The Quantity, Price, and Variety Response of U.S. Exports to Stronger Patent Protection

By Olena Ivus*

Using detailed product data from 1990 to 2006, I estimate the effect of strengthening patent rights (PRs) in developing countries on U.S. export variety, prices, and quantity. Colonial origin and cross-industry variation in patent effectiveness are used to identify these effects. I find that strengthening PRs under TRIPs added over $300 million (1990 US dollars) to U.S. exports into the average developing country. New products accounted for 75 percent of the increase in exports. Patent-relying industries are impacted most. Quantities of already exported products fell and their unit prices rose. The results are independent of global trade policy changes.
JEL: F10, K33, O34
Keywords: Trade; International law; Intellectual property rights

Though intellectual property rights have been designated as 'trade-related' since the 1994 ratification of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs), it remains unclear *how* intellectual property rights are related to trade. For over 20 years, questions have persisted over whether intellectual property rights impact the variety, quantity, and unit price of traded goods, and if so, the direction and degree of such impact. These issues have direct bearing on developing countries not only in terms of their access to high-tech products and technologies, but also their actual and potential roles in the global marketplace. Yet despite these implications, and the obvious relevance of these issues to the broader debate among economists over the ramification of strengthening intellectual property rights in developing countries, these questions have been largely left unexamined to date.

This paper analyzes the trade impact of patent rights (PRs) in terms of variety, price and quantity components by estimating the response of U.S. exports to the strengthening of PRs in 64 developing countries from 1990 to 2000. Highly detailed U.S. export data organized by 10-digit Harmonized System (HS) product categories allow me to analyze how the individual components of exports were affected.[1] I first decompose U.S. exports into the variety, price and quantity components. I then attempt to estimate the causal effect of the strengthening of PRs in developing countries on each component.

I find that the strengthening of PRs in developing countries under the TRIPs agreement increased the value of U.S. exports in those industries that rely most heavily on patent protection

* Queen's School of Business, Queen's University, Goodes Hall, 143 Union Street, Kingston, ON K7L 3N6, Canada. E-mail address: oivus@business.queensu.ca. Phone: 613-533-2373. The work on this paper began at and was partly funded by the Institute of Economic Research, Hitotsubashi University while I was a Visiting Researcher. M. Scott Taylor provided valuable insight and comments which have led to significant improvements to the paper. Feedback from Daniel Trefler and seminar participants at Rotman School of Management, University of Toronto is also gratefully acknowledged. I would also like to thank Walter Park and seminar participants at Hitotsubashi University, Kyoto University, Osaka University, Soka University (Japan), the Fall 2010 Midwest International Trade Meetings, and the World Trade Organization for their helpful comments.

[1] Robert C. Feenstra, John Romalis, and Peter K. Schott (2002) data on U.S. exports organized by 10-digit HS classification codes is employed. More than 7,600 product categories were exported into the 64 developing countries in my sample over the 1990-2006 period. As examples, the Pharmaceuticals, Medicinal Chemicals, and Botanical Products industry contains 202 categories, such as aminoglycoside antibiotics, insulin and its salt, sulfonamides used as drugs, etc., and the Special Purpose Machinery industry contains 469 categories, such as humidifiers and dehumidifiers, brewery machinery, snowplows, parts of guided missiles, etc.

by 7.87 percent. About 75 percent of this increase in exports was driven by an expansion in product variety. Among those products already exported prior to this PRs strengthening, quantities fell while unit prices rose. Patent-relying U.S. exports into the average developing country increased by $317 million (1990 US dollars), totalling a remarkable $7.6 billion (1990 US dollars) in additional patent-relying U.S. exports to 24 patent-reforming countries over the 1990-2000 period. This is a nontrivial effect given that the total of patent-relying U.S. exports into these countries was $9.7 billion in 1990. The strengthening of PRs affected industries differently, with the strongest impact observed in industries which rely on patent protection the most. The impact of PRs is most pronounced among countries which had weak PRs in 1990 and managed to sufficiently improve their PRs by 2000.

To reliably estimate the impact of PRs, the following three possible econometric problems are identified and addressed. First is the difficulty of quantifying PRs, as such measure must take into account not only the content of legislation, but also the degree of enforcement.[2] Second, a wide range of domestic factors may influence countries' imports and their implementation of patent laws.[3] This concern of confounding factors is highly relevant for developing countries, where reforms to PRs are typically not clearly defined and often tied together with other trade-related market reforms.[4] Third and finally, the decision to strengthen PRs could be driven by trade itself: technological information received through imports of high-tech products, for example, could help a country to build its own innovative capacity and thus motivate stronger PRs.

To confront these concerns, I implement an instrumental variable approach in which colonial origin explains changes in developing countries' PRs over the 1990-2000 period. 24 developing countries which were not colonized by Britain or France (non-colonies) are classified as treated, while 40 developing countries formerly colonized by Britain or France (colonies) are non-treated. To control for unobserved measures of exports correlated with colonial origin, I measure the outcome variable as the growth of an export component in a given industry *relative to* the average growth in industries with the lowest patent effectiveness. By doing so, I remove the cross-country variation in U.S. export growth. By using colonial origin as an instrument for PRs changes, I also ensure that the cross-industry variation of the data used to identify the impact is absent of factors that affect industry exports into the treated and non-treated countries similarly.

The empirical strategy is based on a simple observation that the time pattern of PRs changes is strongly correlated with British or French colonial origin of a developing country. Prior to 1990, colonies implemented most of the strengthening of PRs, while non-colonies were less willing to enforce patent laws. As a result, non-colonies' PRs protection was the least stringent by the time of global effort to strengthen PRs. This pattern changed in the 1990s, when over the course of ten years non-colonies managed to substantially improve their PRs, thereby exceeding the level of colonies' PRs in 2000. The strengthening of PRs in non-colonies in the 1990s was externally imposed rather than internally motivated by import-related factors. The external imposition came in the form of the global movement towards stronger intellectual property rights, which culminated in the ratification of TRIPs. The TRIPs agreement prescribes minimum standards for domestic protection of intellectual property rights on par with developed countries and also requires effective intellectual property rights enforcement.[5]

[2]Developing countries' judicial systems may vary in their independence, efficiency in dealing with violations, and susceptibility to institutional corruption. These factors are difficult to identify and quantify, leading to a potential systematic overstatement of the actual strength of PRs in a given country.

[3]For example, competition policy, innovative capacity, openness to trade, economic integration, and level of development.

[4]The agreement on TRIPs, for example, was bundled together with other multilateral agreements into a single package, and these changes also may have affected exports.

[5]Members' compliance with their obligations under TRIPS is closely monitored by the TRIPs Council (comprised of all WTO Members), and intellectual property rights disputes are resolved by the WTO's Dispute Settlement Body. The inclusion of TRIPs on the agenda of the Uruguay Round is discussed thoroughly in Keith E. Maskus (2000) and Klaus

The changes of PRs and colonial origin are strongly correlated, suggesting that colonial origin is a relevant instrument and the causal impact of PRs can be measured by comparing U.S. export performance across non-colonies and colonies.[6] The instrument however is unlikely excluded. Colonization could have been determined by a wide range of factors related to trade (e.g., geographical proximity to the colonizing power), and these other factors must be isolated from effects properly attributable to PRs. I aim to meet the exclusion restriction by first measuring each export component in growth rates, and then comparing growth across industries on the basis of industry classification by patent effectiveness.[7] Specifically, I identify the comparison industry group, which is composed of industries with the lowest patent effectiveness, and measure growth in a given industry relative to growth in the comparison industry group.

