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Intellectual property rights protection and export product quality: Evidence from China☆

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ABSTRACT

Intellectual property rights protection (IPP) at destination countries is an important determinant of exports, a result shown by the existing literature. This paper empirically examines the effect of the degree of IPP on export product quality at the origins, using firm-product level data from Chinese exporters and city-level statistics of IPP. To establish the causal relationship, we employ an instrumental variable (IV) approach. Our panel regression results from 2008 to 2013 show that the de facto IPP contributes to the export product quality upgrading and the result is robust against variations of IPP measures, IVs, and different combinations of control variables such as the firm and industry level subsidies. Our heterogeneity results indicate that the betterment of IPP favors less capital-intensive firms; foreign-owned firms relative to domestic-owned firms; and firms in innovation-intensive industries. The effect of IPP on export product quality is statistically insignificant in certain geographic regions (i.e., central and western regions) and trade mode (i.e., processing trade). In addition, we show that the channels through which IPP takes effect on product quality include strengthened R&D input, new product development, and mitigated financial constraints.

1. Introduction

It has been long recognized that intellectual property rights protection (IPP) institutions play an important role in determining the pattern of international trade. A number of studies find that countries with better institutions trade more (Dollar & Kraay, 2003; Levchenko, 2007). A more subtle question is that whether a specific institution contributes to the value-added of trade. The current paper examines the impact of de facto IPP institutions on the product quality of the exporters measured by the excessive returns that cannot be observed from the data. Although this relationship appears to be intuitive, its possible heterogeneity, endogeneity, and channels, are not straightforward. The lack of firm-level evidence in the literature further strengthens the significance of the research.

In the literature, a more fundamental relationship between technology and trade which was firstly investigated empirically by Soete (1981) using cross-sectional country-industry level data. It is shown that there is a significant positive association between technological performance, as proxied by patenting, and export performance as proxied by export market shares. This first evidence

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triggered a series of subsequent studies on this so-called "international competitiveness" (e.g., Amable & Verspagen, 1995; Amendola et al., 1993; Carlin et al., 2001; Dosi et al., 1990; Fagerberg, 1988). The seminal work by Maskus and Penubarti (1995) offers a trade related intellectual property rights (IPR) theory in which the betterment of IPP in destination countries has two countervailing effects on exports: on the one hand, it eliminates competition from imitation and thus encourages export which is coined as market expansion effect; on the other hand, the strengthened market power leads to higher prices which reduces the intensive margin. Their empirical analysis using 28 manufacturing sectors of OECD countries and 25 developing countries show that the market power effect is stronger in industries most sensitive to patent protection as the impact of IPRs on trade is weakest in these industries. The empirical findings by Maskus and Penubarti (1995) are echoed by some later studies such as Fink and Braga (1999) and Co (2004). Smith (1999) further adds local R&D intensity on top of weak IPP as the combined threat of imitation and shows that US exports were hindered in countries with weak patent protection and strong imitation capacity. However, a larger body of subsequent studies generally find that improvements of IPP stimulate trade flows, or the market expansion effect dominates the market power effect (see, e.g., Awokuse & Yin, 2010; Ivus, 2010; Falvey et al., 2009).

The effect of origin countries' IPP on exports is often overlooked, although a small but growing literature began to tackle this problem. For instance, Delgado et al. (2013) and Maskus and Yang (2018) present evidence that emerging economies witness increased export of IP intensive products following their IPR reform. On the channels through which IPR reform took effect, empirical studies in this line of research found that improvement of patent laws generally stimulates domestic exporting firms to import high-technology inputs (Delgado et al., 2013) or invites FDI and inward technology transfer (Bilir, 2014; Javorcik, 2004; Nagaoka, 2004; Branstetter et al., 2006). However, firm or product level research on the impact of an improvement of an origin country's IPP on its exports is still rare. One exception is Lai et al. (2020) who use the Chinese firm-level data from 2000 to 2006 and proxies of IPP institutions at the province level to study firms' response to regional variations of de facto intellectual property protection. In particular, they find weak evidence that firms expand their extensive margin in provinces with stronger intellectual property protection; but for intensive margins, technology adoption measured by capital-goods imports, and innovation proxied by new products, mixed results with conflicting signs of the key coefficients are reported. Hence there are no clear-cut messages learned from the existing literature.

While this literature appears to be rigorous and extensive, it still suffers at least from two shortcomings. First, most studies use country or industry-level data, making identification unconvincing and more refined questions left unanswered; and for exceptions using firm-level data, no clear-cut results are obtained. Second, because of the first shortcoming, the channels or mechanisms through which IPP influences product quality at firm-level is understudied.

In the current paper, we try to explore the relationship between de facto IPP and firms' manufacturing and exporting behavior using intra-national firm-level data. Specifically, we investigate the impact of IPP institutions on export product quality across Chinese localities. The quality of export product is particularly important and relevant in this context for the following reasons. First, for the sake of data availability, for most economies, statistics on domestic commerce is not well recorded at firm-product level which prevents one from estimating product quality using Khandelwal (2010) and Khandelwal et al. (2013) techniques from domestic commerce data. Second, on the one hand, China's opening up marked by the WTO accession and gradual removal of trade barriers brought more intense import competition for final products in the domestic market. On the other hand, reduced tariffs lowered cost of high-quality intermediate input and capital goods for domestic firms, and both factors provided domestic firms impetus to improve product quality through more innovation. Indeed, Dai et al. (2018) find that the R&D expenditures of Chinese exporters increased by 11% more than that of non-exporters during 2005–2007, and new product development of exporters increased 1.5 times more than that of non-exporters. Third, the ratio of ordinary trade in China's export product mix increased from about 45% in the late 1990s to 65% in the late 2010s. The fact that ordinary trade performs much better in innovation relative to processing trade, gives rise of significance of the research topic.

Several existing papers investigated the impact of trade liberalization on export product quality (e.g., Fan et al., 2018; Fieler et al., 2018). Fan et al. (2018) show that tariff reduction favors less productive firms more in the sense that it brings more incentives for these firms to innovate using more expensive imported input at a reduced price and achieve higher gains in quality upgrading. This is because more productive firms are less affected by a marginal reduction of price of imported inputs. However, in the case of improvement of local IPP, the nominal gains to the firms under the same jurisdiction are the same. However, the changes on export product quality respond differently with respect to that of the degree of IPP. In particular, our findings show that less capital-intensive exporters upgrade more product quality in response to the same IPP improvement. One possible channel, as also shown by our results, is that IPP improvements alleviate firms' external financial constraints. Our results also show that better IPP favors patent-intensive firms more than their counterparts since better IPP directly encourages more innovations. By the same token, exporters conducting ordinary trade is found to respond more to an improvement of IPP relative to those doing processing trade. The effect is more pronounced for exporters in the eastern region of China and foreign-owned firms relative to domestic-owned.

One explanation for the high responsiveness of more patent-intensive firms may also arise from the larger gains in international market competition when the existing quality is higher. Liu et al. (2020) show that patent protection promotes export product quality improvement if a country's product quality is sufficiently close to the world's frontier level. The logic in Liu et al. (2020) that only countries whose technologies are close enough to the frontier would generate sufficient market returns from R&D investment can be readily applied to and tested by firm-level data. This argument is parallel to a similar argument in the literature of optimal commercial policy where the optimal degree of IPP may depend on the level of economic development (Chen & Puttitanun, 2005).

