Do Preferential Trade Agreements Stimulate Patenting? Evidence from BRICS

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Abstract

Utilizing a novel cross-country dataset on patent filings, this study employs an augmented version of gravity model to explore the impact of preferential trade agreements (PTAs) on non-resident patent filings in emerging market economies of BRICS. However, PTAs vary in terms of content and design, therefore we analyse the differential impact of PTAs while focussing on deep and shallow agreements. The PPML estimates suggest that PTAs have a positive and statistically significant impact on non-resident patent filings in BRICS. In particular, country-pairs with PTAs increase their patent flows by 43% relative to control group (dyads with no PTAs). Further deep PTAs matter more in foreign patenting upsurge in BRICS compared to shallow PTAs. The shallow PTAs exhibit positive medium- term but negative long- term effects on patent flows, whereas deep PTAs unveil positive anticipatory effects.

Key words: Gravity model, Multilateral resistance, Preferential trade agreements, Patent filings, PPML

JEL Classification: F00, O33

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1. Introduction

In today's globalized economy, the importance of owning patents have grown significantly. For firms, investors and entities patenting beyond their national borders has become a popular strategy to seek protection on their intellectual property (IP) and eventually appropriate rents in the destination markets. Since patents are territorial. They protect an innovation only in the jurisdictions in which they have been filed. Firms, thus, have an incentive to patent in several countries. However, not all firms engage in this activity as the decision when, where and what to patent abroad is complex and usually involves costs and risks. Besides the cost of filling patents in various destination markets, there are translation and maintenance costs associated with patenting abroad. Often firms have to bear substantial costs that arise out of imitation risk and theft of IP in the destination markets. Small businesses and entrepreneurs, in particular, are vulnerable to these hazards, as they typically face time constraints, limited financial resources, and less knowledge of foreign IP systems.

Despite these obstacles, evidence suggests that the exploitation of technology through international patenting has become popular during last couple of decades. For example, Archibugi and Iammarino (2002) show that the share of non-resident patenting and the share of patent applications for national inventors abroad increased in all OECD countries during the early 1990s. Data from WIPO (2009) reveals a significant increase of international patent applications in the late 1990s and early 21st century. For U.S. assignees WIPO applications more than doubled, rising from 23,845 in 1997 to 50,134 in 2006. Studies such as Schmoch (1999) and Mogee (1996) point to similar conclusions. The national patent offices of BRICS countries witnessed a similar surge in patent applications, specifically in non-resident patent filings. More than 1.65 million patent applications were filed in BRICS in 2018 as against about 0.39 million in 2008 reflecting a more than fourfold rise in the number of filings between 2008 and 2018. During the same period the patent filings at USPTO, EPO and JPO put together grew from 0.99 million applications to just over 1 million applications. The rise in IP filings is largely due to an excessive growth of foreign filings in BRICS as opposed to domestic filing. The surge is puzzling because the legal and intellectual property regime in BRICS has been questioned in recent times (Prud'homme and Zhang, 2019). In other words, unlike the 1980s patenting boom in advanced countries where IP rights are rigorous, the recent filing surge in BRICS occurred in presence of relatively weak IP system existing in these countries.

The prevailing literature documents that market covering, competition and imitative threat hypotheses explain the majority of patent flows from a country of origin to a country of destination (Cai et. al., 2020; Hu, 2010; Sun, 2003). Our study takes a different perspective and analyses the impact of trade agreements on the level of non-resident patenting in BRICS group. We argue that the trade agreements specifically agreements that tackle behind the border regulations and membership in multilateral trade treaties (GATT/WTO) have substantially reduced the trade and patenting frictions, eventually leading to higher bilateral patent flows. In addition to the formation of large multilateral treaties focussing on IPRs and trade liberalisation across member nations, there has been the proliferation of regional and bilateral trade agreements many of which include explicit regulation regarding IPRs, in particular about patents (Coleman, 2022). A close inspection of the data on trade and patenting activity suggest a significant link between acceleration of trade flows and a rise in cross-country patenting. In particular, this cohesive movement between trade flows and patent numbers becomes more evident post the introduction of the WTO/TRIPS in the world trade.

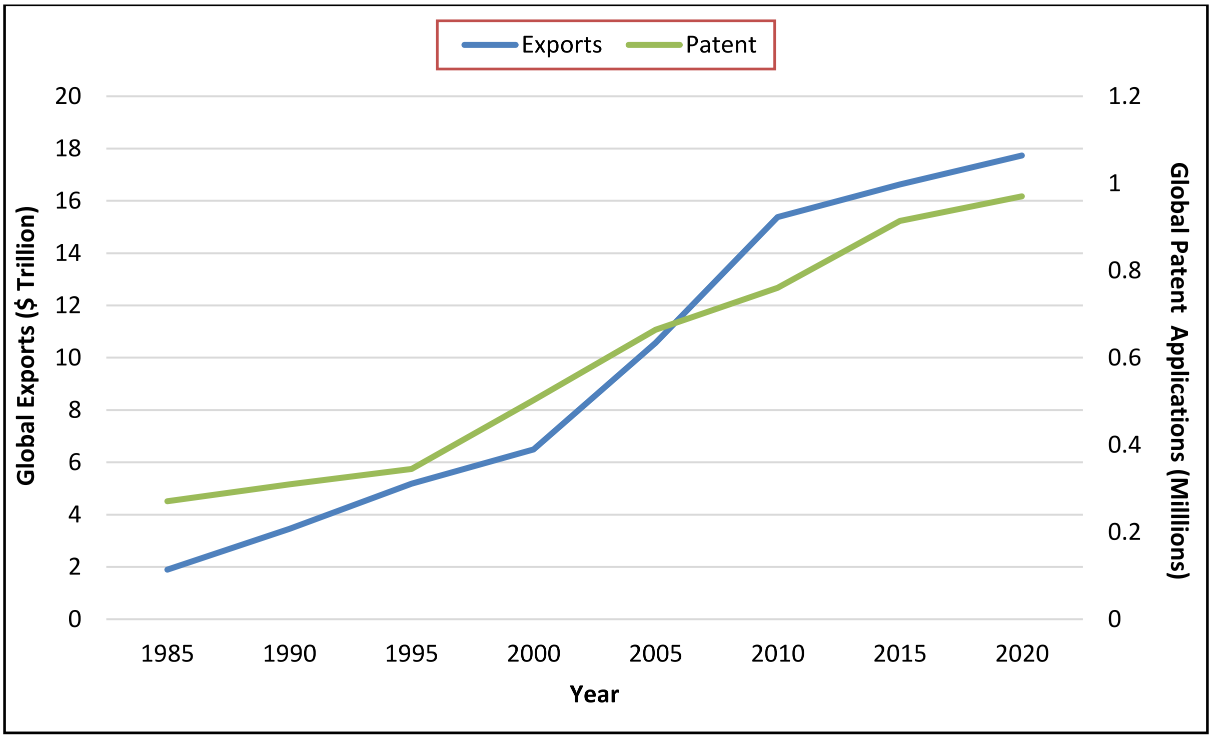

Figure 1: Exports vs. Patenting. *"Domestic" patents have been removed to be comparable to exports which does not include "domestic" trade. The two measures are plotted on different scales to be visually comparable, trade flows follow the left axis, patent flows follow the right axis. Trade flows are measured in total USD value; patent flows are measured as aggregate patent applications.*

Thus far, less empirical research has been devoted to evaluate the impact of multilateral treaties and trade agreements on patent filings. We attempt to develop an integrated approach that incorporates trade agreements, and joint membership to multilateral treaties while controlling for the market size, imitation and competition variables in the analysis on patenting. In this direction we study the flow of patents across various industries from a group of origin countries which include a set of advanced countries (mainly OECDs) to the destination markets comprising BRICS group. Based on the trade-patenting nexus and controlling for endogeneity in trade agreements, the analysis produces three major findings. 1) PTAs and joint member to multilateral treaties have significant impact on non-resident patenting in BRICS. 2) Further, deep PTAs matter more than shallow PTAs in enhancing patent flows. These agreements have both anticipatory and lagged short-and-long term effects on non-resident patenting in our sample.

