Unlocking Innovation: The Impact of Free Trade Zones on Corporate Innovation in China*

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Abstract

If the domestic market operates under an inefficient economic structure, then access to foreign markets can lead to long-term benefits. In this paper, we examine the effect of free trade zones (FTZs), a progressive trade liberalization program, on corporate innovation. By using data on Chinese publicly listed firms, we find that firms operating in FTZs experience significant increases in their innovation output. These positive effects are primarily attributed to the easing of financial constraints, increased market competition, and improved access to foreign markets, even though their effects on the quantity and quality of corporate innovation can be noticeably distinct. Our empirical findings are rationalized by a simple Schumpeterian model with endogenous quality improvement, and they provide implications for policymakers to promote domestic firm growth in the global marketplace.

JEL classification: G30, G31, G32, O19, O30

Keywords: Free Trade Zone, Corporate Innovation, Financial Constraint, Market Competition, Trade Liberalization

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1 Introduction

Many emerging countries have opened their domestic markets and provided offshoring opportunities for corporate managers in advanced countries. The benefits of international reallocation of labor and capital contributes to the growth of multinational global giants (Amiti and Konings, 2007; Bai, 2021; Coelli *et al.*, 2022). At the same time, the intensification of global competition has been driven by the remarkable expansion of the Chinese economy. The unprecedented economic growth of China has ignited heated debates surrounding critical issues, notably the concept of the "China Threat." While academic research is now exploring the trade links between Chinese and US manufacturing (Autor *et al.*, 2020; Pierce and Schott, 2016; Hombert and Matray, 2018), there remains a lack of studies investigating the productivity of Chinese multinational firms as they enter the global market amid China's continuing social and economic reforms.

The objective of our research is to provide, for the first time, a comprehensive analysis of corporate innovation within the context of China's gradual trade liberalization, namely, the establishment of free trade zones (FTZs). This program enables CEOs on both sides of the markets, in FTZ areas and outside of China, to free trade goods and services within their other markets. The inaugural FTZ was launched in Shanghai in August 2013. Given its successful experience, China has expanded FTZs to 18 provinces by the end of 2019 (See Figure 1 for details of the implementation), spanning from coastal to inland areas, which largely promotes China's interaction with the global economy.

FTZs in China have been instrumental in promoting comprehensive reforms and openness beyond the scope of trade liberalization. Particularly, it extends to the domains of investment facilitation, financial openness and innovation, government function transformation, and improvement of the legal environment. The development of these high-quality business platforms has attracted a wide range of factors of production and market entities (including R&D headquarters), and facilitated the accumulation and agglomeration of industrial, value, and innovation chains. By the end of 2019, 18 FTZs taking less than one-thousandth of the national land area had surprisingly attracted 393,000 new enterprises, utilized 176.38 billion RMB in actual foreign investment, and achieved a total import and export volume of 4.7 trillion RMB, which accounted for 17.6% of foreign investment and 14.7% of import and export values in the country.[1]

Those stylized facts suggests productivity improvement in free trade areas, at least at the aggregate level. A critical question to address is how and to what extent policies tailored specifically for FTZs become a driver of micro firm-level innovation, which is a major determinant of firm performance and growth.[2] In this study, we contribute to the literature by utilizing panel data on publicly traded companies in China to conduct a comprehensive assessment. This study also identifies novel mechanisms through which easing financial constraints, fostering market competition, and enhancing linkages between domestic and foreign goods markets can promote corporate patenting activities, along the quantity and the quality dimensions. Particularly, we adopt the establishment of FTZs as a quasi-natural experiment, and employ the difference-in-differences (DiD) method to investigate the overall effect and identify plausible channels propagating the policy shock.

Our analysis documents a positive and statistically significant effect of FTZ establishment on corporate innovation output. The baseline estimation controlling for firm-specific characteristics and industry and year fixed effects suggests that FTZ firms exhibit an average increase of 17% and 14% in the number of patents applied and granted, respectively, more than the non-FTZ counterparts one year after the FTZ establishment. Furthermore, the establishment of FTZs leads to an average increase of 10% in the number of patent citation, indicating a remarkably higher quality of innovation achieved by FTZ firms. Following Schoar (2002), we compute the total factor productivity (TFP) at the firm level, and find that FTZ firms exhibit rising TFP compared with non-FTZ firms. Robustness analysis exploiting the staggered establishment of FTZs in Shanghai, Tianjin, Guangdong, and Fujian from 2013 to 2015 yields similar findings. In addition, we explore the potential heterogeneous effect of FTZ establishment. On the one hand, the quantity and quality of innovation output produced by high-tech and non-high-tech firms rise in response to FTZ establishment, whereas the stimulating effect on innovation quantity seems larger among non-high-tech firms. On the other hand, FTZ establishment fails to boost the innovation novelty of state-owned enterprises (SOEs).

[1] Statistics are quoted from the press conference of the Ministry of Commerce on February 3, 2021.
[2] Please refer to Hall (2005) for a detailed survey.

As highlighted by Akcigit and Melitz (2022), the connections between innovation and globalization are multi-dimensional. In this study, we explore the potential mechanisms that propagate the innovation-stimulating effect of FTZ policy regime changes. First, following Lamont *et al.* (2001), we construct the Kaplan-Zingales (KZ) index to capture the strength of financial constraints faced by individual firms. Tightening financial constraints significantly retards patenting activities, but financially constrained firms in FTZs, on average, manage to deliver more innovation outputs than their non-FTZ counterparts after the FTZ establishment. This interesting observation seems attributed to the fact that FTZ establishment helps relax the financial constraints faced by firms within the region.[3] These findings align, at least partially, with some recent evidence in the literature. For example, based on survey data, Hottenrott and Peters (2012) find that financial constraints hinder innovation activities. Investigating the interstate banking deregulation in the US during 1980s and 1990s, Amore *et al.* (2013) show that credit expansion induced by bank deregulation leads to increases in innovation quantity and quality. Different from Amore *et al.* (2013), however, we find that easing the financial constraints does not help firms achieve higher quality of innovation.

Second, we explore whether increasing market competition can be an alternative channel that stimulates corporate innovation. In the literature, the impact of market competition on corporate innovation remains an open question, and empirical evidence is also mixed.[4] We use the Herfindahl-Hirschman index (HHI) to capture the degree of market concentration, and find that the establishment of FTZs tends to foster market competition and leads to more and higher quality of innovation output. This finding is in line with Blundell *et al.* (1999) and Bloom *et al.*

[3] In our empirical analysis, we consider several measures of financing conditions and provide evidence that the financial constraints become relaxed after the establishment of FTZs.

[4] Canonical Schumpeterian endogenous growth models, as pioneered by Aghion and Howitt (1992), predict that high levels of market competition can decrease firm profits, thereby reducing the internal funds available for innovative activities. However, Arrow (1992) argues that a higher degree of product market competition may actually stimulate innovation due to the replacement effect. Bloom *et al.* (2021) develop a general equilibrium model featuring trapped factors, and show that increased import competition from low-wage countries can incentivize domestic incumbents to innovate more. In addition, the theoretical exposition in Aghion *et al.* (2005) indicates that the relationship between market competition and innovation can be inverted-U shape.

(2016).[5] [6]

In addition, we examine the effect of FTZ establishment through the channel of export opportunities. A spate of literature on trade liberalization highlights the effects of import competition, foreign input competition, and access to imported intermediates, but the inlfuence of increased access to foreign markets has received little attention. Our study reveals that rising foreign sales of Chinese firms located in FTZs results in a remarkable increase in the quantity of corporate innovation, whereas its effect on the quality of innovation seems insignificant. Our evidence based on the quasi-natural experiment of FTZ establishment complements some recent empirical findings. Ahn *et al.* (2018) employ data on South Korean firms and find that rising import and export with China stimulate patent applications. Aghion *et al.* (2018) investigate French firms between 1994 and 2012, and show that responses of corporate innovation to foreign demand shocks depend on firms' initial productivity. Coelli *et al.* (2022) study the effects of international tariff cuts during the 1990s, and find a substantial and positive effect on innovation and growth.

We also propose a simple Schumpeterian endogenous growth model to develop and support our empirical practice. The model, featuring financing constraints on innovative activities, endogenous quality improvement pursued by R&D firms, and an exogenously determined foreign sector, is adapted to capture the key policy measures related to FTZ establishment. First, we show that relaxing the financing constraints unambiguously increases the quantity of innovation. Second, fostering market competition can motivate R&D firms to pursue high-quality innovation. At the same time, in the presence of endogenous step size of quality improvement, our model does not rule out the possibility that the quantity of innovation may rise in response to lower firm profits associated with a higher degree of market competition. In addition, the effect of improved access to foreign goods markets on innovation quality is undetermined, primarily

[5] In contrast to Bloom *et al.* (2016), Autor *et al.* (2020) suggest that rising import competition from China yields a negative effect on the innovative activities by US firms. Xu and Gong (2017) find a reallocation effect of import competition, where researchers move from declining industries to booming ones, leaving the aggregate innovation largely unaffected. Liu *et al.* (2021) demonstrate that import competition has a negative effect on the innovation pursued by Chinese firms. For a detailed survey, please see Bloom *et al.* (2019).

[6] Lim *et al.* (2018) highlight the importance of the scale and competition channels to innovation activities undertaken by Chinese firms. Their structural model and empirical evidence suggest that greater competition tends to reduce aggregate innovation overall, whereas increased market size stimulates innovation. Particularly, greater competition may motivate firms to innovate more when innovation can help escape the competition.

because it hinges heavily on the profitability of exporting activities. The empirical findings turn out to be largely consistent with the prediction of our theoretical framework.

This paper contributes to several strands of the economics and finance literature. First, it fills the gap of the debate on the evaluation of the economic consequences of FTZ establishment. Yao and Whalley (2016) provide a background and development review of the Shanghai pilot FTZ, offering a preliminary assessment and outlook. Our study complements theirs by presenting micro evidence of rising corporate innovation triggered by FTZ establishment. Our empirical findings are of critical policy relevance and speak to the literature of place-based policies. Representative studies investigating place-oriented polices in the US and European countries include Glaeser and Gottlieb (2008), Glaeser *et al.* (2010), Kline (2010), and others.[7] Lu *et al.* (2019) evaluate the effectiveness of alternative place-based policies in China, namely, the establishment of special economic zones (SEZs) between 2005 and 2008. Their study suggests that SEZs generate positive effects on capital investment, employment, productivity, wages, and entrepreneurial activities. This paper differs from theirs in two aspects. First, our study primarily focuses on the effect of FTZ establishment on the quantity and quality of corporate innovation. Second, the preferential policies of SEZs and FTZs are discernably distinct, which allows us to examine alternative channels transmitting the policy shock.[8] On the basis of aggregated city-level data, Tian and Xu (2022) find positive effects of China's national high-tech zone policies on innovation and entrepreneurial activities through relaxing financial constraints, reducing administrative costs, and cultivating talent. By considering the establishment of FTZs which delivers deepened economic reform in a broader scope, we complement the inspiring study of Tian and Xu (2022) by highlighting the importance of several additional channels to firm-level innovation, such as market competition and access to international markets.

Second, this study contributes to the emerging literature on how finance promotes corporate innovation. Bencivenga and Smith (1991) highlight the role of financial intermediaries in

[7] Please refer to Neumark and Simpson (2015) and Duranton and Venables (2018) for a comprehensive survey.

[8] Specifically, SEZs' preferential policies include tax deduction and customs duty exemption, discounted land-use fees, and special treatment in securing bank loans (Wang, 2013; Alder *et al.*, 2016). By contrast, FTZ establishment aims to deliver economic reform to the next level. Major policies include opening up new investment sectors, promoting the transformation of trade development approach, stimulating innovation, and liberalizing cross-border financing (Yao and Whalley, 2016)

allocating savings to investment, which, in turn, boosts firm productivity (Greenwood and Jovanovic, 1990; King and Levine, 1993). Existing studies (Kortum and Lerner, 2000; Lerner *et al.*, 2011) have shown that venture capital and private equity promote corporate innovation, but the effect of banking on innovative activities remains less clear. In particular, existing studies have questioned the benefit of funding innovation via public capital due to uncertain returns on innovation (Atanassov *et al.*, 2007), sensitive information leakage to competitors (Bhattacharya and Ritter, 1983; Maksimovic and Pichler, 2001), and cost to managers tolerating the failure in public markets (Ferreira *et al.*, 2014). Although mixed, empirical studies (Benfratello *et al.*, 2008; Ayyagari *et al.*, 2011) have generally documented a positive effect of banking on innovation. Acharya and Xu (2017) show that the positive influence of public listing on innovation is only observed in industries more dependent on external (instead of internal) finance. The emerging literature exploits the quasi-natural experiment of the banking deregulation in the US to identify the effect of banking development on innovation. Amore *et al.* (2013) suggest that interstate banking deregulation benefits the innovative performance of manufacturing firms. Chava *et al.* (2013) find a positive effect of interstate bank deregulation on innovation, but an innovation-retarding effect of intrastate deregulation among young firms. Cornaggia *et al.* (2015) find that banking competition induced by deregulation increases the innovation of private firms depending on external finance while reducing the state-level innovation by public firms whose headquarters are located in the deregulating states. Our paper complements these studies by investigating the responses of patenting activities among Chinese public firms to FTZ establishment, and highlighting the relaxation of financial constraints as an important channel stimulating the quantity of innovation.