We contribute to the existing literature in the following dimensions. First, we obtain a set of consistent and clear-cut results on the relationship between IPP and export product quality at firm-level, using matched data between China Customs Data and Annual Survey of Industrial Firms in China (ASIFC) for the years 2008–2013 where prefecture level de facto IPP data is available. Second, we investigate the possible channels for IPP to take effect, i.e., more R&D input and output, as well as more access to external finance.

Third, our instrumental variable (IV) approach confirms the statistical causality between IPR institutions and export product quality. To the best of our knowledge, no existing study has ever combined the most exhaustively disaggregated firm-level (export and ASIFC) data, city-level IPP measures, and firm-level innovation data together to tackle this problem. Our paper is the first to show that better IPP institutions stimulate origin exporters' product quality, a finding consistent with that of Faruq (2011) who used general institutions at country-level and a different measure of export product quality. Our paper fills the gap in presenting firm-level evidence on the impact of origin country/region IPP improvement on local firms' export pattern.

In a related article, Li et al. (2020) study the impact of property rights protection (PRP) proxied by the 2007 enactment of property law in China on Chinese firms' export product quality. Using a difference-in-difference approach, they find that property rights legislation benefited firms with more tangible assets in improving product quality, and this effect is only found for non-state-owned private firms. In addition, Li et al. (2020) show that two possible channels are improved access to external finance and boosted TFP. Their results validate the premise that lower expropriation risk implied by better PRP will bring more incentives to capital-intensive firms in quality upgrading investment. It also facilitates the financing of the firms since better PRP also provides better protection to the creditors hence alleviates the under-financing problem in the case of weak PRP (Djankov et al., 2008).

In the Chinese language literature, Wu and Tang (2016) study the impact of IPP on firm-level innovation and performance. Using the city-level degree of IPP and Chinese listed firm data, it is found that better IPP contributes to both more R&D input and more patent registrations. It is also shown that the channels for IPP institutions to take place are reduced R&D spillovers and alleviated external financial constraints. However, the paper does not address export product quality.

The rest of the paper is organized as follows: Section 2 discusses the institutional background and data; Section 3 describes the model specification and variables; Section 4 discusses the empirical results; Section 5 is related to possible channels of IPP affecting export quality; Section 6 presents the heterogeneity tests, while Section 7 concludes.

2. Institutional background and data

2.1. Intellectual property rights protection

Since China's openness and reform in the 1980s, China's IPP system has witnessed rapid growth in the transition from a centrally planned economy to a market-based economy. It is the transition that provides China the strong impetus and great opportunity to foster modern IPP institutions in China. In addition, the most recent wave of globalization facilitated China's remarkable transformation into the world's manufacturing powerhouse. The enormous amount of FDI inflows had a profound impact on the degree of IPP by the Chinese localities in the mid-to long-run. Beginning with the first legislation of China's patent law in 1984, such as the, a major revision in 2000, and the announcement of China's Median and Long-range Science and Technology development plan in 2006, China's IPP evolved tremendously over the past three decades. As a most widely used index that measures a country's patent reform, Ginarte-Park (GP) index is used to examine what factors or characteristics of economies determine how strongly patent rights are protected.[1] China's Ginarte-Park (GP) index rose from 2.37 in 1995 to 4.42 in 2015. However, since the GP index, as a legislation-based measure, is only calculated at the country-level, it fails to capture provincial differences in IPP, let alone inter-city differences in IPP thus unfit for intra-national studies.

A number of previous studies used provincial measures of IPP based on the reported IPR litigation cases prior to the year 2014. However, this measure is intrinsically biased since unconditional publicization of court rulings, required by the Supreme Court of China, only became mandatory by January 1, 2014. Prior to this date, only a tiny fraction of cases was publicized. Different from previous studies which use provincial indexes, we exploit the city level IPP scores provided by "Annual Report of City Competitiveness" (Ni, 2008–2013) to reflect prefectural IPP differences. Specifically, the reports provide IPP scores of 65 major cities that correspond to more than 65% of the total GDP in China and 71.3% of the firms in our sample. The research group conducted annual questionnaire surveys from 2002 to 2011 of which over 6000 experts, entrepreneurs of representative enterprises (larger or typical industry), and randomly selected citizens were asked questions such as "What do you think of the degree of protection of IPRs in this city?". The scores of respondents were aggregated to the prefecture city level.[2] The provincial IPP measures, such as provincial winning rate, are vulnerable to explanatory power. On top of the incompleteness of the reported cases from the PKULAW.cn prior to the year 2014, the provincial IPP measures, such as winning rate, may still suffer from downward bias. Winning rates only capture a fraction of de facto enforcement efforts, which includes the time required to settle litigation, the possibility of preliminary injunctions and so forth (Lai et al., 2020). This situation could exacerbate the downward bias in locations where the effective enforcement is greater. The provincial IPP measures, proxied by total counts of litigations or the winning ratio of the plaintiffs, are vulnerable to a number of criticisms. The numbers of litigation cases, in the law literature, could merely reflect the litigiousness of a society or locality, rather than the

[1] It was constructed using a coding scheme applied to national patent laws. Five categories of the patent laws were examined: (1) extent of coverage, (2) membership in international patent agreements, (3) provisions for loss of protection, (4) enforcement mechanisms, and (5) duration of protection. Each of these categories (per country, per period) was scored a value ranging from 0 to 1. The un−weighted sum of these five values constitutes the overall value of the patent rights index. The index, therefore, ranges in value from zero to five. Higher values of the index indicate stronger levels of protection by country and year (Ginarte & Park, 1997).

[2] The score includes 5 points (very high degree of protection), 4 points (high degree of protection), 3 points (normal degree of protection), 2 points (poor degree of protection), 1 (very poor protection). Assuming the proportions of respondents rated 5, 4, 3, 2, 1 are X1, X2, X3, X4, X5, then the city's IPP score is "2·X1 + 1·X2 + 0·X3 + (−1) ·X4 + (−2) ·X5".

betterment of IPP. The winning rate of the plaintiffs as a proxy of the degree of IPP, suffers from similar pitfalls. More problematically, the statistics from PKULAW.cn prior to the year 2014 was incomplete and biased. To avoid such shortfalls, we instead use the city-level IPP scores as our main dependent variable.

Fig. 1 presents two histograms of the IPP scores at prefecture-level in China for the years 2008 and 2010. Several patterns stand out: first, IPP scores increase in 2010 relative to 2008 for most cities in the sample as shown in both panels in Fig. 1; second, IPP scores are on average much higher in southeast coastal cities such as Shanghai, Dongguan, Zhuhai, Zhongshan, and Suzhou. In contrast, central and western cities such as Kunming, Huhehaote, and Changsha present weaker IPP performance.[3]

The scores of IPP in these cities directly represent the de facto local degree of protection of IPRs and conceptually superior to most other measures used in the existing literature. We merge the IPP score with ASIEC and GACC database by firms' locations. Our matched sample accounts for about 71.3% of total firm-level observations.

Anecdotes in China show that stronger city level IPP encourage and motivate innovation at firm level. In recent years, several well-known IPR infringement cases were probed and prosecuted, e.g., 25 tons of faked Dupont pesticide case in Ningbo in 2016; over RMB10 million value of faked 3 M face masks confiscated in Shanghai in 2015; and 2016 Beijing IPR Court's ruling of a punitive fine of RMB 49 million of the USB flash shield patent infringement case etc. Such IPR prosecution cases reported by the media often concentrated in areas with better IPP institutions. In 2014, the Congress passed a decree to establish IPR Courts in Beijing, Shanghai, and Guangzhou, reflecting the emphasis of IPP in these cities. In 2016, IPR tribunals were established in Nanjing, Suzhou, Wuhan, Chengdu, Ningbo, and Hefei. Not surprisingly, patent registration in cities with better IPP surpassed national average and grew faster. For instance, the city of Ningbo received 18,497 patent applications and its per capita number of patents is well ahead of national and provincial average in 2017.