The remainder of this paper is organized as follows. Section 2 briefly outlines the related literature. Section 3 reviews the construction of the dataset. Section 4 presents a model of patent flows that motivates the subsequent empirical analysis. In section 5 we present a discussion on empirical strategies and results of the study. Finally, section 6 provides some closing remarks.

1. Literature

Patenting depends on the volume of ideas generated in a country which in turn is a function of the stock of knowledge capital. An increase in the knowledge capital generate new ideas and technologies to be exploited for commercial gains necessitating source country firms to tap destination markets. To ensure the continued exploitation of their technological knowhow, firms excessively undertake patents in the destination markets. Therefore, the theoretical notion of knowledge or capability exploitation appears to be a useful starting point to understand the increase in cross-country patent flows. A further theoretical justification for the upsurge in cross-country patenting comes from the resource-based theory. According to this theory, possession of valuable intellectual resources provides foreign firms a competitive edge over rivals. To protect their intellectual resources and sustain the competitive advantage, they excessively indulge in strategic patenting which involves building patent portfolios so that their technological development activities are not stifled by patent infringement suits from rival firms (Hall & Ziedonis 2001; Ziedonis 2004).

The exploitation of intellectual resources and the appropriation of returns thereof largely depend on the market size of the host country. Bosworth (1984) mentions recipient country's market size and trade inflows as key factors shaping the decision of source country firms to demand IP rights of the former. Yang and Kuo (2008) find that when countries' increase their exports and outward foreign direct investments they tend to file more patents in the partner country. In their analysis on bilateral patenting among OECD countries, Eaton and Kortum (1996) mention market size as the major determinant of a firms patenting activity. However, in the destination market foreign firms have to face the imitation hazard which constraints their ability to appropriate the innovation rents. In the presence of imitation threat, profits of foreign firms are either completely or in part, wiped out depending upon the imitative capability of the local firms and the strength of IPRS in the destination market. Higher imitative capability of destination country firms compels foreign firms to undertake protection of their innovations. Depending upon the nature of IPR regime, the ability to appropriate rents increases with the patent protection. Stringent IPR regimes are believed to discourage the imitation activities and help innovating firms to recoup their innovation costs. Therefore, in addition to market size, the decision to patent also depends on the presence of imitation risks and the nature of IPR regime in the destination country.

Another strand of trade-literature builds on the theoretical underpinnings of the gravity model. This strand broadly studies the impact of multilateral trade and IP treaties and free trade agreements (FTAs), on the international trade flows. It also provides evidence for the impact of technology-related content of FTAs on trade flows and internationalization of technology. (Maskus & Ridley, 2016; Campi & Duenas, 2019; Martinez-Zarzoso & Chelala, 2021). The provisions covered in FTAs ensure implementation of policy commitments by the member states that can create incentives for firms to exchange technology-intensive goods with their trading partners (Buthe & Milner, 2008; Santacreu, 2022). Capitalizing on the recent advances in the empirical structural gravity literature, Larch et al., (2019) find conclusive evidence that both GATT/WTO has been effective in promoting trade between member states. However, as opposed to the conventional view, Rose (2004) reported striking findings that countries acceding or belonging to the GATT/WTO did not have significantly different trade patterns than non-members. In line with Rose's (2004) seminal work, Silviano et al., (2020) find that unlike regional trade agreements (RTAs) and currency unions, the GATT/WTO accession has not generated positive trade effects. Accounting econometrically for the endogeneity in FTAs, Baier and Bergstrand (2007) find that the effect of FTAs on trade flows is quintupled. By the same token, Baier et al., (2019) applied a novel two stage methodology to study the empirical determinants of the *ex post* effects of past FTAs and estimate *ex ante* predictions for the effects of future FTAs. Their results indicate asymmetries in FTA effects, e.g., FTA effects are weaker for more distant dyads and for dyads with otherwise high levels of *ex ante* trade frictions. Furthermore, Anderson and Yotov (2016) show FTAs have varying effects across industries and these industry-level differences in turn have important consequences for quantifying the welfare impact of FTAs.

Over the years, the scope of FTAs has grown from mere trade liberalization to a vast range of policy areas that include the IPRs, the labour market, the environment, as well as investment and technology transfers (Dur et al., 2014; Hofman et al., 2017). The existing empirical literature has shown that content of trade agreements fosters internationalization of technology through bilateral exchange of goods with diverse technological intensities (LaBelle and Santacreu, 2021; Erixon et al., 2022). However, the impact of the content of trade agreements on international patent filings remains, to the best of our knowledge, understudied. This paper attempts to bridge this gap in the literature by examining the role PTAs in explaining the flow of non-resident patents in the BRICS group. Moreover, we exploit the variation across PTAs in terms of their substance and design to see whether the differences in the scope and depth of these agreements matter for cross-border patent flows. Incorporating design differences will assist us to better understand why states sign PTAs and why a narrow or shallow agreement is unlikely to have same consequences as broad and deep one for some sectors of the economy.

Our study is closely related to Coleman (2021) who investigates the impact of trade liberalizing treaties as well as on treaties strengthening intellectual property rights on patent flows, to Santacreu et. al., (2022) which study the effect of RTAs on bilateral patenting activity, and to Jinji (2019) that focus on the link between ratification of FTAs and patent citations across countries. We contribute to this emerging literature by emphasizing on deep and shallow PTAs, and highlighting their anticipatory and phase-in effects on the outcome variable both at the industry and country levels. Since trade agreements take several rounds of negotiations before they enter into force and there is a possibility that due to anticipation effect, the impact of trade agreements could occur before their promulgation. Therefore, to evaluate the full impact of PTAs, one need to capture both anticipatory and lag effects of these agreements.

2. **Dataset on Patent Filings and PTAs**

Our dataset on patent filings is unique. It differs from other widely used patent databases in many ways. For instance patent data provided by USPTO archives applications filed only in the United States with no information on applications filed with other major patent offices. Compared to USPTO, the publicly available OECD database is more general in that it covers patent applications filed in US as well as with EPO and under the PCT. The problem with OECD database is that, except OECD and a few emerging economies, it does not provide data on patents filed with the patent offices of other countries. The only publicly available database comprehensive in terms of coverage is WIPO. It accounts for patents filed in the patent offices across all countries and disaggregates them into three categories viz. total filings, resident filings and non-resident filings. However, a major issue with WIPO and other publicly available databases is that patent data is reported under various technology domains/fields (35 technology areas). In the absence of one-to-one correspondence between tech-fields and manufacturing industries, it becomes increasingly difficult to assign patents to the industries. Moreover, many of these tech-fields have multiple facets making it doubly challenging to link them with the industry of their relevance.

To map tech-fields with industries, we generate weights using four-digit alpha-numeric International Patent Classification (IPC) codes. Following the IPC system each of the 35 tech-domains is assigned a certain number of IPC codes. These codes link invention patents and utility models with their technology areas[1]. Based on the count of IPC codes in each tech-filed we track their distribution across industries using IPCV8-NACE2 concordance scheme[2]. This scheme relates industries to relevant technology classes. Depending upon the total IPC code counts belonging to each tech-field and their distribution across various industries, we were able to generate the weights that an individual industry carries in each tech-field. Weights actually describe the fraction of an industry patent codes falling in each tech-field[3].

