Journal of The Japanese and International Economies xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of The Japanese and International Economies

journal homepage: www.elsevier.com/locate/jjie

Patent reforms and exporter behaviour: Firm-level evidence from developing countries☆

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ARTICLE INFO

Keywords:
Intellectual property rights

JEL classification:
O34
O33
F13
F14

ABSTRACT

Using product-level data from 1997 to 2014, this paper examines the impact of patent reforms on the micro-foundations of developing countries' export growth. In a difference-in-difference setting, we compare exporter characteristics in sectors intensive in intellectual property (IP) relative to non-IP-intensive sectors. We find that high-IP exports expanded along the extensive (firm-count) margin around the time of the reforms, but with the passage of time expansions along the intensive (firm size) margin took on more importance. Changes in the exporting behaviour of entrants were the key drivers, while incumbents were largely unaffected. Exporter entry and exit rates in IP-intensive sectors rose after the reforms, shifting the distribution of exporters towards larger and more IP-intensive firms. The first year survival rate of entrants was unaffected, but the destination entry rate of survivors fell. The findings signify that patent reforms did influence local productive and innovative capacity of developing countries.

1. Introduction

The Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), which came into effect on 1 January 1995, is the first agreement to include intellectual property rights (IPRs) provisions under the multilateral trading system. It sets down minimum standards of IPRs at a level that major industrialized countries provide and stipulates effective enforcement.[1] The Agreement was designed to achieve universal standards of intellectual property (IP) laws, which necessarily required countries in the developing world—where IP protection had been notoriously weak or altogether absent—to strengthen their IPRs relatively more. Its acceptance is a compulsory requirement of WTO membership but depending on the level of economic development of the country concerned, WTO members were given different transitional periods to comply with the Agreement. As a result, several developing countries implemented substantial reforms of their patent systems during the 1994–2005 period in order to establish the strong standards mandated by the Agreement. These reforms expanded access to protection, broadened the types of inventions that were patentable (such as medicines and biotech-related inventions), increased the duration of protection, and in many cases, also reduced the scope for a loss of rights. Proponents of the Agreement argued that national IP reforms will accelerate the transfer and dissemination of technology into the developing world and promote developing countries' industrial and technological development.

In this paper, we evaluate the impact of national patent reforms in 42 developing countries on the characteristics and dynamics of these countries' exports. We use product-level data from 1997 to 2014 about the basic characteristics of exporters, the degree of firm diversification and market concentration, and the measures of exporter and destination dynamics. We find that high-IP exports expand when patent reforms occur in developing countries. The expansion in exports is primarily driven by a rise in the number of exporters (i.e., extensive margin) but over time, expansions in the (mean and median) size of exporters (i.e., intensive margin) become more important. This result is not driven by unobserved cross-country heterogeneity and obtains with equal strength when we study changes in exports that occur around the time of patent reforms.

We further find that the effect of patent reforms on the unit price per exporter takes time to appear: the unit prices do not change around the time of patent reform but grow more rapidly after reforms. The results also add new insights into how patent reforms are manifested in

☆ We thank Keith Head, Keiko Ito and other participants at the 27th NBER-TCER-CEPR Conference in Tokyo, 2018 for helpful comments and discussions. We also thank Simon Iskander for his invaluable research assistance.

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[1] For example, trade disputes over IPRs can be pursued through the WTO dispute settlement system.

https://doi.org/10.1016/j.jjie.2019.02.002
Received 25 October 2018; Received in revised form 17 December 2018; Accepted 18 February 2019
0889-1583/

exporter behavior. Patent reforms are simultaneously creative and destructive: both exporter entry and exit rates in high-IP sectors rise around the enactment of patent reform, and these effects persist over time. However, exiting exporters tend to be of smaller size and have lower unit prices and so, as new IP-dependent firms are displacing existing firms, the distribution of exporters shifts towards larger and more IP-intensive firms. We further find that the observed effects of patent reforms on exports are driven by changes in the exporting behaviour of entrants, while the exporting behaviour of incumbents is largely unaffected. Patent reforms have no effect on the size of incumbents, their total export value, destination entry and exit rates, or market diversification. Likewise, patent reforms do not affect the first year survival rate of new entrants into export markets. But the destination entry rate of surviving entrants and the shares of new destinations in their total export value fall following patent reforms. We also find that exporter concentration in terms of the number of exporters per destination rises around the time of the reform, but this increase is driven by large destination markets and falls over time after reforms. Taken as a whole, our micro-level data and treatment analysis allow us to uncover a number of rich exporter and destination market dynamics.

Our analysis exploits the fact that not all developing countries had undertaken major reforms in their patent systems, and those that did enacted them in different periods. The variation in patent reforms across countries and years improves our identification and also enables us to study the changes in exporter behaviour that occur around the time of patent reform. Moreover, our product-level data allows us to distinguish IP-intensive 'treated' products from non-IP-intensive 'control' products and use variations in sensitivity to patent reforms across the two product groups to account for impacts common to all products within a country.

A key question is the issue of endogeneity in the adoption of patent reforms. Thriving exports in IP-intensive industries could very well provide an incentive for a developing country to reform its patent regime in the hope of fostering further exports. In this sense, IP-intensive exports cause patent reforms and not the reverse. While this is a valid concern, it is unlikely to apply here. The timing of patent reforms across developing countries in our data is most likely exogenous, since it largely coincides with the TRIPS compliance schedule. The WTO's deadlines for complying with the TRIPS provisions differed across countries, but countries were limited in their ability to change their compliance schedule (Delgado et al., 2013). To further ease the endogeneity concern, we study the timing of patent reforms, following the approach in Branstetter et al. (2006). In order to increase the number of years prior to the date of reform, we use the UN Comtrade export data from 1990 to 2016 for this analysis. The estimated timing of export changes confirms that there is no pre-reform trend, suggesting that the endogeneity in the adoption of patent reforms is not an issue.

Patent reforms can impact exporter behaviour and dynamics through many channels. Three major channels are international trade in goods and services, FDI through multinational enterprises (MNEs), and the licensing of technology and intangible assets.[2] Stronger IPRs promote developing countries' imports of new goods and technological inputs as well as intra-firm technology transfer and arm's length licensing, and the stock of knowledge available for local producers rises as a result. As firms learn from the operations of MNEs and the local technology pools, they develop new products and create platforms for exports (He and Maskus, 2012). Unintended spillovers of technological information and know-how from MNEs, which happen alongside with intentional technology transfer through market transactions, may also contribute to quality improvements and reductions in the production costs of export goods (Javorcik, 2004b; Lopez, 2008). Another important channel is appropriability hazards and the return to innovation. Stronger IPRs limit the risk of technology misappropriation and product imitation by rivals. Lower appropriability hazards may increase exporter survival and encourage incumbent firms to develop new product varieties destined for export markets or upgrade the quality of existing export goods (Amiti and Khandelwal, 2013). A final significant channel is the sunk cost of entry into export markets (Aw et al., 2011). With substantial foreign-market entry costs, a firm must earn a sufficient present value of the expected future export profit stream in order to begin to export. To the extent that stronger IPRs increase the economic returns of exporting and reduce uncertainty about future export profits, they impact the market entry strategy of firms facing entry costs and also affect expected future probabilities of exit.

There is already a considerable empirical literature examining the impact of strengthening IPRs in developing countries on technology transfer via exporting, foreign direct investment (FDI) or licensing.[3] This literature has focused on inward technology flows into IP-reforming countries and ignored outward flows. The three exceptions are Branstetter et al. (2011), Briggs and Park (2014), and Yang and Maskus (2018). Branstetter et al. (2011) studied patent reforms in 16 countries (high and upper middle income economies) and focused on initial episodes of exports to the U.S. market. The paper finds that the number of product classes in which countries export increased in postreform years, which would be a consequence of new goods production by firms in the reforming countries. Briggs and Park (2014) also analyzed the effect of patent protection on the outward orientation of firms, but for the affiliates of U.S. multinational companies. More recently, Yang and Maskus (2018) examined the impact of patent rights on the exports of high-R&D products. The past literature's focus on inward technology flows is not surprising, considering the limited postreform data available, compounded by the delayed impacts on developing countries' innovation, product upgrading, and foreign market entry. More years of data since developing countries' major patent reforms allow us to study the short-run and long-run impacts on the capacity of developing countries for exporting and their outward orientation.

Our paper contributes to the previous literature in that we explore the microfoundations of developing countries' export growth. Understanding these impacts is particularly important given that the share of developing economies in world merchandise exports is large and growing.[4] Similar to Branstetter et al. (2011), Briggs and Park (2014), and Yang and Maskus (2018), we focus on the outward orientation of patent-reforming countries but unlike these studies, we document export episodes at the firm, rather than country, level. Also, Branstetter et al. (2011) used data for the 1982–1999 period, which are mainly pre-TRIPS data, while we study the period of 1997–2014.

Our empirical strategy is a combination and an extension of the approaches adopted in the literature. As such we owe much to previous work. We consider a difference-in-difference setting that compares the export outcomes in the group of IP-intensive products relative to the control group of non-IP-intensive products to evaluate the impact of patent reforms. Our classification of the products into the two groups follows (Delgado et al., 2013). Our approach of interacting product IP-intensity with patent reforms is also akin to that of Yang and Maskus (2018), which adopts a generalized factor-proportions framework where industry research intensity is interacted with national PRs and the strength of national PRs is viewed as an exogenous institutional endowment affecting countries' comparative advantage in R&D intensive goods. Our approach is also similar to that of

[2] See the specific evidence in Maskus and Penubarti (1995), Smith (1999), Nunnenkamp and Spatz (2004), Co (2004), Javorcik (2004a), Branstetter et al. (2006), Ivus (2010), Ivus (2015), and Ivus et al. (2017).

[3] This literature is thoroughly reviewed in Maskus (2000) and Saggi (2016).

[4] Based on U.N. statistics, the share of developing economies in world merchandise exports grew from 24.1% in 1990 to 44.4% in 2017. See http://unctadstat.unctad.org.

Branstetter et al. (2006) in that we use interact the postreform dummy variable and a time trend that measures the number of years that have passed since the reform year in order to quantify the duration of effects after reform. In contrast to previous work, we specify the exponential model for the observed outcomes and estimate it using the non-linear Poisson pseudo-maximum-likelihood (PPML) estimator proposed by Silva and Tenreyro (2006). We use this model to identify the multiplicative treatment effect which can be given a causal interpretation under the key assumption of a common time trend in a multiplicative form (Ciani and Fisher, 2018).

The rest of the paper proceeds as follows. Section 2 describes our methodology. In Section 3, we describe our data on firm exporter behavior and dynamics, discuss our product classification, and outline our patent reform and other country data. Section 4 presents our results on export margins, exporter and destination dynamics, and the diversification and concentration of export destinations. We study the timing of patent reforms in Section 5, discuss our results in Section 6 and conclude in Section 7.

2. Methodology

The unit of analysis are firms in country i which export a product j in sector s in year t. To test the effect of patent reforms on the characteristics and dynamics of domestic exporting firms, we examine export outcomes in the two groups of traded products: the treated group of products with the highest IP intensity versus the control group of products with low IP intensity. The statistical model for the observed outcomes is specified as follows:

$$Y_{ijt} = \exp(\alpha + \beta_1 R_{it} + \beta_2 H_j + \gamma H_j R_{it} + X'_{ist}\delta)\varepsilon_{ijt}, \quad (1)$$

where the outcome Y_{ijt} is a measure of the basic characteristics of exporters, the degree of diversification and concentration, or a measure of exporter and destination dynamics. We discuss our outcomes in detail in the following section. The independent variable R_{it} is the postreform dummy variable, which is equal to one if year t is in the postreform period in country i. Next, H_j is the high-IP intensity dummy variable, equal to one if product j is in the treated group, and $H_j R_{it}$ is the product of H_j and R_{it}. The control for H_j allows the outcome to differ across the two product groups in the absence of a patent reform, while the interaction term $H_j R_{it}$ allows the impact of patent reforms to differ across the two product groups. The vector X_{ist} includes time-varying exporting country controls (X_{it}), fixed effects for each year (α_t) and country-by-sector (α_{is}), and time trends specific to each country (τ_{it}) and each sector (τ_{st}). Country controls are the log of real gross domestic product (GDP) per capita; the log of capital stock; human capital index; the index of the degree of economic freedom in the legal system and the security of property rights; the index of the degree of economic freedom to trade internationally; corruption perception index; the Chinn-Ito index of financial openness; and two measures of financial credit controls, on inflows and outflows. Last, α is the constant term and ε_{ijt} the error term which is mean independent of product group and time, controlling for X_{ist}: $E[\varepsilon_{ijt}|1, R_{it}, H_j, X_{ist}] = 1$.