2.2. Firm-level data

The data we use in the empirical section includes three data sets: (1) the firm-level export and import data which collected by the General Administration of Customs of China (GACC) from 2008 to 2013; (2) firm-level production and financial data from the Annual Surveys of Industrial Enterprises in China (ASIEC), and (3) the firm-level innovation data obtained from China's National Bureau of Statistics (NBS).

The GACC dataset provides a variety of information, including each trading firm's product price, quantity, value, and destination at the HS 8-digit level. We first estimate the export quality using product-level data in GACC, and then aggregate them to obtain firm-level export quality. Column (2) of Table 1 reports the sample size from 2008 to 2013.

The ASIEC dataset is the most comprehensive annual survey of manufacturing enterprises in China which includes all manufacturing firms whose annual turnover is greater than RMB 5 million. This firm-level unbalanced panel data includes over 3 million firms every year. It covers all 425 manufacturing industries at 4-digit Chinese Industrial Classification (CIC) level. Besides the basic registration information, the data set also includes the main indices from firms' accounting statements such as sales, capital stock, employment, and so on. We clean the sample and drop outliers following the criteria from Yu (2015) [4] and the final sample size of the merged data is reported in Column (1) of Table 1.

The literature finds that improved IPP often contributes to the proliferation of R&D activities, proxied by patent applications or R&D spending (Ang, Cheng, & Wu, 2014; Arrow, 2015). In the current paper, we exploit the firm-level innovation data which contains key variables [5] at the firm-level to investigate possible channels through which strengthened IPP facilitates export product quality. It covers more than 30 thousand firms in all 31 mainland provinces and 345 cities. Although the patent is frequently used in the innovation literature, the R&D intensity as a measure of innovation may outperform the patent in firm-level studies for two reasons as follows. First, as pointed out by Hall et al. (2005), a variety of knowledge stocks such as patents and citations are extremely skewed, whereas the ratio *R&D stock/assets* is distributed more symmetrically, reflecting a stronger predicting power. Second, R&D is a time and resource-consuming process which features uncertain time lagging in the eventual transformation into a patent. For the aforementioned reasons, it is difficult to expect patents to generate a positive effect on the contemporaneous product quality of exporters while more intensive R&D inputs are more effective in a short time period. Thus, we use R&D intensity (*R&D stock/asset*) as the total R&D expenditure divided by firm's assets in a given year to measure innovation input. It is assumed that the R&D stock is subject to a 15% depreciation rate which is a common assumption in the literature, such as Hall et al. (2005). R&D intensity will be used in Section 5 in the analysis on possible channels through which IPP takes effect.

The GACC, ASIEC, and innovation datasets are merged using the method developed by Fang et al. (2020) who match these datasets using firms' names and locations. The sample size for the combined dataset is shown in Table 1. We derive a highly comprehensive firm-level panel data from 2008 to 2013 which contains Chinese manufacturing exporters' information, such as firm export quality, firm financial information, and innovation information.

[3] In Fig. 1, for comparability, we only keep cities of which the year 2008 data and year 2010 data are both available.

[4] We drop the observations without key financial variables and less than 8 workers; deleting observations cannot satisfy the basic rules of the Generally Accepted Accounting Principles (GAAP).

[5] The variables in the innovation data include the number of patent applications, effective patents, the size of the research staff, R&D expenditures, etc.

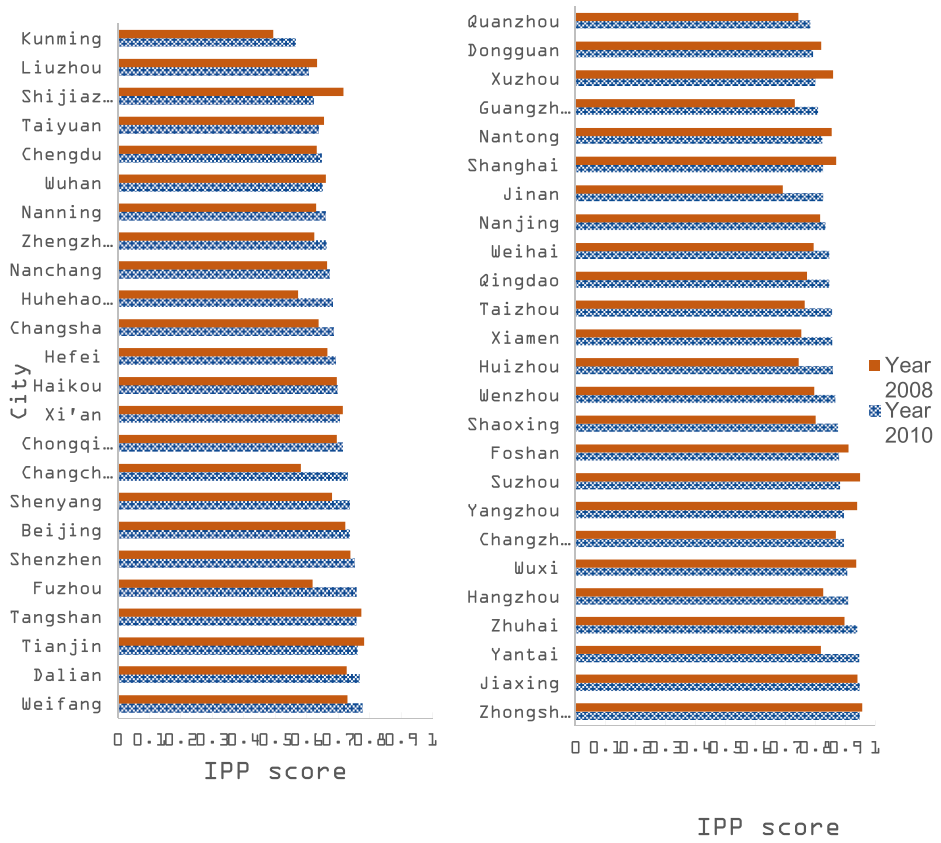

Fig. 1. IPP scores for cities in China for 2008 and 2010.

Table 1
Matching ASIEC data and GACC data.

Year	Our sample				
	No. of firms in ASIEC (1)	No. of firms in GACC (2)	No. of innovation firms (3)	GACC matched ASIEC (4)	Innovation firms matched ASIEC & GACC (5)
2008	362,560	206,529	30,267	66,312	8191
2009	422,129	216,230	37,369	75,953	9565
2010	310,637	234,386	42,139	54,674	13,193
2011	302,593	254,644	53,708	68,434	22,113
2012	311,314	269,576	67,009	71,742	27,676
2013	345,936	282,436	76,167	76,371	27,965

3. Model specification and variables

To explore the relationship between the de facto IPP and the export product quality at firm-level across Chinese localities using merged manufacturing firms' dataset, we estimate product quality using the approach in Khandelwal et al. (2013) and construct a city-level IPP measure both of which constitute our key variables. We intend to clarify that better IPP can substantially boost the product quality of exporters. Although this relationship appears to be intuitive when the local firms' technology is close to the world frontier, there is a lack of empirical evidence. The robustness and heterogenous impacts and possible channels through which more stringent IPP affects export quality of exporters are still worth investigating.