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[1] IPC has defined 35 technology areas and each technology area may have many facets. These technology areas can be linked to various manufacturing industries according to IPC-NACE concordance scheme.

[2] The concordance IPCV8-NACE2 relates industries to relevant technology classes. NACE2 is the statistical classification of economic activities in the European Community and it serves a similar purpose as the NAICS (North American Industry Classification System) and SIC (Standard Industrial Classification). The concordance table between IPCV8 and NACE2 maps IPC main groups/ IPC sub classes to the first 2-4 digits of the hierarchical NACE code. For further details see Patent Statistics: Concordance IPC V8-NACE REV.2 available at *forums.epo.org/concordance-table-between-ipc-and-nace2-9756*

[3] Each technology area has a certain number of IPC codes, for instance the tech-field electrical machinery apparatus energy has a total of 33 IPC codes and these codes have been distributed across various industries such as electrical equipment (27 codes), computer, electronics and optical products (5 codes) and, machinery and equipment (1 code). The weights thus calculated are 27/33 = 0.81, 5/33=0.15 and 1/33=0.03 implying 81%

The weights vary between 0 and 1, where extreme value 0 means absence of a link between a tech-field and an industry and value 1 suggests a complete overlap between the two. However, a value between 0 and 1 would mean that each tech-field can be connected to many industries. This procedure results into a fractional patent counts ensuring none of the tech-field is missed out or underrepresented in the final analysis of patenting at industry level. Moreover, fractional count allows us to take care of double counting which otherwise plagues the datasets on patent counts. To arrive at yearly bilateral patenting dataset by country and industry, we multiply the patent numbers filed in each tech-class with the weights and then sum across industries. Finally, through text matching two-digit NACE2 is compared with the two-digit ISIC3 and then mapped to the later[4]. This is done to get our filing data as per the two-digit ISIC3 which is a widely accepted industry classification.

Data on design and content of PTAs is from the Design of Trade Agreements (DESTA) by Dur et al., (2014). DESTA project aims to systematically collect data on various types of preferential trade agreements (PTAs). These may be customs unions, free trade agreements or partial free trade agreements (or what economists often call economic integration agreements). The database manually coded design features for more than 710 agreements. These include fine-grained data with information on a large set of design features ranging from market access commitments, flexibility instruments, enforcement tools, to non-trade issues for the time period between 1948 and 2019. Based on the seven key provisions that can be included in a PTA, the database uses two different measures to operationalize depth of a PTA[5]. The first measure *depth_index* is an additive index that assumes a value between 0 and 7 depending upon the number of provisions included in the PTA. The second measure *depth_latent* is more comprehensive. It covers a total of 49 items that theoretically relate to

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of total patents filed in the tech-field electrical machinery apparatus energy in a year are mapped to electrical equipment industry [ISIC 27], 15% to computer, electronics and optical products [ISIC 26] and about 3% to machinery and equipment N.E.C. industry [ISIC 28].

[4] We compare NACE2 and ISIC3 using text matching and observed that both classifications overlap at two-digit level. NACE is derived from ISIC, in the sense that it is more detailed than ISIC, and both ISIC and NACE have exactly the same items at the highest levels, where as NACE is more detailed at lower levels.

[5] Depth_index is an additive measure that combines seven key provisions that can be included in PTAs. These include a provision on creation of a full-FTA which essentially indicate that all tariffs (with few exceptions) should be eliminated among the trading partners. The other six provisions capture cooperation that goes beyond tariff reductions, in areas such as services trade, investments, standards, public procurement, competition and IPRs.

the depth of an agreement and employs latent trait analysis to retain only items which are vital in establishing the extent of countries' commitments[6].

3. BRICS as Destination of Patent Applications

We use our dataset to document salient features of international patenting flows across industries and countries. Among other facts, we document the rise of BRICS as a destination of patents applications over the past decades.

Figure 2 tracks the evolution of the total, resident and non-resident patent applications filed in BRICS group from past four decades spanning 1980-2021.

The recent upsurge in the total patent applications received by the BRICS group, as whole, appear to be mainly driven by rise in domestically filed patent applications. In 1995, out of the total patent applications filed in BRICS, around 48% were resident patent applications and nearly 52% constitute the non-resident patent applications. However, in 2021 patent filings claiming domestic ownership soared as high as 86% reducing non-resident share to just 14%. The reason behind this apparent catch-up between domestic and total filings is the excessive rise in the number of domestic applications in China which disproportionately contribute to the total resident filings in the BRICS group.

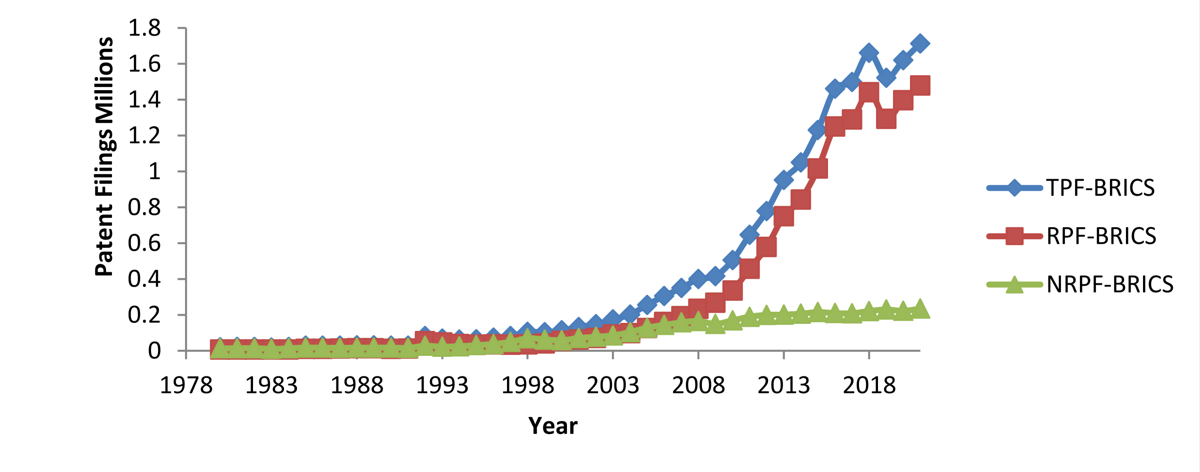

Figure 2: Growth of Total Patent Filings (TFP), Resident Patent Filings (RPF) and Non-Resident Patent Filings (NRPF) in BRICS.

[6] Depth_latent relies on latent trait analysis which a type of factor analysis for binary data (Bartholomew et al., 2011). The analysis allows to deal with highly correlated data and accounts for the fact that not all items are equally important in establishing the extent of countries' commitments. The measure uses a total of 49 variables pertaining to such aspects as services liberalisation, trade-related investment measures, IPRs and standards. The information on these variables is provided in the main codebook available under the "Content Coding" section of the DESTA.

The non-resident patenting trends plotted in figure 3, indicate that among the BRICS group, China is the main destination of non-resident patent applications followed by India, Brazil, Russia and South Africa. During the second half of 1990s decade, China overtook all other major economies except US as a major destination of non-resident patent applications. In 2021 as many as 0.16 million foreign patent applications were received by Chinese Patent Office (CNIPA) as opposed to 0.33 million, 0.11 million and 0.07 million by three major global IP offices viz., the United States Patent and Trademark Office (USPTO), the European Patent Office (EPO) and the Japanese Patent Office (JPO) respectively. While US is still a top destination in terms of patents applications received, its growth path is almost mirrored by China since the mid-1990s.

