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RESEARCH NOTE

Does stronger patent protection increase export variety? Evidence from US product-level data

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Abstract
Proponents of global intellectual property rights (IPRs) reforms have argued that developing countries' weak IPRs limit their access to foreign innovative products and technologies. Central to our understanding of the effects of IPRs on product access is the influence of national differences in patent protection on corporate behavior and business strategy of multinational firms. Using detailed product data on US exports from 1990 to 2000, this research note assesses the impact of strengthening IPRs in developing countries on product variety of US exports. Colonial origin and cross-industry variation in patent effectiveness serve to identify the impact. The results show that the strengthening of IPRs increased exports of new products in patent-sensitive industries. The expansion in product variety accounted for the entire increase in US exports. The findings substantiate claims that ratification of TRIPS by developing countries promotes access to new foreign products and technologies. Additionally, the results demonstrate that patent protection is a significant institutional factor in US firms' business decisions over the introduction of new products and processes into a developing country marketplace.
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INTRODUCTION

The 1994 Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) proclaims that "the protection and enforcement of intellectual property rights should contribute … to the transfer and dissemination of technology to the mutual advantage of producers and users of technological knowledge." For developing countries that have ratified TRIPS, the prospect of increased access to foreign innovative products and technologies is a major incentive for adopting the stronger intellectual property rights (IPRs) and standards which TRIPS requires. This result, unfortunately, is far from certain. The theoretical literature provides valuable insights into the complex relationship between IPRs and product access, but because of the various and often opposing effects, the direction of the impact of IPRs is not predetermined and becomes an empirical question.

This research note investigates whether stronger IPRs in developing countries increase the variety of products exported from the developed world. Answering this question is important, as it bears

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directly on developing countries and their prospects for advancement in the global marketplace. Additionally, the question cuts to the heart of the efficacy of TRIPS as an instrument to enhance global welfare and establish a reciprocity of benefits among member countries. As stated in Saggi (2013), "for TRIPS enforcement to increase global welfare, it is imperative that [developed countries'] firms respond to such enforcement by selling more products in [developing countries]."

Central to our understanding of the effects of TRIPS on product access is the influence of national differences in patent protection on corporate behavior and business strategy of multinational firms. Recent business trends show that multinational firms increasingly rely on foreign operations for their new products. Weak IPRs in developing countries pose a threat to multinational firms of technology misappropriation and imitation. The strengthening of IPRs mandated by TRIPS serves to limit this threat and in so doing, may increase the involvement of multinational firms in cross-border operations and ultimately, exports.

The theoretical literature identifies numerous channels through which the strengthening of IPRs in developing countries (South) affects the variety of exports from developed countries (North). One theory is that when IPRs are weak, Northern firms engage in costly rent protection activities (e.g., developing private barriers to imitation, monitoring for infringement, litigating patents, etc.) to increase the return on innovation, whereas stronger Southern IPRs stimulate Northern innovation and encourage new exports to South (Davis & Sener, 2012; Taylor, 1993). North may invent new products to meet South's production needs and consumer tastes (Diwan & Rodrik, 1991). These positive effects are not certain, however. Innovation may fall with prolonged monopolies of patent-holders and increased transaction costs in technology markets. Also, innovation may be unaffected due to small South market sizes (Allred & Park, 2007).

Another theory is that Southern IPRs directly induce Northern firms to export, for example by blocking imitative products in South, thereby increasing South's demand for the genuine counterparts (Helpman, 1993), or by reducing competition from Southern imitators, thereby increasing Northern export profits (Saggi, 2013), or finally, by increasing the pricing power of Northern firms and reducing the risk of low South's prices spilling over through parallel trade (Maskus, 2000; Roy & Saggi, 2012). With increased ability to price discriminate, Northern firms have further incentive to export their newest innovations and technology (Saggi, 2013).

Southern IPRs may also shift the location of assembly operations or innovation activities of multinational firms, or influence firms' multinational integration strategies and their choice for a particular mode of market access more generally. Stronger IPRs may induce Northern firms to supply foreign markets via foreign subsidiaries or offshore parts of their value chain using arm's length Southern firms (Ivus, Park, & Saggi, 2015; Yang & Maskus, 2001). Such changes influence intrafirm and arm's length trade in complicated ways, making the link between IPRs and access to foreign innovative products a priori unclear.