3.1. Model specification

To empirically study the impact of IPP on product quality manufacturers' export, we use the two-stage panel data model of fixed effects. The estimating equation is set as Eqn 1 as follows:

$$lnquality_{fjct} = \beta_0 + \beta_1 lncityIPP_{ct} + \beta_2 X_{ft} + \beta_3 X_{ct} + \lambda_j + \lambda_t + \varepsilon_{fjct}, \quad (1)$$

where $lnquality_{fjct}$ is the firm-level export product quality for firm f located in city c in industry j at year t *and takes log form*; $lncityIPP_{ct}$ is the level of de facto IPP of the city where firms are located and takes log form; X_{ft} refers to firm-level control variables and X_{ct} refers to city-level macroeconomic fundamentals; λ_j is the industry fixed effect; λ_t is the year fixed effect,; and ε_{fjct} refers to the error term clustered at 2-digit CIC industry-level.

3.2. Variables description

Product Quality of Exporters. Export product quality is estimated according to the approach developed in Khandelwal et al. (2013) at HS 6-digit level estimate. This method can alleviate estimation bias arising from the "price-quality" approach in Schott (2004) and is widely used in the recent literature (Fan et al., 2015; Li et al., 2020). Specifically, the quality of product n exported by exporter f to destination d in year t is estimated using the following log-linearization of the demand function as Eqn 2:

$$\ln(q_{fndt}) + \sigma_n \ln(p_{fndt}) = \phi_n + \phi_{dt} + \varepsilon_{fndt}, \tag{2}$$

where q_{fndt} denotes the demand for product n exported by a particular exporter f in destination country d in year t, p_{fndt} refers to the price of exported product n charged by the particular export f sold in destination market d in year t; ϕ_n is the product fixed effect; ϕ_{dt} represents destination-year fixed effect; and σ_n is the elasticity of substitution across 6-digit HS products within the same HS 3-digit products category. The estimation values of elasticity of substitution within HS 3-digit products category σ_n, is taken from Broda et al. (2017) who use a sample of data of 73 countries to obtain elasticities of substitution and supply for a large number of sectors in each country. The product-level export product quality is then $product\_quality_{fndt} = \varepsilon_{fndt}/(1 - \sigma_n)$. We aggregate the product-level quality to firm level using the export share of each HS 6-digit product within firms as weights.

Measures of City-Level IPP. As mentioned in Section 2.1, the GP index captures the overall development of legal provisions at the national level while city IPP scores reflect cross-city variations in IPP. In this part, we measure de facto IPP by interacting city-level IPP with the national GP index. This method can mirror both national IPP and variations in city-level IPP, which only leads to parallel shifts of the IPP at the prefecture-level without altering the relative magnitudes across cities. In addition, GP index is only a legislation-based measure, so that we further introduce Fraser index,[6] which is constructed by Canada Fraser Institute to evaluate cross-country de facto protection of IPRs. To accurately measure the variations between cities within the country, we calculate the product of GP index, Fraser index, and city level IPP score mentioned above as shown in Eqn 3 below:

$$cityIPP_{ct} = GP_t \times Fraser_t \times cityIPPscore_{ct}, \tag{3}$$

Then we take $cityIPP_{ct}$ as logarithm form in our regressions.

Control Variables. The ASIEC firm-level dataset contains some key financial information of a firm, such as sales, capital, and asset. In line with related literature, we also take several relevant firm characteristics into account, such as firm age (*lnage*), firm size (measured by firm's total assets, *lnasset*), and firm's leverage (*leverage*) which is measured by the ratio of total liability to total assets, as well as city characteristics such as proportion of urban population of a city (*cpoprate*) and per capita GDP growth rate of a city (*pgdprate*) (Fang et al., 2020; Liu and Ma, 2020).[7]

Fixed Effects. In the empirical specification, we further include industry fixed effect and year effect. λ_j is the industry fixed effect, controlling for other policy changes that may correlate with the IPP environment. λ_t is the year fixed effect, indicating unobserved aggregate shock common to firms.

3.3. Descriptive statistics

Each firm belongs to an industry according to the four-digit Chinese Industry Classification (CIC) system. In 2011, the Chinese classification system was revised to incorporate more details for some industries, while some other industries were merged. To make the industry codes comparable across the entire sample period, we unify the CIC code into 2011 version to ensure consistency before and after 2011.

We also consider the characteristics of different geographic regions and merge prefecture-level data obtained from CEIC database from 2008 to 2013 by firm location information. Per capita GDP growth and urbanization are calculated to control firms' prefecture-level characteristics.

An unbalanced panel of 82,822 firms and a total of 235,665 observations, spanning 472 4-digit CIC industries between 2008 and 2013 is obtained after matching and cleansing. Table 2 presents the summary statistics of the main variables used in this paper.

Before moving on to the formal empirical tests corresponding to the impact of city-level IPP on product quality of what Chinese

[6] The details of Fraser index can be available on website: https://www.fraserinstitute.org/economic-freedom/dataset?geozone=world&page=dataset&min-year=2&max-year=0&filter=0. For the sake of suitability, we only use the "legal system & property rights" dimension from the Fraser Index.

[7] TFP as a key driver, can determine the firm performance, such as export margins, R&D decisions and so forth. However, there is lack of data needed to estimate TFP using estimation methods such as OP method (Olley & Pakes, 1996), LP method (Levinsohn & Petrin, 2003) and ACF method (Ackerberg et al., 2015) commonly used in literature. The required data such as firm investment and intermediate goods data are not available in our refined firm data from 2008 to 2013. Therefore, we did not consider the impact of TFP on firm export quality.

Table 2
Summary statistics.

	N	Mean	Std. Dev	Min	Max
	(1)	(2)	(3)	(4)	(5)
Panel A dependent variables					
Quality	235,665	0.673	0.141	0	1
Lnquality	235,645	−0.424	0.261	−5.798	0
Panel B independent variables					
lncityIPP	167,164	2.902	0.0969	2.396	3.076
lnprovinceIPP	114,347	5.249	1.040	−0.386	6.684
Panel C controls					
Lnage	230,166	2.172	0.701	0	5.118
Lnasset	235,656	10.61	1.345	7.872	12.92
Leverage	235,604	0.703	0.993	0.00165	27.69
Pgdprate	219,151	0.166	0.327	−0.241	3.940
Cpoprate	219,151	0.492	0.305	0.0437	1
Panel D channel variables					
R&D intensity	235,656	0.0281	0.0712	0	0.368
new product	235,665	0.0502	0.218	0	1
trade credit	225,059	0.238	0.407	−28.00	48.67
Panel E instrument variables					
UK_colony	235,665	0.154	0.361	0	1
Treaty Port	219,151	0.497	0.500	0	1
Panel F other variables					
lncic2_subsidy	116,520	12.81	2.833	0	15.16
Subsidy	235,665	0.0851	0.279	0	1
cap_intensity	188,468	196.4	2323	−32.39	500,798

manufacturers export, we start by summarizing the features of variables in Table 2. Panel A relates to our key dependent variables, firm-level export quality, which suggests that the mean of firms export quality, *quality*, is 0.673, with a standard deviation of 0.141, ranging from 0 to 1. Logarithm form of firm export quality is used in the regressions, and the corresponding mean value is −0.424, ranging from −5.978 to 0, with a standard deviation of 0.261. Panel B refers to the key independent variables. The main IPP measure, *lncityIPP*, ranges from 2.396 to 3.076, with a mean value of 2.902 and a standard deviation of 0.0969. Another IPP measure is at the province level which will be used in robustness checks. Panels C, D, E, and F describe controlling variables, channel variables, instrumental variables, and several other variables used in robustness checks, respectively.

