Tickets to the Global Market: First U.S. Patents and Chinese Firm Exports*

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Preliminary. Please Do Not Circulate

Abstract

This paper investigates how the approval of a US patent affects the subsequent performance of Chinese firms in foreign markets. We match Chinese exporters with US patent applicants, and leverage the quasi-random assignment of USPTO applications to examiners to identify the causal effect of US patent grants. Successful first-time patent applicants achieve significantly higher export growth, largely because they retain and expand into incumbent destination-product markets. The response across products and destinations reveals that these effects operate only in small part through the protection of market power in the US, and not through the relaxation of financial frictions or the promotion of follow-on innovation. Instead, evidence indicates that a first US patent award signals the Chinese firm's capacity to produce high quality and credibility to honor contracts, mitigating information frictions in international trade.

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1 Introduction

Global patent activity has increased steadily in recent decades, with a remarkable rise in the number of patents taken out by foreign firms in a select few patent jurisdictions. For example, the United States Patent and Trademark Office (USPTO) - one of the largest, most active, and most reputed patent institutions in the world - receives over 500,000 applications each year, with the share of foreign applicants growing from 44% in 2000 to 51% in 2015 and the number of applicant countries expanding from 112 to 143. Given the role of innovation for economic growth and the need for intellectual property rights (IPR) protection to incentivize innovation, these trends raise policy questions of first-order importance: Why do firms patent their innovations abroad? What challenges do firms from emerging economies with weak IPR face in the global marketplace, and can established patent authorities in developed countries act as global hubs for alleviating these challenges?

Patent institutions in principle grant exclusive market rights only within their respective jurisdiction. Consistent with this, there is a strong positive correlation between the growth rate of the number of USPTO patent applications and the growth of exports to the US across countries over the 2000-2010 period (Figure 1A). At the same time, there is a similarly strong positive correlation across countries between USPTO patent applications and exports to the rest of the world (ROW) (Figure 1B). This raises the possibility that the US's global reputation for strict patent standards and strong IPR enforcement may confer additional advantages to successful USPTO applicants that extend beyond the US market.

[Figure 1]

To shed light on these questions, we investigate how the approval of a US patent affects the subsequent performance of Chinese firms in foreign markets. We match Chinese exporters with US patent applicants, and leverage the quasi-random assignment of USPTO applications to examiners to identify the causal effect of US patent grants. Successful first-time patent applicants achieve significantly higher export growth, largely because they retain and expand into incumbent destination-product markets. The response across products and destinations reveals that these effects operate only in small part through the protection of market power in the US, and not through the relaxation of financial frictions or the promotion of follow-on innovation. Instead, evidence indicates that a first US patent award signals the Chinese firm's capacity to produce high quality and credibility to honor contracts, mitigating information frictions in international trade.

The US-China context is particularly well suited to studying these questions. While both countries have consistently ranked among the top-3 trading economies in the past decade, they emblematize an advanced economy with strong institutions and an emerging economy undergoing rapid structural transformation. Moreover, China's dramatic expansion in international trade since joining the WTO in 2001 has been accompanied by a steep rise in Chinese patent applications both at home and abroad. Although China today hosts some global innovation leaders, however, there have been increasing concerns about the quality of patents issued by China's State Intellectual Property Office (SIPO).[1] In addition, Chinese products are often stigmatized to be of low average quality and high quality variance, in the face of significant contracting frictions and idiosyncratic Chinese institutions. Since the US is an important export market for China and US patents are highly regarded internationally, the US patent activity of Chinese exporters thus provides an opportunity to assess the market power and information signaling functions of foreign patents.

We exploit three rich datasets for the 2000-2016 period: the universe of first-time US patent applicants and their complete application record from USPTO's Patent Application Information Retrieval (PatEx), the universe of Chinese export transactions from the Chinese Customs Trade Statistics (CCTS), and comprehensive accounting statements from the Chinese Annual Survey of Industrial Enterprises (ASIE). Manually matched on firm name and location, our baseline sample comprises 2,831 Chinese exporters, which accounts for over half of all USPTO applicants from China.

Estimating the trade impact of a patent grant poses significant identification challenges due to concerns about omitted variable bias and reverse causality. A patent application implicitly signals that a firm has undertaken innovation, and innovating firms are known to be bigger, more productive, more technologically advanced, and more successful in foreign markets (Aw *et al.* 2008, 2011). Separately, firms' inherent innovation capability may drive their export performance, but potential export access or actual export activity may also boost innovation intensity (Shu and Steinwender 2019). We confirm that Chinese firms filing for a US patent are indeed very different from Chinese firms that do not, such that one cannot simply compare their export performance.

We overcome this econometric challenge by capitalizing on institutional features of the USPTO review process: the randomness in the allocation of patent applications to examiners (Lemley and Sampat (2012); Sampat and Williams (2019)), combined with systematic variation in examiners' proclivity to approve patents that is exogenous to the applicant and to the allocation process (Lemley and Sampat (2012)). Upon submission, each USPTO file is assigned to an art unit based on its technology class. Within each art unit, however, the assignment of patents to examiners has been described as a random lottery draw and with little evidence of synchronization across art units.

To identify the causal effect of a US patent award on the subsequent export activity of Chinese firms, we therefore compare the export performance of first-time patent applicants whose application has been approved vs. denied for arguably exogenous reasons related to the assignment of patent examiners. In particular, we follow Sampat and Williams (2019) and Farre-Mensa *et al.* (2020), and instrument the outcome of a firm's USPTO application with the leniency of the assigned examiner. We proxy the latter by the share of patents

[1] In a survey of IPR professionals by Thomson Reuters and Intellectual Asset Management magazine, SIPO patent quality ranked last among the world's five largest patent offices (Song and Li 2014), while an OECD study scored China's patent quality below the world average (Squicciarini *et al.* 2013). Boeing and Mueller (2019) compare patents filed under the Patent Cooperation Treaty (PCT), and find the average quality of Chinese applications to be only a third of that of non-Chinese applications and decreasing over time.

the examiner has approved prior to that specific application, demeaned by art unit and first-action year to guard against potentially strategic application timing. This instrument delivers a powerful first stage, and is uncorrelated with a wide range of firm characteristics. Rather than self-selected groups of innovative patent applicants and non-innovative non-patent filers, our treatment and control groups are thus both highly innovative firms that a series of balance tests confirm are similar prior to USPTO submission.

We find that USPTO patent approval significantly improves the export activity of Chinese applicants. A successful first patent application increases annual export growth by 18 percentage points over the 3 years following the patent grant. This growth is driven in equal parts by higher survival probability and greater expansion into incumbent destination-product markets (88%), with little contribution of entry into new markets (12%). Event studies reveal that the gains materialize quickly and persist, while placebo tests corroborate the lack of pre-trends. Although we focus on first-time applicants because of identification concerns with sparse serial applicants, the evidence if anything suggests muted effects of subsequent patent approvals. All of these results obtain conditional on a stringent set of industry by application year pair fixed effects, as well as firm controls for initial exports, export experience, and size.

Having agnostically established the large causal impact of US patenting on Chinese firms' export growth, we explore several possible underlying mechanisms that are not mutually exclusive. The premise of this analysis is that each mechanism would manifest in disproportionately higher growth in destination-product markets with certain characteristics. We evaluate this by assessing the contribution of different markets to overall export growth at the firm level in cross-firm regressions, as well as by studying export growth at the granular firm-destination-product level in within-firm regressions.

Since a patent gives exclusive rights to deploy an invention in the patent authority's jurisdiction, it may in the first instance increase monopoly power there (Kogan *et al.* 2017; Kline *et al.* 2019). However, we find that exports to the US of products that are technologically related to a firm's USPTO patent contribute less than 14% of its overall export growth, while exports of unrelated products to the rest of the world account for 78%. Moreover, there is no differential growth in export sales or prices of related vs. unrelated products in the US vs. ROW within firms. This suggests that US patent grants confer broader benefits to Chinese recipients that extend globally beyond market power in the US.

We propose that US patent recognition acts as a signal that can alleviate information frictions in international trade. Asymmetric information is arguably more prevalent and more costly in international than domestic transactions, because international partners are less familiar with foreign economic and institutional conditions, risk bigger hold-up problems in finding alternative buyers and suppliers, and face greater contractual frictions due to transacting across jurisdictions. Asymmetric information would presumably be more problematic, and hence the value of a patent signal greater, for exporters from a country with less developed institutions and greater firm heterogeneity such as China that want to serve advanced economies. Meeting the high standards of the USPTO examination process can give such firms a globally recognized stamp of approval, and thereby allow them to expand into destination-product markets that are not directly affected by the US patent.

We provide evidence consistent with a US patent sending a signal about two desirable attributes of a Chinese firm: its capacity to deliver high-quality products and its credibility to honor contractual obligations. In particular, a first US patent benefits export growth more for differentiated goods that have greater scope for quality differentiation than homogeneous goods, especially in richer destinations that have greater willingness to pay for quality. USPTO patent approval also boosts exports relatively more in contract intensive products that require more relationship-specific investment in production, especially to destinations with stronger rule of law and hence higher demand for such goods. The interpretation and measurement of these product and country dimensions builds on prior work on quality differentiation and contractual frictions in international trade (Rauch 1999; Nunn 2007; Manova and Zhang 2012; Manova and Yu 2017).

Finally, we find little support for two other mechanisms through which US patents could enhance the export performance of Chinese firms: The variation in the estimated effects across sectors at different levels of financial vulnerability is not indicative of USPTO approval alleviating financial frictions, while patent activity within China does not suggest that patenting in the US enables follow-on innovation or patenting elsewhere.

Our work bridges two large and active strands of research - on the drivers and consequences of innovation and patent activity, and on the two-way relationship between international trade and innovation. We bring novel insights that advance understanding of questions at the heart of both literatures by focusing on the role of patenting for trade performance.

Of central interest in the innovation literature is the impact of patent rights on firm operations that matter for firm performance short-term and aggregate growth long-term. For example, studies have explored the consequences for patent holders' survival, subsequent innovation and rent sharing (Galasso and Schankerman 2018; Kline *et al.* 2019), as well as for spillovers across the economy such as the diffusion of new products (Cockburn *et al.* 2016), start-up growth (Farre-Mensa *et al.* 2020) and follow-on innovation by other firms (Williams 2013; Galasso and Schankerman 2015; Williams 2017; Sampat and Williams 2019). The main emphasis in this literature has been on IPR protection and associated market power conferred by patents within the patent jurisdiction. Recent work finds that IPR enforcement and patenting in a destination country increase exports to that country through the monopoly channel (Palangkaraya et al. (2017), Rassenfosse et al.(2022)). Instead, we draw attention to the increasingly important cross-border patent activity. We provide novel evidence for its effects on firms' export performance, and establish that the reduction of information frictions in international trade is its primary driver.

In turn, the link between firm productivity, innovation and trade participation is focal to the trade literature. Selection bias and reverse causality, however, pose serious identification challenges. There is extensive evidence that firm productivity strongly predicts export activity, global input sourcing, and the response to trade reforms in the spirit of Melitz (2003).[2] There is also growing evidence that export demand shocks and export liberalization induce innovation and technology upgrading, by increasing expected profits and incentivizing firms to incur the necessary fixed innovation costs (Lileeva and Trefler (2010); Bustos (2011); Aw *et al.* (2011); Aghion *et al.* (2018); Liu and Ma (2020); Coelli *et al.* (2022)).[3] Import competition can likewise boost innovation and upgrading as a means of remaining competitive and retaining market share. In comparison, we shift focus away from innovation to patenting conditional on firms' innovation prowess. This allows us to identify clean and novel causal effects of international patenting on export performance.

We also contribute directly to the literature on information asymmetry in international trade. Information frictions pose a substantial barrier to trade (Chaney 2014), as cross-border trade partners have incomplete information about the supply and demand shocks they incur, as well as more limited legal recourse in case of contract breaches.[4] This especially plagues exporters from developing countries that produce differentiated products and sell to developed destinations (Rauch 1999), and can potentially restrict their exports and positioning in global value chains. The literature has uncovered various strategies for exporters to overcome this problem. These include reputation building (Banerjee and Duflo 2000), relational contracting and repeat buyer-seller relationships Macchiavello and Morjaria (2015); Monarch and Schmidt-Eisenlohr (2017), business and social networks (Rauch 1999, 2001; Rauch and Trindade 2022), trade intermediation (Casella and Rauch 2002; Feenstra and Hanson 2004; Ahn *et al.* 2011), and information and communication technologies (Rauch and Trindade 2003; Steinwender 2018; Akerman *et al.* 2022). We complement this line of work by showing a novel strategy for firms to signal quality capacity and contractual credibility by obtaining patent recognition from a lgobal patent hub such as the USPTO.

The remainder of this paper is organized as follows. Section 2 introduces the institutional context and the rich US and Chinese data. Section 3 outlines the empirical approach and IV strategy. Section 4 presents the baseline effects of a first US patent on Chinese exporters. Section 5 evaluates possible underlying mechanisms. The last section concludes.

[2]Bøler *et al.* (2015) find that the introduction of an R&D tax credit in Norway stimulated R&D and imports of intermediates, but not exports. Others structurally evaluate the impact of R&D investment on export outcomes, such as Aw *et al.* (2011) and Maican *et al.* (2020).

[3]See Burstein and Melitz (2013) and Shu and Steinwender (2019) for recent reviews. Endogenous growth models (Costantini and Melitz 2008; Atkeson and Burstein 2010; Van Long *et al.* 2011) also show that lower trade costs can increase firms' incentives to invest in R&D or new technologies.

[4]Most studies consider information frictions from the exporters' perspective. For example, exporters may have incomplete information about foreign demand and market prices (Albornoz *et al.* 2012; Defever *et al.* 2015; Allen 2014), or may need to incur search costs to match with foreign buyers (Eaton *et al.* 2021; Chaney 2014). We focus instead on the incomplete information of importers about the exporter.

2 Data and Institutional Context

2.1 Institutional Background

Intellectual property rights (IPR) protection has a long institutional history aimed at establishing new inventions and safeguarding their deployment. In particular, a *utility patent* is a patent that covers the creation of a new or improved product, process, or machine. Also known as a *patent for invention*, it prohibits other individuals or companies from making, using, or selling an invention without authorization.