We estimate the exponential model (1) using the non-linear Poisson pseudo-maximum-likelihood (PPML) estimator proposed by Silva and Tenreyro (2006). We chose this empirical strategy, as opposed to estimating the model in the log-linear form by ordinary least squares (OLS), for three key reasons. First, our export data have a large occurrence of zero values. The export value variable, for example, is equal to zero for 13,999 observations, which is 10.5% of the data. Second, some outcomes (e.g., the number of exporters) are discrete counts. Third, PPML avoids the biases caused by log-linearization in the presence of heteroscedasticity.

In the model (1), the exponentiated coefficient on the interaction term identifies the multiplicative treatment effect on the average as a ratio of ratios (ROR):

$$\exp(\gamma) = \frac{\text{Ratio for treated}}{\text{Ratio for control}}, \quad \text{where} \quad (2)$$

$$\text{Ratio for treated} = \frac{E[Y_{ijt}|H_j = 1, R_{it} = 1, X_{ist}]}{E[Y_{ijt}|H_j = 1, R_{it} = 0, X_{ist}]}; \quad (3)$$

$$\text{Ratio for control} = \frac{E[Y_{ijt}|H_j = 0, R_{it} = 1, X_{ist}]}{E[Y_{ijt}|H_j = 0, R_{it} = 0, X_{ist}]}. \quad (4)$$

Ratio for treated in (3) measures the multiplicative effect of a patent reform on the average outcome in the treated group of high-IP products; and Ratio for control in (4) measures the multiplicative effect of a patent reform on the average outcome in the control group of low-IP products. The average outcome changes in the postreform years, compared to the prereform years, by a factor of $\exp(\beta_1)$ in the control group and a factor of $\exp(\beta_1 + \gamma)$ in the treated group. The factor impact is thus $\exp(\gamma)$ times greater in the treated group. The ROR estimate of $\exp(\gamma)$ can be given a causal interpretation under the key assumption of a common time trend in a multiplicative form (Ciani and Fisher, 2018). This assumption requires that in the absence of the reform, the outcome in the treated group would have changed over time by the same factor as it did in the control group.

The treatment effect can also be interpreted in terms of percentage, rather than factor, changes. The percentage change in the outcome over time equals $\exp(\beta_1) - 1$ in the control group and $\exp(\beta_1 + \gamma) - 1$ in the treated group. If the assumption of a common time trend in a multiplicative form holds, the percentage treatment effect of a patent reform equals $\exp(\gamma) - 1$. In terms of the potential outcomes, the estimate of the treatment effect is given by:

$$\exp(\gamma) - 1 = \frac{E[Y_{1ijt}|H_j = 1, X_{ist}] - E[Y_{0ijt}|H_j = 1, X_{ist}]}{E[Y_{0ijt}|H_j = 1, X_{ist}]},$$

where Y_{1ijt} is the potential outcome when treated (i.e., the outcome in country i had this country implemented a patent reform, irrespective of whether it actually implemented a patent reform) and Y_{0ijt} is the potential outcome when not treated.

We further augment the model (1) and estimate the following specification:

$$Y_{ijt} = \exp(\alpha + \beta_1 R_{it} + \beta_2 H_j + \gamma H_j R_{it} + \beta_3 R_{it} T_{it} + \beta_4 H_j T_{it} + \varphi H_j R_{it} T_{it} + X'_{ist}\delta)\varepsilon_{ijt}, \quad (5)$$

where T_{it} is the number of years that have passed since the reform year. This model allows the strength of the multiplicative treatment effect to grow (or weaken) over time. Specifically, the treatment effect depends on the number of years since reform as follows: $ROR = \exp(\gamma + \varphi T_{it})$. As such, $\exp(\gamma)$ measures the ROR estimate in levels and $\exp(\varphi)$ measures the average annual factor change in the ROR estimate during the postreform period. To put it differently, $\exp(\varphi) - 1$ measures the average annual percentage change in the ROR estimate during the postreform period.

3. Data description

3.1. The exporter dynamics database

Our data on firm exporter behavior and dynamics come from the Exporter Dynamics Database (EDD), provided by the World Bank.[5] The data were gathered primarily from government customs administrations and are based on firm-level customs information from 70 countries for the period between 1997 and 2014 (with gaps). The measures are calculated

[5] We use the second version of the EDD, which was released on October 20th, 2015. The data are available here: http://microdata.worldbank.org/index.php/catalog/2545/study-description and are described in detail in Cebeci et al. (2012) and Fernándes et al. (2016).

using all firms available (domestic and foreign-owned), with no restrictions on export values, and are available at different levels of aggregation.

Our analysis uses data at the exporting country-year-product level where products are classified using the Harmonized System (HS) at the 6-digit level. A specific HS 6-digit code represents the same product in all countries in a given year and so allows for comparisons across countries. We use the measures on the basic characteristics of exporters, the degree of diversification and concentration, and exporter and destination dynamics. Our measures of basic characteristics are the number of exporting firms, export value per exporting firm (mean and median), and unit price per exporting firm. Depending on its status in a given year, each exporting firm is further classified as entrant, exiter, survivor, or incumbent; and the measures of basic characteristics are provided for each such firm class. Next, the measures of the degree of diversification and concentration include the number of destinations per exporter (mean, median), the number of exporters per destination (mean, median), Herfindahl-Hirschman index (HHI), and the share of the top 1% or top 5% exporters in total export value. Last, our measures of exporter dynamics are the rates of firm entry, exit, and survival; and our measures of destination dynamics are the destination entry rates of incumbents and survivors, the destination exit rate of incumbents, and the shares of new destinations in the total export value (TEV) of incumbents and survivors. Table 1 lists our dependent variables and their definitions, where necessary.

Table 1
Dependent variables and definitions.

Definitions of firm types

Exporter$_t$: any firm that exports in year t

Entrant$_t$: a firm that does not export in year $t-1$ but exports in year t

Exiter$_t$: a firm that exports in year $t-1$ but does not export in year t

Incumbent$_t$: a firm that exports in both years $t-1$ and t

Survivor$_t$: a firm that does not export in year $t-1$ but exports in both years t and $t+1$.

Basic characteristics of firms

Number (N) of Exporters, Entrants, Exiters, Survivors, Incumbents

Export Value (EV, ths USD) per Exporter, Entrant, Exiter, Survivor, Incumbent (mean, median)

Total Export Value (TEV, bn USD) = N of Exporters * Mean EV per Exporter

TEV of Entrants = N of Entrants * Mean EV per Entrant

TEV of Exiters = N of Exiters * Mean EV per Exiter

TEV of Survivors = N of Survivors * Mean EV per Survivor

TEV of Incumbents = N of Incumbents * Mean EV per Incumbent

Unit Price (TEV/Quantity) per Exporter, Entrant, Exiter, Survivor, Incumbent (mean, median)

Diversification and concentration

Number of Destinations per Exporter (mean, median)

Number of Exporters per Destination (mean, median)

Herfindahl-Hirschman Index

Share of top 1% Exporters in TEV

Share of top 5% Exporters in TEV

Exporter dynamics

Firm Entry Rate$_t$= N of Entrants$_t$/ N of Exporters$_t$

Firm Exit Rate$_t$= N of Exiters$_t$/ N of Exporters$_{t-1}$

First-year Entrants' Survival Rate$_t$= N of Survivors$_t$/ N of Entrants$_t$

Destination dynamics

$$\text{Destination Entry Rate of Incumbents}_t = \frac{\text{N of destinations not exported in } t-1 \text{ but exported in } t \text{ by Incumbent}_t}{\text{N of all destinations exported by Incumbent}_t \text{ in } t}$$

$$\text{Destination Entry Rate of Survivors}_t = \frac{\text{N of destinations not exported in } t-1 \text{ but exported in } t \text{ by Survivor}_{t-1}}{\text{N of all destinations exported by Survivor}_{t-1} \text{ in } t}$$

$$\text{Destination Exit Rate of Incumbents}_t = \frac{\text{N of destinations exported by Incumbent}_t \text{ in } t-1 \text{ but not in } t}{\text{N of all destinations exported by Incumbent}_t \text{ in } t-1}$$

$$\text{Share of New Destinations in TEV of Incumbents}_t = \frac{\text{EV of Incumbent}_t \text{ from destinations not exported in } t-1 \text{ but exported in } t}{\text{TEV of Incumbent}_t \text{ in } t}$$

$$\text{Share of New Destinations in TEV of Survivors}_t = \frac{\text{EV of Survivor}_{t-1} \text{ from destinations not exported in } t-1 \text{ but exported in } t}{\text{TEV of Survivor}_{t-1} \text{ in } t}$$

3.2. Product classification

We examine the patterns of firm exporter behavior and dynamics in the group of IP-intensive products (high-IP group) relative to the control group of non-IP-intensive products (low-IP group). We rely on Delgado et al. (2013) to classify the products into the two groups. The high-IP group includes six (mutually exclusive) clusters of traded products with the highest IP intensity: analytical instruments; biopharmaceuticals; chemicals; ICT; medical devices; and production technology. The low-IP group includes clusters of traded products with the lowest IP intensity, such as food and live animals, crude materials, mineral fuels, animal and vegetable oils, goods manufactured from leather, textiles, metals, and other consumable and unprocessed or semi-processed products. The grouping is based on a careful and conservative mapping and excludes any products with low IP-intensity within high-IP clusters or products with high IP-intensity within low-IP clusters.

The definitions of the two product groups in Delgado et al. (2013) are by SITC Rev.3 codes. Thus, we first need to link HS 6-digit product codes in the EDD to SITC Rev.3 codes and then isolate those HS6 codes that fall into each group.

The HS 6-digit codes in the EDD have been consolidated among four different revisions of HS classifications (HS 1996, 2002, 2007, and 2012) to allow tracking of the product data over time. The consolidation process, which is described in detail in Cebeci (2012), accounts for the revisions in the HS codes across the classifications (e.g., converting two different codes into a single code or splitting a code into several codes) and replaces the revised HS codes related to each other with a single "consolidated" code for the entire period, thus creating a consistent HS classification over time.[6]

To link HS 6-digit product codes in the EDD to SITC Rev.3 codes in Delgado et al. (2013), we use two correspondence tables. First is the United Nations Statistics Division concordance between the SITC Rev. 3 codes and the HS 6-digit codes for each of the four revisions (HS 1996, 2002, 2007, and 2012).[7] In total, there are 20,680 HS 6-digit codes across the four revisions. Of these codes, 2771 are in the high-IP group and 8076 are in the low-IP group. Second is the EDD concordance between the HS 6-digit consolidated codes and the HS 6-digit original codes, by the year of HS classification. As many as 5370 (out of 20,680) HS 6-digit codes have been consolidated. Group assignment was ambiguous for 14 consolidated codes. Of these 14 codes, 8 HS codes corresponded to SITC codes assigned to the low-IP group mixed with SITC codes unassigned to any group; 4 HS codes corresponded to a mix of high-IP and unassigned SITC codes; and 2 HS codes corresponded to a mix of high-IP and low-IP SITC codes. We re-assigned these codes manually to remove these ambiguities. In the end, our sample contains 197,083 observations and includes 2176 unique HS 6-digit (original and consolidated) codes, of which 507 codes are in the high-IP group and 1669 codes in the low-IP group.

To account for cross-country differences in export-sector characteristics as well as sector-specific time trends, we follow Fernandes et al. (2012) and work with 16 broad sectors which are groups of HS 2-digit products. Table 2 lists these sectors.[8]

[6] A list of consolidated codes and concordances is available at http://econ.worldbank.org/exporter-dynamics-database. Fernándes et al. (2016) note that a similar process was used by Schott and Pierce (2012) to concord 10-digit United States Harmonized System codes between 1989 and 2007 and by Wagner and Zahler (2011) to homologate among 6-digit HS 1992, HS 1996, and HS 2002 classifications.