Third, this study connects to the literature that explores the effect of product market competition on firm productivity, a debate that has attracted wide attention recently (Gilbert, 2006; Cohen, 2010). Existing theories argue that high degree of market competition reduces corporate innovation due to the Schumpeterian effect (Schumpeter, 1942; Aghion and Howitt, 1992), but raises innovation output due to the replacement effect (Arrow, 1992). Aghion *et al.* (2005) suggest that the impact of market competition is contingent on the distance in technological level between competing firms. A recent study by Bloom *et al.* (2021) discusses the effect of market competition in a general equilibrium framework with trapped factors. Our theoretical model differs from theirs by incorporating endogenous quality increment, which permits a theoretical assessment of the impact of market competition on innovation output along the quantity and quality dimensions. For empirical evidence, exploiting the trade liberalization episode in Latin America and Asia, many studies have found a promoting effect of market competition on TFP (Pavcnik, 2002; Schor, 2004; Amiti and Konings, 2007; Fernandes, 2007; Bas and Ledezma, 2010).[9] This study complements the aforementioned ones by examining the impact of goods market competition on firm patenting activities. Empirical assessment of patenting activities using firm-level data in developed countries seems relatively nuanced. A growing literature has investigated the effect of China's entry into the World Trade Organization (WTO) and/or Chinese import penetration on broad measures of technological change and patenting activities (Bloom *et al.*, 2016; Xu and Gong, 2017; Ahn *et al.*, 2018; Hombert and Matray, 2018; Autor *et al.*, 2020; Yang *et al.*, 2021; Bloom *et al.*, 2021).[10] The focus of this paper is quite distinct from theirs, given that we explore the competition faced by Chinese listed firms in the global marketplace and its economic consequences. By examining the effect of China's WTO accession, Brandt *et al.* (2017) find that cuts in input and output tariffs promote firm productivity (especially for entrants), even though their effects on markups are of the opposite sign. Bombardini *et al.* (2017) report a positive effect of competition on patenting and R&D activities only for firms that are sufficiently productive before China joining the WTO. Liu and Qiu (2016) suggest that China's input tariff cut in 2002 reduces the innovation output by Chinese firms. Liu *et al.* (2021) show the retarding effect of import competition on innovation among Chinese firms. We complement these studies by examining further deepened market competition induced by the recent economic reform of FTZ establishment, and demonstrate that greater competition motivates firms to pursue more and higher quality of innovation output.

Lastly, this study is linked to the literature studying the influence of improved access to foreign markets on the number and/or quality of firm products (Verhoogen, 2008; Baldwin and

[9] Iacovone (2012) finds that NAFTA increases the labor productivity in Mexico, but yields insignificant effect on R&D expenditure and technology transfers.

[10] Please refer to Shu and Steinwender (2019) for a detailed survey.

Gu, 2009; Iacovone and Javorcik, 2010; Bernard *et al.*, 2011; Manova and Yu, 2017; Atkin *et al.*, 2017), labor productivity (Lileeva and Trefler, 2010; Iacovone, 2012; Mayer *et al.*, 2021; Munch and Schaur, 2018), TFP (Van Biesebroeck, 2005; De Loecker, 2007; Bas and Ledezma, 2010; Aw *et al.*, 2011), and innovation (Bustos, 2011; Aghion *et al.*, 2018; Ahn *et al.*, 2018; Coelli *et al.*, 2022). Unfortunately, quite limited attention has been paid to Chinese exporting firms. An exception is that Manova and Yu (2017) utilize the customs data in China between 2002 and 2006, and shed light on the operations of multi-product firms facing rising export opportunities (the removal of multi-fiber agreement) through the lens of product hierarchies and quality differentiation. By contrast, our study focuses on the innovative and patenting activities of Chinese firms before and after the novel economic reform of FTZs.

The remainder of the paper is organized as follows. Section 2 presents our theoretical framework and develops the main testing hypotheses. Section 3 describes the data, variable definition, descriptive statistics, and empirical specification. Section 4 reports the empirical results and explores the plausible channels. Finally, Section 5 concludes this paper.

2 Theory and Hypothesis Development

In this section, we present a simple Schumpeterian growth model to develop the test hypotheses. This framework allows the quality and quantity of firm innovation to be endogenously determined. Particularly, we intend to demonstrate that relaxing the financial constraints, fostering market competition, and improving firms' access to foreign goods markets can affect innovation activities along the quality and quantity dimensions. As a simple demonstration, the baseline model in this section only incorporates an exogenous foreign sector which absorbs a fraction of the intermediate goods produced in the domestic country. In Appendix C, we present a full-fledged two-country model, which yields the same model implications.

2.1 Theoretical Model

Household Preference. We assume that there is a representative consumer who derives utility from consumption:

$$U(t) = \int_t^{\infty} \exp\left(-\rho(s-t)\right) \ln C(s) ds, \tag{1}$$

where $C(t)$ represents consumption at time t, and $\rho > 0$ is the subjective discount rate. The budget constraint of the representative consumer is given by $\dot{A}(t) = r(t)A(t) + w(t)L(t) - C(t)$, where $L(t)$ denotes labor (supplied inelastically), and $A(t)$ denotes total asset holdings. We normalize labor supply, such that $L(t) = 1$. The relevant prices are the interest rate $r(t)$, the wage rate $w(t)$, and the price of the domestic consumption good $P(t)$, which is taken to be the numeraire. Henceforth, when possible, we will drop time subscripts to save notation. Solving the household's maximization problem yields the typical Euler equation that determines the interest rate in the economy, such that $r = \dot{C}/C + \rho$.

Final Goods. The economy produces unique final goods for consumption. In the domestic country, indexed by d, final goods are produced in perfectly competitive markets according to the following production technology:

$$\ln Y^d = \int_0^1 \ln X^d(j) dj, \tag{2}$$

where $X^d(j)$ is the domestic demand of intermediate goods in industry $j \in [0,1]$. Each variety is produced by a monopolist in the domestic country, which we will describe later. The final goods production function in Equation (2) yields a unit elastic demand with respect to each variety, such that

$$X^d(j) = Y^d / p^d(j), \tag{3}$$

where $p^d(j)$ denotes the price of $X^d(j)$.

Intermediate Goods and Innovation. There is a unit continuum of industries producing differentiated intermediate goods. Each industry is temporarily occupied by an industry leader until the arrival of the next innovation. The production function for the domestic leader in industry j is

$$X(j) = \lambda^{n(j)}[L_x(j) - \kappa], \tag{4}$$

where $\lambda > 1$ is the quality increment of an innovation, $n(j)$ is the number of innovations that have occurred in industry j as of time t, $L_x(j)$ is the production labor in industry j, and κ is a fixed production cost. In addition to meeting the domestic demand $X^d(j)$, we assume that the industry leader can export $X^f(j)$ units of intermediate good j to foreign countries, as shown as follows:

$$X(j) = X^d(j) + X^f(j). \tag{5}$$

We further assume that the final goods production technology in the foreign market is identical to the domestic one, such that the demand function of $X^f(j)$ is the same as that of $X^d(j)$. For tractability, we impose a simplifying assumption that $X^f(j) = \theta X^d(j)$, where the parameter $\theta > 0$ measures the access to foreign markets. θ also captures the policy instruments that facilitate or restrict export activities. Accordingly, the share of $X^f(j)$ in $X(j)$ is $\theta/(1+\theta)$.

The marginal cost of a monopolist j is $MC(j) = w/\lambda^{n(j)}$. The Bertrand competition in domestic markets implies that the ideal price-marginal cost markup is governed by the step size of quality improvement (λ). To capture the degree of market competition, we introduce a parameter $1/\lambda < \eta \leq 1$, such that the actual markup is $\eta\lambda$, satisfying $1 < \eta\lambda \leq \lambda$. In this sense, the profit-maximizing price $p^d(j)$ is given by $p^d(j) = \eta\lambda MC(j)$. In addition, we assume that the monopolist can set a potentially different markup in the foreign market, where $p^f(j) = m\lambda MC(j)$, with $1 < m\lambda \leq \lambda$.[11] Then, the expected monopoly profit in industry j is

$$\begin{aligned} \pi(j) &= p^d(j)x^d(j) + p^f(j)x^f(j) - wL_x(j) \\ &= \left(1 + \frac{m\theta}{\eta}\right) p^d(j)x^d(j) - wL_x(j) \\ &= \left(1 + \frac{m\theta}{\eta} - \frac{1+\theta}{\eta\lambda}\right) Y^d - \kappa w. \end{aligned} \tag{6}$$

[11] Manova and Zhang (2012) document the empirical evidence that firms set different prices across export markets with distinct country characteristics. Using data on footwear exporters in Taiwan, Aw (1993) shows that cross-country price differences can be jointly accounted for by imperfect competition, trade restrictions, and tastes. Similar setting that allows domestic producers to choose different prices for domestic and foreign markets can be found in Antoniades (2015).

$V(j, \lambda)$ denotes the value of the monopolistic firm in industry j that attempts to create an invention with a quality step size of λ. Equation (6) implies that the profit flow of each monopolist across industries $j \in [0, 1]$ is identical, such that $V(j, \lambda) = V(\lambda)$ in a symmetric equilibrium. Then, the familiar no-arbitrage condition for V is

$$rV = \pi + \dot{V} - \mu V, \tag{7}$$

where μ is the aggregate intensity of research targeting at a state-of-the-art product and the arrival rate of the next innovation. Intuitively, the value of rV is equal to the sum of the profit flow π, the potential capital gain $\dot{V}$, and the expected loss μV due to creative destruction.

The economy admits a unit continuum of entrepreneurs who employ R&D labor for innovation. Suppose that an entrepreneur $\omega \in [0, 1]$ who undertakes at intensity $\mu(\omega)$ for a time interval of length dt achieves success with a probability of $\mu(\omega)dt$. The resource cost of research effort depends on the size of the innovation that the entrepreneur pursues. In particular, research at intensity $\mu(\omega)$ requires $\mu(\omega)f(\lambda)$ units of labor, where $f'(\lambda) > 0$, and $f''(\lambda) > 0$. $\epsilon \equiv \lambda f'(\lambda)/f(\lambda) > 1$ denotes the elasticity of the resource requirement with respect to the size of attempted innovation. Assume that firms' innovating activity is subject to a financial constraint. Specifically, the R&D cost is given by $\mu(\omega)f(\lambda)w(1 + \xi)$, where $\xi > 0$ reflects the additional cost due to financing.[12] The entrepreneur ω chooses λ and $\mu(\omega)$ at every moment to maximize her expected profit, such that

$$\max_{\{\lambda, \mu_t(\omega)\}} \mu_t(\omega)v_t(\lambda)dt - \mu_t(\omega)f(\lambda)w_t(1 + \xi)dt.$$

The optimal choice of quality increment satisfies the following first-order condition:

$$V'(\lambda) = f'(\lambda)w(1 + \xi), \tag{8}$$

[12]In this study, we assume that firms need to make a fraction of the wage payment to R&D labor upfront through financing, which incurs additional innovation cost. The parameter ξ is similar to the product of the strength of the financial constraint and the nominal interest rate in canonical Schumpeterian models featuring cash-in-advance (CIA) constraints. We do not explicitly model the nominal interest rate, because monetary policy in this paper is only of the second-order importance, compared with other policy instruments related to FTZs. Our model implications, however, are robust to explicitly adding the CIA constraints.

which equates the marginal benefit of a larger innovation to the marginal cost of achieving it. The maximization of net benefits from R&D with respect to the choice of research intensity yields the zero-expected-profit condition, such that

$$V(\lambda) = f(\lambda)w(1+\xi). \tag{9}$$

In equilibrium, the unit measure of entrepreneurs implies that the aggregate research intensity is equal to the counterpart at the individual level, namely, $\mu \equiv \int_0^1 \mu(\omega)d\omega$.

Steady-state Equilibrium. We solve for the steady-state equilibrium of the model. In equilibrium, all individuals and firms optimize their utility and profit, and all markets are clear. In the steady state, the firm value V grows at the same rate as the consumption and final goods, and labor allocations are stationary. Applying the Euler equation $r = g + \rho$ and the no-arbitrage condition (7), we can obtain the steady-state value of innovation, such that

$$V(\lambda) = \frac{\pi}{\rho + \mu}, \tag{10}$$

which we use to calculate $V'(\lambda)$. Substituting $V'(\lambda)$ and Equation (10) into (8) and (9) yields

$$\frac{V'(\lambda)}{V(\lambda)} = \frac{f'(\lambda)}{f(\lambda)} \Leftrightarrow \lambda = \frac{(1+\theta)(1+1/\epsilon)}{\eta + m\theta - \kappa\eta\left(\frac{w}{Y^d}\right)}. \tag{11}$$

Furthermore, substituting $V(\lambda)$ in (9), together with (10) yields

$$\frac{Y^d}{w} = \frac{\eta\kappa\lambda + \eta\lambda(1+\xi)(\rho+\mu)f(\lambda)}{\eta\lambda + m\theta\lambda - (1+\theta)}. \tag{12}$$

Consequently, the steady-state labor in the manufacturing sector is given by

$$L_x = \kappa + \frac{(1+\theta)(1+\xi)(\rho+\mu)f(\lambda) + \kappa(1+\theta)}{(\eta + m\theta)\lambda - (1+\theta)}. \tag{13}$$

Given $L_r = \mu f(\lambda)$ and $L_x + L_r = 1$, we derive the first condition that solves for the two endogenous variables $\{\lambda, \mu\}$:

$$\mu = \frac{(1-\kappa-\kappa\Phi)/f(\lambda) - \rho\Phi(1+\xi)}{1+\Phi(1+\xi)}, \tag{14}$$

where $\Phi \equiv (1+\theta)/[(\eta+m\theta)\lambda-(1+\theta)]$. We label Equation (14) the "Labor Condition," which features a positive slope and a positive λ-intercept in the $\{\lambda, \mu\}$ space, as shown in Figure 2.[13] In addition, by using Equations (11) and (12), we derive another condition, that is,

$$\mu = \frac{\kappa(1+\theta)/\epsilon}{[\lambda(\eta+m\theta)-(1+\theta)(1+1/\epsilon)]f(\lambda)(1+\xi)} - \rho, \tag{15}$$

which features a negative slope in the $\{\lambda, \mu\}$ space, as shown in Figure 2. We label Equation (15) the "R&D Condition." Note that the intersection at Point O in Figure 2 determines the unique steady-state values for μ^* and λ^*.