With the changes outlined above, the exclusion restriction requires that colonial origin has no effect on the differential growth in U.S. exports in patent-relying industries, other than its effect through changes in PRs. It would fail if the strengthening of PRs in non-colonies was determined partly as a function of U.S. differential export growth. This concern is likely absent since countries in the non-colony group were not selected based on their potential for U.S. export growth in patent-relying industries.

The existing theoretical literature provided valuable insights into the relationship between Southern intellectual property rights and Northern export variety, prices, and quantities. Stronger intellectual property rights encourage Northern firms to develop new technologies Ishac Diwan and Dani Rodrik (1991) and export a wider range of goods Olena Ivus (2011). Prices may rise whith increased monopolistic power of innovators (Judith C. Chin and Gene M. Grossman 1990; Alan V. Deardorff 1992; Keith E. Maskus and Mohan Penubarti 1997) or decreased innovation for quality improvements (Amy Jocelyn Glass and Kamal Saggi 2002).[8] Prices may fall if innovators employ the best practice research technologies (M. Scott Taylor 1994). Quantities may rise if demand for Northern products rises (Maskus and Penubarti 1997), production reallocates to the North (Elhanan Helpman 1993), or Northern firms free resources from masquing their technologies to compensate for lax PRs (M. Scott Taylor 1993); but may fall if newly exported goods dilute the market share away from existing exports (Ivus, 2011).

The methodology of export decomposition into the individual components follows Robert C. Feenstra and Hiau Looi Kee (2004) and David Hummels and Peter J. Klenow (2005). As such I owe much to these authors. Variety is measured by the extensive margin of exports, where product categories are weighted by their importance in U.S. exports. Existing exports are measured by the intensive margin, which is further divided into price and quantity components. The decomposition utilizes cross-country variation in exports, which is akin to my empirical strategy of comparing U.S. export growth across non-colonies and colonies.

The empirical strategy used here is related to Olena Ivus (2010), however in that study no distinction was made between new and already exported products, and this distinction is critical for the results. As such, while Ivus (2010) concluded that stronger PRs increased the value of developed countries' exports by increasing the quantity of exports, rather than their price, this paper clarifies that the positive impact on export quantity is driven by new products exported. The expansion in export variety is strong enough that it more than offsets the contraction in the quantity of existing exports.

Stegemann (2000).

[6]The approach of using colonial origin to explain changes in PRs follows Ivus (2010). The strength of PRs is measured by the Juan C. Ginarte and Walter G. Park (1997) index which is available for each five-year time period from 1960 to 2005. The first-stage regression results are provided in Section I.

[7]The classification of industries by patent effectiveness is documented in Wesley M. Cohen, Richard R. Nelson, and John P. Walsh (2000).

[8]In the presence of foreign direct investment, stronger intellectual property rights may encourage the introduction of new varieties (Edwin L.-C. Lai; 1998), but discourage quality improvements in existing products (Amy Jocelyn Glass and Xiaodong Wu 2007). In the presence of technology licensing, stronger intellectual property rights can increase innovation (Guifang Yang and Keith E. Maskus 2001).

This is the first paper to estimate the impact of PRs on export variety, prices, and quantities. Whether the adoption of stronger PRs results in an expansion of the range of exported goods, as opposed to resulting in merely higher prices and lower quantities of existing exports, are crucial considerations from the perspective of developing countries. There is a substantial empirical literature that has considered whether PRs are related to trade,[9] but the prediction on aggregate exports may hide important differences across individual export components.

The remainder of this paper is organized as follows. Section I describes the data on PRs changes in developing countries, U.S. exports, and industry patent effectiveness. In Section II, I outline my empirical strategy, and I decompose exports into the variety, price, and quantity components in Section III. The results are presented in Section IV, their sensitivity is examined in Section V, and the paper is concluded in Section VI.

I. The Data

A. Patent rights

I examine the changes of PRs in 64 developing countries which imported U.S. products during the 1990-2006 period, and for which data on the strength of PRs are available. These countries are classified as developing economies in the International Monetary Fund's World Economic Outlook for the year 2009.[10] The newly industrialized countries (NICs), such as Brazil, China, India, Malaysia, Mexico, Philippines, South Africa, and Thailand, are excluded from the analysis. This is done to ease the concern that PRs changes in the NICs were influenced by U.S. export growth in patent-relying industries to those countries. There are two potential grounds for this concern. First, PRs strengthening in the NICs during the 1990s is not entirely attributable to external international pressures. In particular, PRs reforms in the NICs often were motivated by internal business interests seeking to protect their domestic innovations and improve access to technology (Keith E. Maskus 2000). Second, it is well known that specific measures to enhance PRs in NICs were pushed forward by U.S. through its Office of the United States Trade Representative (USTR). Prior to TRIPs, these rapidly developing countries were among the first targeted for the USTR's intervention pursuant to Section 301 of the *U.S. Trade Act of 1974*, as they were seen by the U.S. to provide unique growth prospects for U.S. exports in patent-relying industries.[11] As the majority of NICs are non-colonies, if the NICs are included and either of the above concerns bears out, then the identification strategy implemented in this paper would be rendered suspect.[12]

An additional concern about including the NICs is that the strengthening of PRs in these countries could result in U.S. firms switching from exporting to serving these countries' markets through affiliate sales or licences (Pamela Smith 2001). This effect would interfere with my

[9] See, for example, Michael Ferrantino (1993), Keith E. Maskus and Mohan Penubarti (1997), Carsten Fink and Carlos A. Primo Braga (1999), Pamela J. Smith (1999), Mohammed Rafiquzzaman (2002), Catherine Y. Co (2004), Rod Falvey, Neil Foster, and David Greenaway (2009), and Olena Ivus (2010).

[10] IMF World Economic Outlook, October 2009 is available at: `http://www.imf.org/external/pubs/ft/weo/2009/02/weodata/groups.htm`. Trinidad and Tobago is excluded from the analysis since it is classified as a developed economy by the World Bank.

[11] Targets for the USTR's intervention under Section 301 are recommended by four industry associations: Pharmaceutical Research and Manufacturers of America, Biotechnology Industry Organization, International Intellectual Property Alliance (representing U.S. copyright-dependent industries), and the Computer and Communications Industry Association. Countries which are rigourously targeted for the USTR's intervention pursuant to Section 301 are placed on the 301 Report under the "Priority Watch List" category (which emphasizes increased attention in the area of concern) or the "Priority Foreign Country" category (which triggers an additional investigation, after which sanctions may follow). Of the 64 developing countries considered here, only two appeared on the "Priority Watch List" before 1994: Argentina (non-colony) and Egypt (colony). As I show in Section V.C, the results remain when these two countries are excluded.

[12] This is because the validity of my instrumental variable approach requires that (i) the strengthening of PRs in the treated countries (i.e., non-colonies) be externally imposed and (ii) the treated countries are not selected into strengthening PRs based on their potential for U.S. export growth in patent-relying industries.

estimate of the impact of PRs on exports, and excluding the NICs from the analysis also serves to limit this interference.[13]

The strength of countries' patent protection is measured by the index of patent rights documented in Juan C. Ginarte and Walter G. Park (1997) and Walter G. Park (2008). The index 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 patent rights. For each of these measures, a country is assigned a score between zero and one depending on the share of conditions satisfied. The final index is an unweighted sum of the five scores.