[7] The correspondence tables are available at https://unstats.un.org/unsd/trade/classifications/correspondence-tables.asp.

[8] The EDD omits HS Chapter 27 (hydrocarbons such as oil, petroleum, natural gas, and coal), since these exporter-level data are missing for Burkina Faso, Cameroon, Iran, Kuwait, and Yemen.

Table 2
Sector definitions.

Groups of HS 2-digit codes	HS section description
0105	Live Animals and Animal Products
0615	Vegetable Products (including Animal and Vegetable Fats)
1624	Foodstuff (Beverages, Spirits, Vinegar, Tobacco, etc.)
2526	Mineral Products (except hydrocarbons)
2838	Chemicals and Parachemical Products
3940	Plastics and Articles Thereof
4446, 4749, 94	Wood and Articles Thereof (including Paper & Articles, Furniture)
5059, 41	Textiles (Including Raw Skins and Leather)
6063, 6467, 4243	Apparel (Including Footwear, Headgear, Art. of Feathers, Fur, Leather Products)
6870	Glass, Ceramics and Articles of Stone, Cement, etc.
71	Precious Metals (Pearls, Jewelry, Coin, Precious Stones, etc.)
7283	Base Metal and Articles Thereof
84, 9192	Mechanical Machinery (including Clocks and Music Instruments)
85, 90	Electrical Machinery (including Optical, Medical, Photographic Instruments)
8689	Transportation Vehicles
93	Arms and Ammunitions

Notes: Source: Fernándes et al. (2012).

3.3. Patent reforms

To test the effect of patent reforms, we use a postreform dummy variable which equals one in a postreform year t in country i. When selecting the year of major patent reform, we considered only the most significant shifts in patent laws during the period from 1994 to 2005 and ignored minor revisions to countries' patent laws and practices.[9] These were reforms that enabled technology developers to acquire patent rights, enforce them, and avoid revocations or the diminishing of patent rights.

We have data on the year of major patent reform, or its absence in the period of 1994–2005, for 42 developing countries in the EDD. Our sample of countries excludes high-income economies, as defined by World Bank based on gross national income (GNI) per capita for the year 1995. Table 3 lists the countries in our data, together with their patent reform years. It also provides for each country the explanation of the most significant shifts in patent laws, focusing on the five key measures of patent strength: coverage, membership in international patent treaties, provisions against losses of protection, enforcement mechanisms, and duration of protection.

Exporter behavior is unlikely to respond to a change in countries' patent laws in that same year. Firm adjustment is expected to take time. We allow for a four-year delay in response and define the first year of the postreform period as the year of major patent reform plus four years. Accordingly, if a country implemented a major patent reform in year t, then the postreform dummy variable for this country equals one in year $t + 4$ and all following years, and equals zero in all years prior to $t + 4$. By choosing a four (rather than for example, three) year gap, we maximize the number of countries with the EDD data in both the pre- and postreform periods and still have a sufficiently long series of postreform data to study changes in the treatment effect over time.

Export data are available in both pre- and postreform periods for 19 of 42 countries in our sample when we choose the four-year gap.[10] Panel A in Table 4 lists these countries. Panel B further lists 15 countries which implemented patent reforms before the start of our sample period, and Panel C lists 8 countries which either did not reform their patent laws during the 1994–2005 period or do not have at least four years of postreform data. Thus the postreform dummy variable varies over time for the 19 countries in Panel A and is constant over time for the 23 countries in Panels B and C.

To begin, we estimate the effect of patent reforms using the sample of 42 countries. In these regressions, the coefficient on the postreform dummy variable is identified using both cross-country and within-country over time variation in patent reforms. We then limit our analysis to the 19 countries with both pre- and postreform period data and study the changes in exporter behaviour that occur around the time of patent reform. It is apparent from Panel A in Table 4 that across these 19 countries, one has the year 1999 as the first year of the postreform period, one—the year 2003, 11—the year 2004, and the remaining six countries—the year 2009 as the first year of the postreform period.

Table A1 in the Appendix describes the availability of export data for the 19 countries in more detail. Column (1) shows that four countries have only one year of the prereform period data, and as many as 15 countries have no more than 4 years of the prereform period data. Column (2) further shows that 10 countries have at least 9 years of the postreform period data. The average number of years is 3.4 in the prereform period and 7.5 in the postreform period. Table A2 further reports the frequency counts of the EDD data by year for each of the two samples: 42 and 19 countries. It is apparent that the export data are primarily available in the period of 2002–2012. These data limitations are important to keep in mind when studying the trends in exporting.

3.4. Data from other sources

We use a number of exporting country controls from different sources. GDP per capita (PPP) data are from the World Bank (2010). The capital stock measure and the human capital index (based on the average years of schooling from Barro and Lee (2013)) are from the *Penn World Tables* version 9.0 (Feenstra et al., 2015). The index of the degree of economic freedom (EFI) is from Gwartney et al. (2016). We utilize EFI in two areas: (i) the legal system and security of property rights and (ii) the freedom to trade internationally. The index of corruption perception is from Transparency International. We also use the Chinn-Ito index of financial openness (Chinn and Ito, 2006). This index measures a country's degree of capital account openness, based on the binary variables that codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). Our measures of financial credit controls on inflows and outflows are from Fernández et al. (2015).

Table 5 provides summary statistics of the variables used in the analysis for the two samples of countries (42 and 19) over the entire period of 1997–2014. The sample of 42 countries, for example, includes 133,741 observations. The number of exporters variable, for example, has no missing values. But the export value per exporter has 44,417 missing values over the sample period, with the corresponding values of

[9] This is comparable to a change of at least a half standard deviation in the Park (2008) index of patent rights (PRs).

[10] This number falls to 17 if we instead choose the three-year gap, 10 with the two-year gap, and 5 with no lag.

Table 3
Patent reforms.

Country	Reform Year	Patentability of						Enforcement
		Microbiological Process	Pharmaceuticals	Chemicals, Food	Surgical applications	Software	Plant & Animal Products	Burden of Proof
Bangladesh	1995	x						
Bolivia	1994		x					x
Botswana	2000							x
Bulgaria	2000					x		
Burkina Faso	2005						x	
Chile	1994							
Colombia	1995							x
Costa Rica	2000		x	x				
Dominican Rep	2000	x			x			
Ecuador	2000							
El Salvador	1996		x					
Gabon	2005	x						
Guatemala	2005		x	x				x
Ivory Cst.	2000	x						x
Jordan	2000	x						x
Kenya	1995							
Malawi	2000	x						
Mali	2005	x						x
Mauritius	2005							
Mexico	1995	x	x	x			x	x
Morocco	2000	x						
Nicaragua	2000	x		x				x
Niger	2005							x
Pakistan	2000				x			
Paraguay	2000							x
Peru	1995							
Romania	1996							x
Senegal	2005							x
South Africa	1996						x	
Sri Lanka	2000	x						
Swaziland	2000	x						
Tanzania	2000	x						
Thailand	1995	x	x					
Uganda	2000							x
Uruguay	1999	x		x				x
Zambia	2005	x						

Country	Enforcement		Membership			Other			
	Preliminary Injunction	Contributory Infringement	Paris Treaty member	Patent Cooperation Treaty	UPOV (Plant varieties)	Utility Models	Increased Duration	No Working Requirement	Abandon Revocation
Bangladesh							x		x
Bolivia	x		x						
Botswana	x						x		x
Bulgaria	x						x		x
Burkina Faso							x		x

(*continued on next page*)

Table 3 (*continued*)

Country	Enforcement		Membership			Other			
Chile			x				x		
Colombia							x		x
Costa Rica				x		x	x		x
Dominican Rep							x		
Ecuador		x	x		x				x
El Salvador								x	x
Gabon									
Guatemala	x	x					x		
Ivory Cst.									
Jordan							x		
Kenya				x					
Malawi									
Mali									x
Mauritius							x	x	
Mexico				x			x		
Morocco	x	x		x		x			
Nicaragua	x		x						
Niger									x
Pakistan		x							
Paraguay	x			x					
Peru			x				x		
Romania	x		x	x			x		x
Senegal									x
South Africa				x			x		
Sri Lanka									
Swaziland									x
Tanzania				x					
Thailand							x		
Uganda	x			x					
Uruguay									x
Zambia				x		x			

Notes: Six countries (Burma, Cambodia, Ethiopia, Iran, Madagascar, and Rwanda) implemented no patent reforms in the 1994–2005 period.

Table 4
Postreform dummy variable.

Country	The first year of the postreform period	EDD period
Panel A: postreform dummy = 0 or 1		
Botswana	2004	2003–2013
Bulgaria	2004	2001–2006
Burkina Faso	2009	2005–2012
Costa Rica	2004	1998–2012
Dominican Rp	2004	2002–2014
Ecuador	2004	2002–2014
Guatemala	2009	2005–2013
Jordan	2004	2003–2012
Mauritius	2009	2002–2012
Morocco	2004	2002–2013
Nicaragua	2004	2002–2014
Niger	2009	2008–2010
Pakistan	2004	2002–2010
Peru	1999	1997–2013
Senegal	2009	2000–2012
Tanzania	2004	2003–2012
Uganda	2004	2000–2010
Uruguay	2003	2001–2012
Zambia	2009	1999–2011
Panel B: postreform dummy = 1 in all years		
Bangladesh	1999	2005–2014
Bolivia	1998	2006–2012
Chile	1998	2003–2012
Colombia	1999	2007–2013
El Salvador	2000	2002–2009
Ivory Cst.	2004	2009–2012
Kenya	1999	2006–2014
Malawi	2004	2006–2012
Mexico	1999	2000–2012
Paraguay	2004	2007–2012
Romania	2000	2005–2011
South Africa	2000	2001–2012
Sri Lanka	2004	2013-2013
Swaziland	2004	2012-2012
Thailand	1999	2012–2014
Panel C: postreform dummy = 0 in all years		
Burma	no	2011–2013
Cambodia	no	2000–2009
Ethiopia	no	2008–2012
Gabon	2009	2002–2008
Iran	no	2006–2010
Madagascar	no	2007–2012
Mali	2009	2005–2008
Rwanda	no	2001–2012

the number of exporters variable equal to one in 68% of cases. These data are entered as missing to protect the confidentiality of the firm whose identifying information must not be revealed.

4. Results

4.1. Export margins

Table 6a shows the results of estimating the model (1) for the full sample of 42 countries. The dependent variables are: total export value in columns (1)–(2), the number of exporters in columns (3)–(4), export value per exporter in columns (5)–(7), and unit price per exporter in columns (8)–(10). For the last two variables, we work with means in columns (5)–(6) and (8)–(9) and medians in columns (7) and (10). The sample utilized here excludes all observations where the number of exporters equals one, for which the corresponding values of exports and unit price are missing.

In column (1), the coefficient β_1 on the postreform dummy variable R_{it} is negative (-0.406) and highly statistically significant, while the coefficient γ on the interaction term H_jR_{it} is positive (0.452) and marginally statistically significant. The precision of the estimate γ rises in column (2), where we also control for the country-specific and year-specific time trends. The results of this statistically more demanding specification imply that in the postreform years, relative to the prereform years, total export value changes by a factor of $e^{-0.424} = 0.65$ in the control group of low-IP products and a factor of $e^{0.835-0.424} = 1.51$ in the treated group of high-IP products. In other words, low-IP exports are 35% lower while high-IP exports are 51% higher in the postreform years, as compared to the prereform years. The ROR estimate of the treatment effect (which is identified using both cross-country and within-country over time variation in patent reforms) equals $e^{0.835} = 2.30$. It implies that the effect of patent reform on total export value in the high-IP product group is 2.3 times higher than that in the low-IP product group.