2.2 Model Prediction and Hypothesis Development

Equations (14) and (15) reveal that any policy instrument potentially shifting the labor and/or R&D condition curves can affect μ^* and λ^* in equilibrium. In this study, we analytically evaluate how innovation activities respond to changes in financing cost (ξ), market competition (m and η), and access to foreign markets (θ). Table 1 summarizes the key analytical results, and details are provided in Appendix B.

Based on these model implications, we formalize our refutable test hypotheses as follows. First, we expect the establishment of FTZs, along with their preferential policies, to generate an overall positive effect on firms' innovation activities.

Hypothesis 1. *The establishment of FTZs can significantly raise the quantity and quality of innovation by FTZ firms.*

Second, preferential FTZ policies have greatly facilitated investment and financing, which potentially ease the financial constraints faced by FTZ firms. For example, the Shanghai FTZ pioneered the free trade account system, which enabled cross-border financing at the microlevel

[13] A sufficiently small elasticity ϵ ensures that $\partial\mu/\partial\lambda > 0$ holds for any $\lambda \geq 1$.

under macroprudential supervision. By the end of 2019, 58 financial institutions, including commercial banks, financial companies, and security companies, gained direct access to the free trade account monitoring and management information systems, with around 131,000 free trade accounts opened. The total amount of onshore and offshore financing obtained through the free trade account exceeded 1.7 trillion RMB. Financial innovation pilots, such as two-way currency capital pools and centralized execution of foreign exchange funds in multinational company headquarters, have been implemented on a large scale. As of the end of 2019, a total of 1,064 enterprises had engaged in cross-border two-way RMB capital pool business, with a total funding of 1.94 trillion RMB. In light of these developments, we propose that

Hypothesis 2. *The establishment of FTZs can relax the financial constraints on FTZ firms, thereby increasing the quantity and quality of their innovation.*

In addition, FTZs kept expanding foreign investment access, expectedly attracting large enterprises to establish a presence in the regions, which might lead to remarkably intensified market competition. For instance, in Shanghai FTZ, the negative list for foreign investment in 2013 contained a total of 190 prohibited and restricted measures, which decreased to 139 in 2014. By 2020, the negative list for foreign investment access in China's FTZs had been reduced to 30, and the negative list for foreign investment access in the Hainan FTZ had been shortened to 27. The relaxation of foreign investment access has resulted in a surge of the number of businesses established in FTZs. By June 2020, the Shanghai FTZ had accumulated 67,000 newly established firms, including 12,000 foreign-funded enterprises. Combining these stylized facts with the prediction of our theoretical model, we propose that

Hypothesis 3. *The establishment of FTZs intensifies market competition, thereby promoting larger quantity and higher quality of corporate innovation pursued by FTZ firms.*

Finally, FTZs provided trade facilitation and enabled more enterprises to effectively explore international markets. Cross-border flows of capital, goods, services, personnel, technology, and information enhanced firms' ability to allocate resources more effectively. The establishment of FTZs has not only been creating favorable circumstances to attract foreign investment but also facilitated Chinese firms to enter the global marketplace. By 2019, the Shanghai FTZ had completed more than 2,800 overseas investment projects, with cumulative Chinese investment exceeding 90 billion US dollars. According to preliminary statistics, more than 50 of the key measures for trade facilitation among the 60 major free trade agreements worldwide have been implemented in the Shanghai FTZ. As of the end of 2020, the Port of Shanghai has maintained its position as the world's top container port for 11 consecutive years. Therefore, we propose that

Hypothesis 4. *The establishment of FTZs can improve FTZ firms' access to foreign markets, thereby raising the quantity and quality of their innovation.*

3 Data, Variable Construction, and Descriptive Statistics

3.1 Data

Our sample includes all Chinese A-share firms listed in the Shanghai Stock Exchange and Shenzhen Stock Exchange ranging from 2000 to 2019. We choose the year of 2000 as the starting point because fewer firms had access to the international markets prior to that time. Our data are from two major sources. Corporate financial data are obtained from the China Stock Market and Accounting Research (CSMAR) Database, and the patent information is collected from the application of the State Intellectual Property Office of China (SIPO).[14] Note that the whole patent application process in China would usually take 2-3 years. Therefore, although the database provides patent data up to 2022, we only can obtain reliable measures of patents granted by 2019, which is the main reason why our sample period ends in that year.

Concerning extreme values and outliers, we winsorize all firm characteristics at the 1st and 99th percentiles. We drop listed firms under special treatment because they are subject to different regulation requirements by the China Security Regulation Committee (CSRC). We further exclude firms in the financial industry, since they are under substantially different financial disclosure regulations and their liquidity positions are distinct from listed firms in other industries.

[14] China Intellectual Property Network is created and managed by the Intellectual Property Publishing House. IPR Publishing House is supervised and sponsored by the SIPO and is the legal publishing unit of Chinese patent documents and the unified export unit of foreign patent information services of SIPO. See the website for details: http://www.sipo.gov.cn.

Similarly, we drop listed firms with class B shares, because such shares are only eligible for foreign investors with a discount on A shares (Sun *et al.*, 2002). The final sample consists of 28,522 firm-year observations with nonmissing variables.

3.2 Variable Definition and Summary Statistics

A spate of literature suggests using patent-related variables as a proxy for corporate innovation activities (i.e., Kogan *et al.* (2017) for publicly traded firms and Lerner *et al.* (2011) for privately held firms). Our patent data are from the official innovation database and cover all patents filed and granted by the SIPO. The database provides detailed information on patent assignee (owner) names, the patent number, application year, and grant year. Due to the lagged grant process of patent applications, some of which can take up to 36 months, we use the number of patents applied and granted as a measure of the quantity of corporate innovation.

In comparison with the US Patent and Trademark Office (USPTO), the SIPO has its same classifications on patents. According to the Chinese Patent Law, Chinese patents are categorized into three groups: invention patents, utility model patents, and design patents. The quality and innovation levels of these patent types are different. Invention patents are for new technological solutions that would have substantial and fundamental improvements on products or applications, whereas utility model patents are associated with improvements on shapes or structures of products. Design patents only focus on the innovation of art and design of the industrial products, including new art layout, new shape creation, and new color improvements. We use the number of total patent applications *PatentApply*, and the number of total patent grants *PatentGrant* of listed companies as the main explained variables to measure the corporate innovation capability. We also construct the TFP as an alternative measure.

A potential concern associated with this variable is that it measures only the quantity, not the quality of innovation. The existing literature on corporate innovation uses the number of future citations that a patent receives as a measure of patent quality, assuming that more influential and higher-impact patents receive a larger number of subsequent citations. In this study, we use the citation information from the SIPO for the measure of innovation quality. They also cooperate with the World Intellectual Property Organization for international patent applications under the PCT to form the foreign citation number. We use this number to construct domestic patent citation and international citation from the PCT network. Another alternative measure is the number of invention patent, because of its originality according to the Chinese patent law. In unreported results, we also use it for the robustness check and the results remain unchanged. Given that the patent data are usually right-skewed, as suggested in Cao *et al.* (2020), we take the natural logarithm to obtain $Ln\ PatentApply$, $Ln\ PatentGrant$, $Ln\ ForeignCitation$, and $Ln\ DomesticCitation$. Other variable names and definition are given in Appendix Table D1.

Table D2 shows the summary statistics of key variables used in our empirical studies during the sample period. About 12.5% of listed companies are affected by the establishment of FTZs. The average value of $Ln\ PatentApply$ ($Ln\ PatentGrant$) is 1.638 (1.434), which indicates that the average annual patents applied (granted) is about 5.146 (4.194). The average value of $Ln\ DomesticCitation$ ($Ln\ ForeignCitation$) is 0.570 (1.818), which implies that the average annual domestic and foreign citation is about 1.769 and 6.157, respectively.

3.2.1 Empirical Specification

To test the impact of FTZ establishment on corporate innovation, we adopt multiple linear regressions. To test Hypothesis 1, we take companies that are not in the region with FTZ establishment as a control group and construct the following DiD model:

$$Y_{it} = \alpha + \beta FTZ_{it} + \gamma X_{it} + \omega_{i(k)} + \delta_t + \varepsilon_{it}, \tag{16}$$

where i, k, and t denote firm, industry, and year indicator, respectively. The value of dummy variables FTZ depends on whether firm i is located in a FTZ after its establishment. This variable is our main interest, which captures the average effect of FTZ on corporate innovation. We also use $\omega_{i(k)}$ and δ_t to capture the unobserved firm (industry) and time variation.[15] Y_{it} represents the innovation measures, such as patent-related measures, citation measures, and TFP. Control variables include firm size, Tobin's Q, cash flow, and intangible assets. Hypothesis 1 predicts that

[15]We also use industry×time to control for the macrotrend at the industry level and the results remain unchanged.

the coefficient estimate of β should be significantly positive.

To test Hypothesis 2, we incorporate KZ, the measure of corporate financial constraints, and its interation with FTZ into the Equation (16):

$$Y_{it} = \alpha + \beta_1^1 FTZ_{it} \times KZ_{it} + \beta_2^1 FTZ_{it} + \beta_3^1 KZ_{it} + \gamma^1 X_{it} + \omega_{i(k)} + \delta_t + \varepsilon_{it}. \tag{17}$$

The definition of other variables are the same as those in Equation (16). Hypothesis 2 indicates that the coefficient estimate of β_1^1 should be significantly positive.

To test Hypothesis 3, we add HHI, the measure of market competition, and its interation with FTZ to (16):

$$Y_{it} = \alpha + \beta_1^2 FTZ_{it} \times HHI_{it} + \beta_2^2 FTZ_{it} + \beta_3^2 HHI_{it} + \gamma^2 X_{it} + \omega_{i(k)} + \delta_t + \varepsilon_{it}. \tag{18}$$

The definition of other variables remain the same. Hypothesis 3 suggests that the coefficient estimate of β_1^2 is significantly negative.

For Hypothesis 4, firms' foreign sales $Fsales$, along with its interation with FTZ, is incorporated into Equation (16):

$$Y_{it} = \alpha + \beta_1^3 FTZ_{it} \times Fsales_{it} + \beta_2^3 FTZ_{it} + \beta_3^3 Fsales_{it} + \gamma^3 X_{it} + \omega_{i(k)} + \delta_t + \varepsilon_{it}, \tag{19}$$

where the definition of all other variables remain unchanged. Hypothesis 4 predicts that the coefficient estimate of β_1^3 is significantly positive.

4 Empirical Results

4.1 Overall Effect of FTZ Establishment

We first investigate the overall effect of FTZ establishment on corporate innovation and report the results of the baseline estimation in Table 2. Column (1) in Table 2 indicates that without any control variables, the coefficient estimate of FTZ is 0.18 and significant at the 1% level. When the vector of firm-specific controls is added, as shown under Column (2), the estimated effect of FTZ establishment on patents applied remains largely the same. Thus, the number of patent applications of a treatment firm increases by 17% more than that of a control firm one year after the FTZ establishment, compared with the number before the establishment. Under Columns (3) and (4), we replace the dependent variable with the number of patents granted. When the control variables are incorporated, the DiD estimator turns out to be 0.14 and significant at the 1% level, which further confirms the stimulating effect of FTZ establishment on firms' innovation quantity. In addition, we examine the impact of FTZ establishment on firm-level TFP. Columns (5) and (6) report the coefficient estimates. When we control for firm-specific characteristics, firms in the treatment group exhibit an 8% larger increase in TFP after the FTZ establishment, relative to firms in the control group.

Second, we examine how FTZ establishment affects the quality of firm innovation by replacing the dependent variable with patent citation measures. Column (2) in Table 3 shows that firms in the treatment group exhibit an 11% larger increase in the total number of patent citation one year after the FTZ establishment, compared with firms located in non-FTZ regions. The sizable overall effect of FTZ establishment on innovation quality is statistically significant at the 1% level. Taking one step further, we decompose total citation into domestic and foreign citations and investigate whether domestic and foreign markets hold different views on the innovativeness of patents granted to Chinese firms. Columns (3)-(6) in Table 3 report the estimation results. When the control variables are incorporated, our DiD estimators reveal that the estimated effects of FTZ establishment on raising the number of domestic and foreign citations are quantitatively similar (10%), indicating that the novelty of innovation output by FTZ firms are recognized and cited in domestic and foreign markets.