From the past two decades, rest of the BRICS economies notably India and Brazil have also shown some strides in attracting a higher number of foreign patent applications than filled domestically. Out of the total of 61,537 applications filled at Indian Patent Office (IPO) in 2021 around 58% applications have foreign origin. However, this percentage was 54% in 2000 and grew as high as 84% in 2008. Since then the applications claiming foreign ownership have shown a consistent decline in terms of their percentage share in total filings though their absolute number at IPO has risen. For Brazil out of the total of 24,232 patent applications filed in 2021 only 19% applicants have claimed domestic ownership. For Russia and South Africa, the percentage share of non-resident to total filings stands at 37% and 84% in 2021.

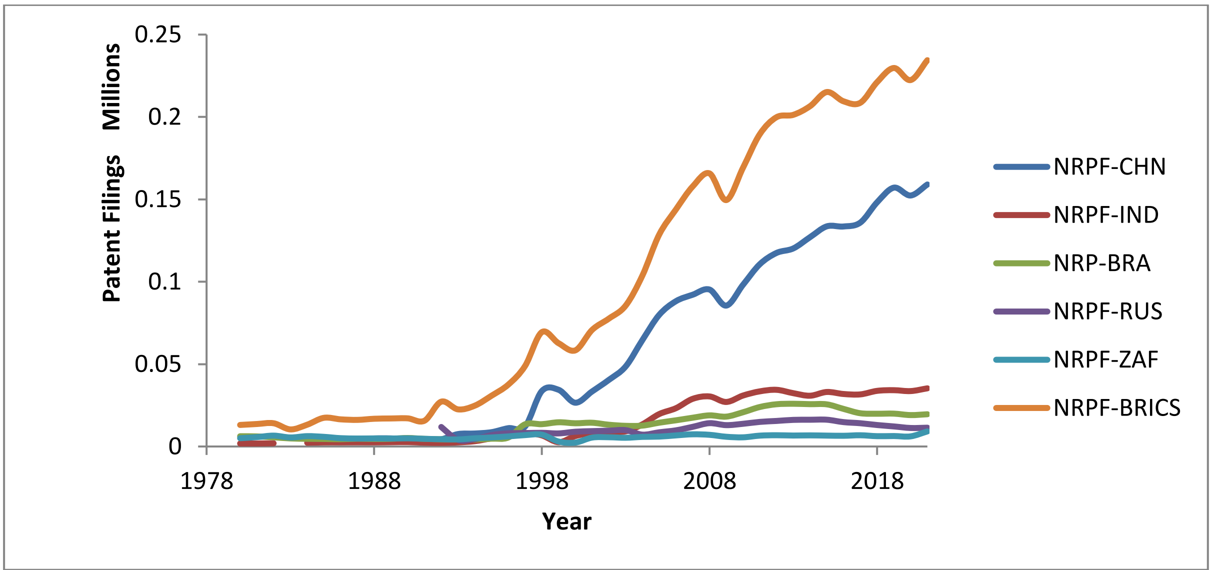

Figure 3: Country wise trends in Non-Resident Patent Filings (NRP) in BRICS since 1980s.

4. The Motivating Model

Patents empower a firm to charge a mark-up and seek monopolistic profits over its patented products within a given territory. The rents from a patent mainly depend upon many of the same factors that incentivise international trade such as size and wealth of the destination market, the iceberg trade costs etc. Given these similarities in factors explaining patent and trade flows, we adopt a model developed in Coleman (2022) which modifies the gravity equations described in Anderson and Van Wincoop (2003). Based on the several structural characteristics of the country pairs, a gravity equation that models the patent flow from a country of origin to a country of destination is given as:

$$N_{od,t} = \frac{Y_{ot} E_{dt}}{Y_t^w} \left(\frac{t_{odt}}{P_{ot} P_{dt}} \right)^{1-\sigma} \qquad (1)$$

Where:

N_{odt} indicate the number of patent applications filed by origin *o* in destination *d* at time *t*. Y_{ot} and E_{dt} denote actual output and expenditure of origin *o* and destination *d* respectively. $Y_t^w = \sum_{O=1}^{N} Y_{ot} = \sum_{d=1}^{N} E_{dt}$ is the world income. t_{odt} is a vector of bilateral resistance. P_{ot} and P_{dt} designate the multilateral resistance faced by the origin *o* and destination *d* from their trading partners. These multilateral resistance terms can be expressed as:

$$P_{ot}^{1-\sigma} = \sum_d \left(\frac{t_{od,t}}{P_{dt}} \right)^{1-\sigma} E_{dt} \qquad (2)$$

$$P_{dt}^{1-\sigma} = \sum_o \left(\frac{t_{od,t}}{P_{ot}} \right)^{1-\sigma} Y_{ot} \qquad (3)$$

The expression in (2) sums bilateral trade resistance across *d* often termed as multilateral resistance faced by origin country across its destination markets. Similarly, the expression (3) sums bilateral trade cost factors across *o*, therefore denotes multilateral resistance faced by country of destination across its trading partners. Therefore equation (1) states that after controlling for size bilateral trade depends on bilateral trade resistance relative to the product of multilateral resistance.

We use the model developed by Coleman (2022) which modifies the gravity equations in Anderson and Van Wincoop (2003) to describe bilateral patent flows

$$N_{od,t} = \left(\frac{P_{dt}}{\mu c_{ot}\tau_{odt}}\right)^{\theta}\left(\frac{E_{dt}}{\sigma}\right)^{\frac{\theta}{\sigma-1}} \ell_{ot} b_{ot}^{\theta} \left(\frac{\psi_{od,t}}{F_{odt}}\right)^{\frac{\theta}{\sigma-1}} \qquad (4)$$

Where c_o is the cost of factor-input in origin country *o*, ℓ_o represents the total number of innovations in source country *o* at time *t*, b_o is the minimum productivity of those innovations with exponent θ as the dispersion parameter[7]. The term $\psi_{od,t}$ is expected gain in the profits of the origin *o* with patent protection in destination market *d*. The vector of filing costs F_{od} signifies formal application fee, some legal and translation costs.

Equation (4) expresses patenting as an increasing function of the destination market size $\left(\frac{E_d \psi_{od}}{P_d^{1-\sigma}}\right)$ as well as of the product of innovative capacity and factor inputs costs $(\ell_o C_o^{-\theta})$ of the origin but it is decreasing in the level of bilateral trade and patenting frictions $(\tau_{od} F_{od})$.

This model provides some insights into why trade treaties could impact patent flows. Treaties dealing with IPRs will affect both the overall value of patent (Ψ) and the cost of the patent application (F) whereas treaties involving trade liberalization (GATT/WTO) will have an effect through a reduction in trade fictions (τ).

5. Empirical Strategy

In this section we discuss the different empirical strategies adopted in this paper and the estimations obtained from various model specifications.

5.1. Random Effect with cross section control on MRT

To determine the possible impact of PTAs on the patent flows among country pairs, we transform equation (4) into an estimable form with origin and destination fixed effects. We begin with random effect estimation that assumes country specific characteristics are random (uncorrelated with either PTA or the vector of control variables). The estimation equation, therefore, becomes:

$$\ln(N_{od,t}) = \alpha_0 + \lambda_d + \delta PTA_{od,t} + T_{od,t}\gamma + X\beta + \varepsilon_{odt} \qquad (5)$$

[7] Productivity is distributed according to Pareto distribution with minimum b and dispersion θ. The value or productivity of innovations (Patents) is highly skewed, so their productivity is typically modelled using Pareto or lognormal distribution (Hall and Harhoff, 2012). In other words, the size distribution of profit returns on innovations is highly skewed to the right. The most valuable patents contribute a disproportionate fraction of the total profits from innovation.