The results in columns (3)–(4) further show that the total export value of high-IP products expands in the postreform years along the extensive margin (i.e., the number of exporters rises). In column (4), the coefficient on R_{it} is negative (-0.276) while the coefficient on H_jR_{it} is positive (0.467); and both coefficients are statistically significant at the 5% level. As such, the factor impact of patent reform on the number of exporters equals $e^{-0.276} = 0.76$ in the low-IP group and $e^{0.467-0.276} = 1.21$ in the high-IP group. In other words, the number of low-IP exporters falls in the postreform years (relative to the prereform years) by 24% while the number of high-IP exporters rises by 21%. The ROR estimate of the treatment effect on the exporter base equals $e^{0.467} = 1.6$. The data also do not provide evidence that the total export value of high-IP products expands along the intensive margin, or that the observed expansion in high-IP exports is driven by an increase in the unit price per exporter. The estimate of γ is not statistically different from zero at the 10% level in columns (6)–(10), suggesting that patent reforms do not affect the average or median exporter size and the unit price per exporter.

Next in Table 6b, we re-examine the above four outcomes (i.e., total export value, the number of exporters, export value per exporter, and unit price per exporter) for the sample of 19 countries with both prereform and postreform export data and evaluate the factor change in each outcome that occurs around the time of patent reform. Here, we estimate the model (1), followed by the model (5). Table 6b shows the results which for the model (1) are strikingly similar (qualitatively and quantitatively) to those in Table 6a. This similarity strengthens the credibly of our findings as it shows that our results are not driven by a particular sample of countries or variation used to identify the effects. From column (1), the ROR estimate of the treatment effect on total export value equals $e^{0.706} = 2.03$.

The results from the model (5), where the strength of the treatment effect is allowed to change over time, deepen out understanding of the effects. It is apparent from column (4) that high-IP exports expands around the time of patent reform on the extensive margin, with the ROR estimate for the number of exporters equal to $e^{0.494} = 1.64$. While the multiplicative treatment effect on the number of exporters exceeds one, it does not grow after reforms. By contrast, the multiplicative treatment effect on the (mean or median) exporter size is indistinguishable from one around the time of patent reform, but it grows with the number of years since reform. From column (6), the ROR estimate of the effect on the mean exporter size grows by a factor of 1.20 per year on average (since $e^{0.185} = 1.20$) in the postreform period. That is, the percentage treatment effect of patent reform on the average exporter size is indistinguishable from zero four years after reform (i.e., when $T_{it} = 0$) but equals 20% five years after reform (i.e., when $T_{it} = 1$), 44% six years after reform (i.e., when $T_{it} = 2$), etc. Importantly, this positive growth is not driven by some very large exporters, since the effect on the median exporter size is even more pronounced: the estimate of φ is positive and larger in magnitude in column (8). Taken together, these results imply that the observed expansion in exports in the first years of the postreform period is primarily driven by expansions in the number of exporters but in later years, expansions in the average size of exporters become more important. The combined effect of these changes is a large

Table 5
Summary statistics.

Variables	42 Countries			19 Countries		
	Obs.	Mean	St. Dev.	Obs.	Mean	St. Dev.
Number of:						
Exporters	133,741	18.616	86.635	73,724	10.728	40.485
Entrants	113,374	10.347	43.483	65,526	6.210	22.580
Exiters	97,847	11.370	43.975	54,974	6.698	22.073
Survivors	79,863	3.126	15.037	48,254	2.102	8.992
Incumbents	113,374	7.383	42.637	65,526	4.308	19.049
Total Export Value:						
Exporters	103,323	12.112	183.254	54687	5.732	67.921
Entrants	94,859	0.739	10.846	53268	0.422	6.458
Exiters	79,614	0.721	10.027	43062	0.471	10.267
Survivors	77,478	0.523	9.762	46629	0.294	5.591
Incumbents	106,645	8.617	153.568	61368	4.313	61.864
Export value (mean) per:						
Exporter	103,323	0.455	8.233	54687	0.317	4.658
Entrant	94,859	0.058	1.109	53268	0.039	0.420
Exiter	79,614	0.056	1.563	43062	0.045	0.635
Survivor	77,478	0.093	2.458	46629	0.056	0.823
Incumbent	106,645	0.633	11.373	61368	0.431	6.919
Export value (median) per:						
Exporter	103,323	0.148	5.102	54687	0.099	2.660
Entrant	94,859	0.028	0.738	53268	0.020	0.339
Exiter	79,614	0.030	1.442	43062	0.024	0.471
Survivor	77,478	0.063	1.757	46629	0.039	0.761
Incumbent	106,645	0.336	8.122	61368	0.250	5.439
Unit price (mean) per:						
Exporter	68,297	213.545	4355.852	34,660	70.428	1011.272
Entrant	53,715	198.895	4721.492	29,157	85.765	1619.546
Exiter	53,377	158.832	3693.885	28,937	75.167	1411.461
Survivor	28,013	143.372	2971.485	15,129	56.691	439.897
Incumbent	44,371	185.141	6366.992	23,257	63.412	1007.293
Unit price (median) per:						
Exporter	68,297	83.203	3480.083	34,660	40.516	915.87
Entrant	53,715	98.944	4386.61	29,157	51.890	1145.074
Exiter	53,377	55.827	964.779	28,937	42.060	887.841
Survivor	28,013	99.054	2602.362	15,129	44.127	390.987
Incumbent	44,371	96.044	1999.527	23,257	47.966	982.591
Diversification and Concentration:						
Number of Destinations per Exporter (mean)	89,324	1.475	0.865	45,585	1.431	0.852
Number of Destinations per Exporter (median)	89,324	1.146	0.634	45,585	1.164	0.678
Number of Exporters per Destination (mean)	89,324	2.577	3.667	45,585	2.257	2.466
Number of Exporters per Destination (median)	89,324	1.634	2.396	45,585	1.582	1.635
Herfindahl-Hirschman Index	89,324	0.506	0.281	45,585	0.537	0.276
Share of Top 1% Exporters	4912	0.332	0.203	1301	0.274	0.174
Share of Top 5% Exporters	21,929	0.541	0.219	7810	0.493	0.205
Exporter dynamics:						
Firm Entry Rate	99,375	0.668	0.320	56,424	0.683	0.332
Firm Exit Rate	97,847	0.656	0.322	54,974	0.664	0.336
Entrant 1st Year Survival Rate	72,502	0.230	0.288	43,443	0.226	0.299
Destination dynamics:						
Destination Entry Rate of Incumbents (mean)	66,172	0.233	0.261	34,472	0.230	0.273
Destination Entry Rate of Incumbents (median)	66,172	0.175	0.288	34,472	0.183	0.296
Destination Entry Rate of Survivors (mean)	40,935	0.250	0.305	21,633	0.247	0.316
Destination Entry Rate of Survivors (median)	40,935	0.203	0.332	21,633	0.212	0.338
Destination Exit Rate of Incumbents (mean)	66,172	0.232	0.260	34,472	0.228	0.273
Destination Exit Rate of Incumbents (median)	66,172	0.172	0.287	34,472	0.180	0.296
Share of New Destinations in TEV of Incumbents (mean)	66,172	0.194	0.262	34,472	0.191	0.273
Share of New Destinations in TEV of Incumbents (median)	66,172	0.131	0.281	34,472	0.140	0.290
Share of New Destinations in TEV of Survivors (mean)	40,935	0.227	0.307	21,633	0.224	0.318
Share of New Destinations in TEV of Survivors (median)	40,935	0.177	0.330	21,633	0.185	0.337
Independent variables:						
High IP (dummy)	133,741	0.197	0.398	73,724	0.196	0.397
postreform (dummy)	133,741	0.761	0.426	73,724	0.691	0.462
GDP per capita (in logs)	133,741	8.842	0.813	73,724	8.809	0.700
Capital stock (in logs)	133,741	12.789	1.399	73,724	12.321	0.952
Human capital index	133,741	2.258	0.468	73,724	2.235	0.478
EFI trade freedom	133,741	7.140	1.183	73,724	7.138	1.068
EFI property rights	133,741	4.297	1.666	73,724	4.239	1.533
Corruption perception index	132,723	14.125	17.792	73,567	13.512	18.153
Chinn-Ito index	133,741	0.668	1.524	73,724	1.054	1.567
Fin. cred. controls on inflows	115,608	0.445	0.497	63,449	0.295	0.456
Fin. cred. controls on outflows	115,608	0.483	0.500	63,449	0.414	0.493

Table 6a
Export margins (42 countries).

Dependent variables:	Total export value		Number of exporters		Export value per exporter			Unit price per Exporter		
					mean		median	mean		median
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Postreform*High IP	0.452*	0.835***	0.488***	0.467***	–0.656***	–0.383	–0.103	–0.126	0.106	0.139
	[0.238]	[0.241]	[0.146]	[0.157]	[0.233]	[0.336]	[0.386]	[0.475]	[0.508]	[0.632]
Postreform (dummy)	–0.406***	–0.424***	–0.417***	–0.276**	–0.047	–0.090	–0.155	–0.132	–0.243	0.288
	[0.146]	[0.159]	[0.107]	[0.121]	[0.141]	[0.133]	[0.201]	[0.362]	[0.334]	[0.489]
High IP (dummy)	–1.955***	–2.324***	–0.212	–0.197	–1.661***	–1.916***	–2.275***	0.074	–0.115	–0.470
	[0.380]	[0.386]	[0.131]	[0.138]	[0.346]	[0.355]	[0.354]	[0.571]	[0.619]	[0.770]
GDP per capita (in logs)	1.786*	–3.300	–0.135	0.506	2.667***	2.471*	0.251	1.654	7.277	14.397**
	[1.018]	[3.068]	[0.417]	[0.869]	[0.855]	[1.499]	[3.108]	[1.813]	[4.606]	[7.337]
Capital stock (in logs)	–0.854	0.428	–0.513	0.328	–1.328*	–0.131	0.623	4.959**	2.335	0.487
	[0.813]	[1.993]	[0.403]	[0.847]	[0.681]	[1.694]	[3.081]	[1.959]	[5.171]	[7.577]
Human capital index	–0.284	0.149	–0.215	2.422**	1.115**	5.155***	9.083***	1.304	–7.065	–11.563
	[0.619]	[3.348]	[0.366]	[1.030]	[0.515]	[1.802]	[3.484]	[2.998]	[6.666]	[9.922]
EFI trade freedom	0.033	0.003	–0.013	0.001	–0.027	–0.094	–0.138	0.088	–0.021	–0.014
	[0.047]	[0.031]	[0.012]	[0.031]	[0.056]	[0.063]	[0.161]	[0.165]	[0.108]	[0.142]
EFI property rights	–0.143**	0.040	–0.049	0.035	–0.141	0.158	0.164	0.337**	–0.128	0.096
	[0.068]	[0.104]	[0.037]	[0.047]	[0.091]	[0.113]	[0.159]	[0.166]	[0.278]	[0.263]
Corruption perception index	0.005	0.010	–0.004	–0.007	–0.007	–0.005	–0.007	–0.012	–0.027	–0.007
	[0.008]	[0.010]	[0.004]	[0.006]	[0.004]	[0.005]	[0.009]	[0.010]	[0.019]	[0.017]
Chinn–Ito index	–0.001	0.001	0.008	0.012	–0.080	–0.011	–0.243**	–0.171	0.065	0.092
	[0.085]	[0.091]	[0.055]	[0.057]	[0.067]	[0.069]	[0.123]	[0.258]	[0.310]	[0.362]
Fin. cred. controls on inflows	–0.086	–0.256	0.188***	0.137*	0.183	–0.065	–0.139	–1.162***	–0.818**	–0.966***
	[0.156]	[0.252]	[0.048]	[0.071]	[0.118]	[0.146]	[0.214]	[0.410]	[0.381]	[0.343]
Fin. cred. controls on outflows	0.061	–0.040	–0.106	–0.058	–0.325**	–0.243	–0.393	0.832	0.803**	2.199***
	[0.166]	[0.181]	[0.140]	[0.116]	[0.142]	[0.211]	[0.322]	[0.656]	[0.354]	[0.331]
Constant	13.427	–26.512	2.977	0.893	18.225***	4.737	–20.315	–6.429	50.654	107.063
	[8.858]	[19.917]	[3.653]	[6.516]	[6.637]	[13.333]	[29.838]	[9.484]	[48.125]	[76.437]
Observations	91,155	91,155	91,155	91,155	91,155	91,155	91,155	60,736	60,736	60,736
R-squared	0.038	0.040	0.116	0.117	0.050	0.050	0.022	0.168	0.188	0.025
Year fixed effects?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-by-sector fixed effects?	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-specific time trends?		yes		yes		yes	yes		yes	yes
Sector-specific time trends?		yes		yes		yes	yes		yes	yes

Notes: PPML estimator. *** $p < .01$, ** $p < .05$, * $p < .1$. Robust standard errors in parentheses are clustered at the country level.