Table 1 enumerates the changes in PRs implemented in the 1990s. In the first column, the first-stage regression results are presented. The next regression was estimated:

$$\Delta PR_j = a_0 + aNC + e_j, \tag{1}$$

where $\Delta PR_j \equiv [\ln(1 + PR_{j,2000}) - \ln(1 + PR_{j,1990})]/(2000-1990)$ is the average annual change in PRs over the 1990-2000 period, and NC is the non-colony dummy variable which equals one if a developing country is a non-colony and zero otherwise. The list of countries (provided in Appendix A) contains 24 non-colonies and 40 colonies. It is apparent that the coefficient on NC is positive (.041) and highly statistically significant. On average, non-colonies increased their PRs more than colonies after the year 1990. These changes were a consequence of the global movement towards stronger intellectual property rights, that culminated in the ratification of TRIPs. By the end of Uruguay Round, acceptance of TRIPs was a condition for World Trade Organization (WTO) membership. Further, if the prospect of exclusion from the WTO was not incentive enough to ratify TRIPs, any unwilling country also would likely have found itself under unilateral pressure and sanctions from the U.S. and obviously, without recourse to the WTO's systems of protection. Faced with such contingencies, many non-colonies ratified TRIPs despite internal opposition and unresolved debate.

Table 1—**The changes in PRs**

	1990-2000		1990-1995		1995-2000	
Non-colony (NC)	0.041***	(0.007)	0.038***	(0.012)	0.043***	(0.012)
Constant	0.017***	(0.002)	0.016***	(0.003)	0.018***	(0.004)
N of observations	64		64		64	
R^2	0.42		0.20		0.22	
$F(1, 62)$	32.01		10.14		12.56	
$Prob > F$	0.000		0.002		0.001	

Note: *** denotes 1 percent significance level. Robust standard errors are in parentheses. The outcome variable is the average annual log change in the PRs index over a given period. For 1990-2000, for example, the outcome variable is computed as $[\ln(1+PR_{2000})-\ln(1+PR_{1990})]/(2000\text{-}1990)$.

The results also indicate that colonial origin is relevant for explaining variation in PRs changes; the instrument is not weak since the F statistic of 32 exceeds its critical value of 10 (James H. Stock, Jonathan Wright, and Motohiro Yogo 2002).[14] The magnitudes of estimates and their significance are not driven by aggregation over time. The coefficients on NC are also positive and highly statistically significant for the 1990-1995 and 1995-2000 periods, which is shown in

[13] I thank anonymous referee for this comment.

[14] Non-colonies increased their PRs more so than colonies both in level and percentage changes. Colonial origin is also relevant for explaining the changes in PRs which are measured in levels, but its explanatory power is slightly lower (i.e., the F-statistic falls from 32.01 to 29.55). I thank anonymous referee for this comment.

the last two columns. The null hypothesis that the coefficients on NC are the same across the two five-year periods cannot be rejected at 5% level of significance.[15]

For the 2000-2005 period, there is no evidence against the hypothesis that the changes of PRs are the same for non-colonies and colonies. This could be because TRIPs required the implementation of most obligations with respect to PRs in developing countries by the year 2000.[16] In reviewing developing countries' progress in 2000, the USTR concluded that "the vast majority of developing countries have made a serious effort to comply with their TRIPs obligations."[17] This was especially true for non-colonies, which had to increase their PRs significantly more to meet the TRIPs standards. Given that non-colonies updated their PRs substantially in the 1990s, the relative constancy of their PRs during the 2000-2005 period is not surprising.

As discussed above, the data indicate that over the 1990-2005 period, non-colonies exhibited relative progress in strengthening their PRs. This is contrasted with the years prior to the global movement towards stronger intellectual property rights, when external pressure was absent and non-colonies did not strengthen their PRs. For example in the period from 1960 to 1990, the level of PRs in non-colonies had actually dropped from 1.67 to 1.11, while the level of PRs in colonies had increased from 2.03 to 2.65. Presumably, this disparity was due to lack of interest among non-colonies in strengthening their PRs and as a result, their PRs protection was weak by the time the global effort to strengthen intellectual property protection began. To comply with TRIPs, non-colonies' PRs required substantial improvement and correspondingly, over the 1990-2005 period non-colonies did manage to increase their PRs to the average level of 2.93, thereby exceeding the average level of colonies' PRs in 2005.

B. U.S. Exports

U.S. exports to each of 64 developing countries are organized by 10-digit HS codes, with each code representing a specific product category.[18] The data are annual and include information on the value, quantity, and units of exports. Since the 10-digit HS codes have been periodically revised, it is important to make sure that a change in the composition of exports is driven by a change in the set of product categories, rather than by a change in the HS code used for the identical category. To achieve this, I use the concordance of HS codes over time documented in Justin R. Pierce and Peter K. Schott (forthcoming) and revise the data so that a newly introduced HS code corresponds with a newly developed category.

I decompose U.S. exports into the variety, price, and quantity components and examine the change in each component over the 1990-2000 period. To measure prices, I construct unit values using the data on values and quantities. About 11.5 percent of HS codes have missing data on units or quantity in the years 1990 and 2000, and another 1.4 percent of HS codes have varying units corresponding to a given HS code. All these codes are disregarded for the price and quantity analysis, but are included for the variety analysis.

Over the 1990-2006 period, the U.S. exported to the 64 developing countries in 4,750 manufacturing categories. These categories have varied over the years, with new products introduced and others discontinued. As shown in Figure 1, since 1990 the number of exported categories has risen overall.

The upward trend is likely a consequence of U.S. progress in fostering product innovations. It

[15] The F-statistic equals $F(1, 124) = 0.007$ (p-value=0.79). I thank anonymous referee for suggesting this test.

[16] Longer transition periods were given for the protection of pharmaceuticals and agriculture chemicals in some developing countries. Also for the least developed countries, the deadline for the implementation of TRIPs was 2006. Most of the least developed countries are in the colony group.

[17] Source: 2000 Special 301 Report, Office of the USTR, p.6.

[18] The data are documented in Robert C. Feenstra, John Romalis, and Peter K. Schott (2002) and can be found at `www.internationaldata.org`.

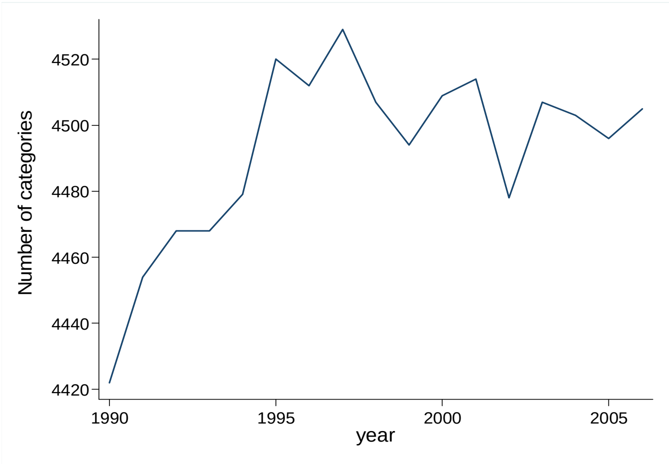

FIGURE 1. **Number of categories**

is notable, however, that a similar pattern does not hold when countries are grouped by colonial origin. This is illustrated in Figure 2, where the number of categories exported into non-colonies relative to colonies is plotted over time on the left. It is apparent that non-colonies' relative number rose during the first two years, began falling in the 1992-1994 period, continued falling until 2002, and thereafter exhibited no discernable trend.