One of the largest and most active institutions that grants patent recognition is the United States Patent and Trademark Office (USPTO). In the last decade, for example, the USPTO received over 500,000 patent applications each year, of which more than 50% submitted by foreign applicants.[5] While a patent granted by the USPTO in principle guarantees IPRs only in the US market, the USPTO's global reputation for strict criteria and the US' overall institutional strength raise the possibility that successful applicants may reap benefits outside the United States as well.

The USPTO review process ensures quality standards and efficient processing by adhering to a fixed series of steps. Figure A1 illustrates this so-called *patent prosecution process*. Each patent application is first assigned to an *art unit* consisting of a group of patent examiners who specialize in the technology fields related to the patent application. The relevant art unit then allocates the application to an *examiner* within the unit, who is responsible for determining whether the patent meets USPTO's requirements for novelty, non-obviousness, and usefulness.[6] Finally, the assigned examiner reviews the application and evaluate the patentability of the claimed invention.

A patent examiner typically chooses between two possible *initial office decisions*: a *notice of allowance*, which opens the door to patent granting, or a *non-final rejection*, which requires further revisions by the applicant. In practice, over 80% of initial decisions are non-final rejections. The examiner then issues a *letter of office action* to the applicant, outlining a detailed justification for the office decision. In the event of a non-final rejection, the applicant has six months to revise and re-submit the application. In an iterative process, the examiner can then issue a notice of allowance or another rejection. Patent applications ultimately end in either *approval* or *abandonment* if the applicant does not re-submit.

While the allocation of patents to art units is deterministic based on the patent's technology class, the choice of examiner within an art unit exhibits a high degree of randomness. In particular, as Lemley and Sampat (2012) and Sampat and Williams (2019) point out, there is little evidence to suggest that a uniform procedure is implemented by all art units when assigning patent applications to examiners. Instead, each art unit normally adopts different rules, many of which would be functionally equivalent to random assignment. For example,

[5]See US Patent Statistics Chart, Calendar Years 1963 - 2020.

[6]General Information Concerning Patents of the USPTO website provides a brief introduction of the conditions for obtaining a patent.

some art units assign patent applications to particular examiners based on the last digit of the application serial number (Lemley and Sampat 2012). Coupled with significant variation in the conditional probability of granting a patent across examiners, this degree of randomness will be key to our empirical identification strategy as we discuss below.

2.2 USPTO Patent Data

The USPTO Patent Examination Research Dataset (PatEx) provides detailed information on all publicly viewable patent applications from 2001 through 2020.[7] For the purposes of this study, we obtain the universe of patent application and examination records for inventors located in mainland China for the period of 2001-2016. This choice of time horizon is governed by the coverage in other data sources we use as described in the next subsection.

We first extract PatEx information for all utility patent applications that are either granted or abandoned between 2001 and 2016.[8] Crucially, we observe the filing date, outcome (issuance or abandonment), and examiner identity for each patent application, as well as the examination history of the inventor.

We then utilize the residence information in the inventor data to restrict the sample to incorporated assignees (i.e. firms rather than individuals) that are located in mainland China.[9] We later use the name of the patent assignee names to match PatEx to Chinese customs data.

Finally, we identify the initial office decision for each patent from the transaction history data for each patent prosecution process, which includes the outcome at each examination step. We define the first Notice of Allowance or the first Non-final Rejection, whichever takes place first, as the first action taken by the examiner for each patent application. We focus on this decision in our baseline empirical analysis to guard against potential sample selection due to attrition of reject-and-resubmit applicants.

Key to the empirical analysis is identifying the first US patent application of each Chinese firm. To this end, we standardize assignee names in PatEx in order to track them over time, and exclude assignees with any patent records prior to 2001. We then define the first US patent application for each remaining applicant as the application with the earliest filing date.

Of note, the USPTO began reporting the names of applicants on rejected applications in 2001. Our definition of a firm's first patent application might therefore be left censored, as

[7] For an introduction of the USPTO PatEx Dataset, see Patent Examination Research Dataset (PatEx).

[8] We exclude pending applications and Patent Cooperation Treaty (PCT) applications. We are unable to acquire identity information of rejected applications before the American Inventors Protection Act came into force in 2000, as per Sampat and Lemley (2010). USPTO's Patent Application Information Retrieval (PatEx) system provides no data on applications abandoned before public disclosure (18 months after initial filing), which accounts for around 15% of unsuccessful applications, see Farre-Mensa *et al.* (2020).

[9] Some patent applications have multiple inventors, and we include them in our sample as long as at least one of the inventors is associated with a Chinese firm. We exclude applicants from Hong Kong, Macao, and Taiwan. We associate each application with the firm that originally submitted it, although the patent assignee (i.e. owner of the patent) can in principle change over time.

we are not able to verify if an applicant has filed unsuccessful applications prior to 2001. This would arguably occur infrequently, since only a few Chinese companies filed with USPTO before the early 2000s when China emerged on the global scene. Moreover, we later show that the first granted US patent generates much more significant export expansion than subsequent patents. To the extent that we fail to observe applications prior to 2001, this would if anything bias our estimates downwards, as we might falsely ascribe moderate export expansion following second or future patents to a first patent grant.

2.3 Chinese Customs and Production Data

The Chinese Customs Trade Statistics (CCTS) cover the universe of export and import transactions in China from 2000 to 2016. The raw data provides rich information at the firm-HS8 product-country transaction level, including the trade value, quantity, regime (ordinary, processing with imports, pure assembly), and transportation type (e.g. land, air).[10]

We are interested in the impact of US patent awards on the export performance of Chinese manufacturers. We therefore focus on export transactions under the ordinary and processing-with-imports trade regimes, as both imply full ownership and control over all inputs and production stages. On the other hand, we drop pure-assembly trade flows that entail assembly according to the designs of and with both inputs and distribution provided by a foreign party.[11] We aggregate the transaction data to the level of the firm or firm-HS6-destination in different steps of the analysis.[12]

We manually match CCTS export data to USPTO patent records in PatEx based on firms' name and location. This process involves translating the PatEx names of applicant companies into Chinese. First, we translate the keywords within the English names into Chinese, and then search the publicly available Chinese company registration database, *Tianyancha*, to find any possible matches. To validate the matched outcomes, we cross-check each candidate's location and main industry of activity against those reported in the patent records. Last, we search the CCTS data for the exact Chinese name of the company in order to obtain its customs identifier.[13]

We further merge the CCTS-PatEx matched sample with the Annual Survey of Industrial Enterprises (ASIE) data, which covers all above-scale manufacturing enterprises in China from 2000 to 2013.[14] ASIE provides standard balance-sheet characteristics of firm operation, such as sales, employment, and operating profits, which we consider in robustness and extension exercises.

[10] Quantity information is missing for year 2016.

[11] Our main findings are robust to further restricting the sample to only ordinary exports or to enlarging the sample to also include pure-assembly exports.

[12] The Harmonized System (HS) is an internationally standardized system that classifies traded products.

[13] We provide an example of the matching procedure in Appendix B.

[14] The ASIE data includes all industrial enterprises (Mining, Manufacturing, and Utilities) with annual sales above 5 million RMB (20 million RMB after 2011).

2.4 A First Glance at the Data

Figure 2 provides an overview of Chinese patent activity in the US and the success rate of the CCTS-PatEx match. It reports the total number of first-time applicants from China in PatEx and the number of such applicants that are in the matched CCTS-PatEx data for each year between 2001 and 2016. The CCTS-PatEx matched data comprises 2,831 unique CCTS exporters that ever applied for a US patent during the sample period. The number of PatEx applicants from China and the number of CCTS-PatEx matched applicants have been growing fast during the last two decades, from less than 20 in 2001 to around 1000 and 500 respectively in 2016. Furthermore, more than 50% of Chinese applicants in the USPTO patent application records can be matched to the CCTS data in any given year, suggesting that the majority of US patent applicants from China engage in export activities. Nevertheless, these CCTS-PatEx matched applicants from China account for a negligible proportion of all Chinese exporters: Only about 1% of all exporters in 2016 have ever applied for a US patent.

[Figure 2]

Table 1 presents summary statistics for the CCTS-PatEx matched sample and compares them with other exporters in the CCTS data. Exporters who file for a US patent differ in almost every respect from other exporters: On average, they report two times larger total exports, and direct a bigger share of their exports to the United States (22% vs. 14%). Furthermore, CCTS-PatEx exporters sell a broader range of products to more destinations, with substantially higher average exports per product-destination pair.

[Table 1]

One potential concern is that patent applications may be concentrated in only a few technology fields, such that any effect of patent grants on export performance may be specific to those technologies. A related concern is that the composition of patents and industries in the CCTS-PatEx matched sample may differ from that of all Chinese firms filing with the USPTO. Table A1 provides little indication for such concerns. We report the share of patent applications in the top 10 technology classes across all first-time Chinese applicants to the USPTO, as well as for the subset of these applicants in the CCTS-PatEx matched sample. In both samples, there is significant diversification across technology classes, as the top 10 account for under 25% of all applications. Also in both samples, the most frequent patent technology classes are pharmaceuticals, molecular- and micro-biology, and electrical systems, components and devices.

3 Estimation Strategy

We are interested in evaluating and understanding the effects of obtaining a patent in the US on the export performance of Chinese firms. To this end, we first exploit unique features of our empirical context to agnostically identify and quantify the causal effect of a first successful US patent application on the subsequent export growth of Chinese manufacturers (Section 4). We then conceptually outline and empirically examine several possible economic mechanisms that could rationalize it (Section 5). This section introduces the estimation strategy that underpins Sections 4 and 5.

Our analysis of the effects of patenting on export success is fundamentally motivated by broader conceptual questions. In particular, we shed light on why foreign firms choose to patent conditional on innovation and what challenges firms from emerging economies face in the global marketplace. A large literature has examined the drivers and impact of innovation activity, and a separate literature has considered the two-way relationship between trade and innovation. We shift focus instead to the role of patenting, and specifically the channels through which patenting can strengthen firms' export performance even conditional on their innovation prowess. The case of US and China is especially relevant to study, both because these countries have been among the top-3 trading economies in the past decade and because they emblematize an advanced economy with strong institutions and an emerging economy undergoing rapid structural transformation.

Estimating the trade impact of patent activity, however, poses identification challenges. Recall from Table 1 that Chinese firms filing for a US patent are very different from Chinese firms that do not, such that one cannot simply compare their export performance. One concern is omitted variable bias: the decision of applying for a U.S. patent might be correlated with the Chinese applicants' unobserved characteristics, such as its production efficiency or technological competencies. Another concern is reverse causality: firms' potential foreign market access or expansion opportunities may also boost their current innovation intensity.

The US-China context we exploit allows us to overcome this econometric challenge. Instead of the impact of innovation on export performance, we will evaluate the impact of a successful patent application, by comparing the export performance of patent applicants whose application has been approved vs. denied for arguably exogenous reasons related to the assignment of patent examiners. In other words, rather than comparing innovative firms to their non-innovative peers, our treatment and control groups will both be highly innovative firms that are quite similar prior to their first US patent filing.

3.1 Empirical Specifications

We estimate the impact of a successful first USPTO application on the export performance of Chinese firms with the following baseline specification:

$$\Delta_k EX_{it+k} = \beta \cdot \mathbb{1}(\text{SuccessFirstApp} = 1)_{iajt} + \Gamma Z_{it} + \lambda_{s\tau} + \epsilon_{it}, \tag{1}$$

where i indexes Chinese firms, s denotes i's main industry of activity, τ indicates the year when i filed a USPTO application for the first time, and t marks the year of the first action (i.e. initial outcome) on this application. Subscripts a and j correspond respectively to the USPTO art unit that was assigned to i's first patent application based on its technology class and to the specific examiner in that art unit who reviewed the application. The binary variable $\mathbb{1}(\text{SuccessFirstApp} = 1)_{it}$ takes the value of 1 if this first patent application is approved in the first round at time t, and 0 otherwise. We cluster standard errors at the art-unit level, to allow for potentially correlated decision making across examiners within the same art unit.

In the baseline, we focus on the first US patent application a firm files for two reasons: the rare incidence of patent activity, and the potentially confounding effects of multiple applications over time. The sample in Specification 1 is thus all Chinese firms that have filed at least one US patent application in the matched CCTS-PatEx data, while the unit of observation is firm i with its first USPTO file. We later explore the role of subsequent patents as an extension.

The key outcome of interest is the growth in firm i's worldwide exports EX_it within k years of its first US patent application, from t to $t+k$. We set $k = 3$ in the baseline, and perform sensitivity analysis on this horizon. Formally, $\Delta_k EX_{it+k}$ is defined as:

$$\Delta_k EX_{it+k} = \frac{EX_{it+k} - EX_{it}}{0.5(EX_{it+k} + EX_{it})}. \quad (2)$$

The main coefficient of interest, β, in principle captures firm export growth that can be attributed to the granting of a US patent. To be precise, we examine export expansion from the first-action year t onward. As Carley *et al.* (2015) note, a first-action letter provides detailed feedback from the examiner, and serves as a critical signal of the application's likelihood of ultimate success. Therefore, the effect of a patent grant would emerge following the resolution of uncertainty by a first-action letter. In contrast, the initial filing date, which usually occurs 1.5-2 years before the first action, clearly predates any patent grant effects. The ultimate grant date for successful applications - which may or may not be the first action date - is likewise problematic, as it is endogenously determined by the applicant's actions.

Specification 1 includes a series of control variables that account for various firm, sector and macro conditions that may influence trade performance independently of patent activity or patent grant success. First, focusing on export growth relevant to a firm's application date is equivalent to first-differencing export levels in an event-study regression. We are thus implicitly removing level effects of any intransient firm characteristic and any time-variant firm attribute at the time of application. This includes, for example, the firm's productivity level, management practices, quality standards, export experience, and innovation activity.