(level) treatment effect of patent reforms on total export value which tends to persist over time. One reason the expansion in the number of exporters contributes relatively more to total exports is that entrants into exporting tend to be larger firms. We probe into this explanation below.

Further from columns (10) and (12), the ROR estimate for the unit price per exporter is not statistically different from one around the time of patent reform, but it rises by 18% per year for the mean unit price and 23% per year for the median unit price in the postreform period. These results thus clarify our earlier finding of a zero price effect and show that the effect of patent reforms on unit prices takes time to become apparent.

In what follows, we work with the sample of 19 countries. In Table 7, we consider different exporter types. In Panel A, we redo our previous analysis of export margins but now use the data on all exporters, without omitting observations where the number of exporters equals one, as we did in Table 6b. The number of observations in columns (3)–(4) rises as a result, and the coefficient γ on the interaction term H_jR_{it} is now more precisely estimated. The sample and thus the results in the other columns remain the same.

A firm that exports in year t is either a new entrant in that year (if it did not export in year $t-1$) or an incumbent exporter (if it also exported in year $t-1$). We limit our analysis to entrants and incumbents in Panels B and C respectively. The comparison of the results reveals that the observed expansion in exports along the extensive margin around the time of patent reforms, as well as the observed expansion in exports along the intensive margin over time following reforms, are largely driven by changes in the entrants' behaviour. From column (3) in Panel B, the ROR estimate of the treatment effect on the number of entrants equals $e^{0.493} = 1.64$. The multiplicative treatment effect on the median entrant size also exceeds one and it grows more rapidly after reforms, which follows from column (8). From column (6), the treatment effect on the mean entrant size is indistinguishable from one but again, the effect grows more rapidly after reforms. The effect on the unit price per entrant also does not change around the time of patent reforms but grows over time after reforms, as columns (10) and (12) show.

At the same time, the exporting behaviour of incumbents is largely unaffected. The coefficient γ is not statistically different from zero at the 5% level in all but columns (3) and (11). The estimates in columns (3) and (11) imply that the treatment effect on the number of incumbents and their unit price equals $e^{0.587} = 1.8$ and $e^{0.604} = 1.83$ respectively. Once we allow the treatment effect to change over time, we find that the coefficient φ is negative and statistically significant at the 5% level in column (12). The estimate of -0.175 implies that the effect on the unit price falls by 16% per year in the postreform period. Patent reforms appear to have no effect on the size of incumbents or their total export value.

Next, Panel D considers surviving entrants, i.e., firms which enter into exporting in year t and continue exporting in year $t+1$. It is apparent that the coefficient on the term H_jR_{it} is positive (1.574 and 0.563) and statistically significant in columns (1) and (3), but the coefficient on the term $H_jR_{it}T_{it}$ is negative (-1.183) and highly statistically significant in column (2). At the same time, the coefficients γ and φ are not statistically different from zero in the other columns. These results imply that the total export value of survivors in the high-IP product group expands around the time of patent reforms along the extensive margin but this positive effect rapidly falls after reforms,

Table 6b
Export margins (19 countries).

Dependent variables:	Total export value		Number of exporters		Export value per exporter				Unit price per exporter			
					mean		median		mean		median	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Postreform*High IP	0.706**	1.229**	0.475**	0.494**	–0.824**	–0.413	0.010	0.939*	0.421	0.509	0.336	0.568
	[0.290]	[0.502]	[0.189]	[0.232]	[0.420]	[0.483]	[0.437]	[0.502]	[0.537]	[0.699]	[0.601]	[0.807]
Postreform*High IP*Years since r.		0.141		–0.009		0.185***		0.288***		0.162**		0.207**
		[0.086]		[0.035]		[0.047]		[0.104]		[0.083]		[0.088]
Postreform (dummy)	–0.129	–0.156	–0.048	–0.051	–0.001	–0.026	–0.166	–0.184	0.148	0.116	0.512**	0.366
	[0.218]	[0.199]	[0.065]	[0.068]	[0.205]	[0.203]	[0.249]	[0.258]	[0.340]	[0.281]	[0.239]	[0.234]
Postreform*Years since reform		0.066		0.001		0.067		0.385		0.293		0.269
		[0.095]		[0.038]		[0.098]		[0.294]		[0.242]		[0.223]
High IP (dummy)	–2.920***	–2.312***	–0.383***	–0.283***	–2.040***	–2.260***	–2.805***	–3.324***	0.233	–0.256	0.215	–0.272
	[0.410]	[0.358]	[0.087]	[0.084]	[0.472]	[0.409]	[0.373]	[0.562]	[0.609]	[0.634]	[0.611]	[0.763]
High IP*Years since reform		–0.311***		–0.027		–0.218***		–0.359***		–0.073		–0.151
		[0.108]		[0.048]		[0.035]		[0.087]		[0.109]		[0.105]
GDP per capita (in logs)	–0.906	–0.744	1.092	1.100	1.028	1.021	0.675	1.127	3.806	4.199	8.431	8.084
	[3.439]	[3.357]	[1.124]	[1.124]	[1.800]	[1.796]	[3.683]	[3.361]	[7.501]	[7.394]	[9.864]	[9.037]
Capital stock (in logs)	–1.380	–0.476	–1.386*	–1.384	–1.379	–0.188	0.026	5.610	2.039	6.359	–3.298	0.530
	[2.195]	[3.445]	[0.726]	[1.091]	[2.065]	[3.095]	[4.080]	[6.992]	[5.052]	[5.846]	[7.258]	[7.928]
Human capital index	4.889***	4.721***	3.825***	3.840***	5.875***	5.586***	7.303	5.757	–1.279	–3.034	–2.196	–4.406
	[1.343]	[1.269]	[0.911]	[0.903]	[2.016]	[1.716]	[4.565]	[3.898]	[6.928]	[7.249]	[8.642]	[8.146]
EFI trade freedom	–0.048	–0.044	0.075**	0.075**	–0.165*	–0.162*	–0.316	–0.286	–0.025	–0.006	0.055	0.028
	[0.083]	[0.084]	[0.033]	[0.033]	[0.096]	[0.096]	[0.204]	[0.175]	[0.112]	[0.106]	[0.159]	[0.144]
EFI property rights	0.039	0.063	0.006	0.006	0.160	0.165	0.165	0.200	0.016	–0.065	–0.540	–0.635
	[0.106]	[0.116]	[0.030]	[0.031]	[0.132]	[0.139]	[0.201]	[0.233]	[0.350]	[0.468]	[0.548]	[0.617]
Corruption perception index	–0.008	–0.008	–0.010***	–0.010***	–0.014	–0.014	–0.025***	–0.024**	–0.023*	–0.024	–0.026	–0.025
	[0.017]	[0.017]	[0.004]	[0.004]	[0.013]	[0.014]	[0.009]	[0.009]	[0.014]	[0.015]	[0.017]	[0.017]
Chinn-Ito index	–0.097**	–0.087**	0.003	0.004	–0.077	–0.072	–0.267***	–0.246***	0.001	0.062	0.115	0.161
	[0.045]	[0.042]	[0.014]	[0.015]	[0.059]	[0.060]	[0.080]	[0.083]	[0.197]	[0.222]	[0.228]	[0.229]
Fin. cred. controls on inflows	–0.026	–0.026	0.140***	0.143***	0.086	0.085	0.237	0.221	0.471*	0.435*	–0.368	–0.452
	[0.112]	[0.115]	[0.053]	[0.054]	[0.175]	[0.170]	[0.261]	[0.230]	[0.256]	[0.240]	[0.377]	[0.325]
Fin. cred. controls on outflows	–0.283	–0.282	–0.176***	–0.178***	–0.327	–0.330	–0.523	–0.534	–0.143	–0.050	1.380***	1.584***
	[0.191]	[0.198]	[0.065]	[0.069]	[0.252]	[0.257]	[0.426]	[0.436]	[0.331]	[0.442]	[0.377]	[0.545]
Constant	–9.552	–11.193	8.825	8.846	0.277	–3.238	–11.156	–24.173	24.311	16.001	74.020	62.353
	[27.604]	[29.934]	[8.969]	[9.489]	[16.894]	[19.720]	[38.365]	[40.011]	[69.337]	[70.326]	[91.832]	[88.978]
Observations	47,624	47,624	47,624	47,624	47,624	47,624	47,624	47,624	30,822	30,822	30,822	30,822
R-squared	0.049	0.050	0.139	0.139	0.053	0.053	0.027	0.027	0.099	0.104	0.102	0.102

Notes: PPML estimator. *** $p < .01$, ** $p < .05$, * $p < .1$. Robust standard errors in parentheses are clustered at the country level. All regressions include year fixed effects, country-by-sector fixed effects, country-specific time trends, and sector-specific time trends.

which could be because survivors achieved incumbent status. Furthermore, the size of survivors and their unit prices do not appear to change following patent reforms.

Finally, Panel E considers exiters, i.e., firms which export in year $t-1$ but do not export in year t. We see a positive and highly statistically significant coefficient on the term H_jR_{it} in columns (1), (3) and (4), implying that the number of exiters and their total export value rise around patent reforms. At the same time in columns (6), (8), and (10), the coefficient on H_jR_{it} is not statistically significant while the coefficient on $H_jR_{it}T_{it}$ is negative and statistically significant at the 5% level. These results suggest that the size of exiters and their unit prices do not change around the time of patent reforms but fall over time in the postreform period. With that, the positive effect on total export value also rapidly falls after reforms, as implied by the negative (-0.687) and statistically significant coefficient on the term $H_jR_{it}T_{it}$ in column (2).

4.2. Exporter and destination dynamics

Tables 8 and 9 consider the effect of patent reforms on exporter and destination dynamics. Table 8 focuses on the exporter entry rate in columns (1)–(2), the exit rate in columns (3)–(4), and the entrant first year survival rate in columns (5)–(6). We find that exporter churning rises around the time of patent reform. In column (2), the coefficient on H_jR_{it} is positive (0.063) and highly statistically significant, while the coefficient on R_{it} is not statistically different from zero. These estimates imply that the exporter entry rate (given by the share of entrants in the total number of exporters in a given year) changes by a factor of $e^{0.063} = 1.07$ (or rises by 7%) in the high-IP product group after patent reform and does not change in the control group of low-IP products. The coefficient on $H_jR_{it}T_{it}$ is positive (0.008) but only marginally significant and thus the effect is unchanged over time. We also observe similar effects on the exporter exit rate, which is given by the ratio of exiters in a given year relative to the total number of exporters in a previous year. From column (4), the exit rate of high-IP firms changes by a factor of $e^{0.083} = 1.09$ (or rises by 9%) after patent reform and does not change over time. The results in columns (5)–(6) further suggest that patent reforms have no effect on the share of entrants that survive in the first year.

Next, Table 9 shows the destination dynamics results. In Panel A, we focus on the three measures of destination dynamics for incumbents: the destination entry rate in columns (1)–(4), the shares of new destinations in total export value in columns (5)–(8), and the destination exit rate in columns (9)–(12). For each measure, we use the data on means in the first two columns and medians in the last two columns. We

Table 7
Export margins, by exporter type.