Table 3
Baseline regressions.

	Dependent variable: *lnquality*			
	OLS			2SLS
	(1)	(2)	(3)	(4)
lncityIPP	0.0945**	0.0857**	0.0867**	0.2301**
	(0.0349)	(0.0352)	(0.0347)	(0.113)
Lnasset	0.0263***	0.0299***	0.0298***	0.0297***
	(0.0029)	(0.0030)	(0.0030)	(0.0029)
Leverage	0.0094***	0.0074***	0.0066***	0.0068***
	(0.0013)	(0.0014)	(0.0012)	(0.0012)
Lnage	0.0039	0.0056*	0.0048	0.0057*
	(0.0029)	(0.00304)	(0.0031)	(0.0033)
Pgdprate			0.0102***	0.0111***
			(0.0028)	(0.0029)
Cpoprate			0.0360***	0.0395***
			(0.0099)	(0.0105)
yearFE	no	Yes	Yes	yes
industryFE	yes	Yes	Yes	yes
Kleibergen-Paap rk LM statistic				12.073 (0.0005)
Kleibergen-Paap rk Wald F statistic				126.51
Observations	163,383	163,383	152,775	152,775

Notes: Robust standard errors in parentheses, clustered at the 2-digit CIC industry level. The constant terms are omitted to save space. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

4. Empirical analysis

4.1. Basic results

The key explanatory variable of interest is the IPP index at city-level, *lncityIPP*, as described in Section 3.2. The coefficient, β_1, on *lncityIPP*, as the key parameter of interest to be estimated using two-stage fixed effect panel model method with instrumental variables, measures the effect of city-level IPP on product quality of what Chinese manufacturers export. Following Li et al. (2020), we incorporate firm characteristics in our estimating equation such as firm establishment duration (*lnage*), a measure of firm size (*lnasset*) and firm's leverage (*leverage*) measured by the ratio of total liability to total assets, as well as city characteristics, such as per-capita GDP growth rate and population growth rate. Further, we also add year fixed effect to control for the trending impact of non-observable factors affecting all industries and enterprises and industry fixed effect, which controls time-invariant non-observable industry-level factors.

In Table 3, the baseline results from Columns (1) to (3) are obtained using OLS method. The regression in Column (1) which includes firm controls and industry fixed effect shows that the city IPP had a statistically significant and positive impact. In Column (2), we further control for year fixed effect and the estimated β_1 is also significant and positive. In Column (3), city characteristics are incorporated and the significant and positive estimated of IPP is also obtained. Overall, the coefficient of interest β_1 is statistically significant, indicating stronger city IPP can encourage exporters to upgrade their export product qualities.

4.2. Endogeneity tests

The endogeneity problem could arise from simultaneity between the IV and outcomes. Specifically, the causal relationship between city IPP measure and product quality of exporters may reverse, i.e., improved product quality of exporters may have promoted the local courts to provide stronger IPR enforcement. In addition, the unobserved forces absent in our equations may also result in this endogeneity problem. To mitigate this potential endogeneity problem, we instrument the possible endogenous variable, city-level IPP measure, with the British settlement dummy, which takes value of one if the city is ever a British settlement before 1949 and zero otherwise.

The foreign extraterritorial settlements or concessions in modern time China, as extraterritorial zones within Imperial China, were surrendered under a series of so-called unequal treaties as punitive territorial and economic concessions. British citizens and subjects enjoyed extraterritorial rights in their settlements were subject to British laws and disciplined by their consular courts overseen by consular officials. Although Chinese citizens and citizens of non-treaty powers were subject to Chinese law, in practice, they were nevertheless subject to a mixed court involving both British and Chinese judges following jointly agreed legal values. For instance, the Shanghai Mixed Court was established in the Settlement in 1864 and ended in 1926, and the British Supreme Court for China was established in 1865 and ceased to function until December 1941 when the court was occupied by the Japanese invasion force. Since most cities with British concession history were either treaty ports or settlements meant for British commercial interest, their legal traditions had a long-lasting impact on local culture and informal institutions which took effect in the de facto enforcement of the laws.

The foreign concession data is sourced from Yang and Ye (1993) and complemented by Fei (1991) who distinguishes foreign concessions that attracted businesses from origin countries and not. We choose this IV because the United Kingdom is the birthplace of patent law (the Monopoly Act of 1623) and the Copyright Law (the Anne Act of 1710). The United Kingdom conducts the administration and legal construction of the concession in accordance with its own legal traditions. Just as Ivus (2010) points out, the formation and successive development of colonies' institutions of law and private property were deeply influenced by their colonizers. Particularly, Britain and France had well developed patent systems which provided fertile environment for their colonies to develop their patent regimes. Indeed, commercial disputes centered on IPR issues, mostly between British and Chinese merchants, began to emerge in late Qing dynasty in British concessions in China. As a reaction to the increasing commercial disputes, in 1902, Britain and China signed the Amendments to the Treaty of Commerce and Navigation between China and Great Britain (McKay Treaty), the first protocol with a clause on IPR protection between the imperial Chinese court and western powers. The McKay Treaty explicitly articulated the mutual protection of trademarks. In 1904, the first ever Chinese law on IPR, i.e., Trademark Registration Statue, was drafted by Robert Edward Bredon and amended by Robert Hart, both of which are British nationals. In 1907, the British consular in Shanghai requested the magistrate of Shanghai to issue public announcement on the prohibition of possible infringement of British trademarks. Ever since the law was put in force, litigation cases related to forging or counterfeiting which constitute infringement of trademarks were brought to court for trials. Notable examples include A. R. Burkill and Sons, Ltd. vs. Hongyuan Foreign Goods Store in 1909 among others, and in most cases, mixed court following the spirit of strong IPP in the British law, ruled against the infringers with punitive fines.

Controlling for endogeneity, we find that the 2SLS estimate of the coefficient of *lncityIPP*, is 0.230, being statistically significant at 5% level and positive and much greater than those in previous columns. This result indicates that stronger city level IPP facilitates exporters to upgrade their exports. Column (4) in Table 3 serves as a benchmark result which is compared in robustness and heterogeneity tests. Test results for the validity of the IV are reported at the bottom of Table 3. The Kleibergen-Paap rk LM statistic reports the results of under-identification of the chosen IV. In Column (4), the Kleibergen-Paap rk LM statistic is 12.073, with p-value 0.0005 implying the IV does not suffer from the under-identification problem. Column (4) indicates that Kleibergen-Paap rk Wald F statistic is 126.51, a value much greater than the 10% level critical value of 16.38 in the Stock-Yogo weak ID test, which implies that the IV is not a weak one. The two statistics jointly confirm the validity of the chosen IV, i.e., city legacy of British concession.

4.3. Robustness checks

In this section, we conduct the following four sets of robustness checks of the impact of IPP at the city level on exporters' product quality. The results are all reported in Table 4.

4.3.1. Alternative IPP measure

To investigate the consistency of the impact of IPP over export product quality using different measures of IPP, we replace the city-level IPP with a provincial IPP measure taken from (Fan et al., 2009) who publish an index of IPP at the province level annually from 2008 to 2013. The Fan and Wang marketization indices are frequently used in studies on the Chinese economy and is conceptually unbiased compared to the numbers of provincial litigation cases or winning ratio based on publicized litigation cases found on PKULaw.cn.