Ultimately, export response of Northern firms to stronger Southern IPRs depends on many factors, such as South's imitation ability, the intensity of competition generated by imitation, the North–South technology gap, differences in consumer tastes and incomes, market sizes, market entry costs, etc. Many of these factors also affect firms' behavior independently of IPRs and so must be isolated when measuring the export impact of IPRs. Industry variation in exports can be used for this purpose, since industries vary in IPRs sensitivity. The theory developed in Ivus (2011), for example, predicts that expansion in Northern export variety is restricted to industries with high effectiveness of IPRs in preventing imitation.

Substantial empirical literature considered how PRs affect the overall value of exports (Co, 2004; Ferrantino, 1993; Ivus, 2010; Maskus & Penubarti, 1995; Rafiquzzaman, 2002; Smith, 1999), but the impact on individual export margins has been largely unexamined. This research note assesses the impact on a key margin: export variety. Ivus (2010) studied the impact on unit prices and quantities of exports, concluding that stronger IPRs increased the value of developed countries' exports by increasing the quantity of exports, and not their price. Those results did not distinguish between new and existing exports, leaving open the question of the precise impact of stronger IPRs on the expansion of export variety, and the dissemination of established and leading-edge technologies. The present article finds that stronger IPRs did not affect existing exports, and that the entire increase in exports observed was driven by the expansion in export variety. Whether firms in developed countries respond to stronger IPRs by exporting a wider set of products to developing countries is a crucial consideration for the role of IPRs in transferring technology. The findings are also

relevant for understanding the role of IPRs in the decision-making of US firms regarding entering new export markets and introducing new products.

Following this introduction, I outline my empirical strategy, describe the IPRs and export data, and present the results. Additional details about the data, analysis, and results are organized in an Author's Supplement available on the author's website.

METHODOLOGY

Reliably estimating the impact of patent rights (PRs) presents three major econometric challenges: (1) PRs strength may be measured with systematic errors; (2) domestic factors may confound the impact; (3) US exports may be causing changes in PRs, but not the reverse. To address these problems, I follow Ivus (2010) and argue that the imposition of TRIPS provided an exogenous shock to the PRs protection offered in a subset of developing countries. To isolate this exogenous variation, I distinguish developing countries by their colonial origin to explain changes in countries' PRs.

The PRs data suggest that the time pattern of PRs changes in developing countries is strongly correlated with British or French colonial origin (Ivus, 2010). Prior to 1990, these former colonies strengthened their PRs more than non-colonies (not colonized by Britain or France). This pattern changed during the 1990s, when non-colonies substantially improved their PRs. This strengthening of PRs in non-colonies was not internally motivated, but externally imposed through the global movement towards stronger IPRs, culminating in the ratification of TRIPS. By 1994, adoption of TRIPS was a precondition for the World Trade Organization (WTO) membership. Where exclusion from the WTO was not sufficient motivation, countries reluctant to ratify TRIPS risked US unilateral trade sanctions. Faced with such perils, many non-colonies ratified TRIPS despite internal opposition.

I use colonial origin as an instrument. Since colonial origin is also correlated with trade-affecting factors (e.g., geographical proximity to the colonizing power), these effects must be isolated from those properly attributable to PRs. To do so, I difference the data along the time and industry dimensions. I measure exports in growth rates and compare growth across industries according to industry classification by patent effectiveness.

The model for the growth of patent-sensitive exports into country j is:

$$\Delta X_j = \alpha + \beta \Delta PR_j + \varepsilon_j$$

where $\Delta X_j \equiv (\ln X_{j,2000} - \ln X_{j,1990})/(2000-1990)$ is the average annual export growth over 1990–2000; ΔPR_j is the average annual change in PRs; α is the constant; and ε_j is the error term.

I instrument ΔPR_j by colonial origin. Since the instrument is binary, the IV estimator of β is:

$$\widehat{\beta} = \frac{\overline{\Delta X_{nc}} - \overline{\Delta X_c}}{\overline{\Delta PR_{nc}} - \overline{\Delta PR_c}}$$

where $\overline{\Delta X_{nc}}$ and $\overline{\Delta PR_{nc}}$ are the sample averages of ΔX_j and ΔPR_j over the sample where j is a non-colony, and $\overline{\Delta X_c}$ and $\overline{\Delta PR_c}$ are the sample averages over the sample where j is a colony.