The dependent variable $\ln(N_{od,t})$ is the logarithm of patent filings by origin *o* in destination *d* at time *t*. The origin and destination fixed effects are denoted by α_o and λ_d. PTA is the target variable denoting presence (or not) of a preferential trade agreement between dyads, $T = [GATT / WTO]$ is the vector denoting the joint membership of the country pairs in international agreements, and $X = [\ln(MODGP_d), \ln(\exp_o), \ln(knowcap_o), ...]$ is a vector of controls. The vector X further includes link specific dyadic variable like common language which is an indicator if dyadic pair shares a common language etc. ε is the error term. The variables included in vector X are further discussed as follows:

$\ln(MODGP_d)$ is the logarithm of modified Ginarte-Park index taken from Sheikh and Kunwar (2022). It incorporates various aspects of legal enforcement and property rights in the destination country. $\ln(\exp_o)$ is the logarithm of exports represents denoting value of merchandise exports from a country of origin to a country of destination. The data on the variable is compiled from UN Commtrade database. $\ln(GDP)$ is the combined gross domestic product in USD representing the market size of the individual country-pairs. The data for the variable is taken from Pen World Table (PWT) version 10.0. $\ln(compt)$ is logarithm of the sum of the patent filings of the rest of the source countries in the destination country, except the country in question. The variable measures the competition faced by a source country from rest of the source countries in the destination. The data on filings is from WIPO database. $\ln(knowcap_o)$ is the knowledge capital measured as the total number of patent filings filed by the origin at USPTO, except for US. For US the same is measured by the total number of US patent filings at EPO. This is to remove the home bias from the patent applications. $\ln(hc\_d)$ denote the human capital of the destination country. It is measured by the number of patent applications filed by of each destination country at the USPTO. $\ln(hc\_o)$ is a measure of human capital of the origin country which represents the total expenditure on education. The variable is taken from PWT Version 10.0.

Finally the link specific gravity variables such as distance $\ln(dst)$ represent the distance between the capitals of country-pairs; common language (com_lang) is an indicator variable set to 1 if country-pairs share a common language and 0 else; common colony (com_col) is an indicator variable set to 1 if the dyads had a common colonizer in the past and 0 else; (com_45) an indicator variable which is set to 1 if one of the countries in a pair had been a colony of the other after the year 1945 and 0 else. All of the mentioned trade cost indicators are taken from geographical database provided by the Centre d' Etudes Prospective et d' Informations Internationales (CPII).

We report the estimations based on model (5) in Table 1. The results inform that PTA, depth_index and depth_latent have no significant impact on the non-resident patent flows in BRICS. Across all four specifications PTA is a dichotomous variable denoting presence or absence of an agreement between country pairs. It, however, ignores heterogeneity in those agreements in terms of institutional design and legal enforceability. The estimates on PTA, except in model (1) are negative and statistically insignificant. The second and third specifications in Table 1 include terms on the depth of the trade agreements. The coefficient on the depth_index in Col. (2) is negative and statistically insignificant. Similarly the estimate on depth_latent in Col. (3) is negative and insignificant. GATT/WTO variable, however, is positive and highly significant across all specification indicating joint member to international treaties improves non-resident filings by a factor of about 0.85 as opposed to non-members.

Finally, to capture the anticipatory and lagged impact of PTAs' on patent flows and distinguish between deep and shallow PTA, we replace depth index with eight dummies (four each for deep and shallow PTAs') in specification (4) of the model (5). For all country pairs with a value of depth index greater than the median across all dyads, the agreement is deep, otherwise shallow. The database further includes the direct contemporaneous, leading (anticipation) and delayed (phasing-in or sluggish adjustment) responses of country pairs' patent flows to the inception of average PTA, for both deep and shallow agreements respectively[8]. The possibility of anticipatory effect arises from the perception that firms may temporarily delay patent filings in the expectation that an impending trade agreement may bring in additional benefits in terms of reduced application fee and relatively higher level of protection than before. The underlying economic motivation for the inclusion of lagged terms of PTA stems from the fact that, on average, each trade agreement is "phased-in" typically over a period of 10 years (Baier and Bergstrand, 2007). Therefore, the total effect cannot be entirely realized instantaneously in the concurrent year only but may spread over a period of time since the inception of the trade agreement. The estimates on the eight dummies, representing lead and lagged effects of deep versus shallow PTAs', are reported in column (4) of Table 1. None of the dummies, except shallow_medium term has a statistically

[8] For example., conditional on the agreement is deep, *deep anticipatory* is an indicator that takes the value of 1 five- years prior to the inception of PTA; in the 5 years post the signature of a PTA, the indicator is labelled as *deep short-term*; between 5 -15 years after PTA, it is labelled as *deep medium-term*; and for 15 and more years' post to the signing of a PTA the indicator is termed as *deep long-term*. Same hold true for shallow agreements.

significant coefficient suggesting shallow PTAs do have a significant impact on filings between 5 -10 years after the shallow agreement is enforced.

5.2. Fixed Effect with cross section control on MRT

Random-effects model suffers from a limitation that if the country- or time-specific effects are correlated with any of the regressors, random-effects estimates are biased and inconsistent while the fixed-effects estimates remain unbiased and consistent. To demonstrate the robustness of results based on random-effects panel regression, we estimate the model using fixed-effects regression. Equation (5) is rewritten as follows:

$$\ln(N_{od,t}) = \alpha_0 + \lambda_d + \phi_t + \delta PTA_{od} + T_{od,t}\gamma + X\beta + \varepsilon_{odt} \quad (6)$$

Where α_0 and λ_d represent time-invariant unobservable country-specific fixed effects. This model works well if multilateral resistances are time-invariant but does not account for time-variant multilateral resistance factors under panel data under which proper treatment of multilateral resistance factors is to use *origin-time* and *destination-time* fixed effects. ϕ_t represent unobserved factors that change over time but affect all countries in the same fashion. Matrices T and X contain same exogenous variables as in (5), and ε_{odt} is a well-behaved random term.

The estimates based on (6) are reported in Table 1. We obtained same results as in random effects specifications, except that coefficient on the variable *shallow_medium* term now turns statistically insignificant. The control variables have expected sign; in particular, the logarithm of human capital (hc_d) of the destination as a proxy for imitative ability reduces foreign patenting in BRICS. The human capital (hc_o) of the origin country has expected positive sign but is insignificant. Similarly, the stock of knowledge assets $(know\_cap_o)$ (international patents) of the origin country enhances non-resident patenting in destination markets.

5.3. Fixed Effect Model with Control for MRT

The empirical specifications discussed in (5.1) and (5.2) do not control for MRT, therefore the parameters of interest obtained from them can be considered as nuisance parameters from an econometric point of view. Further, controlling for MRTs with origin and destination fixed effects may work well in the case of cross-section data. In the case of panel data, it is recommended to use origin-time (α_{0t}) and destination-time (λ_{dt}) FEs to control for time-varying multilateral resistance factors (Olivero and Yotov, 2012). Therefore, Eqn (6) can be rewritten as:

$$\ln(N_{od,t}) = \alpha_{0t} + \lambda_{dt} + \delta PTA_{od,t} + T_{od,t}\gamma + X\beta + \varepsilon_{odt} \quad (7)$$

The findings from FE estimator Equation (7), reported in Table 3 show estimates based on four models. All incorporate time-varying country-specific fixed effects to allow for the effects of institutional and geographic distance on patent flows while avoiding any omitted variable bias that results from time-varying country specific unobservable characteristics, controlling therefore for the so-called time-variant multilateral resistance terms (Anderson & Van Wincoop, 2003).