Second, we allow for the possibility that firm characteristics such as productivity, size, ownership type, or export experience may exert growth effects by conditioning on a set of time-varying firm controls, Z_{it}. In the CCTS-PatEx matched sample, these include firm i's log worldwide exports and export tenure (years since the firm is first observed in the CCTS customs records) in application year t. In the CCTS-ASIE-PatEx matched sample, we further control for log employment as a proxy for size.

Finally, we add a rich set of fixed effects that absorb supply and demand factors exogenous to the firm that may shape export growth. Note this is significantly more stringent than standard fixed effects in levels regressions, both because these now take out systematic variation in growth rates rather than level shifts, and because they account for the (potentially changeable) degree of such systematic variation in the year specific to each firm's first application. In particular, we control for $\lambda_{s\tau}$ industry-application year pair fixed effects. In the broader CCTS-PatEx matched sample, we observe the universe of a firm's export transactions by HS-8 product, and define its primary industry of affiliation as the HS-2 sector with the highest share in its export basket. In the CCTS-ASIE-PatEx matched sample, we use instead the firms' reported main industry of activity at the CIC 2-digit level. In this sample, we are also able to account for time-varying systematic differences across firms of different ownership types (private domestic, state-owned enterprise, foreign affiliate) with ownership-application year pair fixed effects.[15]

As a first step towards unpacking underlying mechanisms, we decompose total export growth in three different ways to document the evolution of its components. We first examine the composition of firms' export portfolio, and decompose export growth into adjustments along the intensive margin of surviving destination-HS6 product markets and along the extensive margin of new or dropped markets:

$$\begin{aligned}
\Delta_k EX_i &\equiv \frac{EX_{ik} - EX_{i0}}{0.5(EX_{ik} + EX_{i0})} \\
&= \underbrace{\frac{\sum_{\omega \in \Omega_i 0}(x_{i\omega k} - x_{i\omega 0})}{0.5(EX_{ik} + EX_{i0})}}_{Incumbent} + \underbrace{\frac{\sum_{\omega \in \Omega_{ik} \setminus \Omega_i 0} x_{i\omega k}}{0.5(EX_{ik} + EX_{i0})}}_{New} \\
&= \underbrace{\frac{\sum_{\omega \in \Omega_{ik} \cap \Omega_i 0}(x_{i\omega k} - x_{i\omega 0})}{0.5(EX_{ik} + EX_{i0})}}_{Continue} - \underbrace{\frac{\sum_{\omega \in \Omega_{i0} \setminus \Omega_i k} x_{i\omega_0}}{0.5(EX_{ik} + EX_{i0})}}_{Drop} + \underbrace{\frac{\sum_{\omega \in \Omega_{ik} \setminus \Omega_i 0} x_{i\omega k}}{0.5(EX_{ik} + EX_{i0})}}_{New},
\end{aligned} \tag{3}$$

where $\Omega_i 0$ and $\Omega_i k$ represent the set of a firm's destination-product relationships respectively at times $t = 0$ and $t = k$. $x_{i\omega t}$ denotes the value of a firm's exports to a destination-product market ω in year $t \in \{0, k\}$. We focus mainly on the two-part decomposition into "incumbent" and "new" components, with the former combining expansion into maintained markets (the "continue" component) and contraction through market exit (the "drop" component).

In a second decomposition exercise we assess the contribution of different product and destination types:

[15] Unlike Sampat and Williams (2019) and Farre-Mensa *et al.* (2020), we do not directly control for art-unit by year fixed effects due to a large occurrence of singleton groups. Instead, we accommodate similar forces by including art-unit by first-action year pair fixed effects when we construct the instrumental variables below.

$$\Delta_k EX_i \equiv \frac{EX_{ik} - EX_{i0}}{0.5(EX_{ik} + EX_{i0})} = \frac{\Sigma_{p\in P}\Sigma_{d\in D}(EX_{ipdk} - EX_{ipd0})}{0.5(EX_{ik} + EX_{i0})}, \tag{4}$$

where p denotes product categories (e.g. differentiated versus non-differentiated products), and d references destination categories (e.g. high-income versus low-income countries). EX_{ipd0} is then defined as the total value of a firm's exports of product category p to destination category d.

In a third and final decomposition exercise, we estimate the impact of a firm's successful first application on export activity at the product-destination level. While this analysis does not constitute an exact decomposition of export growth, it has the same flavor of revealing adjustments to an exporters' portfolio of markets. We estimate a modified version of Specification 1:

$$\Delta_k EX_{ipdt+k} = \beta' \cdot \mathbb{1}(\text{SuccessFirstApp} = 1)_{it} + \Gamma' Z_{ipdt} + \lambda_{p\tau} + \lambda_{d\tau} + \epsilon_{ipdt+k}, \tag{5}$$

where p indexes HS6 products and d destination countries. We focus on two export outcomes ($\Delta_k EX_{ipdt+k}$): a binary indicator for the survival of an incumbent destination-product market, and the growth in the value of exports for surviving markets. At this more disaggregated level of analysis, we expand the set of control variables, Z_{ipdt}, to the firm-product-destination-year level. In particular, we now control not only for the firm's overall log export value and export tenure at time t, but also for it's log export value and relative export tenure in the specific destination-product market at t[16]. We likewise include a richer set of fixed effects. In place of the HS2 industry-application year fixed effects in Specification 1, we now condition on a full set of HS6 product-application year and destination-application year fixed effects, $\lambda_{p\tau}$ and $\lambda_{d\tau}$. We continue to cluster standard errors at the art-unit level.

We present baseline results for Specifications 1 and 5 in Section 4. In Section 5, we then perform two types of additional analyses in order to examine several economic mechanisms of interest. First, we re-estimate Specification 1 separately for different sub-samples of products and destinations, after aggregating the raw data across relevant subsets of products and countries to the firm-year level.

Second, we operationalize a modified version of Specification 5 at the firm-product-destination-year level, where we consider the differential effect of a successful first US patent application within a firm and product type across country categories. To this end, we split the sample of firm-product-destination-year observations by product type, and interact the main indicator variable of interest, $\mathbb{1}(\text{SuccessFirstApp} = 1)_{it}$, with a relevant country characteristic, Z_d. We add a full set of firm fixed effects, λ_i, which now subsume the role of log exports and export tenure at the firm level, while continuing to condition on firm-product-

[16]Relative export tenure is defined as the product-destination specific tenure divided by the firm's export tenure.

destination-year log exports and relative export tenure, as well as product-application year and country-application year pair fixed effects:

$$\Delta_k EX_{ipdt+k} = \beta^{DD} \cdot \mathbb{1}(\text{SuccessFirstApp} = 1)_{it} \cdot Z_d + \Gamma^{DD} Z_{ipdt} + \lambda_i + \lambda_{p\tau} + \lambda_{d\tau} + \epsilon_{ipdt+k}. \quad (6)$$

3.2 Identification

The coefficient of interest in Specification 1, β, should in principle reflect the average treatment effect (ATE) of a successful first US patent application on an applicant's overall export growth. Analogously, coefficient β' in Specification 5 should capture the ATE on a firm's export growth within a specific destination-product market, accounting for market-specific supply and demand conditions. The difference-in-differences coefficient β^{DD} in Specification 6 would in turn quantify the effect of a granted patent on the within-firm reallocation across destination and product markets.

OLS estimates of these coefficients could however be biased, since both export growth and patent application outcomes might be correlated with unobserved firm characteristics, such as firms' inherent innovation capacity or realized innovation quality. To identify the causal effect of a successful first patent application, we exploit the random allocation of applications to specific examiners within an assigned art unit, combined with systematic variation in examiner leniency that is exogenous to the applicant and to the allocation process. In particular, we follow Sampat and Williams (2019) and Farre-Mensa *et al.* (2020) and instrument the outcome of a firm's first US patent application, $\mathbb{1}(\text{SuccessFirstApp} = 1)_{it}$, with a measure of the ex-ante expected approval rate of its randomly assigned USPTO examiner.

Patent examiners have been shown to vary substantially in their propensity of approving patents (Lemley and Sampat (2012)). In other words, given the quality of an invention, its patent application is more likely to be approved if it is assigned to a more lenient examiner. Following Farre-Mensa *et al.* (2020), we construct a measure of examiner leniency relevant to a specific application based on their examination history prior to reviewing that application:

$$ApprovalRate_{iajt} = \frac{\#Granted_{iajt}}{\#Examined_{iajt}}.$$

Here $\#Examined_{iajt}$ and $\#Granted_{iajt}$ denote respectively the number of patents that examiner j has examined and granted prior to making a first-action decision on application i in year t. This measure is thus unique to each patent application, and reflects the examiner's *ex ante* propensity of approving a newly received application.

As noted earlier, the USPTO assigns patent applications to the art unit specializing in the technology field of the underlying invention. In contrast, there are no explicit rules governing the assignment of applications to examiners within each art unit, such that it is quasi-random and can be viewed as a lottery (Farre-Mensa *et al.* 2020). Nevertheless, one may be concerned that approval rates vary systematically across art units and over time. Although it is arguably unlikely that firms have such real-time information and capacity to quickly act on it, they may in principle strategically time their patent application. To address this concern, we demean examiners' approval rates by art unit and first-action year. Figure A2 confirms that the distribution of the residualized approval rates, $\widehat{ApprovalRate}_{iajt}$, is highly dispersed.

[Table 2]

Table 2 demonstrates that $\widehat{ApprovalRate}_{iajt}$ is indeed a strong predictor of a firm's first patent application outcome, $\mathbb{1}(\text{SuccessFirstApp} = 1)_{it}$, and thus fulfills the relevance criteria of a valid instrument. In particular, we report first-stage regressions for the subsequent second-stage IV estimation of Specification 1. We present results separately for the full sample of CCTS-PatEx matched firms and the subsample of CCTS-ASIE-PatEx matched firms, where we include the same set of fixed effects and progressively richer firm-year controls as in Specification 1. A 1 percentage-point increase in the examiner's residualized ex-ante approval rate induces $0.95-0.97$ percentage point higher likelihood of a patent grant. These effects are consistently highly statistically significant at 1%. At the granular level of patent applications, Figure A3 verifies that the kernel density distribution of examiners' ex-ante approval rates for ex-post approved applications is a shift to the right compared to ex-post rejected applications.

Balance tests indicate that the residualized patent approval rates are uncorrelated with observed ex-ante exporter characteristics. This lends credibility to the assumption of quasi-random allocation of patents to examiners that underpins the instrument's exclusion restriction. In Table 3, we regress a series of firm attributes as of the first-action year alternatively on $\mathbb{1}(\text{SuccessFirstApp} = 1)_{it}$ or $\widehat{ApprovalRate}_{iajt}$, controlling for the same set of fixed effects as in Specification 1. We find that neither variable is systematically correlated with firm profits, sales, employment, exports, number of export products, number of export destinations, and average exports per destination-product, with the exception of a weak negative correlation between product scope and first application success (but importantly not with the instrument).[17]

[Table 3]

Righi and Simcoe (2019) point out that the matching of patent applications to examiners may not be completely random due to examiner specialization. They recommend conducting validation tests on the first-stage estimation that control for additional examiner characteristics, to examine whether the magnitudes of the estimated coefficients remain stable. In Table A3, we perform several such additional validation tests. We condition on examiner experience by adding the number of Chinese, foreign, and all patent applications she has reviewed as of the first-action year. We also construct an alternative residualized approval

[17] Table A2 conducts additional balance tests on the product and country composition of firm exports. While successful and unsuccessful applicants differ along a few dimensions (such as their share of exports to the US or OECD countries), the residualized examiner approval rate is uncorrelated with all composition measures, except for the export share of products that are technologically related to the patent application. We have confirmed the robustness of the baseline results to additionally controlling for this variable.

rate measure that takes out both art unit by first-action year fixed effects and technology class by first-action year fixed effects. As expected, the latter is significant in its own right only when $\widehat{ApprovalRate}_{iajt}$ is omitted. The estimates for β range in the narrow band of 0.8 to 1 and within 10% of the baseline in Column 1. Therefore, the allocation of patent applications to examiners appear to be largely exogenous, at least in our sample of Chinese applicants. This is realistic given China's small share of all USPTO filers.

4 Effect of First US Patent on Export Growth

We begin the empirical analysis by agnostically establishing that a successful first US patent application significantly increases firms' subsequent export growth. We isolate this causal effect using the identification strategy from Section 3 and a series of robustness checks. We also examine the response of different trade margins to set the stage for exploring the mechanisms that give rise to patent effects in the next section.

4.1 Baseline Results

We first examine how the value of exports by successful and unsuccessful first-time Chinese applicants for a US patent evolves after the initial decision on their application in the raw data. Figure 3 depicts the average export growth trajectory for both sets of applicants over a five-year horizon. Successful applicants realize an 18.8% export growth one year after the first action, to reach cumulative growth of about 30% within five years.[18] In sharp contrast, the exports of unsuccessful applicants remain almost unchanged in the first four years, and rise by 11.1% after five years. This persistent difference in export growth between successful and unsuccessful patent filers suggests that the first US patent grant is associated with favourable export performance both in the short run and in the long run.

[Figure 3]

Table 4 presents the baseline results for Specification 1. We consider in turn the full sample of CCTS-PatEx exporters (Columns 1-3) and the subsample of CCTS-ASIE-PatEx matched exporters (Columns 4-6). In each sample, we report estimates from both a naive OLS regression and a 2SLS regression instrumenting the indicator for a successful first US patent application with the residualized examiner's approval leniency. We condition on a full set of HS2 industry by year pair fixed effects in the CCTS-PatEx data, and a richer set of both CIC2 industry by year and ownership type by year pair fixed effects in the CCTS-ASIE-PatEx data. We explore the stability of the results to controlling for initial log exports to account for potential convergence or divergence, as well as for export tenure to accommodate life-cycle dynamics. In the CCTS-ASIE-PatEx panel we further add log employment as a proxy for firm size. We cluster standard errors by art unit, to permit correlation in decision outcomes across applications examined within the same art unit.

[18] 70.4% of applicants in our sample received final decisions (granted or rejected) within one year after the first-action date.