The corresponding IV is a British settlement dummy denoting whether the firms are located in provinces where at least one city had a history of British concession. Since the escalation to the elite class in the bureaucracy ever since the self-strengthening or westernization movement during the late Qing dynasty was heavily influenced by western institutions, and China's provincial borders only changed in a negligible way since Qing dynasty, the carryover from city legacy of British colonization to the provincial level conform one's intuition. Indeed, the results from the substitution of provincial IPP, instrumented by provincial British legacy, is reported in Column (1) in Table 4 and the estimated effect is positive and statistically significant, which is consistent with Column (4) in Table 3.

Alternative Instrumental Variable. In the second robustness check, the IV is replaced. Specifically, a dummy variable, *Treaty port*, defined as whether a city is a treaty port since 1842, is employed as the alternative IV. China's Treaty Port system began with the Treaty of Nanking which ceded Hong Kong Island to Britain in perpetuity and stipulated that five ports were to be opened to foreign trade: Canton (Guangzhou), Amoy (Xiamen), Foochow (Fuzhou), Ningpo (Ningbo), and Shanghai. These ever-increasing series of foreign settlements under treaties with China for as many as twenty countries, formally known as Treaty Ports, proliferated in China until 1943, ending the system after some 101 years. Within the treaty ports, Western subjects enjoyed extraterritoriality—i.e., immunity to prosecution for foreigners under Chinese law. Independent legal, judicial, police, and taxation systems were developed in each of the ports, although most of these treaty port cities were still nominally considered Chinese territory. Many Chinese were first acquainted with Western thought and institutions in the treaty ports. One unintended consequence of the opening of China to international trade was modernization in which the missionaries played a role in this because it was due to "schools and other activities that foreign ideas were being introduced to an increasingly politically aware student population" (Nield, 2015, p. 204).

The profound impact of treaty ports in China in terms of modernizing China was recognized by historians. Indeed, "Chinese commercial ideas and trade practices would have developed without Western input, although perhaps on different lines, but the presence of an alien culture accelerated change" (Nield, 2015, p. 11). It is even concluded that the Treaty Ports represented "the largest cultural transfer in human history" (Nield, 2015, p. 11). Apart from education, two main channels treaty ports contributed to modernization are export-oriented industrialization and legal institutions. For instance, the foreign presence since the late 19th century in treaty port cities such as Shanghai and Canton fostered or at least catalyzed China's very first market-oriented industrialization. Within these treaty port cities, a western judicial system was installed to settle civil and commercial disputes. It is almost unanimously agreed that treaty ports were instrumental to verdict traditional China's complacency, disdain to western culture, and deep-rooted antipathy to trade by the imperial court. The 2SLS estimate in Column (2) in Table 4 shows that the coefficient of city IPP, *lncityIPP*, is still highly significant and positive using the treaty port as an alternative instrumental variable, a result consistent with earlier findings.

Subsidy. The Chinese government has been active in promoting industrialization using industry policies such as government subsidies. The firms covered by government subsidies can be motivated to improve export quality to promote their international market shares. In this case, we further incorporate subsidy variables into our baseline regressions, corresponding to results in Columns (3) and (4) in Table 4. In Column (3), we construct a firm-level subsidy dummy variable, which takes one if a firm receives a subsidy from the government, zero otherwise. In Column (4), we aggregate the firm-level subsidy from the government to 2-digit level industry and take logarithm form. The corresponding IV used in Column (3) and (4) is still city-level British settlement dummy, consistent with the benchmark regression in Column (4) in Table 3. The results of both columns in Table 4 are all significant at at least 5% level and positive, confirming the robustness of our main results.

In this section, we check whether subsidy factor will affect our main results that stronger local de facto IPP can result in upgrading of firm export quality. Incorporating firm subsidy only considers the effect of subsidy firms receiving from government on the quality upgrading of what they export, which is from the perspective of within firm factors. However, only within firm subsidy effect will ignore the possible positive externality on firm export quality upgrading originating from subsidies received by other firms within the same industry. This externality should not be omitted. In this case, we further incorporate industry level subsidy to consider the quality upgrading effect resulting from industry-wide subsidy effect, which is from the perspective of subsidy externality outside firms. Although the estimates of firm subsidy and industry subsidy are insignificant and negative, respectively, the estimates of IPP measure are still both positive and statistically significant. These two subsidy considerations can better alleviate our concern on the robustness of our main results.

5. Possible channels

Up to this point, we have asked whether a stronger IPP can cause firms to improve their export quality. This evidence we presented is consistent with our hypothesis that the strengthening of IPP regimes at the city level positively affects firm-level export quality.

Table 4
Robustness checks.

	Dependent variable: *lnquality*			
	Provincial IPP	Alternative IV	Subsidy dummy	Subsidy log
	(1)	(2)	(3)	(4)
lnprovinceIPP	0.0453***			
	(0.0142)			
lncic2_subsidy				−0.0098***
				(0.0037)
Subsidy			0.0031	
			(0.0037)	
lncityIPP		0.5010***	0.2300**	0.5400***
		(0.1190)	(0.1130)	(0.1970)
Lnasset	0.0304***	0.0296***	0.0296***	0.0255***
	(0.0034)	(0.0005)	(0.0030)	(0.0034)
Leverage	0.0074***	0.0072***	0.0067***	0.0007
	(0.0010)	(0.0007)	(0.0012)	(0.0073)
Lnage	0.0039	0.0074**	0.0057*	0.0090**
	(0.0025)	(0.0012)	(0.0033)	(0.0040)
Pgdprate	0.0745**	0.0129***	0.0111***	0.0118***
	(0.0322)	(0.0021)	(0.0029)	(0.0026)
Cpoprate	0.0064	0.0462***	0.0396***	0.0380**
	(0.0095)	(0.0036)	(0.0105)	(0.0158)
yearFE	Yes	yes	yes	yes
indusrtyFE	Yes	yes	yes	yes
Kleibergen-Paap rk LM statistic	8.805 (0.0030)	14.706 (0.0000)	12.072 (0.0005)	10.265 (0.0014)
Kleibergen-Paap rk Wald F statistic	14.258	76.152	126.291	70.810
Observations	108,168	152,775	152,775	76,564

Notes: The 2SLS estimation results use *treaty port* as an alternative IV. Robust standard errors in parentheses, clustered at the 2-digit CIC industry level. The constant terms are omitted to save space. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Those exposed to better city-level IPP export products with higher quality. First, we test whether stronger IPP can result in more firm-level innovation to improve export quality. In this part, we exploit three possible channels, (1) whether stronger IPP encourages higher R&D intensity (*R&D intensity*), (2) whether stronger IPP pushes firms to develop new products (*new product*), (3) whether stricter IPP can alleviate firms' external financial constraints (*trade credit*). Results are all reported in Table 5.

Table 5
Possible channels.

