition (A8) is proved.

Finally, we can prove $\partial_a \pi^* > 0$ by (A7) and (A8) because:

$$\partial_a \pi^* = \partial_a \pi\left(a, I_i(a,m)\right) = \underbrace{\partial_a \pi}_{(+)\text{by(A7)}} + \underbrace{\partial_{I_i}\pi}_{(+)\text{by(3)}} \cdot \underbrace{\partial_a I_i(a,m)}_{(+)\text{by(A8)}} > 0 .$$

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