While the baseline estimation merely takes into account the first establishment of Shanghai FTZ, the aforementioned empirical findings seem to confirm our conjecture (formally indicated in Hypothesis 1) that the establishment of FTZs can boost the quantity and quality of innovation by FTZ firms. As a robustness check, we exploit the staggered establishment of FTZs from 2013 to 2015 in four economic regions, namely, Shanghai, Guangdong, Tianjin, and Fujian, for identification. The estimation results are reported in Tables 4 and 5. For quantity measures, our DiD estimators are once again positive and statistically significant at the 1% level across all model specifications. While the magnitude of these estimates becomes subtly smaller than that in the baseline estimation, these findings suggest that the establishment of FTZs leads to increases in patent applications, patents granted, and TFP of FTZ firms. For quality measures, Table 5 documents a positive overall effect on the quality of innovation achieved by FTZ firms. Differing from the baseline estimation, however, the use of the alternative FTZ definition yields slightly distinct coefficient estimates for domestic and foreign citations. Columns (4) and (6) indicate that the establishment of FTZs seems to generate a larger impact on domestic citation than foreign citation for patents held by FTZ firms. Nevertheless, the major implication that FTZ establishment raises the quality of corporate innovation remains unchanged.

In this study, we also perform a robustness analysis which takes into account the patent type. The patent system in China categorizes patent applications (and grants) into three groups, namely, design patents, utility patents and invention patents. Since the application and grant of invention patents require innovation outcomes to exhibit greater novelty, they are also used to measure the quality of innovation (Li and Zheng, 2016). We re-estimate the baseline regression by replacing the dependent variables using these three patent types. As shown in Table 6, the establishment of FTZs has generated a strongly positive impact on the innovation activities of all three types of patents. In particular, the application and grant of invention patents among FTZ firms exhibit an average increase of 11% and 7%, respectively, more than other listed firms outside of the free trade regions. These findings further confirm that the establishment of FTZs spurs the quantity and novelty of corporate innovation.[16]

4.2 Parallel Trend Assumption

The DiD approach used in our baseline regression relies on parallel assumption based on the postmatch sample. We should ensure that those firms in FTZs do not significantly differ from firms in non-FTZ regions before the FTZ establishment. In order to test the parallel trend, we re-

[16] In an additional practice, we also consider to control for Industry×Year fixed effect. The estimation results for the quantity of innovation are reported in Table 7.

place the FTZ dummy with eight indicators, Shock(-3), Shock(-2), Shock(-1), Shock(0), Shock(+1), Shock (+2) and Shock (+3), Shock(+4) to flag the year relative to the establishment of the free trade areas and re-estimate our baseline regression. The validity of indicators Shock(-3), Shock(-2), Shock(-1) and Shock(0) should be insignificant and economically small if the parallel trend holds for our setting. Figure D1 validates this pattern that the positive effect on corporate innovation starts to kick in after the arrival of the FTZ policy shock.

This result leads to three implications. First, the adoption of FTZs seems unanticipated by the treated firms. Second, even if some treated firms anticipated such change, the actual corporate level innovation did not change immediately until the institution setting took effect. Third, the positive impact of FTZ establishment on corporate innovation is not the result of policymakers simply responding to corporate innovation. Instead, it only triggers a regional effect on firms headquartered in FTZs, which is consistent with the results in Table 2 and further mitigates the reverse causality concern.

4.3 Heterogeneous Effect

POEs and SOEs. We partition the sample into state-owned enterprises (SOEs) and private-owned enterprises (POEs), and run the regressions independently. The economic literature indicates that SOEs are less efficient compared with POEs in terms of operating efficiency and profitability (Boubakri and Cosset, 1998; Dewenter and Malatesta, 2001; Megginson *et al.*, 1994) and R&D efficiency (Munari *et al.*, 2003). In Tables 8 and 9, we present the estimation results.

We find that the establishment of FTZs significantly stimulates the patenting activities of private-owned FTZ firms compared with those outside of the region. For POEs located in FTZs after the establishment, they exhibit an average of 15%, 13%, and 9% larger increases in patent applications, patents granted, and TFP, respectively, than non-FTZ firms that are privately owned. In addition, domestic and foreign citations rise sharply (by 15% and 20%, respectively) one year after the FTZ establishment, signaling that the novelty of their innovation has a remarkable impact both domestically and internationally. As shown in Table 9, SOEs in FTZs also experience rapid increases in the quantity of innovation output, the magnitude of which is largely similar to that of POEs. In sharp contrast, however, the effect of FTZ establishment on the quality of innovation by SOEs is non-existent, and becomes even weakly negative (-0.08) when we replace the dependent variable with domestic citation.

The Chinese Annual Survey of Industrial Production (ASIP) suggest that Chinese SOEs experienced rapid growth in profitability following the enactment of reforms during 1990s. However, Berkowitz *et al.* (2017) show that SOE restructuring yielded quite limited improvement. Evaluating the innovation activities of Chinese SOEs through the lens of government and corporate governance, Jia *et al.* (2019) find that Chinese SOEs that have board members holding more shares and are located in regions of high-quality governance exhibit larger increases in innovation quantity. Our findings complement theirs by showing that the novelty of innovation by SOEs does not necessarily improve in response to favorable place-based economic reforms.

High-tech and Non-high-tech Firms. We undertake this empirical practice, since the economics and finance literature lacks discussion on comparing the innovation activities taken by high-tech and non-high-techn firms.[17] Conditional on the fact that preferential policies in FTZs are highly suppotive of corporate innovation, in general, one would expect that they cast greater impacts on high-tech firms than non-high-tech firms. We run the regressions for these two groups separately and report the results in Tables 10 and 11.

We find that the establishment of FTZs significantly raises the quantity and quality of innovation by high-tech firms located in the regions. According to our estimates, for high-tech firms in FTZs, the post-policy number of patents granted and TFP has an average increase of 9% and 6%, respectively, compared with other high-tech firms outside of the regions. In addition, domestic and foreign citations rise by 10% and 13% more than those non-FTZ counterparts, respectively. Columns (4)-(6) in Table 11 reveal that the positive effect of FTZ establishment on the novelty of innovation extends to non-high-tech firms in the regions. The estimated effects of FTZ establishment on domestic and foreign citations are largely similar to those for high-tech firms. Quite surprisingly, however, Table 11 also shows that the coefficient estimates of FTZ become almost doubled, compared with those for high-tech firms, across all measures of innovation quantity. A

[17] Using a unique data set on Chinese high-tech start-ups, Zhang *et al.* (2018) explore the effect of innovation efficiency and import and export activities on high-tech firms' survival rate.

possible explanation is that high-tech firms had already devoted sufficiently many resources to innovation prior to the FTZ establishment, and the marginal effect of preferential policies on the quantity of innovation output can be potentially diminishing.

4.4 Plausible Channels

4.4.1 Financial Constraints

A large body of literature suggests that access to finance can affect corporate innovation in many different ways. Studies of the relationship between innovation and early-stage financing via venture capital and private equity include those of Kortum and Lerner (2000) and Lerner *et al.* (2011). Empirical exploration of the effect of banking on firm innovation using US data typically yields nuanced findings, even though it is generally agreed that bank credit expansion tends to help private firms relying more heavily on external finance to increase their innovation output (Cornaggia *et al.*, 2015). Amore *et al.* (2013) show that US interstate banking deregulation generates a positive impact on the innovation of manufacturing firms, whereas Chava *et al.* (2013) provide evidence that intrastate banking deregulation retards the innovation output of young firms.

Investigating the establishment of high-tech zones in China, Tian and Xu (2022) suggest that better access to finance can promote city-level innovation and entrepreneurial activities. However, they focus on the effects of favorable tax treatment, early-stage venture capital investment, and land price reduction. In our paper, we utilize the KZ index to capture the financial constraints and evaluate its effect on firm-level innovation.

As shown in Table 12, tightening financial constraints has a strong negative effect on innovation quantity and quality. Except for TFP, the coefficient estimates are all significant at the 1% level. The implication that financial constraints retard innovation activities is in line with Hottenrott and Peters (2012). For the coefficient estimates of the interaction term $FTZ \times KZ$, columns (4)-(6) indicate that the post-policy effect of financial constraints on innovation novelty does not significantly differ from that before the FTZ establishment. In sharp contrast, however, columns (1)-(3) show that the DiD estimators of the coefficients on $FTZ \times KZ$ are all positive, suggesting that FTZ firms that faced tighter financial constraints, on average, manage to produce more innovation output after the FTZ establishment. One possible explanation to this observation is that the establishment of FTZs contains policy measures that improve the financing conditions, and helps firms, which used to be more financially constrained, to raise their innovation output.

To confirm our conjecture, we re-estimate regression (16) by replacing the dependent variable with various measures of firms' financing conditions, and report the results in Table 13. For FTZ firms, we find that their bank loans, average loan term, and bond issuance exhibit significantly larger growth than those of non-FTZ firms after the arrival of the FTZ policy shock. In addition, the probability that FTZ firms make dividend payments to shareholders become higher. The above evidence indicates that the establishment of FTZs has improved the financing conditions of firms located in the regions, which relax their financial constraints.

Notably, the estimated effect of relaxing the financial constraints on innovation activities is consistent with our theoretical model. Our theoretical framework predicts that the relaxation of financial constraints will unambiguously raise the quantity of innovation, which seems supported by empirical evidence. While the theoretical model suggests that the responses of innovation quality pursued by firms to financial constraints are ambiguous, the empirical findings imply that the effect is little to nonexistent.

4.4.2 Market Competition

As mentioned earlier, the impact of market competition on corporate innovation activities has been under heated debate. Empirical evidence based on Chinese import penetration after China's accession to WTO is particularly mixed (Bloom *et al.*, 2016; Xu and Gong, 2017; Ahn *et al.*, 2018; Hombert and Matray, 2018; Autor *et al.*, 2020; Yang *et al.*, 2021; Bloom *et al.*, 2021; Liu *et al.*, 2021). Moreover, researchers seem to reach the consensus, if not quite limited, on the promoting effect of market competition on TFP in emerging market economies.

Different from standard Schumpeterian growth models, our theoretical framework allows for a separation between innovation quantity and quality. It predicts that intensified market competition, which tends to reduce firm profits, will unambiguously motivate R&D firms to pursue innovation with greater novelty while leaving the quantity of innovation undetermined. To test these implications, we construct the HHI at the industry level and use it to capture the degree of market competition. We investigate its impact on related innovation measures and report the empirical findings in Table 14.

First, consistent with our theoretical prediction, the coefficient estimates of $FTZ \times HHI$ are all negative and statistically significant when the dependent variable takes the quality measures. It indicates that higher (lower) market concentration tends to reduce (increase) innovation quality after the FTZ establishment. The promoting effect of market competition on innovation quality seems more pronounced for the number of patent citation in foreign markets (Ln FC).

Second, we find that increased market competition contributes significantly to the increases in the number of patents applied and granted among FTZ firms. According to our theory, it might be attributed to the fact that the effect of market competition on R&D condition curve significantly dominates that on the labor condition curve. This empirical finding is in line with a recent study of Bloom *et al.* (2016), but different from that of Liu *et al.* (2021). While Column (3) shows that the effect of market competition on TPF is insignificant, our empirical evidence suggests that fostering market competition seems an effective tool for promoting firms' patenting activities along the quantity and quality dimensions.

4.4.3 Access to Foreign Goods Markets

According to Shu and Steinwender (2019), the effect of trade liberalization on innovation by focal domestic firms can be primarily transmitted through four channels, namely, import competition, foreign input competition, access to foreign intermediates, and access to foreign goods markets. For export opportunities, an emerging literature triggers the debate on its importance to the quantity and quality of firm products, labor productivity, and TFP. Recent studies, such as Ahn *et al.* (2018), Aghion *et al.* (2018), and Coelli *et al.* (2022), suggest that better access to foreign goods markets plays an important role of stimulating firm-level innovation.

Statistics from the WTO shows that China's import and export values have increased by

766% and 723%, respectively, since its accession to the WTO.[18] Unfortunately, the literature lacks formal assessment of the relationship between improved export opportunities and the innovation activities of Chinese exporting firms. Taking advantage of the FTZ establishment, we undertake this task by estimating Equation (19) and report the empirical results in Table 15.

Under Columns (1) and (2), the coefficient estimates of $FTZ \times FDI$ are both positive and significant at the 1% level, indicating that FTZ firms with larger foreign sales exhibit remarkable increases in the number of patents applied and granted. In the meantime, Column (3) shows that foreign sales barely raise the TFP of FTZ firms relative to firms in the control group, given that the coefficient on the interaction term is statistically insignificant. For innovation quality, the coefficient estimates are all positive but insignificant. Hence, improved access to foreign markets does not promote the innovation novelty pursued by FTZ firms.

Note that the aforementioned finding on innovation quality is not necessarily inconsistent with our theoretical prediction. Our theoretical framework suggests that the quality of innovation is contingent upon the profitability of exporting activities. Although the decision to export is driven by the potential profit earned overseas, Chinese exporting firms might take their time and exploit certain businesses and marketing strategies to build up reputation, compete with foreign incumbents, and foster customer loyalty, all of which can be potentially costly and profit-reducing in the short run. Therefore, regressions pooling all publicly listing firms do not yield a significantly positive effect on innovation quality.