	R&D intensity	new product	trade credit
	(1)	(2)	(3)
lncityIPP	0.140***	0.0659*	0.699***
	(0.0325)	(0.0399)	(0.135)
Lnasset	0.0071***	0.0167***	−0.0219***
	(0.0011)	(0.0016)	(0.0036)
leverage	0.0054***	−0.0022***	0.229***
	(0.0009)	(0.0008)	(0.0107)
Lnage	0.0093***	0.0079***	−0.0198***
	(0.0018)	(0.0026)	(0.0033)
pgdprate	−0.0029***	0.0163***	0.0121***
	(0.00057)	(0.0024)	(0.0046)
Cpoprate	−0.0120***	−0.0611***	0.213***
	(0.0018)	(0.0058)	(0.0132)
yearFE	yes	yes	Yes
industryFE	yes	yes	Yes
Kleibergen-Paap rk LM statistic	12.074 (0.0005)	12.074 (0.0005)	12.101 (0.0005)
Kleibergen-Paap rk Wald F statistic	126.449	126.449	123.042
Observations	152,785	152,785	147,617

Notes: Robust standard errors in parentheses, clustered at the 2-digit CIC industry level. The constant terms are omitted to save space. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

5.1. R&D intensity

To improve product quality, firms need to develop advanced technology and modify product designs that entail much R&D inputs. In this case, to explore whether strengthened IPP can result in higher export quality, the identification of a causal relationship between IPP and R&D input is necessary. In this part, we use *R&D intensity* to represent the firm's R&D spending measured by the ratio of R&D expenses stock to the firm's total assets. The data is from Chinese firm-level innovation dataset from 2008 to 2013 which contains relevant firm-level innovation variables. The result of this channel is reported in Column (1) in Table 5. It suggests that better protection of IPRs at the city-level encourages firms to conduct more R&D activity which is conducive to product quality improvement.

5.2. New product

Whether firms report new products to some extent reflects firms' ability to transform the R&D spending to final product achievements which can better satisfy the needs of consumers. Different from patents, this channel reflects innovation output in another way which complements R&D channel to mirror the effect of more vigorous IPP. Following Audretsch and Feldman (1996) and Lai et al. (2020), we construct a *new product* dummy (*new product*), which denotes whether a firm reports new product production or not: taking 1 if a firm reports positive new product production value, 0 otherwise. The data is from the ASIEC dataset. The second channel result is reported in Column (2) in Table 5. It shows that more stringent city IPP promotes new products which can better satisfy updated consumption preferences.

More intensive R&D expenditures and stronger capacity of innovation are both necessary for firms to improve their export quality. The first two channels, R&D intensity, and production of new products both act as important influencing channels through which stronger IPP upgrades product quality, which is consistent with findings in Lin et al. (2010), Chen and Puttitanun (2005), Maskus et al. (2019) and Qian (2007).

5.3. Trade credit

Small firms may face limited access to capital markets, especially those with little physical assets which can be used as collaterals. In addition to borrowing from financial institutions, firms may be financed by their suppliers and use trade credit more intensively facing limited financial provision from formal institutions (Petersen & Rajan, 1997). Besides, the use of trade credit is prevalent as an important source of external financing in both developed and developing markets (Fisman & Love, 2003). As a considerable informal financial institution, trade credit is relevant for the growth and expansion of Chinese enterprises (Allen et al., 2005; Li et al., 2020). In this part, we further consider whether trade credit will be a channel through which de facto IPP affects product quality of exports. In line with the literature, we measure trade credit exporters face (*trade credit*) as the ratio of accounts payable to total assets. The data is sourced from the ASIEC dataset. The result of this channel is reported in Column (3) in Table 5. The estimate of the coefficient of *lncityIPP* is positive and highly significant, which is consistent with findings in Li et al. (2020).

Firms can spend more on the quality improvement of their exports if they face less financial constraints. Our estimate shows that stronger de facto IPP substantially mitigate the external financial constraints measured by the trade credit, which uncovers another channel through which stronger IPP institutions can betterment the product quality of exporters.

6. Heterogeneity checks

6.1. Patent intensity

Firms in patent-intensive industries are more responsive to IPP reforms. We classify Chinese industries into patent-intensive industries and non-patent intensive industries. Owing to the lack of unified formula of patent intensity, based on Hu and Png (2013), we compute four patent-related indexes to classify patent intensity industries.⁸ An industry is identified as patent-intensive industry if it ranks high and stable in the four indexes. The estimates are reported in Columns (1) and (2) in Table 6. In Column (1), the estimate of *lncityIPP*, related to the patent-intensive group, is highly significant and positive while the estimate in Column (2), which reflects a non-patent intensive group, shows no significant effect due to local IPP reforms. One explanation is that firms in patent-intensive industries are more sensitive to IPP reforms. Stronger local IPP can better protect the technology and designs embodied in the products exported. In comparison, firms in non-patent intensive sectors are less affected by the IPR reforms, and thus, stronger IPP produces little effect on product quality promotion.

6.2. Capital intensity

Recent studies show that exporters are larger and tend to employ more skilled workers than non-exporters, which leads to lower

[8] We calculate the ratio of the number of Invention Patent Applications (IPA) per capita of each industry to the average of industrial IPA per capita, the ratio of the number of Invention Patent Stock (IPS) per capita of each industry to the average of industrial IPS per capita, the ratio of the number of Invention Patent Applications (IPA) per unit output value to industrial average of IPA per unit output value and the ratio of the number of IPS per unit output value to the average of industrial IPS per unit output value.

Table 6
Heterogeneity checks.

	patent intensity		capital intensity		trade modes	
	(1)	(2)	(3)	(4)	(5)	(6)
lncityIPP	0.386***	0.176	0.275**	0.217**	0.192*	0.272
	(0.044)	(0.131)	(0.130)	(0.111)	(0.103)	(0.472)
lncityIPP_capital			−0.004***			
			(0.001)			
high_capital				−0.018***		
				(0.006)		
Lnasset	0.0366***	0.0264***	0.0351***	0.031***	0.029***	0.037***
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.006)
Leverage	0.010***	0.005***	0.0024	0.006***	0.007***	0.008***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
Lnage	0.004	0.007**	0.004	0.005	0.006*	0.002
	(0.008)	(0.003)	(0.003)	(0.003)	(0.003)	(0.009)
Pgdprate	0.018***	0.008***	0.013***	0.011***	0.010***	0.003
	(0.004)	(0.002)	(0.003)	(0.003)	(0.003)	(0.005)
Cpoprate	0.069***	0.030***	0.038***	0.041***	0.034***	0.010
	(0.022)	(0.009)	(0.011)	(0.011)	(0.009)	(0.031)
yearFE	yes	Yes	Yes	yes	yes	yes
industryFE	yes	Yes	Yes	yes	yes	yes
Kleibergen-Paap rk LM statistic	3.278 (0.0702)	8.963 (0.0028)	10.753 (0.0010)	12.040 (0.0005)	12.277 (0.0005)	7.528 (0.0061)
Kleibergen-Paap rk Wald F statistic	81.585	109.461	45.802	124.898	158.743	38.425
Obs.	48,020	104,755	124,874	152,775	142,825	9948

Notes: Robust standard errors in parentheses, clustered at the 2-digit CIC industry level. The constant terms are omitted to save space. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

capital intensity. Ma et al. (2014) find that exporters are less capital-intensive than non-exporters. Based on this finding, we further consider the capital intensity heterogeneity. The results are reported in Columns (3) and (4) in Table 6.

In Column (3), this paper interacts city IPP measure with logarithm form of firm capital intensity. The result demonstrates that the positive export quality effect of IPP will decrease with higher firm capital intensity (*cap_intensity*). In Column (4), we build a dummy, *high_capital*, denoting whether a firm is classified as firms featuring high capital intensity if a firm's capital intensity is above the median level of *capital_intensity* within the same 2-digit industry. We incorporate the dummy variable, *high_capital*, into baseline regressions, and the corresponding estimate is significantly negative, which is consistent with earlier findings in Column (3). This result shows that compared to firms in less capital-intensive industries, stronger local IPP generates smaller effect on firms' quality improvement in high capital-intensive industries. One possible explanation is that firms with high capital intensity have much easier access to financial support, while firms in less capital-intensive industries generally face finance constraints. In this case, stronger de facto local IPP provides more financial support and technology sources, which can get better protection, to firms in less capital-intensive industries, while those in high capital-intensive industries show little response when their degree of capital intensity increases at the industry level.