[Table 4]

We estimate consistently large, positive effects of a successful first US patent application on the future export performance of Chinese applicants. Naive OLS estimates suggest that patent recipients experience 6-6.7 percentage points higher annualized 3-year export growth than rejected applicants. These estimates are highly significant at least at the 5% level. The 2SLS results indicate even larger causal effects significant at the 1%: A successful first patent application triggers 17.4-17.8 percentage points faster annual growth in the CCTS-PatEx sample, and grants as much as a 20.4-21.8 percentage point advantage in the CCTS-ASIE-PatEx subsample. The findings are generally not sensitive to the choice of firm controls.[19]

It is noteworthy that the 2SLS estimates in Table 4 are about three times bigger than the OLS estimates. One possibility is that OLS is subject to downward omitted variable bias due to unobserved firm or patent quality. Standard models of firm heterogeneity would predict that inherently better firms have both superior export performance and higher innovation quality. This might generate a positive correlation between export levels and the likelihood of a patent grant. Whether it also implies a positive correlation between export growth and patent grant would, however, depend on assumptions about the export dynamics path. Separately, firms may differ along two dimensions - production efficiency and innovation capacity - that can in principle be negatively correlated with each other. But even if these are positively correlated in the long run or there is a single dimension of firm heterogeneity, there may be a trade-off between export and innovation success, at least short-term, because of limited managerial attention, financial constraints or capacity constraints. These are examples of forces that can introduce negative bias in the baseline OLS regression.

A second possible explanation for the larger IV estimates is that they identify the causal local average treatment effect (LATE) of the patent grant on export growth, while OLS quantifies an average treatment effect (ATE). The LATE could be larger if exporters whose patent applications are marginally approved or rejected by USPTO examiners are more responsive to the patent grant event than the average exporter who applies for a US patent. In this case, the 2SLS approach of course still delivers more reliably causal and unbiased estimates, but they would need to be interpreted with caution when extrapolating to patent impacts across the full firm distribution.

4.2 Margins of Adjustment

How do Chinese firms expand exports following a successful US patent approval? We now examine how firms adjust along different margins, in order to guide our subsequent analysis of the mechanisms through which patent grants stimulate trade activity. We present results only for the CCTS-PatEx sample in the interest of space; similar patterns obtain in the matched CCTS-ASIE-PatEx subsample.

[19] Interestingly, this magnitude is comparable to Farre-Mensa *et al.* (2020), who estimate that a successful first US patent application leads to a 80% higher 5-year sales growth in US start-up firms.

First, our baseline analysis focuses on export growth in the 3 years after a positive patent review. To explore the evolution of this response over time, we perform a more flexible event study. We conclude that the baseline 3-year horizon is informative, as the effects of a patent grant materialize quickly and are relatively stable 5 years out.

We visualize the event-study analysis in Figure A4. We redefine the unit of observation to be the firm-year, and follow the log export level (rather than export growth rate) of first-time patent applicants from five years before to five years after their first-action year. We estimate the export differential between successful and unsuccessful candidates for each year in this 11-year event window using an OLS regression with the same fixed effects as the baseline. The analogous event study for the 2SLS specification is a reduced-form OLS regression with the patent examiner leniency in place of the patent award indicator. Reassuringly, we find no significantly different pre-trends between successful and unsuccessful applicants, nor between applicants assigned to examiners with different approval rates. After the patent event, by contrast, the exports of applicants with granted patents and with relatively lenient examiners expand significantly compared to those respectively with rejected applications and with relatively strict examiners. Moreover, the export gap opens quickly within 2 years of the patent decision, and remains stable thereafter.

Second, our baseline considers the effect of a successful first US patent application for two reasons. Conceptually, we conjecture that the first patent grant is the most critical event, compared to potential subsequent applications. Moreover, patent activity is in practice rare in the full population of Chinese exporters, while 39.6% of patent applicants in the CCTS-PatEx panel file multiple times with USPTO. Pooling the effects of all firm patents or comparing the effects of first, second, third, etc. patents may thus be subject to sample selection bias, confounding effects across applications, or weak identification power.

For completeness, we explore the role of a successful second patent application in Table A4. The sample is now reduced to the second patent filing of 409 Chinese exporters that have submitted at least two USPTO applications, regardless of the outcome of their first one. Consistent with our conjecture, a successful second patent review exerts a much smaller effect on annualized 3-year export growth (2.1%-2.6%) than the first patent grant, and the 2SLS estimates are statistically insignificant.

Third, we assess the impact of a successful first US patent application on different trade margins. As shown in Table A5, a patent award triggers an expansion along both the extensive and the intensive margins of exports. In particular, patent recipients do not broaden their overall product portfolio or country reach, but they do offer their existing products to more of their active destinations (which can occur through more entry and/or less exit). They also increase sales in incumbent destination-product markets. In terms of annualized 3-year growth rates, the number of markets and average exports per market grow respectively 7.97% and 11.6% faster for successful applicants than for rejected applicants.

[Table 5]

Finally, we decompose firm-level export growth into constituent margins, and evaluate the response of each component by way of an accounting exercise, as per equation 3. Table 5 reports the impact of a first US patent grant on the incumbent and new export components in terms of pre-existing and newly added destination-product markets; we present only 2SLS results to economize on space. Fully 87.6% (0.156/0.178) of the overall export effect is driven by growth in the incumbent component, and the point estimates are statistically significant at 1%. The new component explains only 12.4% (one eighth), and the point estimates are statistically insignificant. Further explorations in Table A8 reveal that the growth in the incumbent component reflects both improved survival of existing destination-product links and expansion in continuing destination-product markets in equal measure.[20] Since we do not observe the identity of foreign buyers, the results are thus consistent with the granting of a US patent enabling exporters to establish trade relationship with new customers and/or increase sales to existing customers, both within existing destination-product markets.

To further unpack these margin adjustments, we analyze the survival probability of incumbent export flows and the behavior of export value, price and quantity of continuing export flows at the firm-product-destination level. Table 6 reports the results from estimating a version of Specification 6 with a full set of HS6 product by year and destination by year pair fixed effects. This is a more stringent specification in that it accounts for supply and demand conditions not just across broad industries, but within narrower segments of the global economy. We purposefully do not add firm fixed effects, to make this margin analysis comparable to the baseline. However, we do control for the initial log export value at both the firm and the firm-product-destination level, as well as for the overall export tenure of the applicant and the relative tenure of the specific product-destination flow in the applicant's export portfolio.

[Table 6]

Even at this granular level of analysis, we continue to observe that successful patent applicants have a much greater probability of maintaining existing destination-product markets and grow their export sales faster in continuing markets than unsuccessful applicants. Although sizeable, the point estimates are statistically insignificant in the baseline IV regressions that give equal weight to all firm-product-destination triplets (Columns 2 and 4 in Panel A). However, they become larger and statistically significant at conventional levels when we account for the skewed distribution of firms' export portfolios and weight observations by their firm-specific initial export share (Columns 3 and 6 in Panel A): A successful first application causally improves the survival rate of incumbent export flows by 14.9% and the value growth of surviving relationships by 23.5%. The stronger weighted-IV results suggest that patent grants are especially beneficial for the core destination-product markets in a firm's export basket, rather than its peripheral links. Panel B in turn examines the sources of export value growth in maintained destination-product markets. Export expansion occurs entirely through higher quantities traded, while export prices barely move.

[20]Table A9 repeats the decomposition exercise in the CCTS-ASIE-PatEx subsample. The point estimate on the new component becomes statistically significant at 5%, but still explains only 24% of the overall export growth effect.

In sum, a first US patent grant significantly stimulates firms' export growth by raising firms' survival probability in incumbent destination-product markets and by increasing export quantites and thereby export sales in surviving markets. These effects are large, materialize quickly and persist 5 years out, and considerably muted for any subsequent patent approvals.

4.3 Sensitivity Analysis

We have confirmed the robustness of the baseline results to several sensitivity checks. We begin with a placebo test whether export growth over the three years prior to a patent grant ”responds” to the award of a first successful US patent. Recall from the balance tests (Table 3) and event study (Figure A4) that successful and unsuccessful patent applicants have similar ex-ante export trends. Consistent with this, both the OLS and IV placebo estimates in Table A6 are small in magnitude and statistically insignificant. This provides further assurance that the baseline results are unlikely to be driven by unobserved correlation between ex-ante determinants of export performance and USPTO decisions.

We next demonstrate in Table A7 that our findings are robust to a number of alternative specifications. Column 1 replicates the baseline regression from Column 3 of Table 4 for reference. Column 2 uses an alternative instrumental variable, whose construction ignores the art unit by year and technology class by year pair fixed effects that account for technology-specific factors in the baseline IV. Column 3 instead controls for additional examiner characteristics following Righi and Simcoe (2019), namely their years of experience and log number of foreign and of Chinese patents reviewed. Columns 4-6 experiment with different sets of fixed effects at the level of the application year, first-action year, and HS2 by first-action year, in place of the baseline HS2 by application year fixed effects. All estimates remain highly statistically significant and quantitatively similar across perturbations.

5 Impact Mechanisms

We next explore possible mechanisms that could give rise to the significantly positive impact of a successful first US patent application on the subsequent export growth of Chinese firms. We discuss the micro-foundations of each mechanism, and state their distinctive predictions as testable hypotheses that we then take to the data. It is important to emphasize that these mechanisms are not mutually exclusive, such that our goal is to assess the presence and magnitude of each one.

We establish that the effects of a patent cannot be easily attributed to the protection of a firms' (i) monopoly power, which patent rights might grant in the first instance. Instead, we find evidence consistent with a US patent acting as both a (ii) product quality signal and a (iii) firm credibility signal that reduce asymmetric information about a firm's output quality and contractual trustworthiness, respectively. Additional analysis reveals no support for three other possible mechanisms related to (iv) financial frictions, (v) strategic patenting, and (vi) follow-on innovation.

5.1 Monopoly Power

By definition, a patent grants the patent owner the exclusive rights to the use of a new technological solution (invention) for a specified period of time. Thus, a natural conjecture is that patents bestow monopoly power that allows the inventing firm to charge higher prices and gain monopoly profits (Kogan *et al.* 2017; Kline *et al.* 2019; Balasubramanian and Sivadasan 2011). Since a patent granted by the USPTO to a Chinese firm has legal recognition only in the US market, this monopoly power mechanism would imply that the Chinese firm might be able to charge a higher export price and thereby earn higher export revenues in the US, but not in other markets. Moreover, these effects should be confined to the products that are directly covered by the patent, but not carry over to other products:[21]

Hypothesis 1 (Monopoly Power) US patent rights strengthen exporters' monopoly power and sales of protected products in the US market, but not of other products or markets.

To test this hypothesis, we examine whether the baseline patent effect on exports is driven by the technologically related products sold in the US and whether the values and prices of those export flows are improved. This requires a mapping between a firm's patent application and the products in its portfolio that are covered by the patent rights. In practice, patents are categorized according to USPC technology classes, while trade flows are observed in the HS 6-digit product classification system. We use the USPC-HS6 crosswalk from Goldschlag *et al.* (2020) to identify "technologically related" products that are potentially protected by the patent application (i.e. products with ALP weights $> 5\%$).[22]

We perform two exercises to test Hypothesis 1. We first implement an exact decomposition of firms' export growth following equation (4), where we distinguish between exports to the US and to the rest of the world (ROW) and between products related and unrelated to the firm's patent application. We then estimate the effect of a successful first US patent application on the export growth of Chinese applicants by destination or product type (Panel A in Table 7) and alternatively by destination-product type pair (Panel B in Table 7). We use the CCTS-PatEx sample and the same fixed effects and controls as in the baseline.

The monopoly power mechanism would imply that the overall patent effect should be driven primarily by the expansion of exports of patent-protected products to the US. Instead, we find that it reflects mainly an increase in exports to ROW rather than the US and in exports of unrelated rather than related products (Panel A in Table 7). In fact, the biggest boost is

[21] Complementarity or substitution in consumption could in principle increase or decrease sales of other products in the firms' portfolio. The systematic patterns we establish through our difference-in-differences estimation strategy make it unlikely that such spillover effects could resuscitate the monopoly mechanism.

[22] The Algorithmic Links with Probabilities (ALP) weights are developed using the methodology from Lybbert and Zolas (2014) as follows: (1) Compare keywords in HS 6-digit industry descriptions with keywords in patent abstracts; (2) Tabulate the number of patents for each Cooperative Patent Classification (CPC) group to industry/product classification combination based on the m-to-m matches; (3) Re-weight the results using a modified Bayesian weighting scheme, the hybrid weighting approach, which increases the weights of specific matches and reduces the weights of generalized matches. For details, see Lybbert and Zolas (2014) and Goldschlag *et al.* (2020).

to exports of unrelated products to the ROW, while the gain in exports of related products to the US is substantially weaker in magnitude and significance (Panel B in Table 7).[23]

[Table 7]

As a second test of Hypothesis 1, we turn to the granular firm-product-destination level, and evaluate the differential impact of a US patent award on the export value and price of continuing export flows. We estimate Specification 6, where we regress the growth of the relevant export margin on the indicator for a successful first US patent interacted with a dummy for the US as the destination country. We run this regression first pooling all products and then separately for products that are related vs. unrelated to the firm's patent application. We add all controls, product-application year and destination-application year pair fixed effects as in the baseline, but now also firm fixed effects to identify differential trends across destinations and products within firms . As shown in Table 8, exporters do not revise the pricing or sales of their surviving relationships differentially in the US market.

[Table 8]

In sum, we find little evidence for the monopoly power mechanism that the award of a first US patent improves the export performance of Chinese awardees by giving them exclusive market rights for patent-protected products in the US market. Instead, results point to alternative mechanisms that enable broader-based expansion of export activity across products and markets at the firm level.

5.2 Asymmetric Information

Chinese firms may apply for a US patent not only to ensure market power for a specific product in the US, but also to enhance their export activity in other destination-product markets. One possibility is that receiving a US patent constitutes a signal that can alleviate information frictions in international trade. In the presence of such frictions, meeting the high standards of the USPTO examination process can give firms a globally recognized stamp of approval, and thereby allow them to expand into products and destinations that are not directly affected by the market protection granted by the US patent. Moreover, this signaling mechanism can rationalize not only the large export boost following a successful first US patent application, but also the insignificant impact of subsequent patent awards that plausibly contain less novel information on the margin.