4.4.4 Additional Channels

In empirical practice, we also explore two additional channels beyond the prediction of our theoretical model. First, we assess the effect of foreign direct investment (FDI) on corporate innovation. When FDI and its interaction with FTZ are incorporated into Equation (16), Table 16 indicates that higher FDI has a weakly positive effect on the patent applications of FTZ firms. The effect of FDI on the number of patents granted to FTZ firms is of similar magnitude but more statistically significant at the 5% level. We also find that FDI contributes significantly to the

[18]Source: https://wits.worldbank.org/.

increases in TFP of FTZ firms.

Girma *et al.* (2009) exploit the data on Chinese SOEs and find a positive relationship between foreign capital participation and innovation activities. Glass and Saggi (2002) propose a product cycle model and show that resource scarcity triggered by higher intellectual property rights protection in the South Countries tends to lower FDI, the effect of which can be transmitted back to the North Countries and reduce innovation activities. Our evidence complements these intriguing studies.

For quality measures, Table 16 reveals that higher FDI does not generate a perceptible impact on domestic and total citation of patents held by FTZ firms. Hence, it seems that the effect of raising FDI on corporate innovation is almost identical to that of relaxing the financial constraints. However, Column (5) reveals that encouraging FDI can benefit FTZ firms by boosting their patent citation in foreign markets. This novel finding indicates that FDI can be an effective tool for enhancing the visibility of domestic firms' innovation activities in the global marketplace.

Finally, we investigate how government subsidies can affect firm-level innovation, which has also been a critical question drawing increasing attention recently. Table 17 reports our estimation results. Exploiting the establishment of FTZs, we find a weakly negative effect of government subsidies on the quantity of innovation. When the dependent variable is the number of patent granted (Ln PG), the estimated coefficient is -0.02 and significant at the 10% level. The empirical observation on the relationship between government subsidies and firm innovation is consistent with Wallsten (2000), which might be attributed to the possibility that government subsidies crowd out self-financed R&D spending.[19] This finding, however, is in contrast to the study of Almus and Czarnitzki (2003), which shows that the public R&D subsidy scheme in eastern Germany leads to a 4% increase in the innovation activities of German firms.

In addition, we find a strong promoting effect of government subsidies on the quality of innovation achieved by FTZ firms. The post-policy effect is more pronounced on domestic citation than foreign citation. One possible explanation to this interesting finding is that the "government subsidy award" triggers a positive signal of firm quality to market participants (Feldman and

[19]Using data on Chinese firms, Liu *et al.* (2019) and Xu *et al.* (2023) suggest an inverted-U effect of government subsidies on corporate innovation. In this study, however, we do not focus on the exploration of the nonlinear effect.

Kelley, 2006), which helps FTZ firms raise funding from alternative sources and gain access to high-quality input factors (i.e., talented researchers and experienced partners) for innovation.

5 Conclusion

This study uncovers a robust and positive effect of FTZ establishment on corporate innovation. Through the utilization of the DiD approach, our findings indicate that firms operating within FTZs experienced substantial increases in their innovation quantity and quality, which are jointly driven by several key factors, including the alleviation of financial constraints, increased market competition, and improved export opportunities. Our empirical results highlight the important role of FTZs in fostering a conducive environment for innovation within firms, ultimately leading to enhanced innovative performance.

This study carries significant implications for market participants. First, it shows that the participation in exporting activities in the global product markets has emerged as a crucial external governance mechanism, incentivizing firms to engage in innovation activities. This phenomenon may help explain the remarkable performance of the Chinese manufacturing sectors in innovation after China's accession to WTO. Moreover, Chinese emerging multinationals are increasingly competitive and are beginning to catch up with the leading foreign counterparts in several important sectors. This trend underscores the evolving landscape of global innovation and highlights the growing competitiveness of Chinese firms.

Different from earlier studies on place-based policies in the US and European countries (Glaeser and Gottlieb, 2008; Glaeser *et al.*, 2010; Kline, 2010), however, we acknowledge that our investigation does not take into account the costs of implementing the preferential policies in the free trade regions, and is thus not a cost-benefit analysis in nature. Missing the implementation costs, this study can hardly shed light on the changes in social welfare before and after the novel economic reform of FTZs. However, this paper still provides meaningful implications for policy makers. First, our empirical findings show that building highly competitive business platforms seems the most effective tool in stimulating simultaneously the quantity and novelty of corporate innovation. Second, different policy tools, such as relaxing the financial constraints, facilitating access to foreign markets, increasing FDI, and subsidizing innovation firms, may have distinct effects on the quantity and quality of innovation. Hence, preferential policies can be potentially tailored based on firm- and industry-level characteristics. In this paper, however, we leave the optimal combination of innovation-promoting policies an open question.

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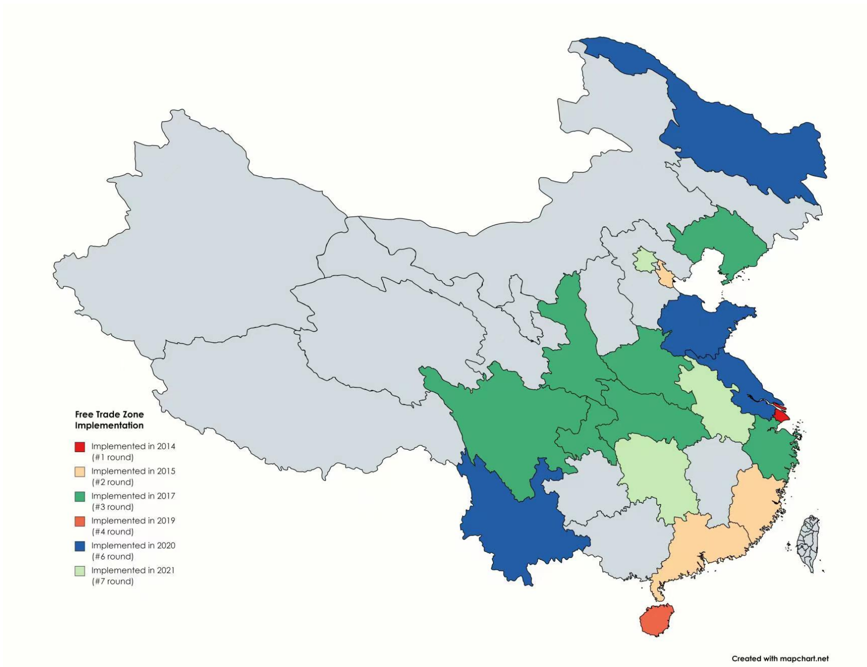
Figure 1: Geographic Location of FTZs



This map illustrates the staggered process of FTZ establishment in China from 2013 to 2019. We set July 1 as the cutoff for effective year. For example, if province j starts to set up an FTZ after July 1 in year t, we construct the effective year for firms headquartered in that area as year $t+1$. Some regions (e.g., Shanghai) experienced multiple waves of FTZ establishment, within which the free trade areas expanded. In that case, we use the initial year of the establishment.

Figure 2: Steady-state Equilibrium

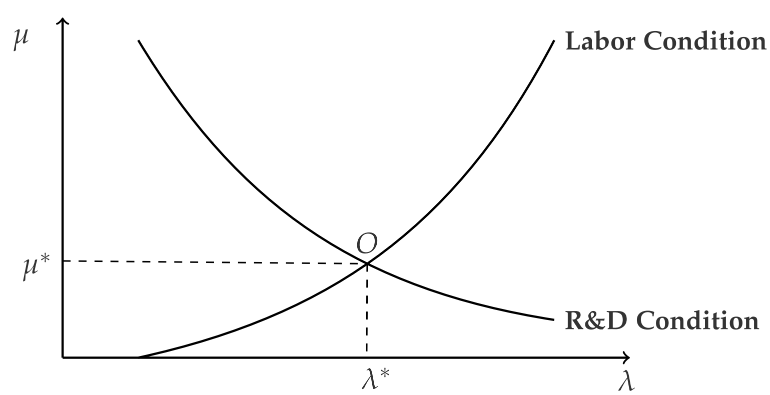


Table 1: Effects on Innovation Quantity and Quality

Parameter	Scenario	LC	RC	Effect
$\xi \downarrow$	lower financing cost	$\uparrow$	$\uparrow$	$\mu \uparrow; \lambda ?$
$\eta \downarrow$ or $m \downarrow$	lower domestic or foreign markup due to increased competition	$\downarrow$	$\uparrow$	$\mu ?; \lambda \uparrow$
$\theta \uparrow$	increased share of exports (when $\eta > m$)	$\downarrow$	$\uparrow$	$\mu ?; \lambda \uparrow$
	increased share of exports (when $\eta < m$)	$\uparrow$	$\downarrow$	$\mu ?; \lambda \downarrow$

Notes: LC denotes labor demand condition curve, and RC denotes R&D condition curve.

Table 2: Effect of FTZ Establishment on Corporate Innovation Quantity: Baseline

	Ln Patent Apply		Ln Patent Grant		TFP	
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ	0.18***	0.17***	0.15***	0.14***	0.09***	0.08***
	(0.04)	(0.04)	(0.03)	(0.02)	(0.02)	(0.02)
Size		-0.07***		-0.06***		-0.01***
		(0.01)		(0.01)		(0.00)
Tobin's Q		0.01		-0.01		0.01
		(0.01)		(0.01)		(0.00)
ROA		0.67		0.59		0.11
		(0.62)		(0.57)		(0.25)
Tangibility		-0.56***		-0.61***		-1.41***
		(0.21)		(0.19)		(0.09)
Cash Flow		-0.02		0.05		0.60**
		(0.59)		(0.54)		(0.24)
Constant	0.19***	1.56***	0.15***	1.30***	0.03	0.30***
	(0.03)	(0.23)	(0.03)	(0.21)	(0.03)	(0.10)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28,522	28,503	28,522	28,503	22,892	22,891
Adjusted R^2	0.178	0.180	0.173	0.175	0.001	0.022

This table reports the effect of FTZ establishment on corporate innovation from 2000 to 2019. The dependent variable is the natural logarithm of firms' patents applied and granted and TFP. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai FTZ after 2013. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 3: Effect of FTZ Establishment on Corporate Innovation Quality: Baseline

	Ln Total Citation		Ln Foreign Citation		Ln Domestic Citation	
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ	0.08***	0.11***	0.08***	0.10***	0.07***	0.10***
	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)
Size		0.63***		0.36***		0.61***
		(0.01)		(0.01)		(0.01)
Tobin's Q		0.02***		0.04***		0.02***
		(0.00)		(0.00)		(0.01)
ROA		1.74***		0.51		1.73***
		(0.62)		(0.41)		(0.61)
Tangibility		-0.82***		-0.55***		-0.76***
		(0.18)		(0.10)		(0.17)
Cash Flow		0.37		0.63		0.28
		(0.59)		(0.39)		(0.57)
Constant	0.61***	-12.58***	0.30***	-7.38***	0.53***	-12.34***
	(0.05)	(0.23)	(0.04)	(0.18)	(0.05)	(0.23)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28,522	28,503	28,522	28,503	28,522	28,503
Adjusted R^2	0.267	0.397	0.121	0.243	0.279	0.409

This table reports the effect of FTZ establishment on corporate innovation from 2000 to 2019. The dependent variable is the natural logarithm of domestic, foreign, and total citations of firms' patent. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai FTZ after 2013. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4: Effect of FTZ Establishment on Corporate Innovation Quantity: Robustness Check with Alternative FTZs

	Ln Patent Apply		Ln Patent Grant		TFP	
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ broad	0.15***	0.14***	0.12***	0.11***	0.08***	0.07***
	(0.04)	(0.04)	(0.03)	(0.03)	(0.01)	(0.01)
Size		-0.07***		-0.06***		-0.01***
		(0.01)		(0.01)		(0.00)
Tobin's Q		-0.01		-0.01		0.01
		(0.00)		(0.01)		(0.00)
ROA		0.72		0.63		0.13
		(0.62)		(0.57)		(0.25)
Tangibility		-0.58***		-0.63***		-1.42***
		(0.21)		(0.19)		(0.09)
Cash Flow		-0.07		0.01		0.58**
		(0.59)		(0.54)		(0.24)
Constant	0.19***	1.56***	0.15***	1.30***	0.03	0.30***
	(0.03)	(0.23)	(0.03)	(0.21)	(0.03)	(0.10)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28,522	28,503	28,522	28,503	22,892	22,891
Adjusted R^2	0.178	0.180	0.173	0.174	0.001	0.021

This table reports the effect of FTZ establishment on corporate innovation from 2000 to 2019. The dependent variable is the natural logarithm of firms' patents applied and granted and TFP. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai after 2013; or in Fujian, Tianjin, and Guangdong after 2015. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5: Effect of FTZ Establishment on Corporate Innovation Quality: Robustness Check with Alternative FTZs

	Ln Total Citation		Ln Foreign Citation		Ln Domestic Citation	
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ broad	0.05*	0.09***	0.04**	0.06***	0.04	0.09***
	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)
Size		0.63***		0.36***		0.61***
		(0.01)		(0.01)		(0.01)
Tobin's Q		0.02***		0.04***		0.02***
		(0.01)		(0.00)		(0.01)
ROA		1.77***		0.54		1.76***
		(0.62)		(0.41)		(0.60)
Tangibility		-0.83***		-0.57***		-0.77***
		(0.18)		(0.10)		(0.17)
Cash Flow		0.34		0.59		0.25
		(0.59)		(0.39)		(0.57)
Constant	0.61***	-12.58***	0.29***	-7.38***	0.53***	-12.34***
	(0.05)	(0.23)	(0.04)	(0.18)	(0.05)	(0.23)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28,522	28,503	28,522	28,503	28,522	28,503
Adjusted R^2	0.267	0.397	0.121	0.243	0.279	0.409