Dependent variables:	Total export value		Number of firms		Export value per firm				Unit price per firm			
					mean		median		mean		median	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Exporters												
Postreform*High IP	0.706**	1.229**	0.527***	0.540***	–0.824**	–0.413	0.010	0.939*	0.421	0.509	0.336	0.568
	[0.290]	[0.502]	[0.170]	[0.204]	[0.420]	[0.483]	[0.437]	[0.502]	[0.537]	[0.699]	[0.601]	[0.807]
Postreform*High IP*Years since r.		0.141		–0.016		0.185***		0.288***		0.162**		0.207**
		[0.086]		[0.030]		[0.047]		[0.104]		[0.083]		[0.088]
Postreform (dummy)	–0.129	–0.156	–0.055	–0.061	–0.001	–0.026	–0.166	–0.184	0.148	0.116	0.512**	0.366
	[0.218]	[0.199]	[0.064]	[0.066]	[0.205]	[0.203]	[0.249]	[0.258]	[0.340]	[0.281]	[0.239]	[0.234]
Postreform*Years since reform		0.066		–0.012		0.067		0.385		0.293		0.269
		[0.095]		[0.036]		[0.098]		[0.294]		[0.242]		[0.223]
High IP (dummy)	–2.920***	–2.312***	–0.419***	–0.297***	–2.040***	–2.260***	–2.805***	–3.324***	0.233	–0.256	0.215	–0.272
	[0.410]	[0.358]	[0.089]	[0.070]	[0.472]	[0.409]	[0.373]	[0.562]	[0.609]	[0.634]	[0.611]	[0.763]
High IP*Years since reform		–0.311***		–0.024		–0.218***		–0.359***		–0.073		–0.151
		[0.108]		[0.042]		[0.035]		[0.087]		[0.109]		[0.105]
Observations	47,624	47,624	63,291	63,291	47,624	47,624	47,624	47,624	30,822	30,822	30,822	30,822
R-squared	0.049	0.050	0.139	0.140	0.053	0.053	0.027	0.027	0.099	0.104	0.102	0.102
Panel B: Entrants												
Postreform*High IP	0.906*	0.171	0.493**	0.429**	0.474	0.938*	–0.093	0.926***	0.638	1.029	0.422	1.048
	[0.478]	[0.515]	[0.201]	[0.206]	[0.491]	[0.504]	[0.295]	[0.330]	[0.528]	[0.691]	[0.706]	[0.922]
Postreform*High IP*Years since r.		–0.413		–0.059		0.193***		0.427***		0.291***		0.437***
		[0.277]		[0.094]		[0.056]		[0.096]		[0.059]		[0.076]
Postreform (dummy)	–0.283	–0.578*	–0.017	–0.020	–0.276	–0.438	–0.244	–0.364	0.151	–0.017	0.752***	0.373
	[0.328]	[0.302]	[0.101]	[0.100]	[0.613]	[0.580]	[0.811]	[0.754]	[0.232]	[0.280]	[0.219]	[0.271]
Postreform*Years since reform		–0.481**		–0.023		–0.650***		–0.721***		0.626*		0.344*
		[0.220]		[0.048]		[0.211]		[0.266]		[0.321]		[0.178]
High IP (dummy)	–2.135***	–0.860	–0.277**	–0.025	–2.200***	–2.533***	–1.882***	–2.990***	–0.123	–0.980*	0.092	–1.171
	[0.301]	[0.553]	[0.139]	[0.177]	[0.390]	[0.318]	[0.316]	[0.318]	[0.517]	[0.574]	[0.698]	[0.801]
High IP*Years since reform		0.321		0.010		–0.217***		–0.417***		–0.213**		–0.326***
		[0.256]		[0.085]		[0.052]		[0.112]		[0.084]		[0.098]
Observations	45,782	45,782	55,515	55,515	45,782	45,782	45,782	45,782	25,638	25,638	25,638	25,638
R-squared	0.021	0.021	0.181	0.181	0.025	0.027	0.020	0.022	0.069	0.077	0.101	0.104
Panel C: Incumbents												
Postreform*High IP	0.714	1.455*	0.587**	0.550*	–0.626	0.167	–0.486	0.216	0.535	0.108	0.604**	0.211
	[0.518]	[0.809]	[0.287]	[0.324]	[0.570]	[0.473]	[0.688]	[0.742]	[0.374]	[0.371]	[0.299]	[0.340]
Postreform*High IP*Years since r.		0.184		–0.046		0.339*		0.254		–0.144		–0.175**
		[0.199]		[0.216]		[0.187]		[0.171]		[0.097]		[0.069]
Postreform (dummy)	–0.139	–0.132	0.013	0.047	0.224	0.173	0.277	0.194	–0.808***	–0.678**	–0.795**	–0.658*
	[0.238]	[0.220]	[0.090]	[0.084]	[0.204]	[0.173]	[0.284]	[0.278]	[0.278]	[0.308]	[0.327]	[0.348]
Postreform*Years since reform		0.149*		0.068***		0.109		0.547***		0.080		0.234
		[0.085]		[0.023]		[0.090]		[0.120]		[0.287]		[0.355]
High IP (dummy)	–3.060***	–2.513***	–0.587***	–0.324	–2.342***	–2.836***	–2.435***	–2.780***	1.324**	1.276**	1.751***	1.861***
	[0.506]	[0.739]	[0.177]	[0.405]	[0.633]	[0.333]	[0.685]	[0.618]	[0.665]	[0.600]	[0.569]	[0.451]
High IP*Years since reform		–0.376*		–0.014		–0.392**		–0.315**		0.234**		0.227***
		[0.205]		[0.195]		[0.165]		[0.130]		[0.107]		[0.068]
Observations	51,977	51,977	55,484	55,484	51,977	51,977	51,977	51,977	20,967	20,967	20,967	20,967
R-squared	0.042	0.042	0.098	0.098	0.049	0.049	0.033	0.033	0.146	0.147	0.122	0.122
Dependent variables:	Total export value		Number of firms		Export value per firm				Unit price per firm			
					mean		median		mean		median	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel D: Survivors												
Postreform*High IP	1.574**	–0.400	0.563***	0.505*	1.600	0.161	–0.365	–0.563	0.219	0.154	–0.324	–0.475
	[0.660]	[0.666]	[0.191]	[0.299]	[1.082]	[1.206]	[0.592]	[1.010]	[0.465]	[0.629]	[0.523]	[0.816]
Postreform*High IP*Years since r.		–1.183***		–0.067		–0.829		–0.210		0.023		–0.032
		[0.278]		[0.168]		[0.625]		[0.327]		[0.190]		[0.268]
Postreform (dummy)	–0.811	–1.321**	–0.053	–0.036	–1.050*	–1.466***	–1.099*	–1.301**	–0.305	–0.275	–0.247	–0.172
	[0.586]	[0.520]	[0.084]	[0.080]	[0.624]	[0.464]	[0.664]	[0.580]	[0.252]	[0.240]	[0.329]	[0.312]
Postreform*Years since reform		–0.662**		0.031		–1.067***		–0.753**		–0.006		0.169
		[0.275]		[0.037]		[0.257]		[0.326]		[0.274]		[0.281]
High IP (dummy)	–3.187***	–0.138	–0.450***	–0.172	–3.638***	–1.486	–2.052***	–1.523*	0.783	0.550	1.805***	1.602*
	[0.365]	[0.580]	[0.152]	[0.351]	[0.937]	[0.975]	[0.443]	[0.869]	[0.506]	[0.791]	[0.520]	[0.858]
High IP*Years since reform		0.930***		0.000		0.672		0.148		0.044		0.106
		[0.260]		[0.156]		[0.639]		[0.336]		[0.193]		[0.271]
Observations	40,655	40,655	42,058	42,058	40,655	40,655	40,655	40,655	13,778	13,778	13,778	13,778

(*continued on next page*)

Table 7 (*continued*)

Dependent variables:	Total export value		Number of firms		Export value per firm				Unit price per firm			
					mean		median		mean		median	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
R-squared	0.018	0.019	0.117	0.117	0.037	0.039	0.036	0.037	0.432	0.432	0.365	0.368
Panel E: Exiters												
Postreform*High IP	0.958***	–0.236	0.549***	0.528***	0.616	0.125	0.153	–0.299	0.202	–0.598	0.148	–0.468
	[0.190]	[0.708]	[0.175]	[0.151]	[0.782]	[0.534]	[0.762]	[0.700]	[0.498]	[0.376]	[0.452]	[0.558]
Postreform*High IP*Years since r.		–0.697**		–0.039		–0.379***		–0.390**		–0.418***		–0.297
		[0.328]		[0.099]		[0.137]		[0.155]		[0.131]		[0.191]
Postreform (dummy)	–0.508	–0.591*	0.073	0.056	–0.490*	–0.439	–0.101	0.156	0.476	0.857***	1.771***	2.041***
	[0.486]	[0.353]	[0.094]	[0.101]	[0.269]	[0.283]	[0.287]	[0.294]	[0.291]	[0.317]	[0.288]	[0.385]
Postreform*Years since reform		–0.472		–0.044		0.254		0.746**		0.868***		0.538
		[0.343]		[0.050]		[0.263]		[0.336]		[0.335]		[0.360]
High IP (dummy)	–2.019***	–0.235	–0.349***	–0.098	–2.142***	–0.891**	–1.684***	–0.515	0.094	1.378**	0.281	1.210**
	[0.253]	[0.811]	[0.117]	[0.186]	[0.689]	[0.366]	[0.633]	[0.411]	[0.785]	[0.536]	[0.679]	[0.596]
High IP*Years since reform		0.598*		–0.020		0.264**		0.284*		0.332**		0.243
		[0.315]		[0.087]		[0.110]		[0.152]		[0.130]		[0.179]
Observations	37,611	37,611	47,050	47,050	37,611	37,611	37,611	37,611	25,487	25,487	25,487	25,487
R-squared	0.021	0.022	0.170	0.170	0.017	0.017	0.018	0.019	0.057	0.058	0.133	0.133

Notes: PPML estimator. *** $p < .01$, ** $p < .05$, * $p < .1$. Robust standard errors in parentheses are clustered at the country level. All regressions include year fixed effects, country-by-sector fixed effects, country-specific time trends, and sector-specific time trends, and the same controls as in Table 6b.

find no evidence that patent reforms affect incumbents' destination dynamics: the coefficients on H_jR_{it} and $H_jR_{it}T_{it}$ are not statistically different from zero in any columns. In Panel B, we study survivors' destination dynamics. The coefficient on H_jR_{it} is negative although not statistically different from zero at the 5% level in columns (1)–(7); and the coefficient on $H_jR_{it}T_{it}$ is negative and statistically significant in all columns. These results imply that the destination entry rate of surviving entrants, as well as the shares of new destinations in their total export value, decline following patent reforms. This finding could explain the negative long-run effect of patent reforms on survivors' total export value, which follows from the estimates in Table 7 (Panel D).

4.3. Diversification and concentration

Last in Table 10, we evaluate the effect of patent reforms on exporter diversification and concentration. In Panel A, the (mean and median) number of destinations per exporter is in columns (1)–(4) and the (mean and median) number of exporters per destination is in columns (5)–(8). The results show that the coefficients on the terms H_jR_{it} and $H_jR_{it}T_{it}$ are not statistically significant at the 5% level in columns (1)–(4). Thus the market diversification of exporters (in terms of the number of destinations) does not change in the high-IP product group, relative to the low-IP group, when patent reforms occur. Nonetheless from column (6), exporter concentration in terms of the mean number of exporters per destination rises around the time of the reform. The ROR estimate of this effect equals 1.1 and since the factor impact in the low-IP group is indistinguishable from one, it implies that the mean number of exporters per destination in the high-IP group rises by 10% around the time of patent reform. However, this result is sensitive to the measure used: when we work instead with medians in columns (7)–(8), we find that the coefficient on H_jR_{it} is not statistically different from zero. Having said that, the long-run effects on the number of exporters per destination are negative, whether we work with means or medians: the ROR estimate falls by 2% per year for the mean number and by 1.5% per year for the median number.

Panel B further considers the HHI in columns (1)–(2) and the share of the top 1% or top 5% exporters in total export value in columns (3)–(6). The ROR estimate of the effect on the HHI is indistinguishable from one but grows by 1.8% per year on average after reforms, suggesting that export market concentration rises as more years pass since the reform year. At the same time, exporter concentration at the top of the firm-size distribution does not change after patent reforms.

5. Timing of patent reforms

Our empirical approach is valid under the key assumption that the timing of patent reforms is exogenous. This is not improbable, given that the timing of reforms across developing countries in our data largely coincides with the TRIPS compliance schedule. The WTO members were given transitional periods before they were obliged to comply with all of the provisions of the TRIPS Agreement. In particular, developing countries and economies in transition from central planning were given five years, until 2000. For developing countries that did not provide product patent protection in a particular area of technology when the TRIPS Agreement came into force, the deadline was extended to 2005. This schedule largely corresponds to the reform years in our data. Specifically, out of 19 countries with pre- and post-reform EDD data (i.e., the sample used in most of our analysis), as many as 11 countries implemented major patent reforms in 2000 and another six countries did so in 2005.