The estimates on *PTA*, except in model (1) are negative and statistically insignificant. The second and third specifications in Table 3 include terms on the depth of the trade agreements. The coefficient on the *depth_index* in model (2) is positive and statistically significant at 5% level suggesting that, as expected design of trade agreements matter in determining non-resident patent filing in BRICS countries. The estimate on *depth_latent* in col. (3) is positive and significant, offering therefore further support to the argument that depth of a trade agreement significantly determines foreign filings in BRICS. The *GATT/WTO* is omitted across all specifications because of possible collinearity with the *PTA and depth* Variables.

The estimates on anticipatory and phased-in effects of deep and shallow PTAs' are reported in column (4) of Table 3. Out of eight dummies only two unveil positive and statistically significant effect on patent flows. Shallow trade agreements do not have any anticipatory effects on the patent filings nevertheless they appear to adversely affect patent filings in the medium-term that is between 5 and 10 years after the PTA is signed. Deep PTAs' between members, on the other hand, exhibit strong positive anticipatory and post short-term (5 years after a PTA is signed) effects on patent flows. The deep anticipatory effect confirm that dyads register a 104% rise in non-resident patent filings 5-years prior to signing of a deep PTA while 5-years after the PTA is enacted the filings tend to increase by 178% in the treatment group relative to control group. The finding suggests following the entry into force of a deep PTA, IP situation in the destination markets may improve; eventually firms are better able to appropriate rents, leading them to file more patents.

A qualification that needs to be added here is that there are no feedback effects from patent flows to PTA if the latter is a shallow trade agreement. In our panel, if the PTAs are strictly exogenous they should not lead to changes in the patent flows before their inception. Alternatively, strict exogeneity would mean absence of anticipatory effect of PTAs on patent filings. Before the shallow PTAs is implemented, we observe positive but insignificant effect up to five years (Col. 4, Table 3). The finding communicates lack of any substantial anticipatory effect on patent flows in the five years leading up to the actual entry into force of the agreement. However, in case of deep PTAs, the assumption of strict exogeneity does not hold suggesting a feedback effect from the patent flows to the ratification of a deep PTA[9].

5.4.Estimating a Gravity with Zero Patent Flows and Heteroskedastic Residuals

An important feature that patent flows share with the trade flows is the preponderance of zeros in them. This particularly holds for smaller countries as there might be no patent applications between two countries in a given year. The simplest estimation strategy for analysing patent flows is to log-linearize the equations and use OLS. However, the presence of zeros in the patent data eliminates this possibility. Data censoring as a potential solution to remove zeros from patent data would include only larger countries that do not have zeros in the bilateral patent flows. But this method not only ignores the meaning of zeros in the patent data, it will also take away a substantial amount of information by constricting the sample to larger countries positive patent flows only. Adding 1 to all observations is yet another method to get rid of zeros from the data but this understandably produces a significant bias in estimates.

The second complicating facet of the data is that the variance in patent flows concerning large country pairs is relatively higher than the variance in patent flows among smaller countries. The disproportionate variance in patent flows among countries gives rise to heteroscedasticity. If un- addressed, heteroscedasticity has the potential to render estimates as largely biased. As suggested by Silva and Tenreyo (2003), Poisson pseudo-maximum likelihood (PPML) estimator resolves both the issues of excessive zeros and heteroscedasticity prevalent in the patent data. Therefore the specification reads,

$$N_{od,t} = \exp\left[\alpha_{ot} + \lambda_{dt} + \phi_{od} + \delta PTA_{od,t} + T_{od,t}\gamma + X\beta\right] * \varepsilon_{odt} \quad (8)$$

To control for unobserved multilateral resistances such as legal costs, translation fees and formal application costs, etc. we employ origin-year and destination-year fixed effects. This unfortunately absorbs the impact of time-invariant link-specific covariates such as distance, contiguity, common colony as well the effects of time-variant variables like GDP, IPR index, competition, imitative ability and human capital. Therefore we are unable to estimate the

[9] It is imperative to mention that this does not necessarily imply the strict exogeneity in overall PTA indicator does not hold, it is just that deeper agreements may not be strictly exogenous. Our results further suggest that shallow anticipatory agreements are uncorrelated with concurrent patent flows confirming the strict exogeneity of these agreements. A better way is test strict exogeneity assumption is to take one year lead of PTA and regress it on the outcome variable and check if the coefficient is insignificant.

impact of the time-invariant and time-variant covariates on the patent flows. However, this approach fortunately retains our policy variables such as PTAs and joint member to treaties and allows us to estimate their impact on patent flows. Even though the inclusion of 2-way fixed effects puts a limit on what can be incorporated in each regression, nonetheless this inclusion makes the estimates of the trade policy effects more robust. We report the findings from PPML in Table 4.

The estimates on PTA based on column 1 and 4 are highly significant offering strong support for PTA-induced non-resident patent surge in BRICS. The treatment group (dyads with a PTA) increase their filings by about 43% ($e^{0.36}$=1.43, or 43%) as opposed to the comparison group (country pairs with no such agreement). The discrepancy between the OLS and PPML estimates can be possibly attributed to heteroscedasticity bias present in former. The shallow agreements have a positive medium-term but negative long-term impact on patent filings. This possible reason for this result is that shallow agreements might not cover the critical areas of PTAs, for instance, provisions related to IPRs and their de jure enforcement which seem to matter for firms' decision to patent in the destination market. Unlike the shallow PTA, the estimates indicate the existence of anticipation effect -increase in patent flows up to five years before a deep PTA is enacted. We attribute the anticipation effect to the likelihood that negotiations on deep PTAs may signal to the inclusion of property rights provisions in their fold. Firms may therefore file more patents to secure advantages against their rivals in the destination markets. The short-term impact of deep trade agreements turns out to be negative but statistically insignificant. The deep medium-term and the deep long-term effects are not identified because of collinearity with other indicators of trade agreements.

5.5. Estimation on Industries

Most of the existing literature on trade agreements evaluates their effects on the country level (Baier and Bergstrand, 2007; Baldwin, 2008; Freund and Ornelas, 2010; Egger et al. 2011). However, analysing the effects of trade agreements on the country level may hide important sectoral level heterogeneity. There is a possibility that not all industries benefit equally from these agreements-some gain most while others may reap lesser benefits. For, example trade agreements comprising provisions on technology transfer and IPRs may matter more for high-tech and high-IP industries (e.g., pharmaceuticals, chemicals, electronics, and machinery and equipment) than those that rely less on IP and that should be less affected by implementation of such PTAs. Therefore, the differential impact of PTAs in industry context needs some attention.

In this section, we provide additional empirical evidence on the impact of PTAs' on patent filings at the sectoral level We adopt the industry classification of Delgado et., al. (2013)[10], to see if the PTA effects vary across various industries. We group industries into high- IP vs. low-IP sectors in the Comtrade database. In the dataset seven of our industries fall in the category of high-IP and thirteen of them in low-IP category. The break-up of industries into high-1P group vs. low-IP group based on Delgado et., al. (2013), classification is presented in the annex.