The instrument must be exogenous, which requires that colonial origin has no effect on US export growth, other than its effect through PRs changes. This condition will fail if colonization is related to unobserved country-specific measures of exports, α_j, potentially embedded in the error term as $\varepsilon_j = \alpha_j + \tilde{\varepsilon}_j$. I remove α_j from ε_j, and hope to meet the exogeneity requirement by evaluating growth in the patent-sensitive industry group *relative to* growth in the reference group. If the equation for the reference group is $\Delta X^*_j = a + b\Delta PR_j + e_j$, where $e_j = \alpha_j + \tilde{e}_j$, then:

$$\Delta X_j - \Delta X_j^* = \gamma + \delta \Delta PR_j + \varepsilon_j \qquad (1)$$

where $\gamma = \alpha - a$, $\delta = \beta - b$, and $\varepsilon_j = \tilde{\varepsilon}_j - \tilde{e}_j$. Notably, α_j is removed. The instrument is exogenous under the assumption that colonial origin of a developing country does not directly determine the differential US export growth in patent-sensitive industries.

To identify the impact, three sources of variation are utilized: over time, cross-industry, and cross-country. The approach is akin to triple differencing. First is the difference in exports over time. By transforming the data into the growth rates, I control for constant measures of exports. For example, difference in the proximity to the US will not explain country difference in export growth. Second is the difference in export growth across industries within a country. This difference is free from time-varying country factors. Reforms of institutional environment which have equally negative effect on patent-sensitive and patent-insensitive industries will not explain industry difference in export growth. Third is the difference in relative growth across non-colonies and colonies. This difference is clear of factors affecting industry exports into non-colonies and colonies similarly, such as industry-specific shocks and industry responses to global trade liberalization.

SAMPLE AND DATA DESCRIPTION

Key Explanatory Variable

I evaluate the impact of strengthening PRs in 71 developing countries: 29 non-colonies and 42 colonies.[1] The strength of countries' PRs is measured by Ginarte and Park (1997) index, which spans from 1960 to 2005 and is broken into five-year increments. It covers five measures of patent laws: patent coverage, membership in international treaties, duration of protection, method of enforcement, and restrictions on PRs.[2] Across 71 developing countries in 2000, patent protection was the strongest in Chile and weakest in Burma, with the index of 4.28 and 0.2, respectively.

Table 1 shows the results of regressing ΔPR_j on the non-colony dummy variable, *NC*. In the first column, $\Delta PR_j \equiv [\ln(1+PR_{j,2000}) - \ln(1+PR_{j,1990})]/(2000-1990)$. The coefficient on *NC* is positive (0.039) and statistically significant. On average, non-colonies increased their PRs more than colonies after 1990. The *NC* instrument is not weak, since the *F* statistic equals 39.91. The results are not driven by aggregation over time, and also hold for 1990–1995 and 1995–2000. The null hypothesis that the coefficients on *NC* are the same across 1990–1995 and 1995–2000 cannot be rejected at 10% level.

The relative progress of non-colonies in strengthening their PRs in the 1990s is contrasted with the years prior, when external pressure was absent and PRs reforms were slow. Non-colonies' PRs were weak by the time the global effort to strengthen IPRs began. In 1990, the average PRs index was 1.18 in non-colonies and 1.84 in colonies. To comply with TRIPS, non-colonies' PRs required substantial improvement and correspondingly, over 1990–2000 non-colonies increased their PRs to 2.77, which exceeded colonies' PRs (2.40) in 2000.[3]

Dependent Variables

I use highly detailed product-level data on US exports from 1990 to 2000. The data are organized by 10-digit HS codes, with each code representing a specific product category (Feenstra, Romalis, & Schott, 2002). The codes have been periodically revised creating concordance difficulties. To ensure that a newly introduced code corresponds with a newly developed category, I revised the data using Pierce and Schott's (2012) concordance of HS codes over time.

Over 1990–2000, the US exported to the 71 developing countries in 4753 manufacturing categories. While these categories have varied over time, with new products introduced and others discontinued, their number has risen overall. A similar pattern, however, does not hold when non-colonies are compared with colonies. Figure 1 plots the mean number of categories exported into non-colonies relative to that into colonies over time. Non-colonies' relative number of categories was rising until 1993 and fell thereafter.