This table reports the effect of FTZ on corporate innovation from 2000 to 2019. The dependent variable is the natural logarithm of domestic, foreign, and total citations of firms' patents. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai after 2013; or in Fujian, Tianjin, and Guangdong after 2015. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6: Effect of FTZ Establishment on Corporate Innovation Quantity: Robustness Check with Three Patent Types

	Invention Patents		Utility Patents		Design Patents	
	Ln Patent Apply	Ln Patent Grant	Ln Patent Apply	Ln Patent Grant	Ln Patent Apply	Ln Patent Grant
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ	0.11***	0.07***	0.11***	0.11***	0.05**	0.04*
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
Size	-0.04***	-0.01*	-0.06***	-0.06***	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Tobin's Q	0.01	0.00	-0.01	-0.01	0.01	0.01
	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)
ROA	0.95*	0.54	0.06	-0.11	0.51	0.66*
	(0.49)	(0.37)	(0.53)	(0.51)	(0.35)	(0.34)
Tangibility	-0.25	-0.24**	-0.23	-0.26	-0.43***	-0.40***
	(0.17)	(0.12)	(0.18)	(0.17)	(0.11)	(0.11)
Cash Flow	-0.55	-0.30	0.35	0.53	-0.38	-0.56*
	(0.46)	(0.35)	(0.50)	(0.48)	(0.33)	(0.32)
Constant	0.82***	0.24*	1.37***	1.31***	0.08	0.04
	(0.19)	(0.14)	(0.20)	(0.19)	(0.14)	(0.13)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28,503	28,503	28,503	28,503	28,503	28,503
Adjusted R^2	0.168	0.145	0.159	0.157	0.037	0.037

This table reports the effect of FTZ establishment on corporate innovation from 2000 to 2018. The dependent variables are the natural logarithm of firms' invention, utility or design patents applied/granted. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai after 2013. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 7: Effect of FTZ Establishment on Corporate Innovation Quantity: Robustness Check with Industry $\times$Year FE

	Ln Patent Apply		Ln Patent Grant		TFP	
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ	0.16***	0.16***	0.11***	0.13***	0.01	0.09***
	(0.03)	(0.04)	(0.03)	(0.03)	(0.01)	(0.02)
Size	-0.01	-0.07***	-0.01	-0.06***	-0.08***	-0.01***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Tobin's Q	0.01**	-0.01	0.01**	-0.01	0.03***	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
ROA	0.23	1.48**	0.58	1.30**	-1.54***	0.08
	(0.56)	(0.61)	(0.52)	(0.56)	(0.30)	(0.24)
Tangibility	0.20	-0.56***	0.08	-0.60***	-0.40***	-1.42***
	(0.19)	(0.21)	(0.17)	(0.19)	(0.11)	(0.09)
Cash Flow	-0.15	-0.81	-0.36	-0.66	2.09***	0.62***
	(0.53)	(0.57)	(0.49)	(0.52)	(0.29)	(0.23)
Constant	0.19***	1.56***	0.15***	1.30***	0.03	0.30***
	(0.03)	(0.23)	(0.03)	(0.21)	(0.03)	(0.10)
Firm FE	Yes	No	Yes	No	Yes	No
Year FE	Yes	No	Yes	No	Yes	No
Industry$\times$Year FE	No	Yes	No	Yes	No	Yes
Observations	28,503	28,503	28,503	28,503	22,891	22,891
Adjusted R^2	0.733	0.178	0.733	0.172	0.656	0.025

This table reports the effect of FTZ establishment on corporate innovation from 2000 to 2019. The dependent variable is the natural logarithm of firms' patents applied and granted and TFP. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai after 2013. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 8: Effect of FTZ Establishment on Corporate Innovation: POEs

	Ln PA	Ln PG	TFP	Ln TC	Ln FC	Ln DC
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ	0.15***	0.13***	0.09**	0.21***	0.15***	0.20***
	(0.04)	(0.04)	(0.02)	(0.03)	(0.02)	(0.03)
Size	-0.04**	-0.03	-0.01	0.56***	0.34***	0.54***
	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)
Tobin's Q	-0.01	0.01	0.01***	0.01	0.04***	-0.01
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
ROA	0.60	0.60	-0.19	-1.29	-0.19	-1.12
	(0.99)	(0.81)	(0.38)	(0.90)	(0.54)	(0.88)
Tangibility	-1.00***	-1.26***	-1.05***	-0.58***	-0.14	-0.56***
	(0.35)	(0.31)	(0.16)	(0.29)	(0.15)	(0.28)
Cash Flow	-0.31	-0.37	0.84**	3.65***	1.36***	3.41***
	(0.95)	(0.87)	(0.37)	(0.87)	(0.52)	(0.85)
Constant	1.25***	0.98***	0.13	-10.64***	-6.77***	-10.42***
	(0.37)	(0.35)	(0.16)	(0.37)	(0.31)	(0.36)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,424	14,424	14,416	14,424	14,424	14,424
Adjusted R^2	0.122	0.118	0.034	0.354	0.218	0.359

This table reports the effect of FTZ establishment on innovation by private owned enterprises from 2000 to 2019. For the dependent variable, PA and PG denote the number of patent applied and granted, respectively; TC, FC, and DC denote total, foreign, and domestic citations, respectively. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai FTZ after 2013. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 9: Effect of FTZ Establishment on Corporate Innovation: SOEs

	Ln PA	Ln PG	TFP	Ln TC	Ln FC	Ln DC
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ	0.19***	0.14***	0.08**	-0.07	0.01	-0.08*
	(0.07)	(0.06)	(0.02)	(0.05)	(0.03)	(0.05)
Size	-0.04***	-0.03**	-0.03***	0.70***	0.38***	0.69***
	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
Tobin's Q	-0.01	-0.01	-0.01*	0.05***	0.04***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
ROA	0.22	0.17	0.26	4.02***	1.30***	3.86***
	(0.84)	(0.77)	(0.35)	(0.85)	(0.58)	(0.83)
Tangibility	-0.14	-0.06	-1.64***	-1.10***	-0.82***	-1.02***
	(0.26)	(0.24)	(0.12)	(0.22)	(0.12)	(0.22)
Cash Flow	0.48	0.64	0.82**	-2.32***	-0.19	-2.31***
	(0.77)	(0.70)	(0.33)	(0.79)	(0.53)	(0.76)
Constant	0.98***	0.73**	0.70***	-14.33***	-7.91***	-14.07***
	(0.32)	(0.29)	(0.12)	(0.33)	(0.24)	(0.33)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,079	14,079	11,475	14,079	14,079	14,079
Adjusted R^2	0.177	0.172	0.052	0.448	0.280	0.466

This table reports the effect of FTZ establishment on innovation by state owned enterprises from 2000 to 2019. For the dependent variable, PA and PG denote the number of patent applied and granted, respectively; TC, FC, and DC denote total, foreign, and domestic citations, respectively. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai FTZ after 2013. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 10: Effect of FTZ Establishment on Corporate Innovation: High-tech Firms

	Ln PA	Ln PG	TFP	Ln TC	Ln FC	Ln DC
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ	0.12***	0.09***	0.06***	0.14***	0.10***	0.13***
	(0.05)	(0.04)	(0.02)	(0.03)	(0.02)	(0.03)
Size	-0.06**	-0.05***	-0.01*	0.71***	0.45***	0.70***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Tobin's Q	0.01	0.01	0.01***	0.03***	0.05***	0.03***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
ROA	-0.59	-0.59	0.01	5.33***	2.63***	5.24***
	(0.86)	(0.79)	(0.00)	(0.80)	(0.55)	(0.77)
Tangibility	-1.13***	-1.27***	-1.45***	0.10	-0.32**	0.23
	(0.31)	(0.28)	(0.11)	(0.27)	(0.16)	(0.26)
Cash Flow	1.01	1.10	1.23***	-2.92***	-1.13**	-2.93***
	(0.81)	(0.75)	(0.30)	(0.76)	(0.52)	(0.73)
Constant	1.41***	1.05***	0.27**	-14.29***	-9.12***	-13.96***
	(0.32)	(0.30)	(0.12)	(0.30)	(0.26)	(0.29)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,901	16,901	13,020	16,901	16,901	16,901
Adjusted R^2	0.203	0.195	0.035	0.446	0.275	0.463

This table reports the effect of FTZ establishment on innovation by high-tech firms from 2000 to 2019. For the dependent variable, PA and PG denote the number of patent applied and granted, respectively; TC, FC, and DC denote total, foreign, and domestic citations, respectively. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai FTZ after 2013. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 11: Effect of FTZ Establishment on Corporate Innovation: Non-high-tech Firms

	Ln PA	Ln PG	TFP	Ln TC	Ln FC	Ln DC
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ	0.24***	0.21***	0.10***	0.15***	0.12***	0.13***
	(0.06)	(0.06)	(0.03)	(0.05)	(0.03)	(0.03)
Size	-0.03**	-0.03**	-0.03***	0.63***	0.30***	0.70***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Tobin's Q	0.01	-0.01	0.01	0.03***	0.04***	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
ROA	2.10**	1.94**	0.86**	-4.38***	-2.82***	5.24***
	(0.93)	(0.85)	(0.42)	(0.92)	(0.58)	(0.77)
Tangibility	0.06	0.04	-1.45***	-0.97***	-0.56***	0.23
	(0.27)	(0.25)	(0.12)	(0.22)	(0.11)	(0.26)
Cash Flow	-1.50*	-1.43*	0.19	5.03***	3.14***	-2.93***
	(0.86)	(0.79)	(0.39)	(0.87)	(0.55)	(0.73)
Constant	0.92***	0.85***	0.55***	-13.07***	-6.30***	-13.96***
	(0.35)	(0.32)	(0.16)	(0.36)	(0.24)	(0.29)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,602	11,602	9,871	11,602	11,602	11,602
Adjusted R^2	0.147	0.142	0.037	0.369	0.219	0.377

This table reports the effect of FTZ establishment on innovation by non-high-tech firms from 2000 to 2019. For the dependent variable, PA and PG denote the number of patent applied and granted, respectively; TC, FC, and DC denote total, foreign, and domestic citations, respectively. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai FTZ after 2013. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 12: Financial Constraint Channel

	Ln PA	Ln PG	TFP	Ln TC	Ln FC	Ln DC
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ×KZ	0.05***	0.02***	0.03***	0.02	0.01	0.02
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)
FTZ	0.12***	0.09**	0.05***	0.10***	0.09***	0.09***
	(0.04)	(0.04)	(0.02)	(0.03)	(0.02)	(0.03)
KZ	-0.03***	-0.02***	0.00	-0.09***	-0.05***	-0.08***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)
Size	-0.06***	-0.05***	-0.01***	0.65***	0.37***	0.63***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
Tobin's Q	0.01	-0.01	0.00	0.04***	0.05***	0.04***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)
ROA	0.54	0.51	0.14	1.14*	0.18	1.16*
	(0.62)	(0.57)	(0.26)	(0.62)	(0.41)	(0.60)
Tangibility	-0.52**	-0.58***	-1.41***	-0.71***	-0.49***	-0.65***
	(0.21)	(0.19)	(0.09)	(0.18)	(0.10)	(0.17)
Cash Flow	-0.11	-0.03	0.61***	0.06	0.46	-0.01
	(0.59)	(0.54)	(0.24)	(0.59)	(0.39)	(0.57)
Constant	1.51***	1.27***	0.32***	-12.89***	-7.55***	-11.63***
	(0.23)	(0.21)	(0.10)	(0.24)	(0.18)	(0.23)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28,503	28,503	22,891	28,503	28,503	28,503
Adjusted R^2	0.181	0.175	0.022	0.401	0.246	0.413

This table reports the effect of financial constraints on corporate innovation before and after the FTZ establishment. The sample period is $2000-2019$. For the dependent variable, PA and PG denote the number of patent applied and granted, respectively; TC, FC, and DC denote total, foreign, and domestic citations, respectively. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai FTZ after 2013. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 13: Financing Conditions before and after FTZ Establishment

	Bank Loan	Loan Term	Bond Ratio	Ln Bond	Pledge	Dividend
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ	0.05***	0.03***	0.01**	0.02**	0.14*	0.17**
	(0.01)	(0.01)	(0.00)	(0.01)	(0.07)	(0.08)
Size	-0.01*	0.01**	0.01***	0.11***	-0.12***	0.21***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.04)	(0.03)
Tobin's Q	-0.01***	-0.02***	0.00***	0.00	-0.05**	-0.13***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)	(0.03)
ROA	-0.07	0.19	0.04***	0.66*	0.14	18.55***
	(0.08)	(0.17)	(0.01)	(0.14)	(2.66)	(2.60)
Tangibility	-0.07**	0.39***	0.02***	0.37***	1.88***	-1.72**
	(0.03)	(0.07)	(0.00)	(0.06)	(0.66)	(0.76)
Cash Flow	-0.09	-0.41***	-0.02**	-0.56***	-2.84	-0.89
	(0.07)	(0.16)	(0.01)	(0.14)	(2.67)	(2.35)
Constant	0.11***	-0.05	-0.12***	-2.23***	2.01**	-4.50***
	(0.03)	(0.06)	(0.00)	(0.06)	(1.14)	(0.80)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28,503	28,503	28,503	28,503	13,791	28,503
Adjusted/Pseudo R^2	0.178	0.180	0.173	0.175	0.028	0.164