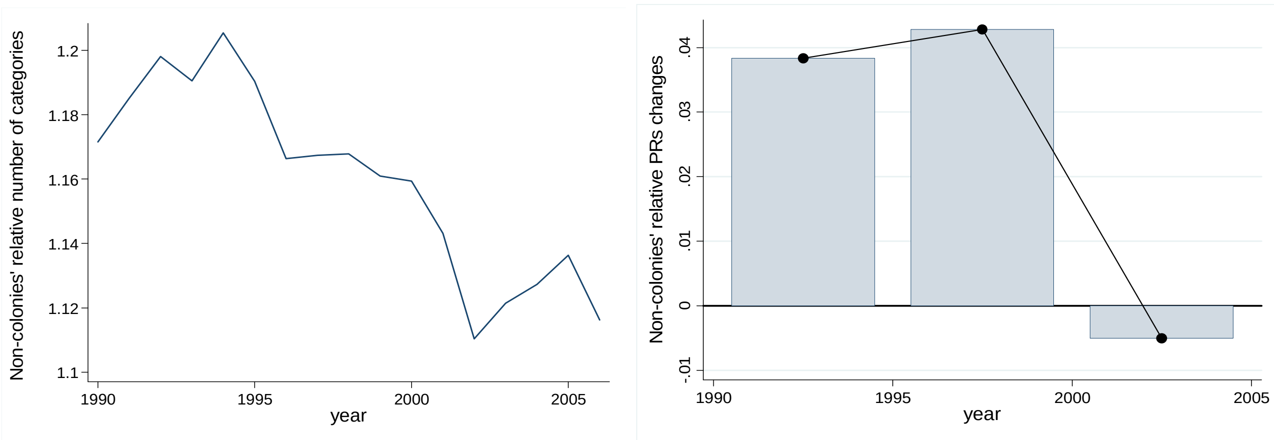

FIGURE 2. **Non-colonies' relative number of categories (left) and PRs changes (right)**

A cursory review of the data thus suggests that the relative importance of non-colonies in the number of categories sent from the U.S. changed over the 1990-2006 period. This could be driven by a wide range of factors common to countries in one group, but not the other. What is interesting however, is that the pattern of changes over time in non-colonies' relative number of categories, shown on the left of Figure 2, closely resembles the pattern of changes over time in the relative progress of non-colonies in strengthening their PRs, shown on the right of Figure 2. On average, non-colonies began major changes to their patent regimes in the early 1990s. Correspondingly, their relative number of categories in U.S. exports started declining. The period over which the decline is observed largely overlaps the period during which non-colonies strengthened their PRs the most. Further, from 2000 to 2005, the PRs data did not provide evidence that non-colonies strengthened their PRs more than colonies. Likewise, non-colonies' relative number of categories stopped declining in or around 2002, following which no remarkable pattern across the groups is observed.

While it appears that the number of categories exported to developing countries and the reforms of these countries' PRs are negatively related, such a conclusion is potentially misleading. As an example, assume that when non-colonies were strengthening their PRs, colonies were implementing other types of domestic policy reforms to attract a wide range of U.S. products. In such circumstances, policy changes in both country groups might well be increasing the number of categories exported from the U.S., 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 unobserved measures of exports potentially correlated with colonial origin. For this purpose, cross-industry variation in exports can be utilized, which I discuss below.

C. Industries

For each HS code, the data include the corresponding codes by SITC Revision 3. I used this information to obtain data by 4-digit ISIC codes Revision 3 and then identified 31 manufacturing industries which conform to the industry definitions used in Wesley M. Cohen, Richard R. Nelson, and John P. Walsh (2000).[19]

These industries are listed in Appendix B, where the data on patent effectiveness documented in Cohen, Nelson, and Walsh (2000) are also provided.[20] *Patent effectiveness* is defined as the mean percentage of product innovations for which patent protection has been effective in securing the "firm's competitive advantage from those innovations." Protecting product innovations from imitation is the primary motive for obtaining patents.[21]

To utilize cross-industry variation in exports, I identify the comparison industry group. This group is composed of 6 industries that have the lowest patent effectiveness and are not covered by other categories of intellectual property rights, namely 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.[22] The remaining 25 industries, for which patent effectiveness is high, comprise the treatment industry group.

Between 1990 and 2006, the number of categories exported in 31 manufacturing industries from the U.S. increased by 7.5 percent for colonies and 2.4 percent for non-colonies.[23] Non-colonies' poor relative performance in attracting a wide range of categories suggests that reforms of PRs in a developing country and product variety in its imports from the U.S. are negatively

[19]The concordance table between SITC Rev.3 and ISIC Rev.3 codes is available at `http://ec.europa.eu/eurostat/ramon`. Each HS code in the final data has a unique industry correspondence. Twenty-two HS codes matched to more than one industry and were therefore excluded. Fifty-three HS codes had unassigned industry for some observations and the same assigned industry for the remaining observations. I assigned that industry to all unassigned observations within that HS code.

[20]Cohen, Nelson, and Walsh (2000) report the results of the Carnegie Mellon Survey administered to 1478 R&D labs in the U.S. manufacturing sector in 1994. Two of the 33 industries defined in Cohen, Nelson, and Walsh (2000) are not included here because of a lack of export data (i.e., Semiconductors and Related Equipment; and Search and Navigation Equipment).

[21]Knut Blind et al. (2006) reviewed recent survey studies on motives to patent and concluded that in all of the studies examined, prevention of imitation is the main motive behind patenting.

[22]It is important that industries in the comparison group are not covered by other categories of intellectual property protection (such as copyright, plant variety rights, geographical indications, trademarks, etc.), because the stringency of PRs in a country is correlated with the stringency of other intellectual property rights. Park, Walter G., and Douglas C. Lippoldt (2008), for example, document a fairly high correlation of the PRs index with indices for copyright and trademarks. Consequently, I excluded from the comparison industry group three industries which are indicated to have the lowest patent effectiveness in Cohen, Nelson, and Walsh (2000) but are covered by other categories of intellectual property rights correlated with PRs. These industries are: (i) Publishing and Printing, which is protected by copyright; (ii) Food Products, which is protected by plant variety rights and geographical indications (Keith E. Maskus 2006); and (iii) Textiles, which is protected by trademarks (Michael Keenan, Ozcan Saritas, and Inga Kroener 2004).

[23]Industry data on the number of categories and the growth in the number of categories over the 1990-2006 period are provided in Appendix B.

related. Importantly, this negative relationship fails to hold when industries are differentiated by patent effectiveness. As such, relative to the comparison industry group, the number of categories exported in the remaining 25 industries fell by 2.1 percent for non-colonies and 8.5 percent for colonies. The positive difference of 6.4 percent is a rough measure of the impact of strengthening PRs in non-colonies.

Most of the growth in the number of categories between 1990 and 2006 occurred in the comparison industry group. For example, in the Basic Metals industry the number of categories rose by 10.6 percent (from 170 in 1990 to 188 in 2006). By contrast, the number of categories in the Basic Chemicals industry (i.e., the treatment industry) rose by only 0.7 percent (from 537 in 1990 to 541 in 2006). Overall, industries in the comparison group grew 2.4 percentage points faster than the others. This difference in growth is even more pronounced when colonies and non-colonies are individually analyzed. As such relative to Basic Chemicals, the Basic Metals industry grew 18.2 and 8.5 percentage points faster in colonies and non-colonies respectively.[24] Overall, industries in the comparison group grew as much as 8.5 percentage points faster in colonies and only 2.1 percentage points faster in non-colonies. Again, the positive difference of 6.4 percentage points can be roughly attributed to the strengthening of PRs in non-colonies.