The reduction in the relative number of US categories exported to non-colonies, shown in Figure 1, occurred at the time of non-colonies strengthened their PRs most, suggesting a negative correlation between the number of categories exported to developing countries and the reforms of these countries' PRs. This suggestion may be misleading. Assume that while non-colonies were strengthening their PRs, colonies were implementing alternative domestic reforms to attract a variety of US products. In such circumstances, policy changes in both country

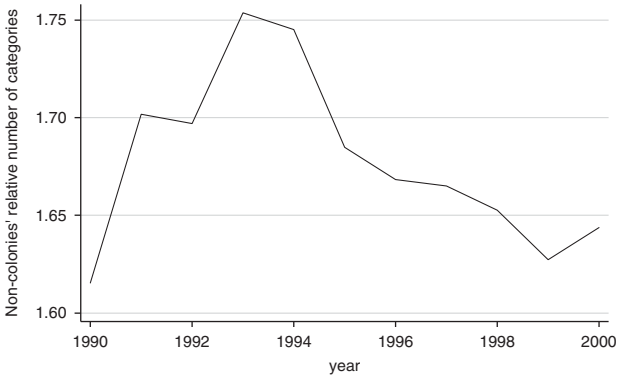

Figure 1 Non-colonies' relative number of categories.

Table 1 PRs changes

	1990–2000		1990–1995		1995–2000	
Non-colony	0.039 ***	(0.006)	0.038 ***	(0.011)	0.040 ***	(0.011)
Constant	0.018 ***	(0.002)	0.017 ***	(0.003)	0.020 ***	(0.004)
R^2	0.42		0.20		0.20	
F	39.91		13.11		13.70	

Note: Seventy-one observations. *** denotes 1% significance level. Standard errors in parentheses are robust.

groups may result in an increased number of categories exported from the US, but if the increase was more pronounced for colonies, then non-colonies' relative number of categories would fall. This example illustrates the importance of controlling for export measures potentially correlated with the country grouping. For this purpose, cross-industry variation in exports is used.

I evaluate export growth in patent-sensitive industries relative to growth in the reference industry group. Patent-sensitive industries have the highest patent effectiveness according to Cohen, Nelson, and Walsh (2000): "Medical and Surgical Equipment," "Pharmaceuticals, Medicinal Chemicals, and Botanical Products," "Special Purpose Machinery," "Autoparts," "Office, Accounting & Computing Machinery," and "Miscellaneous Chemicals." The reference industries have the lowest patent effectiveness and are not covered by other categories of IPRs: "Basic Metals," "Non-metallic Mineral Products," "Electronic Valves, Tubes, and Other Electronic Components," "Basic Iron and Steel," "Electric Motors, Generators and Transformers," and "Communications Equipment."

During 1990–2000, the number of US categories exported in the patent-sensitive industries increased by 0.13% for non-colonies and 2.74% for colonies. Non-colonies' poor relative performance suggests a negative relationship between their PRs reforms and product variety in their patent-sensitive imports. However, when patent-sensitive industries are compared with patent-insensitive industries, the number of categories exported in the reference group increased by 1.17% for non-colonies and 5.32% for colonies. Thus the relative growth in patent-sensitive industries was 1.04 percentage points lower for non-colonies and 2.58 points lower for colonies. The positive difference of 1.54 is a rough measure of the impact of strengthening PRs in non-colonies.

It is also instructive to compare the number of categories exported into all developing countries across industries. Consider patent-sensitive "Special Purpose Machinery" (SPM) industry and patent-insensitive "Basic Metals" (BM) industry. During 1990–2000, the number of categories exported into non-colonies grew by 0.26% in SPM and 3.61% in BM. The relatively slow growth in SPM is even more pronounced in colonies, where SPM grew by 1.64% and BM grew by 8.48%. Hence relative to BM, the growth in BC was 3.35 percentage points lower for non-colonies and 6.84 points lower for colonies. The data again point to a positive impact of PRs on export variety.