Asymmetric information between buyers and sellers can arise for different reasons and therefore manifest in different ways. It is arguably more costly in international than domestic transactions, because international partners are less familiar with foreign economic conditions, risk bigger hold-up problems in finding alternative buyers and suppliers, and face

[23] In a robustness check, we repeat the baseline regression for the export growth rate of each component of firms' total exports, instead of its contribution to the growth in total exports; the difference is in the denominator of each component. The results are qualitatively similar, see Table A10.

greater contractual frictions due to transacting across jurisdictions. Asymmetric information would presumably be more problematic, and hence the value of a patent signal greater, for exporters from a country with less developed institutions and greater heterogeneity in firm quality and credibility, such as China.

We now provide evidence consistent with a US patent sending a signal about two desirable attributes of a Chinese firm: the capacity to deliver high-quality products and the credibility to honor contractual obligations. The common premise of both signaling mechanisms is that they would be more important for some products and destinations than others, such that we can exploit difference-in-differences estimation to uncover evidence of each mechanism that cannot easily be accounted for by alternative explanations.

5.2.1 Product Quality Signal

More successful exporters have been shown to use higher-quality inputs in order to produce higher-quality products, sell to customers in more destinations, and generate higher export revenues (Manova and Zhang (2012), Manova and Yu (2017)).[24] These forces are especially relevant for products with greater scope for quality differentiation and for richer markets with greater willingness to pay for quality.

We conjecture that when downstream producers and final consumers have imperfect information about the quality of a firm's products, the approval of a US patent invented by that firm can convey a strong signal about the firm's capacity to produce high quality in principle and enforcement of quality control in practice. Such a positive signal can moreover apply across a firm's product portfolio. Due to the substantial information asymmetry between exporters and importers of differentiated goods (Rauch 1999), however, we expect the quality signal to stimulate trade relatively more for products with greater scope of quality differentiation and for markets with high-income consumers:

Hypothesis 2 (Product Quality) US patent rights signal firms' quality capacity under asymmetric information, and increase firm exports disproportionately more for more differentiated products and richer destinations.

To test Hypothesis 2, we examine whether the patent effect on exports is greater for destinations with higher average income and/or for products with more scope for quality differentiation. We follow the trade-and-quality literature and proxy the latter with Rauch's indicator for differentiated goods (Rauch 1999).[25] As with Hypothesis 1, we consider both the contribution of different margins to overall export growth across firms and the differential export response across destination-product markets within firms.

[Table 9]

[24] See also the pricing-to-market literature (e.g., Jung *et al.* 2019) and the quality-and-trade literature (e.g., Fan *et al.* 2020) featuring variable markup under the assumption of non-homothetic preferences.

[25] We employ the conservative measure in Rauch's index, and pool the homogeneous and the reference-priced goods as non-differentiated goods.

Consistent with the quality signal mechanism, Panel A in Table 9 shows that a successful US patent application increases the export growth of Chinese firms almost entirely by expanding sales of differentiated goods, with a statistically insignificant contribution of non-differentiated goods. While exports increase to both destinations with GDP per capita above and below the median, about 75% of the overall export growth is driven by richer markets (coefficient estimates of 0.129 vs. 0.0485). Panel B in Table 9 presents the four-way decomposition of export growth into destination-product pairs. In line with the findings in Panel A, export expansion into both high-income and low-income countries is concentrated in differentiated goods.

[Table 10]

We complement this growth decomposition exercise with corroborative analysis of the differential effect of a US patent award across products and destinations within firms. We consider both the probability of export survival and export growth conditional on survival at the firm-product-destination level, and regress each on the interaction of a successful US patent application with destination log GDP per capita. We find strong evidence that an approved US patent improves the probability of export survival disproportionately more for richer markets. This effect is moreover fully driven by differentiated goods. In contrast, exports to maintained markets grow at the same pace across products and destinations within firms.

5.2.2 Firm Credibility Signal

Buyers and suppliers often have to make relationship-specific investments, such as customizing production equipment, sourcing appropriate inputs, and manufacturing according to precise product specifications. This gives rise to hold-up problems ex-post and under-investment ex-ante when contracts are incomplete and cannot be fully enforced (Grossman and Hart 1986; Hart and Moore 1990). Because country borders increase asymmetric information and complicate contract enforcement, contractual frictions are especially acute in international trade and significantly deter trade activity. Indeed, countries with stronger rule of law have been found to export significantly more in contract-intensive sectors that require more relationship-specific investments (Nunn (2007)).[26]

We conjecture that the approval of a US patent can send a strong signal about the credibility of the Chinese patent recipient. This signal can reassure buyers both in the US and in other markets that the Chinese supplier has the technological know-how to make relationship-specific investments and the trustworthiness to honor contracts. We expect this signal to give more impetus to trade in contract intensive products, especially when the destination country itself has stronger contract enforcement and is therefore more likely to demand such products and be capable of effectively transacting in them:

[26] A large literature also examines the impact of contractual frictions on the organization of multinational activity, see for example Antràs (2003).

Hypothesis 3 (Firm Credibility) US patent rights signal firms' credibility under contractual frictions, and increase firm exports disproportionately more for more contract intensive products and for destinations with stronger rule of law.

We empirically evaluate Hypothesis 3 by examining to what extent the rise in export growth following the award of a US patent is driven by exports of high contract-intensity goods and exports to better contract-enforcement countries. As standard, we proxy contract intensity with the value share of an industry's inputs that are differentiated and presumably require relationship-specific investments in production. This index is available from (Nunn 2007) at the ISIC 3-digit level, which we map to HS 6-digit products in our data. We measure the strength of countries' contract enforcement with the overall rule of law index from Kaufmann *et al.* (2003), as in Nunn (2007).

[Table 11]

Table 11 reports the estimated effect of a successful first US patent application on each component of the overall export growth of the Chinese applicant. We present the decomposition exercises by either destination market or product type in Panel A and by destination-product pair in Panel B. Consistent with the firm credibility mechanism, the baseline patent effect is driven by the expansion of exports to countries with a strong contract environment. While exports of products both above and below the median value of contract intensity rise, products more reliant on relationship-specific investments respond significantly more strongly. This differential sensitivity across products is even more pronounced for destinations with strong rule of law.

[Table 12]

Table 12 provides further support for the credibility signaling mechanisms based on the reallocation of activity across products and destinations withing firms. We now regress the survival indicator and the growth of continuing exports on the interaction of a first successful US patent and the importer's rule-of-law index at the firm-product-destination level. We find that patent recipients benefit from disproportionately higher export survival rates in destinations with stronger contract enforcement, especially for contract intensive products in their portfolio. While the patterns are qualitatively similar for expansion into maintained destination-product markets, they are not statistically significant.

5.3 Ruling Out Other Mechanisms

Our analysis has revealed evidence consistent with a successful US patent stimulating export growth by alleviating information asymmetry in international trade. it has in contrast uncovered little support for benefits to export activity through monopoly power. We now consider three other mechanisms through which patenting has been found to improve firm performance in the prior literature, and show that they do not exert similar effects on export expansion.

One possible alternative mechanism is that patents may serve as a signaling device to attract external investors and thus ease financial frictions faced by firms (Budish *et al.* 2016; Farre-Mensa *et al.* 2020). A large literature has documented that credit constraints are an important hindrance to international trade (Manova 2013). Moreover, exporting is significantly more reliant on external finance than production for the domestic market because international sales incur additional upfront costs, longer processing times, and higher transaction risk. A US patent award can thus make it easier for an exporter to raise more external finance if it raises expected revenues and profits, for instance through the monopoly power, quality signal or credibility signal channels.

We evaluate the validity of the financial frictions channel in Table A11. We now split the sample into Chinese firms with measured financial vulnerability above vs. below the sample median, and estimate the effect of a US patent grant on applicants' three-year annualized export growth in each subsample. The prior literature has argued that sectors differ in their long-term external finance dependence, short-term liquidity needs, and asset tangibility that facilitates access to external capital for technological reasons external to the firm. We therefore construct three corresponding measures of financial vulnerability at the firm level by taking the weighted average of these industry variables using the share of each industry in the firm's exports as weights.[27] We find weak evidence for the financial frictions mechanism: while US patent approval does stimulate export growth relatively more for firms with low asset tangibility, it also counter-intuitively expands exports disproportionately more in firms with external finance dependence and liquidity needs below the median.

Another potential mechanism is the effect of a first US patent on follow-on innovation. For instance, Farre-Mensa *et al.* (2020) find that US start-ups increase their innovation activity after the award of their first US patent. In our context, the first US patent could improve Chinese entrepreneurs' expectations about their future innovation or patenting success and thereby their expected profitability. This can induce them to conduct more R%D, upgrade their product quality, and climb up the value chain (Chor *et al.* 2021). To explore this strategic patenting mechanism, we obtain additional data on patent filings with China's State Intellectual Property Office, in the absence of other information on Chinese firms' innovation or global patent activity. In Table A12, we estimate the effect of a successful first US patent application on the growth in patent applications that Chinese firms file in China within one or three years of the US patent award. We find no support for the strategic patenting channel in that the first US patent does not stimulate subsequent patenting in China.

[27] External finance dependence is constructed as the share of capital expenditures not financed with internal cash flows from operations; liquidity needs are measured with the inventories-to-sales ratio; and asset tangibility is calculated as the share of plant, property and equipment in total book value assets. We use the measures as constructed by Manova (2013) and Manova and Yu (2016) at the ISIC 3-digit level.

6 Conclusion

In this paper, we identify the causal impact of the first patent application outcome in the US on the export activities of Chinese firms, based on a unique match between Chinese exporters and USPTO patent applications. We conclude that a successful first-time US patent application substantially improves the export growth of the applicant, especially the survival and expansion of existing product-destination export flows. Further analysis reveals that the effect cannot be attributed to the US patent granting monopoly power in the US product market. Instead, evidence indicates that US patent approval may act as a signaling device of the quality capacity and contractual credibility of the Chinese exporter, alleviating information frictions in exporting abroad.

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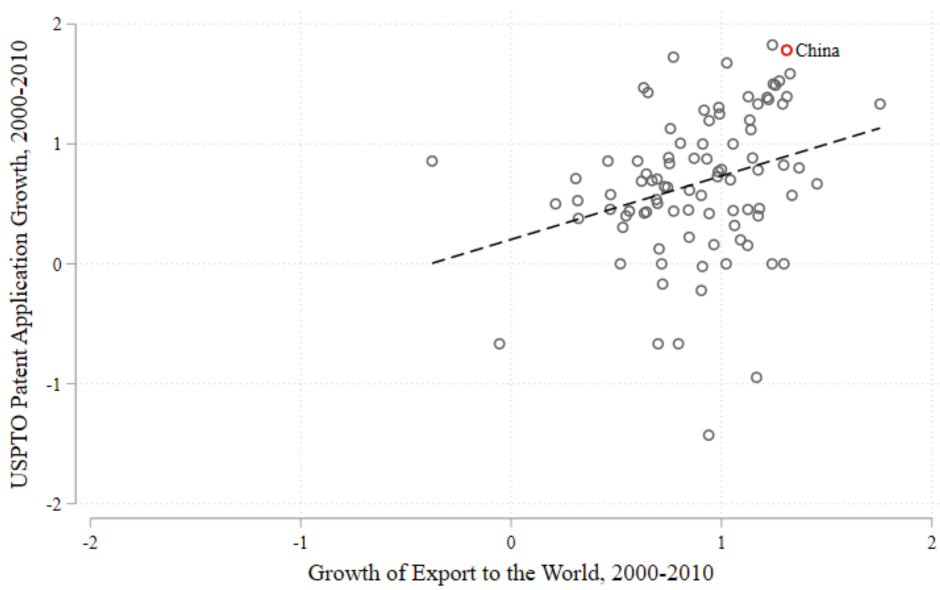
Figure 1: Country-level Export and USPTO Patent Applications

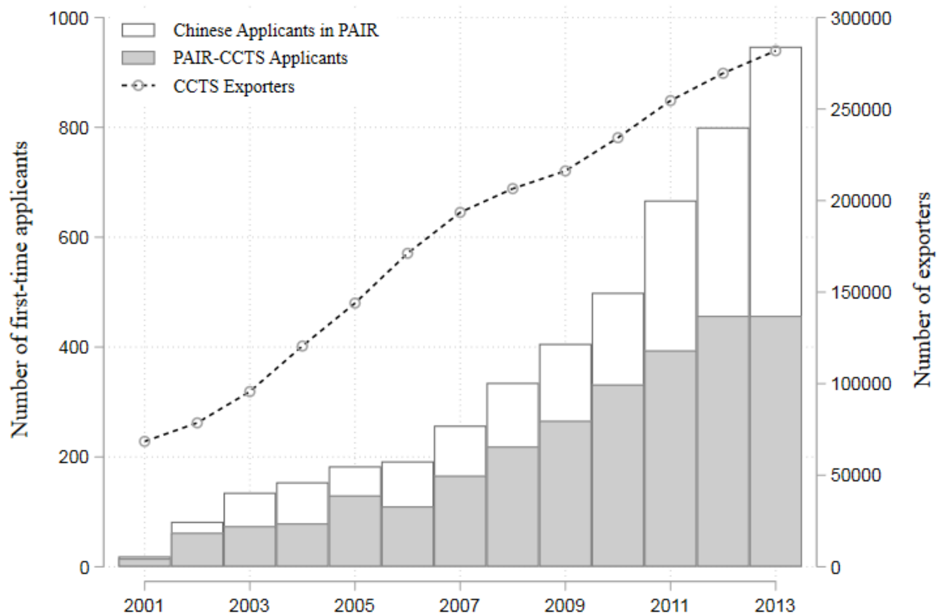
Note: the slope of the fitted line is 0.308(0.107).



Note: the slope of the fitted line is 0.53(0.185).