6.3. Trade modes

In Table 6, Columns (5) and (6) present outputs in terms of trade modes dimension. Column (5) refers to firm groups which mainly engage in ordinary trade, and Column (6) refers to those grouped as processing trade modes. The results show that firms mainly engaged in ordinary trade upgrade their export quality in response to stricter IPP while those engaged in processing trade have no apparent response in their export quality upgrading. One of the possible reasons could be that: processing trade is the process by which a domestic firm initially obtains raw materials or intermediate products from abroad and after local processing, exports the final value-added goods (Feenstra & Hanson, 2005; Yu, 2015) and this feature makes processing firms connect more to foreign markets, leading to insignificant quality effect due to merely stronger IPP. In contrast, firms engaged in ordinary trade involves more arms-length transactions with foreign enterprises. This feature of ordinary trade makes it much easier for domestic firms to contract with foreign enterprises to access advanced technology and relevant product design ideas in the environment with stronger IPP. This results in a more significant quality effect for firms mainly engaged in ordinary trade owing to better local IPP.

6.4. Ownership

In this section, we consider the ownership heterogeneity effect.[9] The results are all reported in Table 7. In Column (1), we add a state-owned firm dummy and foreign-owned firm dummy into baseline regression, and we find the positive quality effect of IPP is weaker for state-owned exporters while stronger for foreign-owned exporters compared to private-owned exporters. In Column (2), we reclassify state-owned exporters and private-owned exporters as domestic-owned exporters and add the interaction of city-level IPP and the domestic-owned firm dummy into baseline regression. We find that domestic exporters display a smaller quality effect of stronger IPP than foreign-owned exporters. In Column (3), we interact city level IPP measure with the state-owned firm dummy, and the regression output shows that state-owned firms have weaker quality effects due to stronger IPP than other exporters.

In Column (4), we interact city level IPP measure with a foreign-owned firm dummy, and the regression output shows that foreign-owned firms have a larger quality effect due to stronger IPP than other exporters. One possible explanation is that foreign firms are generally featured high technology and more innovations. They are much familiar with consumption preference in destination markets, which all bring them greater possibility to upgrade their exports abroad in response to stricter local IPP for foreign firms.

6.5. Region

The last two columns in Table 7 presents the heterogeneity tests from the perspective of regions¹⁰. Column (5) refers to the output of the "eastern regions" regression, and Column (6) refers to central and western regions regression outputs. The estimates corresponding to firms located in the eastern parts of China upgrade their export quality in response to strengthened city level IPP while, in consequence, those in the central and west parts show no apparent quality improvement facing stronger IPP. One possible reason is that firms located in eastern parts in China can enjoy the advantage of the developed economy, more resource agglomeration as well as policy preference to develop quality of their exports in their frequent contact with foreign markets facing stronger de facto IPP. In contrast, firms located in the central and western regions show insignificant quality responses to stricter local IPP.

7. Concluding remarks

IPRs have become increasingly important in international trade as technologically sophisticated products entailing more patents and innovations bring more value-added to the exporters. However, potential infringement of IPR by reverse R&D through product importation places a threat to high quality product trade. There is ongoing literature showing that better IPP at destination countries promotes the imports of high-quality products. However, there lacks research on the effect of IPP improvement at origins on exports. The research question is nontrivial since a betterment of IPP at origin may attract more imports of high-quality products which may either incentivize domestic firms to upgrade their product quality or retreat from too severe competition but specialize on low end products. The current paper uses panel data within China from year 2008–2013 to examine the effect of the degree of IPP on export product quality at the origins. Our data consists of firm-product level data from Chinese exporters and city-level measure of IPP. In addition, to control endogeneity, we use city-level legacy of British colonization to instrument local IPP level today. Our empirical results indicate that local de facto IPP facilitates the upgrading of the export product quality and the result is robust against changes of IPP measures, IVs, and firm and industry level subsidies etc. Further, we find that at the firm level, the channels through which IPP takes effect on product quality include strengthened R&D input, new product development, and mitigated external financial constraints. In the heterogeneity analysis, it is shown that improvement of local IPP benefits less capital-intensive firms; foreign firms relative to domestic firms; and firms in innovation-intensive industries. In addition, the effect of IPP on export product quality is statistically insignificant in central and western China as well as processing trade (as opposed to ordinary trade).

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[9] We divide firm ownership according to the product level transaction data collected by the General Administration of Customs of the China from 2008 to 2013. In our classification, state-owned firms and collective-owned firms are both defined as state-owned firms; exclusive foreign-owned firms, Sino-foreign joint venture and Sino-foreign cooperative firms are both classified as foreign-owned firms; private-owned firms and individual business are classified as private-owned firms. Other firms are treated as other ownership type firms (in our paper, we do not consider firms classified as other ownership type).

[10] Our region definition is based on policy-oriented classification standard, which mainly focuses on differences of economic development across provinces. In our study, east region includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan; middle region includes Shanxi, Neimenggu, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan; west region includes Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, and Guangxi. The middle and west region in our paper jointly refers to both middle region and west region.

Table 7
Heterogeneity checks.

	Ownership				Region	
	(1)	(2)	(3)	(4)	(5)	(6)
lncityIPP	0.275**	0.298**	0.262**	0.276**	0.198*	0.937
	(0.118)	(0.123)	(0.117)	(0.121)	(0.108)	(1.226)
Lnasset	0.028***	0.027***	0.029***	0.027***	0.031***	0.024***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.006)
Leverage	0.008***	0.008***	0.007***	0.008***	0.007***	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.004)
Lnage	−0.005	−0.001	−0.008**	−0.001	0.005	0.024**
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.011)
Pgdprate	0.011***	0.011***	0.011***	0.011***	0.010***	0.037
	(0.003)	(0.0033)	(0.003)	(0.003)	(0.0033)	(0.086)
Cpoprate	0.025**	0.021**	0.032***	0.021**	0.038***	−0.0627*
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.037)
State	−0.034***					
	(0.006)					
Foreign	0.038***					
	(0.005)					
*domestic*lncityIPP*		−0.022***				
		(0.004)				
*state*lncityIPP*			−0.025***			
			(0.004)			
*foreign*lncityIPP*				0.022***		
				(0.004)		
yearFE	yes	yes	yes	Yes	yes	yes
indusrtyFE	yes	yes	yes	Yes	yes	yes
Kleibergen-Paap rk LM statistic	12.161 (0.0005)	12.220 (0.0005)	12.139 (0.0005)	12.220 (0.0005)	12.246 (0.0005)	3.817 (0.0507)
Kleibergen-Paap rk Wald F statistic	134.108	64.641	63.232	64.641	109.197	8.421
Observations	152,775	152,775	152,775	152,775	146,524	6250

Notes: Robust standard errors in parentheses, clustered at the 2-digit CIC industry level. The constant terms are omitted to save space. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Authorship statement

All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript. Furthermore, each author certifies that this material or similar material has not been and will not be submitted to or published in any other publication before its appearance in the *International Review of Economics and Finance*.

Authorship contributions

Please indicate the specific contributions made by each author (list the authors' initials followed by their surnames, e.g., Y.L. Cheung). The name of each author must appear at least once in each of the three categories below.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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