This table reports the effect of FTZ establishment on financing conditions from 2000 to 2019. For the dependent variables, Bank Loan denotes the total amount of loans that firm *i* borrowed from banks within a year; Loan Term denotes the average term of all loans taken out within a year; Bond Ratio refers to the ratio of corporate bonds issued by firm *i* to its total asset value; Ln Bond represents the logarithm of the total value of bond issuance; Pledge is a dummy variable taking the value of 1 if firm *i* is required to provide collateral when taking out loans; and Dividend is a dummy variable taking the value of 1 if firm *i* makes dividend payment to shareholders in a year. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai FTZ after 2013. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 14: Market Competition Channel

	Ln PA	Ln PG	TFP	Ln TC	Ln FC	Ln DC
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ×HHI	-1.31**	-1.62***	0.34	-0.83*	-1.00***	-0.76*
	(0.55)	(0.50)	(0.34)	(0.44)	(0.28)	(0.43)
FTZ	0.25***	0.24**	0.06***	0.17***	0.16***	0.15***
	(0.05)	(0.05)	(0.02)	(0.04)	(0.02)	(0.04)
HHI	0.50***	0.52***	0.15	1.51***	0.77***	1.51***
	(0.21)	(0.19)	(0.12)	(0.28)	(0.22)	(0.26)
Size	-0.07***	-0.06***	-0.01***	0.63***	0.36***	0.61***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
Tobin's Q	-0.01	-0.01	0.00	0.02***	0.04***	0.02***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)
ROA	0.65	0.57	0.10	1.69***	0.49	1.68***
	(0.62)	(0.57)	(0.25)	(0.62)	(0.41)	(0.60)
Tangibility	-0.55**	-0.60***	-1.41***	-0.79***	-0.54***	-0.73***
	(0.21)	(0.19)	(0.09)	(0.18)	(0.10)	(0.17)
Cash Flow	-0.01	0.05	0.61***	0.40	0.64*	0.31
	(0.59)	(0.54)	(0.24)	(0.59)	(0.39)	(0.57)
Constant	1.52***	1.25***	0.29***	-12.71***	-7.45***	-12.47***
	(0.23)	(0.21)	(0.10)	(0.24)	(0.18)	(0.23)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28,503	28,503	22,891	28,503	28,503	28,503
Adjusted R^2	0.180	0.175	0.022	0.398	0.244	0.410

This table reports the effect of market competition on corporate innovation before and after the FTZ establishment. The sample period is $2000 - 2019$. For the dependent variable, PA and PG denote the number of patents applied and granted, respectively; TC, FC, and DC denote total, foreign, and domestic citations, respectively. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai FTZ after 2013. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 15: Access to Foreign Market Channel

	Ln PA	Ln PG	TFP	Ln TC	Ln FC	Ln DC
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ×Fsales	0.33***	0.30***	0.03	0.09	0.03	0.09
	(0.10)	(0.09)	(0.04)	(0.08)	(0.05)	(0.08)
FTZ	0.09**	0.09**	0.08**	0.10***	0.09***	0.09***
	(0.04)	(0.04)	(0.02)	(0.03)	(0.02)	(0.03)
Fsales	0.14***	0.18***	-0.15***	0.07**	0.07***	0.07**
	(0.04)	(0.04)	(0.02)	(0.03)	(0.00)	(0.03)
Size	-0.04***	-0.05***	-0.02***	0.63***	0.36***	0.62***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
Tobin's Q	0.01	-0.01	0.01	0.02***	0.04***	0.02***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)
ROA	0.52	0.70	0.06	1.78***	0.54	1.77*
	(0.67)	(0.57)	(0.25)	(0.62)	(0.41)	(0.61)
Tangibility	-0.67***	-0.63***	-1.40***	-0.83***	-0.56***	-0.77***
	(0.21)	(0.19)	(0.09)	(0.18)	(0.10)	(0.17)
Cash Flow	0.10	-0.04	0.65***	0.34	0.61	0.25
	(0.63)	(0.54)	(0.24)	(0.59)	(0.39)	(0.57)
Constant	0.91***	1.09***	0.45***	-12.66***	-7.45***	-12.42***
	(0.25)	(0.22)	(0.10)	(0.24)	(0.19)	(0.23)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28503	28503	22891	28503	28503	28503
Adjusted R^2	0.210	0.176	0.026	0.397	0.243	0.409

This table reports the effect of foreign sales on corporate innovation before and after the FTZ establishment. The sample period is 2000 – 2019. For the dependent variable, PA and PG denote the number of patents applied and granted, respectively; TC, FC, and DC denote total, foreign, and domestic citations, respectively. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai FTZ after 2013. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels respectively.

Table 16: FDI Channel

	Ln PA	Ln PG	TFP	Ln TC	Ln FC	Ln DC
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ×FDI	0.02*	0.02**	0.02***	0.01	0.01**	0.001
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
FTZ	0.03	-0.02	-0.04	0.07	0.01	0.06
	(0.08)	(0.08)	(0.04)	(0.07)	(0.04)	(0.06)
FDI	-0.01**	-0.01**	0.03***	0.04***	0.03***	0.03***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Size	-0.07***	-0.06***	-0.01***	0.63***	0.36***	0.61***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
Tobin's Q	-0.01	-0.01	0.01	0.03***	0.04***	0.02***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)
ROA	0.65	0.57	0.08	1.77***	0.53	1.76***
	(0.62)	(0.57)	(0.25)	(0.62)	(0.41)	(0.61)
Tangibility	-0.60***	-0.65***	-1.26***	-0.64***	-0.43***	-0.60***
	(0.21)	(0.19)	(0.09)	(0.18)	(0.10)	(0.17)
Cash Flow	0.01	0.07	0.63***	0.32	0.59	0.23
	(0.59)	(0.54)	(0.24)	(0.59)	(0.39)	(0.57)
Constant	1.63***	1.37***	0.01	-12.86***	-7.57***	-12.58***
	(0.23)	(0.22)	(0.10)	(0.24)	(0.18)	(0.23)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28,503	28,503	22,891	28,503	28,503	28,503
Adjusted R^2	0.180	0.175	0.034	0.399	0.246	0.410

This table reports the effect of FDI on corporate innovation before and after the FTZ establishment. The sample period is $2000-2019$. For the dependent variable, PA and PG denote the number of patents applied and granted, respectively; TC, FC, and DC denote total, foreign, and domestic citations, respectively. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai FTZ after 2013. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 17: The Government Subsidy Channel

	Ln PA	Ln PG	TFP	Ln TC	Ln FC	Ln DC
	(1)	(2)	(3)	(4)	(5)	(6)
FTZ×Gov Subsidies	-0.02	-0.02*	0.01	0.04***	0.02*	0.04***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
FTZ	0.46*	0.54**	-0.06	-0.56**	-0.25	-0.52**
	(0.25)	(0.23)	(0.16)	(0.23)	(0.20)	(0.23)
Gov Subsidies	0.01***	0.01*	0.01***	0.08***	0.03***	0.08***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Size	-0.07***	-0.06***	-0.02***	0.55***	0.33***	0.54***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
Tobin's Q	-0.01	-0.01	0.01	0.04***	0.05***	0.04***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)
ROA	0.70	0.59	0.21	2.32***	0.73*	2.30***
	(0.62)	(0.57)	(0.25)	(0.62)	(0.41)	(0.60)
Tangibility	-0.55***	-0.61***	-1.48***	-0.82***	-0.55***	-0.75***
	(0.21)	(0.19)	(0.09)	(0.17)	(0.09)	(0.17)
Cash Flow	-0.06	0.04	0.47**	-0.42	0.33	-0.50
	(0.59)	(0.54)	(0.24)	(0.58)	(0.39)	(0.57)
Constant	1.67***	1.34***	0.51***	-11.09***	-6.83***	-10.86***
	(0.24)	(0.22)	(0.10)	(0.24)	(0.19)	(0.23)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28,503	28,503	22,891	28,503	28,503	28,503
Adjusted R^2	0.180	0.175	0.025	0.415	0.250	0.427

This table reports the effect of government subsidies on corporate innovation before and after the FTZ establishment. The sample period is 2000 – 2019. For the dependent variable, PA and PG denote the number of patents applied and granted, respectively; TC, FC, and DC denote total, foreign, and domestic citations, respectively. The value of FTZ dummy variables depends on whether enterprises are located in Shanghai FTZ after 2013. The detailed definition of other control variables is provided in Table D1. We include year and industry fixed effects. Standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Online Appendix

"Free Trade Zone Establishment and Corporate Innovation"

Appendix A Institutional Background

The establishment of FTZs in China has been part of a broader effort by the Chinese government to promote economic liberalization and attract foreign investment. The government has implemented a range of policies and incentives to encourage companies to set up operations in FTZs, including streamlined customs procedures, simplified administrative procedures, and tax incentives. The first FTZ in China was established in Shanghai in 2013 as a testing ground. In 2015, three coastal provinces in China announced their intention to strengthen regional economic integration through enhanced cooperation and infrastructure improvement. Two years later, the Chinese government established seven additional FTZs to promote economic development in Western China and facilitate the Belt and Road Initiative.

Benefits of FTZs in China include favorable administrative measures, strong human capital, and improved business environment. In addition, a series of policies are particularly relevant to R&D and innovation. Starting with the Shanghai FTZ, China's free trade regions have placed great emphasis on promoting technological innovation through institutional innovation. The Shanghai pilot FTZ proposed to vigorously promote the "double linkage" between the free trade regions and the independent innovation demonstration zone, exploring the physical overlap and chemical fusion of policies supporting investment, trade facilitation, and technological innovation. The overall plans and deepening plans for subsequent FTZs have included specific provisions to support and promote technological innovation, with policies introduced in finance, taxation, subsidies, government procurement, talent, and other areas. In the proposals for the Hainan FTZ, the Shanghai FTZ Lingang New Area, and six other FTZs in Hebei, Jiangsu, Beijing, and other provinces, relevant provisions have been significantly increased. At the same time, refined policies have been introduced for industries that are relatively concentrated in scientific and technological innovation activities (e.g., integrated circuits, biopharmaceuticals, artificial intelligence, and advanced manufacturing), targeting the bottleneck problems that enterprises may encounter in scientific and technological innovation.

Taking Shanghai FTZ as an example, "Further Deepening of the Reform and Opening-up Plan for China (Shanghai) Pilot Free Trade Zone" proposes to deepen the reform of the scientific and technological innovation system and mechanism. It fully leverages the policy overlap advantages of the free trade experimental zone and the national independent innovation demonstration zone; comprehensively promotes the reform of the system and mechanism in the fields of intellectual property rights, scientific research institutes, higher education, talent mobility, international cooperation; and establishes a proactive and flexible innovation talent development system. It improves the system for enterprise innovation input, establishes a sound intellectual property disposal and revenue mechanism supported by fiscal funds, establishes a patent navigation industry development work mechanism, and constructs a market-oriented system for the transfer and transformation of scientific and technological achievements. It also improves the government management system in line with innovation laws; promotes the formation of a new open cooperation situation for the free flow of innovative elements; and increases exploration efforts in innovation in investment and loan-linked financial services, technology-based intangible asset investment, and development of new industry technology research and development organizations. It accelerates the construction of a globally influential science and technology innovation center.

Another example comes from Hebei FTZ. The overall plan of the Hebei FTZ contains more than 360 words detailing the supportive policies for the biopharmaceutical industry, which are "meticulous" in nature. For instance, the plan simplifies the export procedures for drug samples and intermediates weighing less than 1 kg by air; moderately relaxes the management of small-dose special chemical preparations used in pharmaceutical research and development; supports pilot projects for gene mass spectrometry of infectious microorganisms and rare diseases; and establishes a green channel for the import of materials, reagents, and equipment for new drug R&D.

Appendix B Detailed Discussion on Model Predictions

This section derives the analytical results summarized in Table 1. First, according to Equations (14) and (15), a decline in the financing cost (i.e., a lower ξ) shifts up the Labor Condition and R&D Condition curves, leading to a higher arrival rate of innovation. Its effect on the quality of innovation, however, is undetermined. Intuitively, a lower financing cost implies a smaller marginal cost of R&D, which increases the R&D effort and thus raises the arrival rate of innovation. The increased R&D labor demand pushes up the wage rate and thereby reduces the monopoly profit flow for a given size of quality increment, as shown in (6). This incentivizes entrepreneurs to make a radical innovation attempt. This positive effect, however, can be partially offset or even completely dominated by the increase in profit resulting from the reduction in financing cost. The above analytical result is summarized by the following proposition.

Proposition 1. *Lowering the financial constraint increases the quantity of innovation and may increase or decrease the quality of innovation.*

Second, if the FTZ facilitates more firms to engage in exporting activities, we expect to see fierce competition in domestic and foreign goods markets. As a consequence, price markup m and/or η tends to decline, lowering firms' profit. According to our model, a lower m or η shifts down the Labor Condition curve and up the R&D Condition curve. In this case, the size of quality increment increases, and the arrival rate of innovation can be increasing or decreasing in response.