To further ease the endogeneity concern, we follow Branstetter et al. (2006) and study the timing of changes in exports. The EDD data are not suitable for this analysis, because only five countries in the EDD have prereform period data (when we do not choose the four-year gap). As such, we use the UN Comtrade export data instead. In order to increase the number of years of export data prior to the date of reform, we focus on the period of 1990–2016. The data cover all 36 patent-reforming countries used in our above analysis and are organized by HS 6-digit codes, the 1992 HS classification.

We augment the model (1) and estimate the following specification:

Table 8
Exporter dynamics.

Dependent variables:	Exporter entry rate		Exporter exit rate		Entrant surv. rate	
	(1)	(2)	(3)	(4)	(5)	(6)
Postreform*High IP	0.054***	0.063***	0.070***	0.083***	0.049	–0.052
	[0.014]	[0.021]	[0.018]	[0.024]	[0.084]	[0.128]
Postreform*High IP*Years since r.		0.008*		0.007		–0.067*
		[0.004]		[0.005]		[0.040]
Postreform (dummy)	–0.013	–0.018	–0.033	–0.040	–0.054	–0.017
	[0.034]	[0.034]	[0.028]	[0.026]	[0.058]	[0.053]
Postreform*Years since reform		–0.017		–0.025		0.068
		[0.015]		[0.022]		[0.045]
High IP (dummy)	0.041	0.017	0.048*	0.033	–0.171**	–0.013
	[0.025]	[0.027]	[0.027]	[0.032]	[0.085]	[0.125]
High IP*Years since reform		–0.004		–0.006		0.053
		[0.009]		[0.008]		[0.042]
Observations	48,468	48,468	47,050	47,050	37,864	37,864
R-squared	0.154	0.154	0.125	0.125	0.072	0.072

Notes: PPML estimator. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors in parentheses are clustered at the country level. All regressions include year fixed effects, country-by-sector fixed effects,country-specific time trends, and sector-specific time trends, and the same controls as in Table 6b.

$$Y_{ijt} = \exp(\alpha + \sum_{k=1}^{5} [\beta_{1k} R_{it-k} + \gamma_{1k} R_{it-k} H_j] + \sum_{k=1}^{8} [\beta_{2k} R_{it+k} + \gamma_{2k} R_{it+k} H_j] + X'_{ist}\delta)\varepsilon_{ijt}, \quad (6)$$

where the outcome Y_{ijt} is the total value of exports of domestic goods, which excludes re-exports. The independent variables R_{it-k} are the prereform dummy variables. The variable R_{it-1} is equal to one for the year immediately preceding reform and zero during other years. The variables R_{it-2}, R_{it-3}, and R_{it-4} are equal to one for two, three, and four years before reform, respectively, and zero in all other years; and the variable R_{it-5} is equal to one for all years that predate reform by five or more years and zero in all other years. Next, the independent variables

Table 9
Destination dynamics.

Dependent variables:	Destination entry rate				New destinations export value share				Destination exit rate			
	mean		median		mean		median		mean		median	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Incumbents												
Postreform*High IP	0.031	–0.112	0.008	–0.133	0.041	–0.129	0.017	–0.177	0.039	–0.103	0.010	–0.131
	[0.076]	[0.114]	[0.103]	[0.132]	[0.078]	[0.154]	[0.117]	[0.194]	[0.091]	[0.129]	[0.133]	[0.160]
Postreform*High IP*Years since r.		–0.068		–0.058		–0.082		–0.090		–0.074		–0.068
		[0.045]		[0.045]		[0.058]		[0.057]		[0.065]		[0.065]
Postreform (dummy)	0.062	0.103	0.075	0.120	0.054	0.099	0.080	0.129	0.024	0.070	0.045	0.092
	[0.063]	[0.078]	[0.081]	[0.094]	[0.078]	[0.090]	[0.095]	[0.101]	[0.051]	[0.064]	[0.066]	[0.076]
Postreform*Years since reform		0.081*		0.099		0.080		0.088		0.106**		0.116**
		[0.048]		[0.063]		[0.056]		[0.071]		[0.042]		[0.057]
High IP (dummy)	–0.112	–0.009	–0.127	–0.088	–0.054	0.068	–0.020	0.084	–0.097	0.047	–0.130	–0.021
	[0.100]	[0.121]	[0.158]	[0.151]	[0.120]	[0.162]	[0.191]	[0.213]	[0.112]	[0.125]	[0.170]	[0.157]
High IP*Years since reform		0.079*		0.083*		0.095		0.112*		0.074		0.077
		[0.047]		[0.048]		[0.060]		[0.062]		[0.067]		[0.072]
Observations	30,619	30,619	30,571	30,571	30,619	30,619	30,571	30,571	30,617	30,617	30,563	30,563
R-squared	0.090	0.090	0.093	0.094	0.088	0.088	0.081	0.081	0.085	0.086	0.087	0.088
Panel B: Survivors												
Postreform*High IP	–0.055	–0.226*	–0.107	–0.264*	–0.060	–0.268*	–0.124	–0.360**				
	[0.073]	[0.119]	[0.098]	[0.148]	[0.076]	[0.146]	[0.101]	[0.176]				
Postreform*High IP*Years since r.		–0.079**		–0.070**		–0.099**		–0.113***				
		[0.031]		[0.034]		[0.043]		[0.043]				
Postreform (dummy)	–0.129	–0.044	–0.148	–0.070	–0.178	–0.074	–0.176	–0.074				
	[0.115]	[0.171]	[0.147]	[0.215]	[0.118]	[0.170]	[0.162]	[0.224]				
Postreform*Years since reform		0.084		0.079		0.105		0.101				
		[0.091]		[0.108]		[0.095]		[0.116]				
High IP (dummy)	–0.106	0.015	–0.078	0.013	–0.076	0.084	–0.035	0.156				
	[0.089]	[0.122]	[0.107]	[0.137]	[0.100]	[0.149]	[0.115]	[0.170]				
High IP*Years since reform		0.091***		0.086**		0.110**		0.124**				
		[0.034]		[0.037]		[0.047]		[0.048]				
Observations	18,992	18,992	18,959	18,959	18,992	18,992	18,959	18,959				
R-squared	0.069	0.069	0.070	0.070	0.069	0.069	0.067	0.067				

Notes: PPML estimator. *** $p < .01$, ** $p < .05$, * $p < .1$. Robust standard errors in parentheses are clustered at the country level. All regressions include year fixed effects, country-by-sector fixed effects, country-specific time trends, and sector-specific time trends, and the same controls as in Table 6b.

Table 10
Diversification and Concentration.

Panel A:

Dependent variables:	Number of destinations per exporter				Number of exporters per destination			
	mean		median		mean		median	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Postreform*High IP	0.014	0.016	0.023	0.024	0.113***	0.098**	0.038	0.025
	[0.019]	[0.028]	[0.029]	[0.036]	[0.040]	[0.039]	[0.027]	[0.027]
Postreform*High IP*Years since r.		–0.005		–0.008*		–0.024***		–0.015***
		[0.005]		[0.005]		[0.009]		[0.005]
Postreform (dummy)	0.038**	0.040**	0.023	0.023*	–0.068*	–0.065	–0.068	–0.063
	[0.015]	[0.016]	[0.014]	[0.014]	[0.036]	[0.040]	[0.041]	[0.045]
Postreform*Years since reform		0.011		0.001		0.005		0.016
		[0.012]		[0.013]		[0.030]		[0.037]
High IP (dummy)	–0.111***	–0.088***	–0.076***	–0.043*	–0.202***	–0.121***	–0.116***	–0.071***
	[0.026]	[0.027]	[0.025]	[0.024]	[0.041]	[0.028]	[0.030]	[0.027]
High IP*Years since reform		–0.002		–0.001		0.005		0.006
		[0.006]		[0.007]		[0.008]		[0.006]
Observations	40,585	40,585	40,585	40,585	40,585	40,585	40,585	40,585
R-squared	0.127	0.127	0.086	0.086	0.139	0.139	0.099	0.099

Panel B:

Dependent Variables:	Herfindahl Index		Top 1% Exporters export value share		Top 5% Exporters export value share	
	(1)	(2)	(3)	(4)	(5)	(6)
Postreform*High IP	–0.028	–0.005	–0.183	–0.209	0.057	0.057
	[0.027]	[0.024]	[0.150]	[0.155]	[0.054]	[0.077]
Postreform*High IP*Years since r.		0.018***		–0.016		–0.002
		[0.005]		[0.049]		[0.018]
Postreform (dummy)	0.029**	0.022	0.108*	0.145	0.057*	0.068**
	[0.014]	[0.015]	[0.057]	[0.102]	[0.031]	[0.026]
Postreform*Years since reform		–0.014		0.061		0.029
		[0.012]		[0.068]		[0.022]
High IP (dummy)	–0.022	–0.073**	2.413		0.081	0.092
	[0.030]	[0.028]	[2.188]		[0.101]	[0.079]
High IP*Years since reform		–0.012**		0.083		–0.003
		[0.006]		[0.112]		[0.026]
Observations	40,585	40,585	1258	1258	7411	7411
R-squared	0.142	0.142	0.404	0.404	0.161	0.161

Notes: PPML estimator. *** $p < .01$, ** $p < .05$, * $p < .1$. Robust standard errors in parentheses are clustered at the country level. All regressions include year fixed effects, country-by-sector fixed effects, country-specific time trends, and sector-specific time trends, and the same controls as in Table 6b.

R_{it+k} are the postreform dummy variables. When $k = 1, ..., 7$, the variable R_{it+k} is equal to one for k years after reform and zero in all other years. When $k = 8$, the variable R_{it+8} is equal to one for at least eight years after reform and zero in all other years. Each of these reform variables appears in the specification by itself and also as the interaction term with the high-IP intensity dummy variable, H_j. The dummy variable for the year of reform is omitted and so, the coefficients on the reform variables provide estimates relative to the reform year. Each of the 36 countries in our sample has at least four years of pre-reform data and at least seven years of post-reform data.

Table 11shows the results. All specifications include time-varying exporting country controls and fixed effects for each year and each country-by-sector. The specification in column (2) also includes time trends specific to each country, and in column (3) adds further controls for time trends specific to each sector. It is apparent that the coefficients on the pre-reform dummies interacted with the high-IP intensity dummy variable (γ_{1k}) are not statistically significant at the 5% level across all specifications. Thus, the estimated timing of export changes confirms that there is no pre-reform trend. On the other hand, the coefficients on the post-reform dummies interacted with the high-IP intensity dummy variable (γ_{2k}) are positive and statistically significant at the 5% level for four or more years after reform in columns (1) and (2). In column (3), which shows the results of the most demanding specification, the coefficients γ_{2k} are positive and statistically significant at the 5% level for six and seven years after reform. Overall, these results confirm our finding that total export value of high-IP products rises following patent reform but the adjustment takes time. The results further suggest that the endogeneity in the adoption of patent reforms is not an issue.

6. Discussion of results

In summary, we find that the total value of high-IP exports expands when patent reforms occur in developing countries. Exports expand along the extensive (firm-count) margin around the time of patent reforms but over time, expansion along the intensive (the mean and median exporter size) margin makes a more important contribution to within-country high-IP export growth.

Table 11
Timing of Reforms.