The extensive margin of exports measures export variety. It is a more refined measure than the count of the number of products as it factors for products' importance in US exports. Following Feenstra and Kee (2004), I decompose country *j*'s share of US exports into the extensive margin *EM* (new exports) and the intensive margin *IM* (existing exports):

$$\frac{X_{jt}}{X_t} \equiv EM_{jt} IM_{jt};$$

$$EM_{jt} \equiv \frac{\sum_{i \in I^s_{jt}} X_{it}}{\sum_{i \in I_t} X_{it}} = \frac{\sum_{i \in I^s_{jt}} X_{it}}{X_t} \quad \text{and}$$

$$IM_{jt} \equiv \frac{\sum_{i \in I^s_{jt}} X_{ijt}}{\sum_{i \in I^s_{jt}} X_{it}} = \frac{X_{jt}}{\sum_{i \in I^s_{jt}} X_{it}} \qquad (2)$$

where X_{ijt} is the exports of a category i into j at t; $X_{it} \equiv \sum_j X_{ijt}$ is the exports into all developing countries; I^s_{jt} is the set of all categories exported in the patent-sensitive industries s to j at t; and $I_t \equiv \cup_j I_{jt}$ is the entire set of categories exported from the US EM_{jt} equals the share of categories exported in s to j in *total* exports. This share depends on the set of categories exported and not on export value and so, *EM* varies across countries because of the difference in export variety. IM_{jt} equals exports into j relative to exports into all developing countries with both nominal values taken over the set of categories exported in s to j. The set of categories exported to each j does not explain country difference in the *IM*.

The margins for the reference group are defined similarly, except that they are measured over the set of categories exported in the patent-insensitive industries.[4] The relative export growth in (1) is decomposed into new and existing exports as

$$\Delta X_j - \Delta X_j^* = \left(\Delta EM_j - \Delta EM_j^*\right) + \left(\Delta IM_j - \Delta IM_j^*\right) \qquad (3)$$

RESULTS

Table 2 presents the results of estimating (1) for each measure in (3). The coefficient $\hat{\delta}$ is 2.385 for the EM and –0.279 for the IM. The estimates indicate that the expansion in export variety was large enough to more than offset the reduction in existing exports. Accordingly, the export impact was positive (2.106).

The estimate of 2.385 implies that for each 1% increase in the developing countries' PRs index, the variety of US patent-sensitive exports increased (relative to the reference group) by 2.385%. Non-colonies increased their PRs by 7.7% per year over 1990–2000. Accordingly, US patent-sensitive exports

Table 2 Export components

	Extensive margin		Intensive margin		Exports	
PRs changes	2.385 ***	(0.681)	–0.279	(0.737)	2.106 ***	(0.809)
Constant	–0.188 ***	(0.030)	0.075 **	(0.032)	–0.113 ***	(0.030)
Test of endogeneity						
Robust *F*	11.37		0.56		0.98	
p-value	0.00		0.46		0.33	

Note: Seventy-one observations. 2SLS regression. *** and ** denote 1% and 5% significance level. Standard errors in parentheses are robust. First-stage robust $F = 39.91$.

Table 3 Extensive margin

	2SLS			OLS		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
PRs changes	2.385 ***	1.371 ***	1.344 ***	1.015 ***	0.067	0.049
	(0.681)	(0.487)	(0.483)	(0.367)	(0.187)	(0.185)
Constant	–0.188 ***	–0.134 ***	–0.132 ***	–0.141 ***	–0.085 ***	–0.084
	(0.030)	(0.031)	(0.046)	(0.024)	(0.023)	(0.039)
Industry effects?		included			included	
Time effects?		included			included	
Industry-time effects?			included			included
Observations	71	746	746	71	746	746
R^2		0.03	0.05	0.07	0.10	0.12
First-stage robust *F*	39.91	50.95	50.66			
Test of endogeneity						
Robust *F*	11.37	8.39	8.11			
p-value	0.001	0.005	0.006			

Note: *** denotes 1% significance level. Standard errors in parentheses are robust and in Models 2–3, clustered by countries.

increased by 16% (i.e., 7.7×2.106). This increase was entirely driven by an expansion in product variety. New products increased exports by 18%, while existing exports decreased by 2%.

I next examine the sensitivity of the estimates to my model specification. Table 3 reports 2SLS and OLS regressions results for the EM. Model 1 is at country level, as in Table 2. Models 2 and 3 are at country-industry-time level; export growth in each patent-sensitive industry is evaluated relative to growth in the reference industry group over 1990–1995 and 1995–2000. Model 2 includes industry and time fixed effects, and Model 3 includes industry-by-time effects. In all models, the coefficient $\hat{\delta}$ is positive and statistically significant. The test of endogeneity rejects the null hypothesis that ΔPR_j is exogenous at 1% level in all models. Thus, the OLS estimator is inconsistent.