II. Empirical Strategy

I relate the changes in developing countries' PRs to the growth rates of U.S. export components. The average annual growth rate of exports over the 1990-2000 period is approximated by the log change as follows:

$$\Delta X_j^k \equiv (\ln X_{j,2000}^k - \ln X_{j,1990}^k)/(2000-1990). \tag{2}$$

To estimate the impact of PRs changes on export growth, the next model could be postulated:

$$\Delta X_j^k = b_0 + b^k \Delta PR_j + S^k + u_j^k, \tag{3}$$

where ΔX_j^k is the outcome variable. The coefficient b^k is industry subscripted, since patent effectiveness varies across industries.[25] The vector S^k is the set of industry fixed effects, which will pick up the effects of technological progress, changes in industry structure, shifts in output mix, industry specific shocks, etc. Last, b_0 is the constant term and u_j^k is the error term.

Isolating exogenous to exports variation in PRs changes in (3) is highly problematic for three reasons. First, the strength of PRs may be measured with systematic errors. Second, a wide range of domestic factors may confound the impact of PRs (i.e., by influencing countries' trade and their patent reforms). Third, U.S. exports may be causing changes in PRs, but not the reverse. In the face of these problems, I instrument ΔPR_j by colonial origin. This procedure is reliable provided that the colonial origin instrument is (i) not weak; and (ii) excluded. The first criterion was evaluated in Section I.A, where from the first-stage regression results I concluded that the instrument is not weak. The second criterion requires that colonial origin has no effect on U.S. export growth, other than its effect through changes in PRs. In other words, the average value of u_j^k in (3) must not depend on colonial origin. The exclusion restriction will fail if colonial origin is related to unobserved measures of exports, potentially embedded in u_j^k. Denoting the set of these measures by S_j, I rewrite the error term as $u_j^k = S_j + \varepsilon_j^k$. Now (3)

[24]Between 1990 and 2006, the number of categories in the Basic Metals industry grew by 25.6 percent (from 117 to 147) in colonies and by 9.6 percent (from 167 to 183) in non-colonies. The number of categories in the Basic Chemicals industry grew by 7.4 percent (from 364 to 391) in colonies and by 1.1 percent (from 526 to 532) in non-colonies. These data are available in Appendix B.

[25]The coefficient b^k as a function of patent effectiveness is specified in Section V.A.

changes to:

$$\Delta X_j^k = b_0 + b^k \Delta PR_j + S^k + S_j + \varepsilon_j^k, \tag{4}$$

where the vector S_j is the set of factors common to all industries within a country.

I remove S_j from (4), and thus hope to meet the exclusion restriction, by analyzing export growth in relative terms. Specifically, for each country I evaluate the growth rate of an export component in industry k *relative* to the growth rate of that component in the comparison industry group. To rewrite (4) in terms of the relative growth rates, I specify the next model for the comparison industry group:

$$\Delta X_j^* = b_0^* + b^* \Delta PR_j + S_j + \varepsilon_j^*, \tag{5}$$

where the outcome variable ΔX_j^* varies by country only.[26] Now subtracting (5) from (4), I obtain the equation with the relative export growth as the outcome variable:

$$\Delta X_j^k - \Delta X_j^* = \beta_0 + \beta^k \Delta PR_j + S^k + \epsilon_j^k, \tag{6}$$

where $\beta_0 = b_0 - b_0^*$, $\beta^k = b^k - b^*$, and $\epsilon_j^k = \varepsilon_j^k - \varepsilon_j^*$. The equation (6) is the second-stage regression. Notably, the set of factors common to industries within a country, S_j, is differenced out. In other words, the cross-country variation in U.S. export growth has been removed by differencing the outcome variable across industries. The exclusion restriction now requires that colonial origin of a developing country does not directly determine the relative growth rate of U.S. exports. Under this key assumption, the differential effect of strengthening PRs on U.S. export components, β^k, is identified.

When (6) is estimated by the instrumental variable approach, the cross-industry variation of the data used to identify the impact is absent of factors that affect industry exports into colonies and non-colonies similarly. The examples of such factors include industry shocks to exports and industry responses to global movement towards stronger intellectual property rights and more liberalized trade. The IV estimator of β^k simply reduces to:[27]

$$\widehat{\beta}^k = \frac{\overline{\Delta X^k}_{j\in nc} - \overline{\Delta X^k}_{j\in c}}{\overline{\Delta PR}_{j\in nc} - \overline{\Delta PR}_{j\in c}}, \tag{7}$$

where $\overline{\Delta X^k}_{j\in nc}$ and $\overline{\Delta PR}_{j\in nc}$ are the sample averages of ΔX_j^k and ΔPR_j over the part of the sample where a country j is a non-colony, and $\overline{\Delta X^k}_{j\in c}$ and $\overline{\Delta PR}_{j\in c}$ are the sample averages of ΔX_j^k and ΔPR_j over the part of the sample where j is a colony.

III. Export Decomposition

To decompose U.S. export growth into the variety, price, and quantity components, I adopt the methodology developed by Feenstra and Kee (2004) and Hummels and Klenow (2005). The methodology has two advantages for my analysis. First, it measures export variety by the extensive margin, which weights categories by their value in total U.S. exports. Compared to the simple count of the number of categories, the extensive margin is a more refined measure of variety, as it accounts for categories' importance in U.S. exports. Secondly, the decomposition

[26] The set S^k does not appear in (5) because ΔY_j^* does not vary by industry.

[27] This IV estimator is also known as the Wald estimator for binary instrument.

utilizes cross-country variation in exports. This is akin to my empirical strategy of comparing U.S. export growth across non-colonies and colonies.

Let X_{ijt} represent the nominal value of U.S. exports of a category i into a destination country j at year t. The set of all categories i exported within an industry k to country j at year t is given by I_{jt}^k. The decomposition requires choosing a consistent "reference country group" which contains the widest possible set of categories. Let this reference group include all 64 developing countries. Then U.S. exports into the reference group is given by the total value of U.S. exports into the 64 developing countries, that is $X_{it} \equiv \sum_j X_{ijt}$. The entire set of categories exported from the U.S. each year is $I_t \equiv \cup_j I_{jt}$.

For each industry k, country j's share of total U.S. exports into the developing countries can be decomposed into the extensive margin (EM) and the intensive margin (IM) as:

$$(8) \qquad \frac{\sum_{i \in I_{jt}^k} X_{ijt}}{\sum_{i \in I_t} X_{it}} = \frac{X_{jt}^k}{X_t} \equiv EM_{jt}^k IM_{jt}^k,$$

where the respective margins are defined by:

$$(9) \qquad EM_{jt}^k \equiv \frac{\sum_{i \in I_{jt}^k} X_{it}}{\sum_{i \in I_t} X_{it}} = \frac{\sum_{i \in I_{jt}^k} X_{it}}{X_t} \qquad \text{and} \qquad IM_{jt}^k \equiv \frac{\sum_{i \in I_{jt}^k} X_{ijt}}{\sum_{i \in I_{jt}^k} X_{it}} = \frac{X_{jt}^k}{\sum_{i \in I_{jt}^k} X_{it}}.$$

EM_{jt}^k measures the variety of exports in industry k to country j. It equals the total value of U.S. exports summed over the set of categories exported in k to j relative to the total value of U.S. exports summed over the entire set of categories. In other words, it is the share of categories exported in k to j in *total* U.S. exports. This share depends on the set of categories exported and not on export value. As such, the EM varies across developing countries because of the difference in the variety (and not the value) of exports.

IM_{jt}^k equals U.S. exports into j relative to U.S. exports into the reference group with both nominal values taken over the set of categories exported in k to j. As such, the set of categories exported to each country does not explain country difference in the IM.