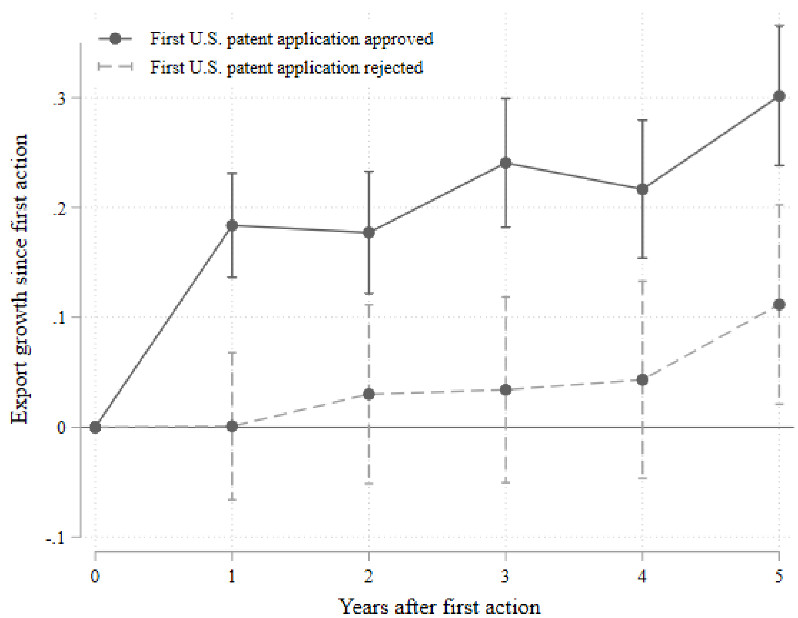
Note: The figures show the correlation between export growth to the US (World) and UPSTO patent application growth of each country from 2000 to 2010. The export data is extracted from the World Bank's WITS database. The patent application data is reported by the UPSTO. The slope of the fitted line and its robust standard error are reported in the figure notes.

Figure 2: Number of First-time US Patent Applicants from China



Note: The figure shows the number of first-time US patent applicants from China by first action year. The white bars display the total number of USPTO applicants located in China. The shadowed bars display the total number of CCTS-PatEx matched exporters. The dashed line displays the total number of exporters in CCTS data.

Figure 3: Export Growth since First Application



Note: The figure shows the average export growth of successful first-time patent applicants and unsuccessful first-time patent applicants, since the first action years of applications. Export growth is measured as $g_{ik} = (exp_{it+k} - exp_{it})/0.5(exp_{it+k} + exp_{it})$, where exp_{it} is the export value of firm i in t, the first action year of its first patent application. exp_{it+k} is the export value of firm i k years after t. 95% confidence intervals are represented by the capped spikes.

Table 1: Comparison of Patent Applicants and Other Exporters

	Matched patent applicants		*Other exporters*		*Differences*	
	Mean	sd	Mean	sd	Mean	sd
Log value of export	15.28	2.71	13.16	2.34	2.12***	0.021
Log value of export to the U.S.	10.01	6.61	5.00	6.14	5.01***	0.054
Log value of export to OECD	13.14	5.11	9.94	5.65	3.21***	0.050
Share of export to U.S.	0.22	0.30	0.14	0.28	0.090***	0.0025
Share of export to OECD	0.54	0.36	0.52	0.41	0.024***	0.0037
Number of products	16.18	40.87	14.58	48.41	1.59***	0.43
Number of destinations	19.68	21.14	8.39	12.76	11.29***	0.11
Average value per prod.-dest. pair (1,000 RMB)	1423.76	8081.73	405.49	5826.35	1018.28***	51.67
Number of observations	12,850		2,318,957			

Note: The table displays the comparison of CCTS-PatEx matched exporters and other exporters in CCTS. Column 1 and 2 show the mean and standard deviations of key export statistics of the CCTS-PatEx matched Chinese patent applicants across all years; Column 3 and 4 show the mean and standard deviations of key export statistics of the other exporters across all years. Column 5 and 6 show the mean and standard deviation of the differences in export statistics between the two groups. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 2: First-stage Results

Dependent variable	*Successful first application*			
	(1)	(2)	(3)	(4)
Examiner approval rate	0.971***	0.969***	0.954***	0.959***
	(0.0693)	(0.0696)	(0.0778)	(0.0781)
Log export		0.00209		0.0151**
		(0.00567)		(0.00752)
Export tenure		-0.00789*		-0.00204
		(0.00437)		(0.00509)
Log employment				-0.0108
				(0.0107)
HS2-year fixed effects	Yes	Yes		
Industry-year fixed effects			Yes	Yes
Ownership-year fixed effects			Yes	Yes
Sample	CCTS		CCTS-ASIE	
F-test: IV = 0	196.51***	193.92***	150.44***	150.97***
Observations	1156	1156	941	941

Note: The table reports first-stage regression results. We predict whether an exporter's first USPTO patent application is approved by the assigned examiner's *ex-ante* residualized approval rate. The sample of Column 1 and 2 covers all CCTS-PatEx matched exporters, and the sample of Column 3 and 4 covers those CCTS-ASIE-PatEx matched exporters. Heteroskedasticity-consistent standard errors are clustered at the examiner's art unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3: Balance Test

Sample	*Characteristics*	*Successful first application*	*Examiner approval rate*
CCTS (Sample size = 1156)	Log export (Custom)	-0.0209	0.123
		(0.162)	(0.465)
	Log # products	-0.143*	-0.0787
		(0.0758)	(0.227)
	Log # destinations	-0.0266	0.156
		(0.0745)	(0.198)
	Log average export (prod.-dest. pair)	0.0875	0.0255
		(0.125)	(0.376)
CCTS-ASIE (Sample size = 941)	Log sales	0.0456	-0.337
		(0.142)	(0.342)
	Log employment	-0.00509	0.0276
		(0.0986)	(0.245)
	Log export (ASIE)	0.258	-0.294
		(0.191)	(0.536)
	Operating profit	0.0100	-0.0320
		(0.00931)	(0.0225)

Note: The table reports results of regressing CCTS or CCTS-ASIE matched exporters' *ex-ante* characteristics on first application successes and examiners' approval rates. The CCTS sample covers all continuing exporters matched to USPTO patent applicants. The ASIE sample covers the continuing exporters also matched with ASIE. Regressions on the CCTS sample control for HS2 by application year fixed effects. Regressions on the CCTS-ASIE sample control for CIC2 by application year fixed effects and ownership type by year fixed effects. Heteroskedasticity-consistent standard errors are clustered at the examiner's art unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4: The Effect of First US Patent on Export Growth

Dependent variable	*Annualized 3-year export growth*					
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application	0.0667***	0.174***	0.178***	0.0601**	0.218***	0.204***
	(0.0214)	(0.0568)	(0.0525)	(0.0253)	(0.0692)	(0.0623)
Log export			-0.0367***			-0.0460***
			(0.00492)			(0.00596)
Export tenure			-0.00297			-0.0139***
			(0.00366)			(0.00372)
Log employment						0.0294***
						(0.00858)
HS2-year fixed effects	Yes	Yes	Yes			
Industry-by-year fixed effects				Yes	Yes	Yes
Ownership-by-year fixed effects				Yes	Yes	Yes
Models	OLS	2SLS	2SLS	OLS	2SLS	2SLS
Sample		CCTS			CCTS-ASIE	
K-P rk Wald F-stats		196.51	193.92		150.44	150.97
Observations	1156	1156	1156	941	941	941

Note: The table reports the estimated effect of successful first US patent application on export growth of Chinese applicants. The dependent variable is annualized 3-year growth rate of export value. Columns 1, 2, and 3 include all CCTS-PatEx matched exporters, and columns 4, 5, and 6 include CCTS-ASIE-PatEx matched exporters, and control for 2-digit industry-year fixed effects and ownership-year fixed effects. Columns 1 and 4 are estimated with OLS, and the rest are estimated with 2SLS, using the residualized examiner approval rates as instruments. Column 3 includes log initial export value and export tenure as controls; column 4 includes log employment as additional controls. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5: Decomposing the Effect on Export Growth

Dependent variables	*Components of annualized 3-year export growth*					
	All	All	Existing	Existing	New	New
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application	0.174***	0.178***	0.156***	0.156***	0.0182	0.0216
	(0.0568)	(0.0525)	(0.0488)	(0.0489)	(0.0311)	(0.0262)
Log export		-0.0367***		-0.00563		-0.0311***
		(0.00492)		(0.00407)		(0.00232)
Export tenure		-0.00297		-0.0000639		-0.00290*
		(0.00366)		(0.00314)		(0.00149)
K-P rk Wald F-stats	196.51	193.92	196.51	193.92	196.51	193.92
Observations	1156	1156	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first US patent application on each component of export growth of Chinese applicants. The sample includes all all CCTS-PatEx matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column controls for HS2 by application year fixed effects. Column 2, 4, and 6 include log initial export value and export tenure as controls. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6: The Effect of First US Patent on Product-destination Level Export

Panel A.Product-destination analysis (survival and value growth)

Dependent variables	Survival indicator			Value growth		
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application	0.0768***	0.129	0.149**	0.0218	0.0824	0.235***
	(0.0177)	(0.0812)	(0.0698)	(0.0143)	(0.0616)	(0.0823)
Product-destination controls	Product-destination level log export value and relative tenure					
Firm controls	Firm level log export value and export tenure					
HS6-by-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-by-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Model	OLS	IV	Weighted IV	OLS	IV	Weighted IV
Sample	Incumbent pairs			Continuing pairs		
K-P rk Wald F-stats		27.626	104.275		20.765	56.063
Observations	86681	86681	86681	38940	38940	38940

Panel B. Product-destination analysis (price and quantity growth)

Dependent variables	Price growth			Quantity growth		
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application	0.0195	-0.0765	-0.00891	0.00875	0.135**	0.223**
	(0.0144)	(0.0736)	(0.0802)	(0.0176)	(0.0688)	(0.0925)
Product-destination controls	Product-destination level log export value and relative tenure					
Firm controls	Firm level log export value and export tenure					
HS6-by-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-by-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Model	OLS	IV	Weighted IV	OLS	IV	Weighted IV
Sample	Incumbent pairs			Continuing pairs		
K-P rk Wald F-stats		14.813	44.293		14.813	44.293
Observations	31320	31320	31320	31320	31320	31320

Note: The table reports the estimated effect of successful first US patent application on the survival rates of incumbent product-destination pairs and the value, price, and quantity growth rates of continuing product-destination pairs. The analysis is conducted at firm-product-destination level. Columns 1 and 4 are estimated with OLS, and the rest are estimated with 2SLS, using the residualized examiner approval rates as instruments. Export shares of product-destination pairs are used as weights in Columns 3 and 6. All columns include HS6-by-year fixed effects and country-by-year fixed effects, and control for log product-destination export value, relative product-destination tenure, log firm export value, and firm's export tenure as controls. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7: Testing the Monopoly Power Channel: Decomposition

Panel A. Decomposition by destination/product types				
	By destinations		By Products	
	U.S.	ROW	Related	Unrelated
Successful First Application	0.0219	0.156***	0.0408	0.137***
	(0.0249)	(0.0428)	(0.0276)	(0.0488)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Panel B. Decomposition by destination-product pair types				
	U.S. + Related	U.S. + Unrelated	ROW + Related	ROW + Unrelated
Successful First Application	0.0259*	-0.00406	0.0149	0.141***
	(0.0136)	(0.0214)	(0.0225)	(0.0403)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first US patent application on each component of export growth of Chinese applicants. The sample includes all all CCTS-PatEx matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include HS2 by application year fixed effects, and control for log initial export value and export tenure. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8: Testing the Monopoly Power Channel: Within-firm Analysis

Product-destination level analysis: the monopoly power channel						
	Value growth			Price growth		
Technology relatedness	All	Yes	No	All	Yes	No
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application × U.S.	0.114	-0.131	0.140	0.0489	0.0426	0.0157
	(0.116)	(0.246)	(0.122)	(0.0651)	(0.166)	(0.0745)
Controls	Product-destination level log export and relative tenure					
Fixed effects	Company fixed effects, HS6-year fixed effects, destination-year fixed effects					
K-P rk Wald F-stats	6.89	7.66	5.85	6.29	8.85	5.15
Observations	38822	7775	30409	31222	6635	24059

Note: The table reports the heterogeneous effect of successful first US patent application on the value and price growth of continuing product-destination pairs. The analysis is conducted at firm-product-destination level. Columns 1 and 4 contain all continuing product-destination pairs of CCTS-PatEx matched exporters, columns 2 and 5 contain continuing pairs of products technologically related to the US patent, and columns 3 and 6 contain continuing pairs of unrelated products. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column includes company fixed effects, HS6 by year fixed effects, and destination by year fixed effects. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 9: Testing the Quality Signal Channel: Decomposition

Panel A. Decomposition by destination/product types				
	By destinations		By Products	
	High income	Low income	Differentiated	Non-differentiated
Successful First Application	0.129***	0.0485**	0.164***	0.0170
	(0.0458)	(0.0243)	(0.0456)	(0.0231)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Panel B. Decomposition by destination-product pair types				
	HI+Diff.	HI+Non-diff.	LI+Diff.	LI+Non-diff.
Successful First Application	0.129***	0.0132	0.0347**	0.00399
	(0.0376)	(0.0220)	(0.0175)	(0.00574)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first US patent application on each component of export growth of Chinese applicants. The sample includes all all CCTS-PatEx matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include HS2 by application year fixed effects, and control for log initial export value and export tenure. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 10: Testing the Quality Signal Channel: Within-firm Analysis

Product-destination level analysis: the quality signal channel						
	Survival Indicator			Value growth		
Product Differentiation	All	Yes	No	All	Yes	No
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application × ln(GDP per capita)	0.0206*	0.0302**	0.00196	0.00304	-0.00384	0.0327
	(0.0120)	(0.0131)	(0.0247)	(0.0195)	(0.0221)	(0.0405)
Controls	Product-destination level log export value and relative tenure					
Fixed effects	Company fixed effects, HS6-year fixed effects, destination-year fixed effects					
Sample	Incumbent pairs			Continuing pairs		
K-P rk Wald F-stats	32.30	26.52	50.70	20.85	18.11	17.26
Observations	85955	70123	10555	38665	32251	4112