In the Supplement, I show that the results are not skewed by the grouping of industries and also hold at the industry level. The results largely remain when: (1) controlling for countries' broader institutional changes, GDP growth, WTO/GATT year of membership, geographical indicators (Africa and the Americas), and the least-developed countries; (2) using alternative instrument (the dummy for membership in Paris convention); and (3) modifying my country sample (excluding the newly industrialized countries and countries with a large share in US exports).

The results show that strengthening PRs in developing countries increases US exports of new products, without affecting existing exports. This may be due stronger PRs reducing the cost of rent protection activities and encouraging US firms to develop and export new products. It may also be that stronger PRs limit imitation and reduce the misappropriation of knowledge associated with exporting to developing countries. New exports may also be created with rising multinational activity, and corresponding demand for new US products.

CONCLUSION

This research note assessed the impact of strengthening PRs in developing countries on product variety of US exports. Several studies have measured the

export impact of PRs, but whether that impact was driven by new or existing products was unclear. This research note shed light on the matter. I isolated new from existing exports and found that such differentiation is decisive: the entire increase in US exports observed is attributable to new products. The findings substantiate claims that ratification of TRIPS by developing countries promotes access to new foreign products and technologies. Additionally, the results demonstrate that patent protection is a significant institutional factor in US firms' business decisions over the introduction of new products and processes into a developing country marketplace.

Although the empirical approach in this research note was designed to account for unobserved factors which could interfere with the result, there remain some limitations. One concern is that former colonies could differ from non-colonies for reasons specific to patent-sensitive imports but unrelated to country differences in patent protection. For example, it could be that former colonies specialize more in resource-intensive industries and so rely on patent-sensitive imports relatively less. Data spanning a longer time (pre and post 1990) would help address this issue.

This research builds on the extensive literature examining firm participation in international business system (e.g., Bernard & Jensen, 2004; Das, Roberts, & Tybout, 2007) and contributes to the discussion concerning the role of IPR protection in business strategy (Aulakh, Jiang, & Li, 2013; Coeurderoy & Murray, 2008; Hagedoorn, Cloodt, & Van Kranenburg, 2005; Wang, Hong, Kafouros, & Wright, 2012). Weak IPRs pose the threat to multinational firms of rent appropriation and so influence the behavior and multinational strategies of US firms. Changes in firms' cross-border operations ultimately impact global trade. This research note showed that the strengthening of PRs under TRIPS has created new US exports into developing countries. This expansion could reflect a change in the pattern of intrafirm trade if, for example, multinational firms responded to TRIPS by establishing fully owned subsidiaries in developing countries and shif their assembly operations within firm boundaries. It could also reflect a change in the pattern of arm's length trade if, for example, stronger PRs has led some firms to offshore fragments of production to unaffiliated firms. Further research using firm-level data could deepen our understanding of these and other underlying changes.

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NOTES

[1]Non-colonies: Angola, Argentina, Bolivia, Brazil, Burundi, Chile, China, Colombia, Congo Dem. Rep., Costa Rica, Ecuador, El Salvador, Ethiopia, Guatemala, Honduras, Indonesia, Mexico, Mozambique, Nepal, Nicaragua, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Rwanda, Thailand, Uruguay, Venezuela. Colonies: Algeria, Bangladesh, Benin, Burkina Faso, Burma, Cameroon, Central African Rep., Chad, Congo Rep., Dominican Rep., Egypt, Fiji, Gabon, Ghana, Guyana Haiti, India, Ivory Coast, Jamaica, Jordan, Kenya, Madagascar, Malaysia, Malawi, Mali, Mauritania, Mauritius, Morocco, Niger, Nigeria, Senegal, Sierra Leone, Somalia, South Africa, Sri Lanka, Syria, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe.

[2]Compared with alternative measures of IPRs (e.g., Ostergard, 2000), the Ginarte and Park index has the important advantage of a long time period.

[3]I discuss PRs changes over 1960–2005 in the Supplement. For 2000–2005, there is no evidence against the hypothesis that PRs changes are the same for non-colonies and colonies.

[4]The extensive and intensive margins of export growth by industry and country groups are summarized in the Supplement.

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