As an example of export decomposition, consider the Basic Chemicals industry, where non-colonies' share of U.S. exports was 6.75 times larger than colonies' share in 1990. The difference is partially explained by a larger number of categories shipped into non-colonies from the U.S.[28] Also, the categories shipped into non-colonies were of a higher value in total U.S. exports in the Basic Chemicals industry. As a result, the EM of U.S. exports was 2.44 times greater for non-colonies than colonies. The remaining difference in export shares was due to the IM, which was 2.77 times greater for non-colonies.

The IM can further be decomposed into the price index and the implicit quantity index as $IM_{jt}^k = P_{jt}^k Q_{jt}^k$. The price index is measured as a weighted average of the price ratios:

$$(10) \qquad P_{jt}^k \equiv \prod_{i \in I_{jt}^k} \left(\frac{p_{ijt}}{p_{it}} \right)^{w_{ijt}},$$

where $p_{ijt} = X_{ijt}/q_{ijt}$ and $p_{it} = X_{it}/q_{it} = \sum_j X_{ijt} / \sum_j q_{ijt}$ are individual prices (unit values) in country j and the reference group respectively. The weights w_{ijt} are computed as the logarithmic

[28]Non-colonies received 549 categories of basic chemicals in 1990, which was 1.44 times more than colonies.

means of s_{ijt} and s_{it} as follows:

$$w_{ijt} \equiv \frac{(s_{ijt} - s_{it})/(\ln s_{ijt} - \ln s_{it})}{\sum_{i \in I^k_{jt}} ((s_{ijt} - s_{it})/(\ln s_{ijt} - \ln s_{it}))}, \tag{11}$$

where $s_{ijt} \equiv X_{ijt}/\sum_{i \in I^k_{jt}} X_{ijt}$ is the share of category i in k's exports to j and $s_{it} \equiv X_{it}/\sum_{i \in I^k_{jt}} X_{it}$ is the share of category i in k's exports to the reference group.[29]

It follows that the growth in country j's share of total U.S. exports $\Delta(X^k_j/X)$, which is measured in log changes, is additively decomposed into the variety, price, and quantity components as $\Delta(X^k_j/X) = \Delta EM^k_j + \Delta P^k_j + \Delta Q^k_j$.

The outcome variable in the second-stage regression (6) is expressed in relative terms and so the next step is to specify the export components for the comparison industry group. Let the extensive and intensive margins for the comparison group be defined as:

$$EM^*_{jt} \equiv \frac{\sum_{i \in I^*_{jt}} X_{it}}{\sum_{i \in I_t} X_{it}} = \frac{\sum_{i \in I^*_{jt}} X_{it}}{X_t} \quad \text{and} \quad IM^*_{jt} \equiv \frac{\sum_{i \in I^*_{jt}} X_{ijt}}{\sum_{i \in I^*_{jt}} X_{it}} = \frac{X^*_{jt}}{\sum_{i \in I^*_{jt}} X_{it}}, \tag{12}$$

where I^*_{jt} indicates that the margins are measured over the full set of categories exported within six industries comprising the comparison group (*). Also, let the price and quantity indices of the IM in the comparison group be defined as:

$$P^*_{jt} \equiv \prod_{h \in I^*_{jt}} \left(P^h_{jt}\right)^{\lambda_{hjt}} \quad \text{and} \quad Q^*_{jt} \equiv \frac{IM^*_{jt}}{P^*_{jt}}, \tag{13}$$

where $\lambda_{hjt} \equiv \sum_{i \in I^h_{jt}} X_{ijt}/\sum_{i \in I^*_{jt}} X_{ijt}$ is the export share of an industry h in the comparison group.

Export growth in the comparison industry group equals $\Delta(X^*_j/X) = \Delta EM^*_j + \Delta P^*_j + \Delta Q^*_j$. As a result, export growth in industry k *relative* to that in the comparison group is decomposed into the the variety, price, and quantity components as follows: $\Delta X^k_j - \Delta X^*_j = (\Delta EM^k_j - \Delta EM^*_j) + (\Delta P^k_j - \Delta P^*_j) + (\Delta Q^k_j - \Delta Q^*_j)$. The three components in brackets are the outcome variables of interest.[30] Specifically, I estimate the following three equations:

$$\begin{aligned} \Delta EM^k_j - \Delta EM^*_j &= \beta_0 + \beta^k \Delta PR_j + S^k + \epsilon^k_j; \\ \Delta P^k_j - \Delta P^*_j &= \beta_0 + \beta^k \Delta PR_j + S^k + \epsilon^k_j; \\ \Delta Q^k_j - \Delta Q^*_j &= \beta_0 + \beta^k \Delta PR_j + S^k + \epsilon^k_j. \end{aligned} \tag{14}$$

where the growth in each of the three components is defined similar to (2).

In the next section, the impact of PRs is estimated under the assumption that all industries in the treatment group are equally affected by the strengthening of PRs, i.e., β^k does not vary across industries. This assumption is relaxed in Section V.A., where the industry response to stronger PRs is proportional with patent effectiveness.

[29]Feenstra and Kee (2004) develop the exact price index given by $\pi_{jt} = P_{jt}(\lambda_{jt}/\lambda_t)^{-1/(\sigma-1)}$. The "conventional" price index P_{jt} assumes the set of categories is the same across the two countries. This index is defined in (10), where the product is taken over the common set of categories. The term λ_{jt}/λ_t reflects cross-country differences in categories. Hummels and Klenow (2005) show that this term is equivalent to EM^k_{jt} in (9).

[30]The data on the relative growth rate of export components are summarized in Appendix C.

IV. Regression results

Table 2 presents the estimation results for the variety component. In Panel A, ΔEM_j^k is the outcome variable. The data are pooled across all 31 industries, and OLS regression is run. Standard errors are robust and clustered by country.[31] The results indicate that the coefficient on ΔPR_j is negative and equals -.136. This estimate, however, is misleading if PRs changes are endogenous to exports (in which case the OLS estimator is inconsistent).[32]

TABLE 2—**The variety component**

Panel A: EM industry growth	OLS			
PRs changes	-0.136	(0.111)		
Constant	-0.066***	(0.014)		
Industry fixed effects (n=30)	Yes			
Number of observations	1593			
R^2	0.22			
Panel B: EM relative growth	OLS		2SLS	
PRs changes	0.757***	(0.255)	1.222***	(0.412)
Constant	-0.204***	(0.023)	-0.220***	(0.027)
Industry fixed effects (n=24)	Yes		Yes	
Number of observations	1293		1293	
R^2	0.14			
First-stage robust $F(1,63)$	45.17 (p-value=0.00)			
Test of endogeneity robust $F(1,63)$	2.43 (p-value=0.12)			

Note: ***, **, and * denote 1, 5, and 10 percent significance level respectively. Robust standard errors clustered by country (64 clusters) are in parentheses. In Panel A, *EM industry growth* (ΔEM_j^k) is the outcome variable, computed for each industry k as the average annual log change in the EM. In Panel B, *EM relative growth* ($\Delta EM_j^k - \Delta EM_j^*$) is the outcome variable, computed as the average annual log change in the EM of industry k relative to the average annual log change in the EM of the comparison group. All averages are taken over the 1990-2000 period. Robust F statistics are adjusted for 64 clusters.