Dependent Variables:	Total export value (1)	Total export value (2)	Total export value (3)
Reform ($t-5$) * High IP	0.426	0.200	0.499
	[0.490]	[0.508]	[0.544]
Reform ($t-4$) * High IP	0.439	0.172	0.407
	[0.585]	[0.530]	[0.538]
Reform ($t-3$) * High IP	0.026	–0.649	–0.528
	[0.634]	[0.515]	[0.523]
Reform ($t-2$) * High IP	0.471	0.055	0.190
	[0.287]	[0.185]	[0.159]
Reform ($t-1$) * High IP	0.655*	0.401*	0.354
	[0.350]	[0.230]	[0.284]
Reform ($t+1$) * High IP	0.181**	0.094	0.063
	[0.087]	[0.070]	[0.077]
Reform ($t+2$) * High IP	0.199*	0.099	0.047
	[0.103]	[0.087]	[0.104]
Reform ($t+3$) * High IP	0.191**	0.093	0.012
	[0.091]	[0.103]	[0.130]
Reform ($t+4$) * High IP	0.286***	0.224**	0.110
	[0.094]	[0.091]	[0.123]
Reform ($t+5$) * High IP	0.406***	0.360***	0.215
	[0.102]	[0.097]	[0.133]
Reform ($t+6$) * High IP	0.500***	0.432***	0.252**
	[0.117]	[0.101]	[0.115]
Reform ($t+7$) * High IP	0.467***	0.457***	0.246**
	[0.115]	[0.094]	[0.118]
Reform ($t+8$) * High IP	0.283***	0.369***	0.046
	[0.109]	[0.064]	[0.152]
Reform ($t-5$)	–0.641	–0.105	–0.108
	[0.500]	[0.568]	[0.538]
Reform ($t-4$)	–1.124	–0.352	–0.350
	[0.737]	[0.492]	[0.470]
Reform ($t-3$)	–0.881	–0.214	–0.205
	[0.614]	[0.388]	[0.371]
Reform ($t-2$)	–0.171	0.149	0.146
	[0.276]	[0.216]	[0.213]
Reform ($t-1$)	–0.162	0.091	0.114
	[0.185]	[0.131]	[0.131]
Reform ($t+1$)	–0.191	–0.090	–0.082
	[0.143]	[0.111]	[0.124]
Reform ($t+2$)	–0.032	0.079	0.091
	[0.138]	[0.118]	[0.123]
Reform ($t+3$)	0.059	0.192	0.202
	[0.131]	[0.194]	[0.184]
Reform ($t+4$)	0.008	0.090	0.101
	[0.146]	[0.214]	[0.200]
Reform ($t+5$)	–0.030	0.017	0.034
	[0.174]	[0.241]	[0.225]
Reform ($t+6$)	–0.059	–0.046	–0.019
	[0.193]	[0.260]	[0.243]
Reform ($t+7$)	–0.089	–0.101	–0.067
	[0.211]	[0.303]	[0.284]
Reform ($t+8$)	–0.093	–0.154	–0.094
	[0.220]	[0.315]	[0.298]
High IP (dummy)	–1.754***	–1.804***	–1.526***
	[0.326]	[0.361]	[0.357]
Constant	–6.456**	–258.762***	–234.996***
	[2.820]	[81.065]	[87.375]
Observations	895,083	895,083	895,083
R-squared	0.024	0.025	0.025
Country-specific time trends?	no	yes	yes
Sector-specific time trends?	no	no	yes

Notes: PPML estimator. *** $p < .01$, ** $p < .05$, * $p < .1$. Robust standard errors in parentheses are clustered at the country level. All regressions include year fixed effects, country-by-sector fixed effects, country-by-sector fixed effects, country-specific time trends, and sector-specific time trends, and the same controls as in Table 6b.

When we classify exporters by their status in a given year, we find that the observed effects of patent reforms on exports are driven by changes in the exporting behaviour of entrants, while the exporting behaviour of incumbents is largely unaffected. Patent reforms have no effect on the size of incumbents or their total export value. This result is consistent with the idea that patents are not the only factor determining innovative and exporting capacity. Prior to reforms, incumbents may already have possessed the advantages to engage in product development and export products or had such advantages that could compensate for a lack of strong patent protection. Upon reform, therefore, the entrants who did not possess prior compensating advantages would find that the reforms facilitate their exporting capacities, as the reforms provided them with the needed institutional security to engage in the global market.

The results further show that patent reforms do not affect the size of surviving entrants. While the total export value of survivors in the high-IP product group expands around the time of patent reforms along the extensive margin, this positive effect rapidly falls over time. The average value per exiter also does not change around the time of patent reforms, but falls over time and with that, the positive effect on the exiters' total export value rapidly falls after reforms. The observed long-run decline in the total export value of surviving entrants and exiters could be due to firms switching to alternative modes of market entry, such as FDI.[11]

We further find that the effect of patent reforms on the unit price per exporter takes time to become apparent: the unit prices do not change around the time of patent reform but grow more rapidly after reforms. This finding is important since patent reforms in developing countries have been largely opposed on the grounds that they would increase the prices of patented goods, which would increase the rents accruing to inventors but also limit local access to new knowledge and technologies. Importantly, the long-run price effect depends critically on the status of exporting firm: the unit price per entrant grows while the unit prices per incumbent falls over time after reforms. The positive effect on entrants' unit prices could reflect the quality upgrading of their export goods, while the negative effect on incumbents' unit prices could be due to increased market competition.

Patent reforms in developing countries also increase exporter churning. Exporter entry rates in the high-IP sectors rise around the time of patent reform and this effect tend to persist over time. This finding could be a result of limited appropriability hazards and lower uncertainty about the future export profits associated with stronger domestic PRs. The observed increase in entry rates in the high-IP sectors is accompanied by a similar increase in exit rates: exit rates rise by 9% around the time of patent reform and also tend to persist over time.

[11] According to UNCTAD, some of the African countries in our sample (e.g., Burkina Faso and Senegal) have experienced increases in outward FDI (as a percentage of GDP) over the 2009–2011 period.

Thus, patent reforms are simultaneously creative and destructive. However in contrast to entering exporters, those exiting tend to be of smaller size and have lower unit prices. These findings suggest that as new IP-dependent firms displace existing firms, the distribution of exporters shifts towards larger and more IP-intensive firms following patent reforms.

At the same time, patent reforms do not affect the destination entry and exit rates of incumbent exporters or their share of new destinations in total export value. Likewise, patent reforms do not affect the first year survival rate of new entrants into export markets. These results suggest that maintaining a long term establishment in a market requires more than patent protection. Patents may provide a nudge for product development and exporting, but long term survival is found in a firm's own competence and strategies, not in a state's policy. In addition, incumbent firms earning 'monopoly' profits may have less incentive to seek additional profit or replace existing products with superior ones (Kamien and Schwartz, 1982). Nonetheless, we find that the destination entry rate of surviving entrants and the shares of new destinations in their total export value fall following patent reforms. One possible explanation is that surviving exporters' behaviour is influenced primarily by the IP and competitive environment in the destination markets. Also, long and broad patent rights may militate against innovation and productivity growth if they lead to reduced market competitiveness and rivalry (Aghion and Griffith, 2005).

Reforms appear to have no effect on exporter market diversification in terms of the number of destinations. Such diversification may be the result of preferential trading arrangements or trade policies in the destination markets—beyond what internal patent reforms can provide. Also rather than pursuing the market diversification strategy (i.e., selling in as many markets as possible), firms can pursue the concentration strategy (i.e., selling intensively in some specific or large markets) in order to recoup their innovation investments. Our results suggest the latter. We find that exporter concentration in terms of the mean number of exporters per destination rises around the time of the reform, while the median number of exporters per destination is unaffected. Thus the observed increase in the mean number of high-IP exporters per destination could be driven by large destinations, which are served by a large number of exporters. Nonetheless, the effect on the number of exporters per destination (mean or median) falls over time after reforms. The analysis of the HHI further reveals that export market concentration rises as more years pass since the reform year. At the same time, the share of the top 1% and top 5% exporters in total export value does not change after patent reforms, implying that exports of smaller firms rise in proportion to the exports of top firms. This finding highlights the role of smaller firms in export expansion, which is important since smaller firms in the EDD have lower foreign shares in ownership (Freund and Pierola, 2016).[12]

7. Conclusion

As noted in the *TRIO Conference* theme, globalization is both costly and beneficial, but the world free trading system makes global technological innovation possible. This possibility for technological innovation arises within an institutional framework in which firms are appropriately incentivized and their innovation investments are adequately protected. To that end, the TRIPS Agreement aimed to ensure that measures and procedures to enforce IPRs did not act as barriers to legitimate trade. To enact the strong standards of IP laws mandated by the Agreement, a wide range of developing economies under the auspices of the WTO underwent substantial reforms in their patent systems during the 1994–2005 period.

This paper examined one key aspect of the debate about the likely consequences of strengthening IPRs protection in the developing world: the impact of patent reforms on the outward orientation of developing countries and the microfoundations of their export growth. The purported goal of patent reforms was to promote developing countries' industrial and technological development. However, the evidence to date is scant, as the literature focused on inward technology flows into IP-reforming countries, via importing, inward FDI, or licensing.

Using product-level data from 1997 to 2014, this paper evaluated the impact of national patent reforms in developing countries on a variety of indicators of exporter characteristics and behavior, including the total value of firm exports, the number and size of exporters, the unit price per exporter, and several measures of exporter and destination dynamics, such as entry, exit, survival, and incumbency. It adopted a difference-in-difference setting, exploiting the fact that not all developing countries had undertaken major reforms in their patent systems, and those that did executed them in different periods, and also comparing the outcomes in the group of IP-intensive products relative to the control group of non-IP-intensive products.

The results show that patent reforms in developing countries had real, positive effects on the exporting capacity of firms, controlling for other influences. High-IP exports expanded along the extensive (firm-count) margin around the time of the reforms but over time, expansions along the intensive (firm size) margin became more important. The unit prices per exporter also rose over time following reforms. Exporter churning (i.e., entry and exit rates) increased, shifting the distribution of exporters towards larger and more IP-intensive firms. The exporting behaviour of entrants was impacted most, while incumbents' behaviour and characteristics were largely unaffected. Exporter concentration in large destination markets also increased around the time of patent reforms. Importantly, the share of 'export superstars'—i.e., top 1% and top 5% firms, which have high foreign share in ownership—does not change after patent reforms.

To sum it up, these results signify that patent reforms did influence the local productive and innovative capacity of developing country firms, which in turn enhanced their export performance. The results support previous research which described the mechanisms by which patent reforms can affect export growth. Chiefly, patent reforms help attract technology transfers from abroad which in turn help build the export capacity of local firms. As Yang and Maskus (2009) show, when Northern firms license their superior technologies to a Southern firm, the latter is able to produce at lower marginal cost. But as Mansfield (1994) documents in the survey of U.S. firms in sixteen countries, when the intellectual property regime is too weak, firms are reluctant to engage in joint ventures with local partners, transfer their newest and most effective technologies to their subsidiaries, or license their technologies to unrelated firms. Ivus et al. (2017) further confirm that a strengthening of patent protection in developing countries increases the incentive of foreign firms to license innovations, particularly to local arms-length parties. In a weak IP environment, on the other hand, foreign firms are present in host markets primarily for purposes of sales, distribution, and marketing, rather than for engaging in local knowledge trade. This has consequences for developing countries where access to knowledge and know-how is critical, especially for small, domestically-owned firms. The growth in the export capacity of the developing economy firms in our sample—from Africa, South America, Central America, and Southeast Asia—required technology that increases the efficiency of production as well as enable product development; such technology most likely originated from abroad. Patent reforms protected local innovators against imitation and thereby created incentives for innovation and export capacity building. Both our work and related empirical studies by Branstetter et al. (2011), Briggs and Park (2014), and Yang and Maskus (2018) are consistent in showing—from different perspectives—that patent reforms impact export growth.

[12] Freund and Pierola (2016) identify firm origins for 10 countries in the EDD data and find that the majority of the top 5% export firms are foreign owned, began operations as large exporters, and did not learn from domestic production to become 'export superstars.'

Further research using detailed product-level data could deepen our understanding of the effects of patent reforms on product quality Henn et al. (2015) and Fan et al. (2015) as well as other measures of developing countries' outward orientation, such as outward FDI and licensing. Possible extensions to this work include studies of how the impacts of patent reforms interact with the strength of IPRs in destination markets or differ across selected IP-intensive sectors.

Appendix A

Table A1
Prereform and postreform number of years.

Number of years	Number of countries	
in the EDD	prereform	postreform
1	4	0
2	7	1
3	1	2
4	3	3
5	0	1
6	1	1
7	1	1
9	1	3
10	1	3
11	0	3
15	0	1

Table A2
EDD year coverage.

Year	Frequency	
	42 country sample	19 country sample
1997	1	1
1998	2	2
1999	3	3
2000	7	5
2001	11	7
2002	19	13
2003	23	16
2004	23	16
2005	28	18
2006	31	17
2007	34	17
2008	36	18
2009	35	18
2010	33	18
2011	30	15
2012	30	14
2013	13	7
2014	6	3
	365	208

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