Proposition 2. *Increasing market competition raises the quality of innovation and can increase or decrease the arrival rate of innovation.*

In addition, it can be shown that the effect of θ on innovation is contingent on the relative magnitude of domestic and foreign markups. If exporting is more profitable, then enlarging the access to foreign markets tends to increase firm profit, disincentivizing R&D firms to pursue high-quality improvement. Graphically, an increase in θ shifts up the Labor Condition curve and down the R&D Condition curve, leading to an unambiguously lower λ^*. By contrast, if serving the domestic market is more profitable (i.e. $\eta > m$), then without explicitly modeling firms' strategic reason of exporting, our model implies a lower total profit (since the share of exports in total production increases) and thus needs to pursue high-quality improvement. In both scenarios, however, the effect of θ on the arrival rate of innovation is ambiguous.

Proposition 3. *If the domestic price markup is higher (lower) than the foreign price markup, enlarging the access to foreign markets θ increases (decreases) the quality of innovation and may increase or decrease innovation quantity.*

Appendix C A Two-Country Model

In this section, we extend the baseline model to a more generalized setting with two countries, namely, the domestic and foreign countries indexed by d and f, respectively. To conserve space, we will only present the equations for the domestic country d. However, there is an analogous equation for the foreign country f when we present each expression in the domestic country.

Household Preference. The utility maximization problem of a representative consumer is largely the same as that in the baseline model. The only difference lies in the incorporation of country-specific notations. Particularly, the utility function and budget constraint are now expressed as $U^d(t) = \int_t^\infty \exp\left(-\rho(s-t)\right) \ln C^d(s) ds$ and $\dot{A}^d(t) = r^d(t)A^d(t) + w^d(t)L^d(t) - C^d(t)$, respectively. Once again, we drop the time index when no confusion is caused. Following this the growth literature, we assume that there is a global bond market, such that the real interest rates (the real return rates of assets) are identical across countries, namely, $r^d = r^f = r$.

Consumption Goods. Consumption goods in country d are produced by a unit continuum of competitive firms that aggregate two categories of final goods using a Cobb-Douglas aggregator, which is given by

$$C^d = \frac{\left(Y^{dd}\right)^{1-\alpha}\left(Y^{df}\right)^{\alpha}}{(1-\alpha)^{1-\alpha}\alpha^\alpha}, \tag{C.1}$$

where Y^{df} denotes country d's final goods that are produced by the intermediate goods imported from country f; Y^{dd} denotes country d's final goods that are produced using domestic intermediate goods. The parameter $\alpha \in [0,1]$ determines the share of foreign goods in domestic consumption. Solving the profit maximization problem yields the conditional demand functions for Y^{dd} and Y^{df}:

$$Y^{dd} = (1-\alpha)P_C^d C^d / P_Y^{dd}; \quad Y^{df} = \alpha P_C^d C^d / P_Y^{df}, \tag{C.2}$$

where P_Y^{dd} and P_Y^{df} are prices of Y^{dd} and Y^{df}, respectively. The familiar price index of consumption goods in country d is $P_C^d = \left(P_Y^{dd}\right)^{1-\alpha}\left(P_Y^{df}\right)^{\alpha}$. We select the consumption goods in country d as the numeraire, such that $P_C^d \equiv 1$. We assume that the law of one price holds. Hence, $P_C^d = \epsilon P_C^f$, where ϵ and P_C^f are the real exchange rate and the price of consumption goods in the foreign country, respectively.

Final Goods. Final goods Y^{dd} and Y^{df} are also produced by a unit continuum of competitive firms. Competitive firms in country d produce Y^{dd} by aggregating a unit continuum of domestic intermediate goods $X^{dd}(i)$, where $i \in [0,1]$. The standard Cobb-Douglas aggregator is

$$Y^{dd} = \exp\left(\int_0^1 \ln X^{dd}(i) di\right). \tag{C.3}$$

Similarly, competitive firms in country d produce Y^{df} by aggregating a unit continuum of foreign intermediate goods $X^{df}(j)$ with $j \in [0,1]$. The Cobb-Douglas aggregator is given by

$$Y^{df} = \exp\left(\int_0^1 \ln X^{df}(j) dj\right). \tag{C.4}$$

From profit maximization, the conditional demand functions for $X^{dd}(i)$ and $X^{df}(j)$ are given by, respectively,

$$X^{dd}(i) = P_Y^{dd} Y^{dd} / p_x^{dd}(i); \quad X^{df}(j) = P_Y^{df} Y^{df} / p_x^{df}(j) \tag{C.5}$$

where $p_x^{dd}(i)$ is the price of $X^{dd}(i)$, and $p_x^{df}(j)$ is the price of $X^{df}(j)$.

Intermediate Goods. Similar to the baseline model, we assume that each industry $i \in [0,1]$ in country d is temporarily dominated by a monopolistic producer who holds the latest generation of patent. The major departure from the benchmark model is that we drop the assumption that an exogenous fraction of product is absorbed by foreign market. Instead, we assume that the industry leader employs workers in country d to produce $X^{dd}(i)$ for sale in country d and $X^{fd}(i)$ for sale in country f. The industry leader's production of $X^{dd}(i)$ and $X^{fd}(i)$ uses the same technology, but selling $X^{fd}(i)$ in the foreign country incurs an iceberg transportation cost $\tau \in (0,1)$. The production functions are given by

$$X^{dd}(i) = \lambda^{n(i)} \left[L_x^{dd}(i) - \kappa\right]; \quad X^{fd}(i) = (1-\tau)\lambda^{n(i)} \left[L_x^{fd}(i) - \sigma\right] \tag{C.6}$$

where κ and σ represent fixed production cost. Thus, the total number of production workers employed in industry i of country d is $L_x^d(i) = L^{dd}({}_x i) + L_x^{fd}(i)$, and the aggregate demand of manufacturing labor is $L_x^d \equiv \int_0^1 L_x^{dd}(i)di$.

Given the production technology $\lambda^{n(i)}$ in industry i, the leader's marginal cost functions for $X^{dd}(i)$ and $X^{fd}(i)$ are, respectively,

$$MC^{dd}(i) = \frac{w^d}{\lambda^{n(i)}}; \quad MC^{fd}(i) = \frac{w^d}{(1-\tau)\lambda^{n(i)}}. \tag{C.7}$$

The pricing strategy is same as the baseline model, where standard Bertrand price competition leads to markup pricing. Given the different markup ratios in the domestic and foreign countries, namely, $\eta\lambda$ and $m\lambda$, the price of $X^{dd}(i)$ and $X^{fd}(i)$ are

$$p_x^{dd}(i) = \eta\lambda MC^{dd}(i) = \eta\lambda\left(\frac{w^d}{\lambda^{n(i)}}\right); \quad p_x^{fd}(i) = m\lambda MC^{fd}(i) = m\lambda\left(\frac{w^d}{\lambda^{n(i)}(1-\tau)}\right). \tag{C.8}$$

Therefore, the amount of monopolistic profit from selling $X^{dd}(i)$ in country d is

$$\pi^{dd}(i) = (1-\alpha)\left(1 - \frac{1}{\eta\lambda}\right)C^d - \kappa w^d \tag{C.9}$$

Similarly, the monopolistic profit from selling $X^{fd}(i)$ in country f is

$$\pi^{fd}(i) = \alpha\left(1 - \frac{1}{m\lambda}\right)C^f - \sigma w^d. \tag{C.10}$$

! In equilibrium, the value of trade in intermediate goods is balanced such that $\int_0^1 p_x^{fd}(j)X^{fd}(j)dj = \int_0^1 p^{df}(i)X^{df}(i)di$. Combined with the symmetric condition, we can obtain the total amount of monopolistic profits earned by the leader in industry i, which is given by

$$\pi^d(i) = \pi^{dd}(i) + \pi^{fd}(i) = (1-\Theta)C^d - (\sigma+\kappa)w^d, \tag{C.11}$$

where

$$\Theta = \frac{1-\alpha}{\eta\lambda} + \frac{\alpha}{m\lambda} > 0. \tag{C.12}$$

Moreover, we derive the total demand of manufacturing labor by the quality leader in industry i in country d, such that

$$L_x^d(i) = \sigma + \kappa + \Theta C^d / w^d. \tag{C.13}$$

Finally, the settings of innovation and R&D activity remain the same as those in the benchmark model.

Steady State Equilibrium. Following the same logic, we solve this extended model. The general equilibrium conditions in (14) and (15) become

$$\mu = \frac{(1 - \sigma - \kappa - \Theta)/f(\lambda) - \rho\Theta(1 + \xi)}{1 + \xi\Theta} \tag{C.14}$$

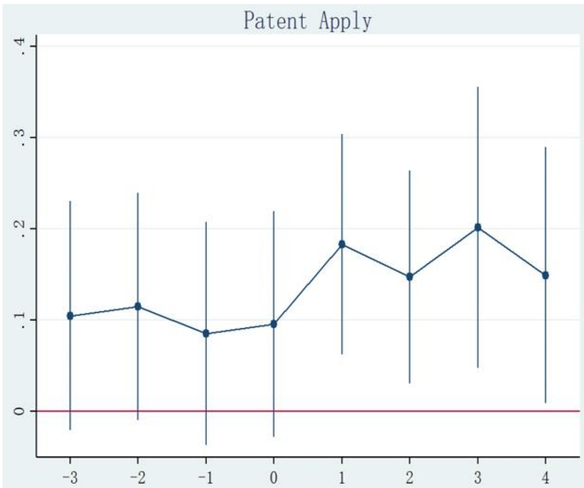
and

$$\mu = \frac{\Theta(\kappa + \sigma)/\epsilon}{[\lambda(1 - \Theta) - \Theta/\epsilon](1 + \xi)f(\lambda)} - \rho. \tag{C.15}$$

It is straightforward to verify graphically that the results in Proposition 1 - 3 still hold. Accordingly, this extended model yields the same theoretical predictions as in the baseline model.

Appendix D Supplementary Figures and Tables

Figure D1: Coefficient of Parallel Trends



(a) Coefficient for Patent Applications

(b) Coefficient for TFP

This figure depicts the difference of patents applied (and TFP) between treated and control firms from $t-3$ to $t+4$, where $t=0$ is the onset year for the FTZ established. The coefficient estimated from parallel trend estimation captures the difference between two groups of firms after controlling for firm characteristics and industry and year fixed effects. The 95% confidence interval is shown.

Table D1: Variable Definition and Construction

Variable	Variable description
Corporate innovation	
Ln PatentApply	Ln (Number of all patents applied by the enterprise in the year +1)
Ln PatentGrant	Ln (Number of all patents granted to the enterprise in the year +1)
Ln DomesticCitation	Ln (Number of domestic citation of all patents to the enterprise in the year +1)
Ln ForeignCitation	Ln (Number of foreign citation of all patents granted to the enterprise in the year +1)
TFP	Total factor productivity, which is computed using the method in Schoar (2002).
Independent variables	
FTZ	The dummy variable takes the value of 1 if a firm's registered address is located in the FTZ after the establishment year; otherwise, it takes the value of 0. In the baseline analysis, we only consider the first FTZ in Shanghai. Hence, the dummy variable takes the value of 1 for Shanghai firms after 2013.
FTZbroad	The definition of this dummy variable is similar to *FTZ*. In the robustness check, however,we consider the staggered establishment of FTZs in Shanghai, Guangdong, Fujian, and Tianjin. Hence, the dummy variable takes the value of 1 for firms in Shanghai after 2013, and those in Guangdong Fujian and Tianjin after 2015.
Size	The natural logarithm of total assets.
Tobin's Q	The Tobin's Q value is calculated as (total asset - owner's equity + market value)/total asset.
ROA	Operating profit/total asset
CashFlow	Operating cash flow/total asset
Intangibility	Intangible assets/total assets
HHI	The HHI is the Herfindahl–Hirschman index. Its formula is: HHI = sum[(individual company's main business revenue/total main business revenue of each company in the industry)^2]. A higher HHI represents a more concentrated competitive industry and a more monopolistic product market.
KZindex	KZ is calculated from Lamont *et al.* (2001) as $KZ = -1.0019 \cdot CashFlow + 0.2826 \cdot TobinQ + 3.1391 \cdot Leverage - 39.3678 \cdot Dividend - 1.3147 \cdot Cash$. A higher KZ indicates a higher degree of financing constraints faced by the firm.
Fsales	Total overseas sales of the enterprise for the year/total sales revenue

Table D2: Summary Statistics

Variables	N (1)	Mean (2)	Median (3)	SD (4)
Ln PatentApply	28,522	1.638	1.099	1.804
Ln PatentGrant	28,522	1.434	0.693	1.653
TFP	28,522	0.014	0.001	0.601
ln DomesticCitation	28,522	0.570	0.000	1.091
ln ForeignCitation	28,522	1.818	1.609	1.865
FTZ	28,522	0.125	0.000	0.331
FTZbroad	28,522	0.197	0.000	0.398
Size	28,522	21.797	21.641	1.207
Tobin's *Q*	28,522	2.444	1.895	1.825
ROA	28,522	0.052	0.043	0.067
Intangibility	28,522	0.046	0.032	0.050
CashFlow	28,522	0.080	0.070	0.071
KZIndex	28,522	0.917	1.086	1.597
HHI	28,522	0.069	0.053	0.083
Fsales	28,522	0.138	0.000	0.288

This table reports descriptive statistics for firms during the period of 2000 – 2019. All variables are defined in Appendix Table D1.