In Panel B, $\Delta EM_j^k - \Delta EM_j^*$ is the outcome variable. Here the concern of potential endogeneity between PRs changes and exports is addressed by measuring the outcome variable in terms of relative growth rates. The data are pooled across 25 industries, with the other six industries populating the comparison group. It is apparent that both OLS and 2SLS estimator produce similar results. The OLS and 2SLS estimates of the coefficient on ΔPR_j are 0.757 and 1.222 respectively. Both estimates are statistically significant at 1 percent level. To check if the OLS estimator is consistent, I tested the endogeneity of PRs changes. The null hypothesis that ΔPR_j is exogenous cannot be rejected at 5 percent level of significance. Thus, I conclude that the OLS estimator is consistent. OLS is also more efficient than 2SLS in Panel B. The OLS estimate implies that for each 1 percent increase in the developing countries' index of PRs, the variety of U.S. exports in patent-relying industries increased by 0.757 percent (relative to the comparison industry group).

Importantly, the sign of the coefficient on PRs changes differs across Panel A and Panel B. This difference could have resulted from systematic measurement errors in PRs, confounding

[31] Clustering the standard errors by country serves to account for the within-country correlation among observations, which is important since strengthening PRs occurs at country level.

[32] Whether the endogenous regressor is in fact exogenous can be tested after 2SLS estimation, provided the instrument is excluded. Colonial origin, however, cannot be treated as excluded instrument in (3).

factors, or reverse causality from exports to PRs. Neither of these three potential problems is addressed in Panel A, and this could have caused an endogeneity bias severe enough that the direction of the impact was reversed.

Table 3 reports the price and quantity results. $\Delta P_j^k - \Delta P_j^*$ is the outcome variable in Panel A, and $\Delta Q_j^k - \Delta Q_j^*$ is the outcome variable in Panel B. The data are pooled across 25 industries, and robust standard errors are clustered by country. In each panel, the test of the endogeneity of PRs changes rejects the null hypothesis that ΔPR_j is exogenous at 5 percent level of significance. Thus, in contrast with the result in Table 2, the OLS estimator is inconsistent in Table 3.

The 2SLS estimation results indicate that the coefficient on PRs changes equals 11.493 for the price component and -10.966 for the quantity component. These estimates are statistically significant at 7 percent and 10 percent levels respectively. The estimates imply that for each 1 percent increase in the developing countries' index of PRs, the unit prices of U.S. exports in patent-relying industries increased by 11.493 percent and quantities fell by 10.966 percent (relative to the comparison industry group).

Table 3—**The price and quantity components**

Panel A: Unit price relative growth	OLS		2SLS	
PRs changes	2.749	(4.612)	11.493*	(6.317)
Constant	0.008	(0.164)	-0.303	(0.192)
Industry fixed effects (n=24)	Yes		Yes	
Number of observations	1213		1213	
R^2	0.013			
First-stage robust $F(1,63)$	48.53 (p-value=0.00)			
Test of endogeneity robust $F(1,63)$	4.23 (p-value=0.04)			
Panel B: Quantity relative growth	OLS		2SLS	
PRs changes	-1.917	(4.664)	-10.966*	(6.515)
Constant	-0.087	(0.168)	0.235	(0.201)
Industry fixed effects (n=24)	Yes		Yes	
Number of observations	1213		1213	
R^2	0.01			
First-stage robust $F(1,63)$	48.53 (p-value=0.00)			
Test of endogeneity robust $F(1,63)$	4.19 (p-value=0.04)			

Note: * denotes 10 percent significance level. Robust standard errors clustered by country (64 clusters) are in parentheses. In Panel A, *Unit price relative growth* ($\Delta P_j^k - \Delta P_j^*$) is the outcome variable, computed as the average annual log change in the price index in industry k relative to the average annual log change in the price index in the comparison group. In Panel B, *Quantity relative growth* ($\Delta Q_j^k - \Delta Q_j^*$) is the outcome variable, computed as the average annual log change in the quantity index in industry k relative to the average annual log change in the quantity index in the comparison group. All averages are taken over the 1990-2000 period. Robust F statistics are adjusted for 64 clusters. Test of endogeneity: changes in PRs are exogenous under H_0.

It appears from Tables 2 and 3 that the impact of PRs changes on unit prices is approximately 15.18 times larger than on export variety. At the same time, the sample standard deviation in $(\Delta P_j^k - \Delta P_j^*)$ is approximately 6.02 times larger than in $(\Delta EM_j^k - \Delta EM_j^*)$ and hence, one point log change in the price component is less important than one point log change in the variety component. To make the comparison more apparent, I computed the standardized coefficients on ΔPR_j. These coefficients are reported in Table 4. For completeness, Table 4 also reports the impact of PRs changes on overall export growth and the intensive margin. In the following discussion and Tables, I report the OLS estimates only if the null hypothesis that ΔPR_j is exogenous cannot be rejected at 5 percent level of significance; otherwise, the 2SLS estimates are reported. The standardized coefficients indicate that for each one for each 1 percent increase in ΔPR_j, the variety of U.S. exports increased by 5.152 standard deviations and the unit prices increased by 12.999 standard deviations (in relative terms). Thus the impact on unit prices is still larger, but now only 2.52 times larger.

The PRs data indicate that non-colonies increased their PRs by 7.8 percent per year on average over the 1990-2000 period. As a result, the annual value of U.S. exports in industries that rely most heavily on patent protection increased by 7.87 percent (i.e., 7.8×1.009). About 75 percent of this increase in exports was driven by an expansion in the set of categories exported. New products increased exports by 5.9 percent (i.e., 7.8×0.757). The remaining 25 percent of the increase in overall exports was driven by an increase in the value of existing U.S. exports. The quantities of already exported products fell as their unit prices rose. This increase in unit prices may be attributable to quality upgrading within product categories, or increased mark-ups above marginal costs, or both, but it is difficult to measure which of the two factors is playing the larger role.

TABLE 4—**Summary of export decomposition**

Relative growth in	Coefficient		Standardized Coefficient		Obs.
	OLS	2SLS	OLS	2SLS	
Overall exports	1.009** (0.383)		5.859		1293
Extensive margin	0.757*** (0.255)		5.152		1293
Intensive margin	0.252 (0.490)		1.470		1293
Unit prices		11.493* (6.317)		12.999	1213
Quantities		-10.966* (6.515)		11.898	1213

Note: See the notes to Tables 2 and 3. *Overall exports relative growth* $(\Delta X_j^k - \Delta X_j^*)$ is the outcome variable, computed as the average annual log change in the exports of industry k relative to the average annual log change in the exports of the comparison group over the 1990-2000 period. *Intensive margin relative growth* $(\Delta IM_j^k - \Delta IM_j^*)$ is the outcome variable, computed as the average annual log change in the IM of industry k relative to the average annual log change in the IM of the comparison group. The standardized coefficients equal β/σ, where σ is the sample standard deviation of the outcome variable. The data on sample standard deviations of the outcome variables are reported in Appendix C.

In terms of dollar value, new products exported in response to the strengthening of non-colonies' PRs during the 1990-2000 period added about $5.7 billion (1990 US dollars) to patent-relying U.S. exports into 24 non-colonies.[33] Across developing countries, the impact of strengthening PRs is most pronounced among non-colonies. These are the countries which had weak PRs in 1990, with substantial room for improvement, but managed to sufficiently improve their PRs over the course of 10 years so as compensate for the initially weak levels.[34]

[33]Non-colonies increased their PRs by 78 percent over the 1990-2000 period. The total of patent-relying U.S. exports into these countries was $9.7 billion in 1990.

[34]The coefficient on ΔPR_j, which is measured as the growth rate, also indicates that the effect of a given unit increase in the PRs index is higher for countries that started from a low level of PRs in 1990. I thank anonymous referee for drawing my attention to this point.