Note: The table reports the heterogeneous effect of successful first US patent application on the survival rates (value growth) of incumbent (continuing) product-destination pairs. The analysis is conducted at firm-product-destination level. Column 1 (4) contain all incumbent (continuing) product-destination pairs of CCTS-PatEx matched exporters, column 2 (5) contain incumbent (continuing) pairs of differentiated products, and column 3 (6) contain incumbent (continuing) pairs of other products. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column includes company fixed effects, HS6 by year fixed effects, and destination by year fixed effects. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 11: Testing the Contractual Signal Channel: Decomposition

Panel A. Decomposition by destination/product types				
	By destinations		By Products	
	High RLI	Low RLI	High Contract Int.	Low Contract Int.
Successful First Application	0.151***	0.0277	0.132***	0.0500**
	(0.0463)	(0.0232)	(0.0460)	(0.0221)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Panel B. Decomposition by destination-product pair types				
	HRLI+High CI	HRLI+Low CI	LRLI+High CI	LRLI+Low CI
Successful First Application	0.118***	0.0374**	0.0149	0.0127
	(0.0422)	(0.0186)	(0.0176)	(0.00984)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first US patent application on each component of export growth of Chinese applicants. The sample includes all all CCTS-PatEx matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include HS2 by application year fixed effects, and control for log initial export value and export tenure. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 12: Testing the Contractual Signal Channel: Within-firm Analysis

Product-destination level analysis: the reliability signal channel						
	Survival Indicator			Value growth		
Contract Intensity	All	High	Low	All	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application × Rule-of-law Index	0.0307**	0.0360**	0.0245	0.00529	0.00340	0.0261
	(0.0150)	(0.0147)	(0.0304)	(0.0244)	(0.0235)	(0.0533)
Controls	Product-destination level log export value and relative tenure					
Fixed effects	Company fixed effects, HS6-year fixed effects, destination-year fixed effects					
Sample	Incumbent pairs			Continuing pairs		
K-P rk Wald F-stats	25.73	23.60	21.71	17.23	14.05	13.50
Observations	86319	56481	29237	38752	26283	12009

Note: The table reports the heterogeneous effect of successful first US patent application on the survival rates (value growth) of incumbent (continuing) product-destination pairs. The analysis is conducted at firm-product-destination level. Column 1 (4) contain all incumbent (continuing) product-destination pairs of CCTS-PatEx matched exporters, column 2 (5) contain incumbent (continuing) pairs of contract intensive products, and column 3 (6) contain incumbent (continuing) pairs of other products. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column includes company fixed effects, HS6 by year fixed effects, and destination by year fixed effects. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix A Additional Figures and Tables

Figure A1: Graphical Illustration of the Patent Examination Process

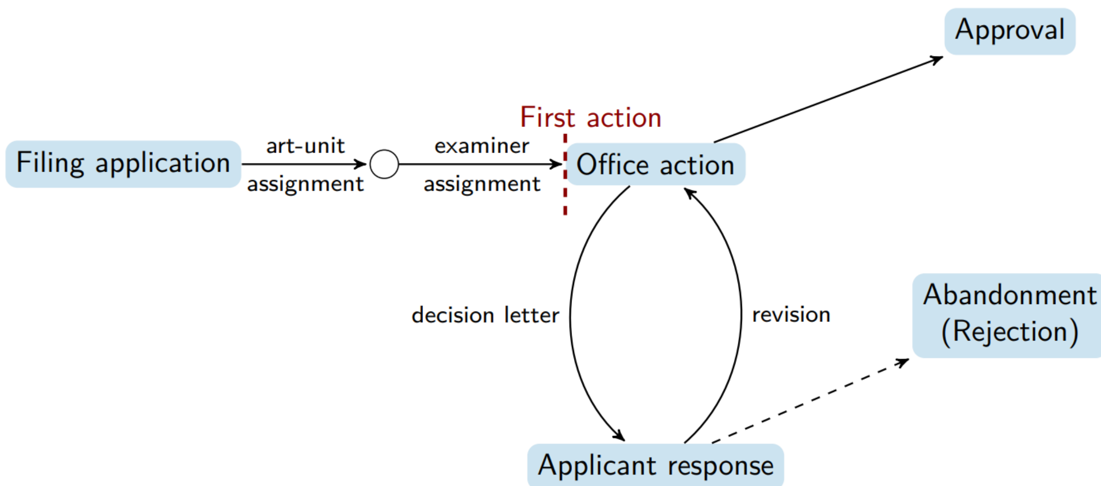
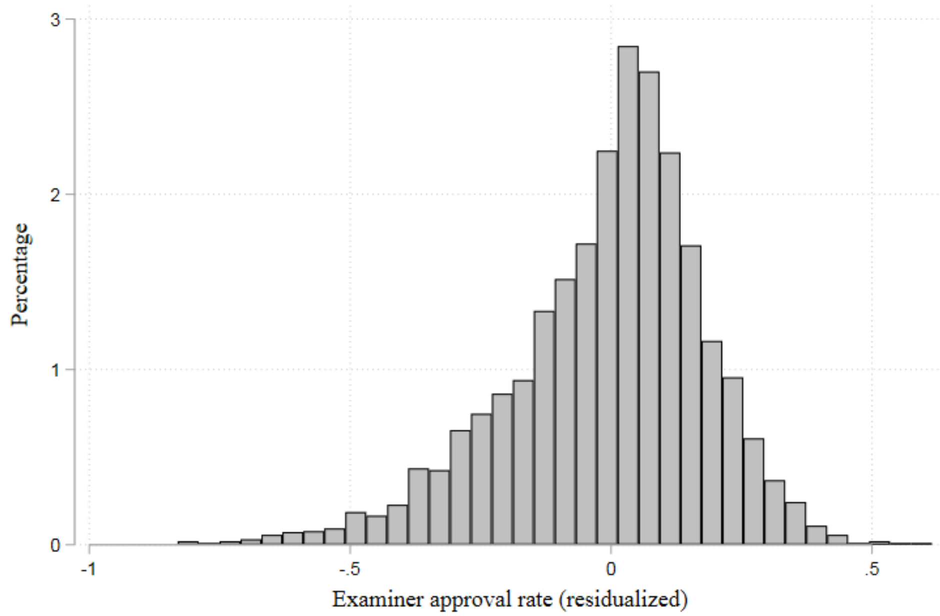
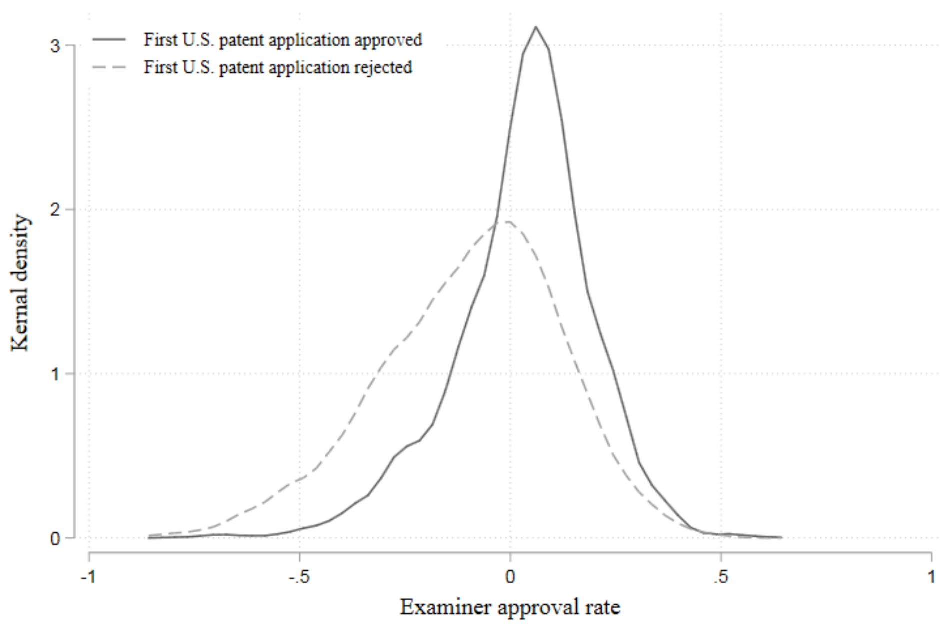


Figure A2: Distribution of Residualized Approval Rate



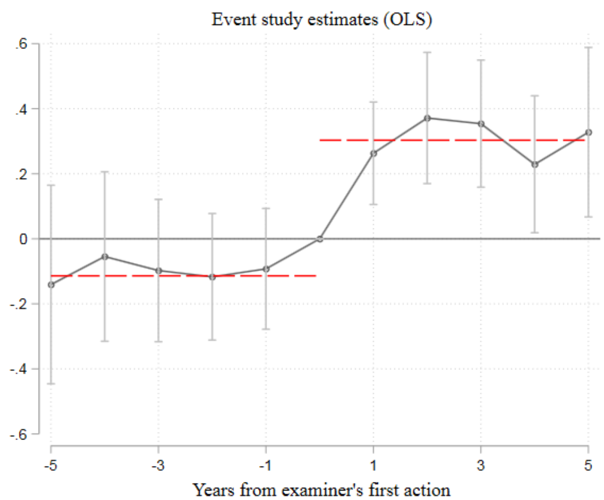
Note: The figure shows the sample distribution of approval rates of patent examiners assigned to CCTS applicants from China, estimated within each art-unit by first-action year group.

Figure A3: Comparison of Examiner Approval Rates for Approved and Rejected Applications

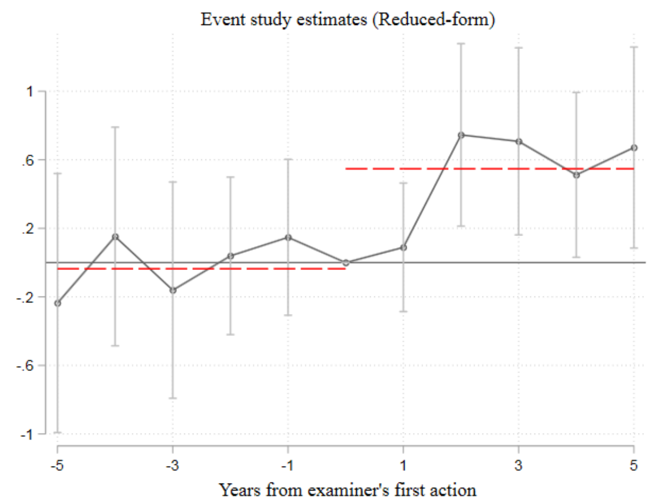


Note: The figure shows the kernel density of examiner approval rates by whether the exporter's first patent application is successful or not. The sample covers all CCTS-PatEx matched exporters. Examiner approval rates are estimated within each art-unit by first-action year group.

Figure A4: Event Study Plots



Note: The figure shows the event study plot of the OLS estimates of the effect of successful first US patent application on export. The sample covers all CCTS-PatEx matched exporters. The dependent variable is log export value, and the regressors include the indicator of first patent application outcome interacted with time dummies. Firm fixed effects and HS2-by-year fixed effects are controlled. Heteroskedasticity-consistent standard errors are clustered at the examiner's art unit level.



Note: The figure shows the event study plot of the reduced-form estimates of the effect of successful first US patent application on export. The sample covers all CCTS-PatEx matched exporters. The dependent variable is log export value, and the regressors include the examiner's residualized approval rate interacted with time dummies. Firm fixed effects and HS2-by-year fixed effects are controlled. Heteroskedasticity-consistent standard errors are clustered at the examiner's art unit level.

Table A1: Technology Classes of First Patent Applications by Chinese Applicants

Sample: all first-time U.S. patent applicants from China				
Rank	USPC class	USPC title	Number	Percentage (%)
1	514	Drug, bio-affecting and body treating compositions	266	5.55
2	424	Drug, bio-affecting and body treating compositions	196	4.09
3	435	Chemistry: molecular biology and microbiology	144	3.01
4	362	Illumination	112	2.34
5	439	Electrical connectors	84	1.75
6	257	Active solid-state devices	77	1.61
7	455	Telecommunications	71	1.48
8	361	Electricity: electrical systems and devices	69	1.44
9	428	Stock material or miscellaneous articles	68	1.42
10	345	Computer graphics processing and selective visual display systems	67	1.40
		Other	3637	75.91
Sample: first-time U.S. patent applicants matched to CCTS				
Rank	USPC class	USPC title	Number	Percentage (%)
1	424	Drug, bio-affecting and body treating compositions	117	4.13
2	514	Drug, bio-affecting and body treating compositions	96	3.39
3	362	Illumination	86	3.04
4	435	Chemistry: molecular biology and microbiology	80	2.83
5	439	Electrical connectors	66	2.33
6	428	Stock material or miscellaneous articles	50	1.77
7	257	Active solid-state devices	45	1.59
8	345	Computer graphics processing and selective visual display systems	41	1.45
9	361	Electricity: electrical systems and devices	40	1.41
10	536	Organic compounds	34	1.20
		Other	2116	76.86

Note: The table shows the top technology classes of the first patent applications filed by Chinese applicants. The top panel displays the top 10 technology classes filed by all first-time US patent applicants from China; the bottom panel displays the top 10 technology classes filed by CCTS-PatEx matched first-time US patent applicants.