We zoom in to distinguish between anticipatory, short-term, medium-term and long-term effects of deep versus shallow PTAs' at a disaggregated sectoral level. The estimates on high IP industries are presented in Table 4. Columns 1 and 2 report estimates based on pooled sample of high IP sectors while rest of the columns (3 to 7) report estimates on effects of PTA on patent filings in several high-IP sectors such as chemical & chemical products, pharmaceuticals; and machinery & equipment. Pooled estimates provide strong evidence that PTAs' and their depth drive patenting in IP intensive industries. Further shallow PTAs' appear to have positive and statistically significant anticipatory effect while in the long-term they tend to reduce filings in high IP industries as a whole. On the individual industry level, PTAs' matter relatively more for machinery & equipment sector and to some extant for chemical & chemical products sector in the high IP group but filings in pharmaceuticals sector appear unaffected by the PTAs'. The reason behind the later finding could be that these PTAs' though deep might not contain provisions on patents which matter more for pharmaceutical sector. We could not identify the coefficients on other high IP industries such as computer, electronics & optics; electrical machinery; and rubber & plastic possibly due to the lesser number of observations in each of them.

For low-IP sectors pooled estimates reported in columns 7 and 8 of Table 6 indicate a significant rise in patent flows as a result of PTA inception. However, the depth of a trade agreement does not seem to have a profound impact on the patent filings in low-IP industries. The patent filings in construction and LET sectors, however, show a robust rise when the deep trade agreement between dyads enters into the force. The depth of the agreement does not stimulate patent filings in some of the low–IP sectors such as basic metals and other consumer goods. For other low-IP industries, we could not identify the coefficient estimates possibly because of the lesser number of observations.

[10] To identify the list of industries with high IP-intensity, Delgado et al. (2013) uses the 2012 report by the Economics and Statistics Administration (ESA) and the USPTO. This report provides a list of broad industries (4-digit NAICS code) with above average IP intensity In the US (based on patents, trademarks or copyrights). For further understanding see *ESA-USPTO Report, US Department of Commerce, 2012*.

6. **Conclusion**

Trade agreements have been studied for their role in stimulating international trade in goods and services, however their possible role in promoting bilateral patent flows is yet to be established empirically. This study has extended the empirical evidence on the determinants of cross-border patenting indicating that trade agreements have the potential to influence the patent flows among member states. Exploiting the recent advances in the empirical structural gravity literature, this study attempts to answer the question of whether and how much PTAs promote patent flows between the members. The research question was built on the premise that PTAs (containing provisions on IP & technology) can have an economic and informational effect on the decisions of the firm to in internationalize their technological activities, and one way of doing that is to file more international patent applications. On the one hand, PTAs increase the economic interaction of members, and eventually the likelihood of firms accessing foreign innovation, relocating their R&D facilities and building technology ties with their trading partners rises. These interactions are likely to generate innovations and the possibility that some of them are applied for patents cannot be ruled out. On the other hand, the technology & IP-related provisions included in PTAs signify a commitment of the trading partners to honour the rights related to IP & technology. This policy commitment provides firms an enabling environment to file patents and seek returns on their innovations.

The significant departure from the existing literature is that the paper provides a quantitative evaluation of the impact of PTAs on patent flows at the level of industry in addition to their impact at aggregate level. We further estimate the anticipatory and lagged response of bilateral patent flows to the inception of the trade agreements while distinguishing between deep vs. shallow agreements. Using the PPML estimator to estimate an augmented gravity model, our study offers new insights on the nexus between filings and trade agreements. The main estimation results indicate that PTAs lead to significant rise in patent flows before and after these agreements are enacted. The PPML estimates suggest that PTAs have a positive and statistically significant impact on non-resident patent filings in BRICS. In particular, country-pairs with PTAs increase their patent flows by 43% relative to control group. Further deep PTAs matter more in foreign patenting upsurge in BRICS compared to shallow PTAs. While shallow PTAs exhibit positive medium- term but negative long- term effects on patent flows, deep PTAs, however, unveil positive anticipatory and short-term effects.

Overall our estimates on PTAs are reliable in that they simultaneously account for multilateral resistance terms with origin-time and destination-time fixed effects as well as for heteroskedastic residuals and zero patent flows with PPML. Importantly, these results are based on a panel of 22 countries; future work should consider expanding the sample size to include more countries in the panel. It is also possible that effect of PTAs on patent filings may vary with the specification of the dependent variable. PTA effects may vary, say, across utility model applications, industrial design, trademarks and copyrights. It will be intriguing to empirically evaluate the impact of trade agreements on these IP forms. In addition, the paper does not distinguish between agreements containing IPR provisions and those which do not include such provisions. A further study could segregate the PTAs based on their content and examine the impact of deep-and-shallow PTAs with IP-provisions on the cross broader patent flows.

Table 1: Random Effect Estimations vs. Fixed Effect Estimations with no control of MLR

	Random Effect Model				Fixed Effect Model			
Variables	*ln(filings) (1)*	*ln(filings) (2)*	*ln(filings) (3)*	*ln(filings) (4)*	*ln(filings) (5)*	*ln(filings) (6)*	*ln(filings) (7)*	*ln(filings) (8)*
PTA_od	0.0129	0.204	0.337	-0.0686	-0.0164	0.0898	0.850*	0.00430
	(0.133)	(0.165)	(0.237)	(0.229)	(0.163)	(0.235)	(0.479))	(0.504)
depth_index		-0.189				-0.0880		
		(0.158)				(0.179)		
depth_latent			-0.206				-0.471	
			(0.160)				(0.288)	
WTO/GATT	0.858***	0.859***	0.852***	0.875***	0.787***	0.787***	0.774***	0.806***
	(0.243)	(0.243)	(0.243)	(0.243)	(0.241)	(0.241)	(0.242)	(0.235)
Shallow _anticipatory				-0.340				-0.423
				(0.222)				(0.374)
Shallow_short-term				0.217				0.226
				(0.223)				(0.277)
Shallow_ medium-term				0.686***				0.831
				(0.221)				(0.502)
Shallow_ long-term				0.265				0.452
				(0.303)				(0.638)
Deep_ anticipatory				-0.394*				-0.382
				(0.238)				(0.288)
Deep_ short-term				-0.0817				-0.183
				(0.254)				(0.585)
Deep_ medium-term				-0.229				-0.345
				(0.236)				(0.520)
ln(MODGP_d)	0.169	0.171	0.115	0.0967	-0.376	-0.365	-0.441	-0.436
	(0.732)	(0.731)	(0.742)	(0.746)	(0.746)	(0.744)	(0.754)	(0.756)
ln(GDP_od)	0.531	0.523	0.494	0.403	0.717*	0.718*	0.654	0.590
	(0.410)	(0.410)	(0.411)	(0.434)	0.416)	(0.416)	(0.418)	(0.447)
ln(exp_o)	0.0240	0.0238	0.0257	0.0303	0.0313	0.0309	0.0365	0.0398
	(0.0251)	(0.0251)	(0.0250)	(0.0258)	(0.0319)	(0.0321)	(0.0329)	(0.0333)
ln(compt_d)	-0.176***	-0.177***	-0.177***	-0.184***	0.00643	0.00449	0.00424	-0.0194
	(0.0441)	(0.0440)	(0.0441)	(0.0450)	(0.0861)	(0.0867)	(0.0865)	(0.0931)
ln(knowcap_o)	0.652***	0.653***	0.651***	0.649***	0.445***	0.444***	0.432***	0.420***
	(0.0335)	(0.0336)	(0.0335)	(0.0343)	(0.121)	(0.121)	(0.122)	(0.137)
ln(hc_d)	-5.333**	-5.557**	-5.334**	-5.967**	-3.130	-3.230	-2.976	-3.732
	(2.557)	(2.602)	(2.562)	(2.907)	(2.447)	(2.478)	(2.463)	(2.918)
ln(hc_o)	-0.379	-0.456	-0.207	-0.341	0.795	0.708	0.884	0.611
	(3.050)	(3.058)	(3.031)	(3.033)	(3.048)	(3.073)	(2.991)	(3.363)
ln(dst)	-0.584***	-0.588***	-0.589***	-0.571***				
	(0.108)	(0.107)	(0.107)	(0.110)				
Com_lang	0.540***	0.538***	0.532***	0.474***				
	(0.166)	(0.165)	(0.166)	(0.181)				
Col_45	-0.363	-0.330	-0.339	-0.301				
	(0.259)	(0.255)	(0.256)	(0.279)				
Origin FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dest FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	No		Yes	Yes	Yes	Yes
Obs	1185	1185	1185	1185	1185	1185	1185	1185