Table A2: Additional Balance Tests

Sample	*Characteristics*	*Successful first application*	*Examiner approval rate*
CCTS (Sample size = 1156)	Share of Heterogeneous Exports	-0.0376*	0.0393
		(0.0201)	(0.0609)
	Share of Tech. Related Exports	0.0219	0.144**
		(0.0286)	(0.0668)
	Share of Processing Export	-0.0321	-0.0159
		(0.0254)	(0.0658)
	Share of Exports to the U.S.	-0.0405*	0.0134
		(0.0220)	(0.0468)
	Share of Exports to OECD Countries	-0.0474**	-0.0357
		(0.0212)	(0.0497)
	Share of Exports to High-RLI Countries	-0.0329**	-0.0610
		(0.0146)	(0.0389)
	Share of Exports to High-PR Countries	-0.0244*	-0.00636
		(0.0129)	(0.0356)

Note: The table reports results of regressing CCTS matched exporters' additional *ex-ante* characteristics on first application successes and examiners' approval rates. The CCTS sample covers all continuing exporters matched to USPTO patent applicants. All columns control for HS2 by application year fixed effects. Heteroskedasticity-consistent standard errors are clustered at the examiner's art unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A3: Tests of Examiner Specialization

Dependent variable	*Successful first application*			
	(1)	(2)	(3)	(4)
Examiner approval rate (residual 1)	0.969***	0.869***		
	(0.0698)	(0.0898)		
Examiner approval rate (residual 2)		0.00150	0.994***	0.871***
		(0.00572)	(0.0681)	(0.0886)
Log export	0.00254	-0.00765*	0.00305	0.00217
	(0.00568)	(0.00435)	(0.00579)	(0.00584)
Export tenure	-0.00801*	-0.00791*	-0.00769*	-0.00741*
	(0.00437)	(0.00437)	(0.00453)	(0.00448)
Log examined Chinese patents		-0.0137		-0.0167
		(0.0231)		(0.0236)
Log examined foreign patents		0.0606**		0.0764***
		(0.0267)		(0.0270)
Log examiner experience		-0.0479		-0.0592
		(0.0425)		(0.0428)
HS2-year fixed effects	Yes	Yes	Yes	Yes
F-test: IV = 0	193.92***	93.73***	213.10***	96.55***
Observations	1156	1156	1156	1156

Note: The table reports validation test results as suggested in Righi and Simcoe (2019). The sample covers all CCTS-PatEx matched exporters. Examiner approval rate (residual 1) is examiner's residualized approval rate after excluding art unit by first action year fixed effects. Examiner approval rate (residual 2) is examiner's residualized approval rate after excluding both art unit by first action year fixed effects and USPC technology class by first action year fixed effects. HS2 by application year fixed effects are controlled in all columns. Heteroskedasticity-consistent standard errors are clustered at the examiner's art unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A4: The Effect of Second Application

Dependent variable: Annualized 3-year export growth	(1)	(2)	(3)
Successful second application	0.0250*	0.0215	0.0255
	(0.0139)	(0.0371)	(0.0344)
Log export			-0.00881***
			(0.00222)
Export tenure			-0.00191
			(0.00218)
Year fixed effects	Yes	Yes	Yes
Models	OLS	2SLS	2SLS
Sample		CCTS	
K-P rk Wald F-stats		40.56	41.92
Observations	409	409	409

Note: The table reports the estimated effect of successful second US patent application on export growth of Chinese applicants. The dependent variable is annualized 3-year growth rate of export value. The sample includes all CCTS-PatEx matched exporters, and control for year fixed effects. Columns 1 is estimated with OLS, and the rest are estimated with 2SLS, using examiner approval rates as instruments. Column 3 includes log initial export value and export tenure as controls. Heteroskedasticity-consistent standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A5: The Effect of First US Patent on Other Export Outcomes

Dependent variables	*Annualized 3-year growth of*			
	#Products	#Destinations	#Prod.-Dest. pairs	Average value
	(1)	(2)	(3)	(4)
Successful first application	0.0664	0.0552	0.0797*	0.116**
	(0.0414)	(0.0345)	(0.0407)	(0.0479)
Log export	-0.00183	-0.0128***	-0.0104***	-0.0372***
	(0.00329)	(0.00297)	(0.00361)	(0.00408)
Export tenure	-0.00442**	-0.00539**	-0.00624***	0.00288
	(0.00224)	(0.00212)	(0.00232)	(0.00310)
K-P rk Wald F-stats	193.92	193.92	193.92	193.92
Observations	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first US patent application on other outcomes of Chinese applicants. The dependent variable is annualized 3-year growth rates of the export-related variables listed below. The sample covers all CCTS-PatEx matched exporters. All columns are estimated with 2SLS, using residualized examiner approval rates as instruments. HS2-application year fixed effects and control variables, including log initial export value and export tenure, are included in all columns. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A6: Placebo Tests

Dependent variable	*Annualized 3-year export growth, 3-year lagged*		
	(1)	(2)	(3)
Successful first application	0.00381	0.0111	0.0134
	(0.00845)	(0.0222)	(0.0214)
Log export, 3-year lagged			-0.00953***
			(0.00146)
Export tenure, 3-year lagged			-0.00916***
			(0.00136)
Models	OLS	2SLS	2SLS
K-P rk Wald F-stats		151.84	150.17
Observations	947	947	947

Note: The table reports the estimated effect of successful first US patent application on the 3-year lagged export growth of Chinese applicants as a placebo test. The dependent variable is annualized 3-year growth rate of export value, 3-year lagged. The sample includes all CCTS-PatEx matched exporters. HS2 by application year fixed effects are controlled in all columns. Columns 1 is estimated with OLS, and the rest are estimated with 2SLS, using the residualized examiner approval rates as instruments. Column 3 includes log initial export value and export tenure as controls. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A7: Alternative Specifications

Dependent variable	*Annualized 3-year export growth*					
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application	0.178***	0.163***	0.253***	0.195***	0.175***	0.181***
	(0.0525)	(0.0544)	(0.0736)	(0.0515)	(0.0494)	(0.0490)
Log export	-0.0367***	-0.0367***	-0.0367***	-0.0377***	-0.0379***	-0.0398***
	(0.00492)	(0.00491)	(0.00499)	(0.00400)	(0.00405)	(0.00473)
Export tenure	-0.00297	-0.00310	-0.00243	-0.00239	-0.00161	-0.000482
	(0.00366)	(0.00364)	(0.00382)	(0.00294)	(0.00305)	(0.00381)
Log examined Chinese patents			0.00153			
			(0.0149)			
Log examined foreign patents			-0.0213			
			(0.0210)			
Log examiner experience			0.00213			
			(0.0279)			
Application year fixed effects				Yes		
First action year fixed effects					Yes	
HS2-application year fixed effects	Yes	Yes	Yes			
HS2-first action year fixed effects						Yes
Instrument	IV1	IV2	IV2	IV1	IV1	IV1
K-P rk Wald F-stats	193.92	213.10	93.73	187.22	182.46	154.86
Observations	1156	1156	1156	1282	1282	1171

Note: The table reports the estimated effect of successful first US patent application on export growth of Chinese applicants, with alternative specifications. The dependent variable is annualized 3-year growth rate of export value. The sample covers all CCTS-PatEx matched exporters. Column 1 replicates the baseline estimate. Column 2 uses the alternative instrument that excludes both art unit by year fixed effects and technology class by year fixed effects. Column 3 add examiner characteristics as control variables. Column 4 to 6 experiment alternative fixed effects rather than HS2 by application year fixed effects. Column 4 includes application year fixed effects. Column 5 includes first action year fixed effects. Column 6 includes HS2 by first action year fixed effects. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A8: Three-part Decomposition

Dependent variables	*Components of annualized 3-year export growth*							
	All	All	Continuing	Continuing	Drop	Drop	New	New
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Successful first application	0.174***	0.178***	0.0686*	0.0693**	-0.0870***	-0.0869***	0.0182	0.0216
	(0.0568)	(0.0525)	(0.0360)	(0.0351)	(0.0311)	(0.0309)	(0.0311)	(0.0262)
Log export		-0.0367***		-0.00978***		-0.00415*		-0.0311***
		(0.00492)		(0.00292)		(0.00241)		(0.00232)
Export tenure		-0.00297		-0.00243		-0.00237		-0.00290*
		(0.00366)		(0.00209)		(0.00204)		(0.00149)
K-P rk Wald F-stats	196.51	193.92	196.51	193.92	196.51	193.92	196.51	193.92
Observations	1156	1156	1156	1156	1156	1156	1156	1156

Note: The table reports the estimated effect of successful first US patent application on each component of export growth of Chinese applicants. The sample includes all all CCTS-PatEx matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column controls for HS2 by application year fixed effects. Column 2, 4, 6, and 8 include log initial export value and export tenure as controls. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A9: ASIE Decomposition

Dependent variables	*Components of annualized 3-year export growth*					
	All	All	Existing	Existing	New	New
	(1)	(2)	(3)	(4)	(5)	(6)
Successful first application	0.218***	0.204***	0.159**	0.155**	0.0595**	0.0490**
	(0.0692)	(0.0623)	(0.0627)	(0.0611)	(0.0287)	(0.0230)
Log export		-0.0460***		-0.0122**		-0.0338***
		(0.00596)		(0.00553)		(0.00323)
Export tenure		-0.0139***		-0.00706**		-0.00681***
		(0.00372)		(0.00332)		(0.00156)
Log employment		0.0294***		0.0109		0.0184***
		(0.00858)		(0.00721)		(0.00413)
Industry-by-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Ownership-by-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
K-P rk Wald F-stats	150.44	159.58	150.44	159.58	150.44	159.58
Observations	941	941	941	941	941	941

Note: The table reports the estimated effect of successful first US patent application on each component of export growth of CCTS-ASIE Chinese applicants. The sample includes all all CCTS-ASIE matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Each column controls for CIC2 by application year and ownership type by application year fixed effects. Column 2, 4, 6, and 8 include log initial export value, export tenure, log initial sales, log initial employment, and initial operating profit as controls. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A10: Testing the Monopoly Power Channel: Export Growth

Panel A. Growth rate by destination/product types				
	By destinations		By Products	
	U.S.	ROW	Related	Unrelated
Successful First Application	0.163*	0.149***	0.191	0.179***
	(0.0882)	(0.0556)	(0.116)	(0.0607)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	948	1152	698	1121
Panel B. Growth rate by destination-product pair types				
	U.S. + Related	U.S. + Unrelated	ROW + Related	ROW + Unrelated
Successful First Application	0.200	0.208**	0.0780	0.181***
	(0.191)	(0.0980)	(0.117)	(0.0639)
Controls	Log export value, export tenure			
HS2-year fixed effects	Yes	Yes	Yes	Yes
Observations	448	878	678	1108

Note: The table reports the estimated effect of successful first US patent application on export growth of each type of product-destination pairs. The sample includes all all CCTS-PatEx matched exporters. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include HS2 by application year fixed effects, and control for log initial export value and export tenure. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A11: Testing the Financial Constraint Channel

Dependent variable	*Annualized 3-year export growth*					
Financial Constraint Proxies	*Ext.Fin. Dependence*		*Liquidity Needs*		*Tangibility*	
Firm group	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(7)	(8)
Successful first application	0.150**	0.187***	0.154**	0.234***	0.138**	0.268***
	(0.0682)	(0.0621)	(0.0619)	(0.0772)	(0.0660)	(0.0823)
Difference (High - Low)	-0.0368		-0.799		-0.130	
	(0.0894)		(0.0971)		(0.0999)	
Custom controls	Log export, export tenure					
HS2-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Sample	CCTS					
K-P rk Wald F-stats	147.46	135.58	180.43	101.28	138.46	102.99
Observations	473	644	646	470	591	511

Note: The table reports the estimated effect of successful first US patent application on export growth of Chinese applicants with different levels of measured financial constraints. The dependent variable is annualized 3-year growth rate of export value. The sample covers all CCTS-PatEx matched exporters, divided by the sample median of measured financial constraints. All columns are estimated with 2SLS, using the residualized examiner approval rates as instruments. Control variables including log initial export value and export tenure and HS2 by application year fixed effects are included in all columns. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A12: Testing the Follow-on Innovation Channel

Depedent variables:	1-year patent growth		3-year patent growth	
	(1)	(2)	(3)	(4)
Successful first application	0.0207	0.00700	0.382	0.754
	(0.179)	(0.384)	(0.298)	(0.737)
Log patent	-0.191***	-0.191***	-0.209*	-0.208*
	(0.0479)	(0.0486)	(0.108)	(0.113)
Application year fixed effects	Yes	Yes	Yes	Yes
Model	OLS	IV	OLS	IV
K-P rk Wald F-stats		55.589		37.686
Observations	244	244	111	111

Note: The table reports the estimated effect of successful first US patent application on subsequent patent applications in China. The sample includes all all CCTS-ASIE-SIPO-PatEx matched exporters. Columns 1 and 3 are estimated with OLS. Columns 2 and 4 are estimated with 2SLS, using the residualized examiner approval rates as instruments. All columns include application year fixed effects, and control for log patent applications in China in the year of first US patent application. Heteroskedasticity-consistent Standard errors are clustered at examiner's art-unit level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix B An Example of the Matching Procedure

(12) **United States Patent**
Wang et al.

(10) **Patent No.: US 7,339,289 B2**
(45) **Date of Patent: Mar. 4, 2008**

(54) **SYNCHRONOUS PERMANENT MAGNET PLANAR MOTOR**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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H20K 41/00 (2006.01)
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(58) **Field of Classification Search** 310/12, 310/13, 15
See application file for complete search history.

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(57) **ABSTRACT**

According to the invention, configurations of X-windings and Y-windings in a synchronous permanent planar motor are improved, X-windings and Y-windings overlap in the direction normal to the planar magnet array and distribute on the entire surface of the thrust core, such that effective wires in the X-windings and Y-windings are lengthened and increased in number, therefore the electromagnetic force generated by the SPMPM of this invention is increased correspondingly; X-windings and Y-windings are mounted on a thrust core made of iron material, thus the electromagnetic force is further increased; in addition, two separated anti-yawing member are provided on the mover for counteracting yawing of the mover, accordingly interference between anti-yawing torque and the electromagnetic force for propelling is eliminated.

8 Claims, 6 Drawing Sheets

The document above shows the record of the first patent filed by **Shanghai Microelectronics Equipment Co.** in USPTO. We first standardize the company's name by replacing "Co." with "Company" and identify its first application. We then translate the two keywords "Microelectronics Equipment" and "Shanghai" into Chinese ("微电子设备"and "上海"), and search them in search engines, such as Google and Baidu. The search results mainly direct to one company named "上海微电子装备有限公司", and we cross-check the name with the publicly available company registration website (*Tianyancha*), which suggests the company is producing electronic components and is established before 2005.