Note: ***, **, *denote significance at 1%, 5% and 10%percent level. Standard errors are clustered at by country-pair are in parentheses.

The impact of deep long-term and common colony is omitted because of collinearity.

Table 2: FE OLS results after controlling for MRT

Variable	*ln(filing)* (1)	*ln(filing)* (2)	*ln(filing)* (3)	*ln(filing)* (4)
PTA_od	**0.235***	**- 0.121**	**-0.123**	**-0.0600**
	(0.130)	**(0.130)**	**(0.131)**	**(0.682)**
depth_index		**0.757****		
		(0.375)		
depth_latent			**0.361****	
			(0.179)	
GATT/WTO				
shallow_ anticipatory				**0.513**
				(0.318)
shallow_ short-term				
shallow_ medium-term				**-1.320***
				(0.758)
shallow_ long-term				**0.163**
				(0.716)
deep_anticipatory				**1.046*****
				(0.360)
deep_ short-term				**1.785****
				(0.680)
ln(dist)	**-0.658*****	**-0.652*****	**-0.652*****	**-0.597*****
	(0.145)	**(0.147)**	**(0.147)**	**(0.168)**
com_lang	**0.702*****	**0.704*****	**0.704*****	**0.717*****
	(0.161)	**(0.161)**	**(0.161)**	**(0.160)**
col_45	**-0.695****	**-0.697****	**-0.697****	**-0.708****
	(0.328)	**(0.328)**	**(0.328)**	**(0.329)**
origin-Year FE's	**Yes**	**Yes**	**Yes**	**Yes**
destination-Year FE's	**Yes**	**Yes**	**Yes**	**Yes**
Obs	**1171**	**1171**	**1171**	**1171**

Note: ***, **, *denote significance at 1%, 5% and 10%percent level. Standard errors are clustered at by country-pair are in parentheses. The impact of deep medium-term, deep long-term and common colony are omitted because of collinearity.

Table 3: PPMLHDFE Estimates after controlling for MRT

Variable	*filing* (1)	*Filing* (2)	*Filing* (3)	*filing* (4)
PTA_od	0.364***	0.242	0.241	0.368***
	(0.0990)	(0.152)	(0.153)	(0.0471)
depth_index		0.221		
		(0.180)		
depth_latent			0.105	
			(0.0860)	
shallow_ anticipatory				-0.563
				(0.390)
shallow_ medium-term				0.759***
				(0.194)
shallow_ long-term				-0.362***
				(0.107)
deep_anticipatory				0.268*
				(0.107)
deep_ short-term				-0.0392
				(0.0980)
ln(dist)	-0.438***	-0.446**	-0.446***	-0.465***
	(0.0909)	(0.0949)	(0.0949)	(0.0976)
Com_lang	0.451***	0.449***	0.449***	0.445***
	(0.0894)	(0.0897)	(0.0897)	(0.0901)
col_45	-0.780***	-0.778***	-0.778***	-0.772**
	(0.238)	(0.239)	(0.239)	(0.239)
origin-Year FE's	Yes	Yes	Yes	Yes
destination-Year FE's	Yes	Yes	Yes	Yes
Obs	2339	2339	2339	2339

*Notes: ***, **, *denote significance at 1%, 5% and 10% percent level respectively. Standard errors in parenthesis are clustered at country pairs. GATT/WTO; Common colony; Shallow short-term; Deep medium-term and Deep long-term in column (4) are dropped because of collinearity.*

Table 4: Estimations on High-IP and Low –IP Industries

	HIGH IP						LOW IP									
	Pooled		CHM		MAC		Pooled		BMT		CON		LET		OTM	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PTA	0.307*** (0.108)	0.707*** (0.238)	0.345 (0.218)	0.675* (0.353)	0.864*** (0.214)	0.333 (0.357)	0.536*** (0.144)	0.342*** (0.128)	0.774** (0.355)	0.485*** (0.158)	-0.373 (0.292)	2.382*** (0.414)	0.255 (0.462)	2.941*** (0.553)	0.552*** (0.179)	0.309 (0.219)
Depth(index)	0.532** (0.219)		0.344 (0.298)		-0.225 (0.321)		-0.0440 (0.234)		-0.117 (0.369)		3.412*** (0.404)		2.069*** (0.558)		-0.126 (0.298)	
GATT/WTO	-2.309*** (0.131)	-2.309*** (0.131)	-2.751*** (0.253)	-2.751*** (0.253)	-3.055*** (0.105)	-3.055*** (0.105)	-0.500* (0.285)	-0.500* (0.285)	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)	-0.506*** (0.00466)	-0.506*** (0.00466)
Shallow ant.		1.254*** (0.237)		2.200** (1.094)		0.655 (0.852)		-0.0154 (0.449)		0 (.)		0 (.)		0 (.)		-0.409 (0.435)
Shallow short-term		-0.575 (0.826)		-0.428 (0.897)		0.972 (0.919)		-0.534 (0.751)		-0.631 (0.827)		0 (.)		0 (.)		-0.876 (0.792)
Shallow medium-term		-0.227 (0.401)		-0.587 (0.670)		0.696 (0.542)		0.794** (0.357)		1.114 (0.768)		-1.241* (0.659)		0 (.)		1.175** (0.480)
Shallow long-term		-0.561** (0.247)		-0.322 0.375)		0.299 (0.377)		-0.0225 (0.162)		-0.498 (0.338)		-3.190*** (0.415)		-2.017*** (0.580)		0.00970 (0.252)
Deep anticipatory		-0.277 (0.362)		-0.460 (0.323)		0.189 (0.376)		0.381* (0.211)		0.686*** (0.0308)		0.274 (0.456)		0 (.)		0.874*** (0.300)
Deep short		0.139 (0.213)		-0.116 (0.366)		0.400 (0.339)		0.162 (0.282)		0.176 (0.229)		0 (.)		0.606 (0.743)		0.0410 (0.383)
Deep medium term		0 (.)		0 (.)		0 (.)		0 (.)		0 (.)		0 (.)		0 (.)		0 (.)
Deep long term		0 (.)		0 (.)		0 (.)		0 (.)		0 (.)		0 (.)		0 (.)		0 (.)
Origin-time FE's	Yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Destination-time FE's	Yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	3012	3012	176	176	172	172	5511	5511	136	130	114	112	81	74	176	176

*Notes: ***, **, *denote significance at 1%, 5% and 10% percent level respectively. Standard errors in parenthesis are clustered at country pairs. Deep medium-term and Deep long-term are dropped because of collinearity.*

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