V. Sensitivity Analysis

To reinforce the results described in the previous section, I now examine the sensitivity of the results to my industry grouping, choice of time interval, and the list of countries.

A. Industries

In this section, the impact of PRs is allowed to vary across industries in the treatment industry group. Let the *individual* industry response be given by $b^k = \gamma \ln E^k$, where E^k is the effectiveness of patents in industry k. Similarly, $b^* = \gamma \ln E^*$ for the comparison industry group, where E^* is the average effectiveness of patents across six industries in the comparison industry group. It follows that $\beta^k = \gamma \ln(E^k/E^*)$ and (14) can be rewritten as follows:

$$
\begin{aligned}
\Delta EM_j^k - \Delta EM_j^* &= \beta_0 + \gamma \ln(E^k/E^*)\Delta PR_j + S^k + \epsilon_j^k; \\
\Delta P_j^k - \Delta P_j^* &= \beta_0 + \gamma \ln(E^k/E^*)\Delta PR_j + S^k + \epsilon_j^k; \\
\Delta Q_j^k - \Delta Q_j^* &= \beta_0 + \gamma \ln(E^k/E^*)\Delta PR_j + S^k + \epsilon_j^k;
\end{aligned} \tag{15}
$$

where $E^k > E^*$ since patent effectiveness is the lowest in the comparison group.[35] Using the data on patent effectiveness documented in Appendix B, I estimate γ. If $\gamma > 0$, the individual industry impact b^k is increasing in E^k; otherwise, it is decreasing in E^k. Table 5 shows the results.

Table 5—**Effectiveness and PRs**

Relative growth in:	Variety		Unit Prices		Quantities	
	OLS	St.Er.	2SLS	St.Er.	2SLS	St.Er.
Effectiveness×PRs changes	1.201***	(0.443)	22.681*	(12.525)	-21.729*	(12.925)
Constant	-0.193***	(0.021)	-0.199	(0.149)	0.137	(0.156)
Industry fixed effects (n=21)	Yes		Yes		Yes	
Number of observations	1126		1048		1048	
First-stage robust $F(1{,}62)$	44.74 (p=0.00)		49.09 (p=0.00)		49.09 (p=0.00)	
Test of endogen. robust $F(1{,}62)$	3.03 (p=0.09)		4.63 (p=0.04)		4.60 (p=0.04)	

Note: See the notes to Tables 2 and 3. Effectiveness×PRs changes is measured as $\ln(E^k/E^*)\Delta PR_j$, where $E^* = 22.57$ is the score of patent effectiveness averaged across six industries in the comparison industry group. Each model has 63 clusters, since the data in the 22 industries considered here are missing for Sudan in the year 2000.

It is apparent that γ is positive for the relative growth in variety and unit prices, but negative for the relative growth in quantity. The results thus confirm the previous finding that industries that rely more on patent protection experience faster growth in export variety and unit prices and slower growth in export quantity when PRs are strengthened. It is also apparent that all coefficients γ in Table 5 are larger than the respective coefficients in Tables 2 and 3. For the variety component, for example, the coefficient on PRs changes equals 0.757 in Table 2, while the coefficient on PRs changes interacted with patent effectiveness equals 1.201 in Table 5. The comparison of the results thus indicates that the impact of PRs is magnified when industries'

[35]For three industries (i.e., Textiles, Food Products, and Publishing and Printing), patent effectiveness is lower than the average patent effectiveness in the comparison group, i.e., $E^k < E^*$. Despite their low patent effectiveness, these industries are not included in the comparison group because they are covered by other categories of intellectual property rights correlated with patent rights (as detailed in footnote 21). While these three industries are analyzed in the rest of the paper, they are excluded from the analysis in Section V.A. because they do not meet the required condition (i.e., $E^k > E^*$).

patent effectiveness (relative to the average patent effectiveness in the comparison group) is accounted for.[36]

Table 6—**Individual industries**

Relative growth in:	Variety		Unit Prices		Quantities	
	2SLS	St.Er.	2SLS	St.Er.	2SLS	St.Er.
Medical & Surgical Equipment	0.336	(0.733)	15.361	(10.003)	-16.262	(10.392)
Pharmaceuticals & Medicinals	1.890**	(0.850)	14.048	(9.146)	-14.364	(9.596)
Special Purpose Machinery	3.416***	(1.232)	14.970*	(7.883)	-14.407*	(8.206)
Autoparts	4.612***	(1.534)	15.485	(9.702)	-16.526	(10.308)
Office & computing machinery	1.051	(1.381)	18.341	(12.490)	-18.957	(13.469)
Miscellaneous Chemicals	-0.302	(1.162)	19.369*	(10.736)	-15.714	(10.874)
Fabricated Metal Products	0.981	(1.351)	19.307*	(10.303)	-17.816*	(10.697)
Car & Truck	0.749	(1.175)	23.517**	(11.589)	-21.543*	(11.938)
Basic Chemicals	1.323	(2.002)	24.039*	(12.486)	-25.041*	(13.122)
General Purpose Machinery	3.863***	(1.451)	20.114*	(11.226)	-19.824*	(11.583)
TV & Radio Receivers	0.214	(1.441)	27.334*	(13.998)	-25.138*	(14.248)
Other Chemical Products	2.284*	(1.206)	19.597	(12.016)	-16.316	(12.434)
Paper & Paper Products	2.509	(1.770)	21.343*	(11.555)	-20.044*	(12.005)
Machine Tools	0.445	(1.304)	25.466**	(12.769)	-23.942*	(13.440)
Electrical Machinery	1.440	(1.413)	27.983*	(15.024)	-21.158	(15.130)
Petroleum	3.162	(2.723)	30.152	(22.250)	-30.237	(23.029)
Plastic Resins	5.137***	(1.840)	25.075	(16.581)	-23.192	(17.354)
Aerospace	2.943	(1.863)	29.802*	(15.742)	-33.693**	(16.616)
Rubber & Plastics Products	4.141**	(1.907)	31.512*	(16.170)	-29.748*	(16.588)
Glass	1.086	(2.021)	38.657*	(22.011)	-39.257*	(23.711)
Concrete, Cement, & Plaster	3.759	(2.550)	26.831	(35.398)	-30.776	(37.006)
Precision Instruments	21.072**	(8.547)	99.629**	(46.631)	-93.132*	(48.184)
Constant	-0.216***	(0.039)	-0.294	(0.188)	0.297	(0.203)
Industry fixed effects (n=21)	Yes		Yes		Yes	
Number of observations	1126		1048		1048	
Test of endogen. robust $F(22,62)$	1.92	(p=.02)	1.79	(p=.04)	2.45	(p=.00)

Note: See the notes to Tables 2 and 3. Each model has 63 clusters, since the data in the 22 industries considered here are missing for Sudan in the year 2000.

To allow for a difference in the impact of PRs across industries, I interact 21 industry indicator variables with $\ln(E^k/E^*)\Delta PR_j$ and estimate the following specifications:

$$\begin{aligned} \Delta EM_j^k - \Delta EM_j^* &= \beta_0 + \gamma^k I^k \ln(E^k/E^*)\Delta PR_j + S^k + \epsilon_j^k; \\ \Delta P_j^k - \Delta P_j^* &= \beta_0 + \gamma^k I^k \ln(E^k/E^*)\Delta PR_j + S^k + \epsilon_j^k; \\ \Delta Q_j^k - \Delta Q_j^* &= \beta_0 + \gamma^k I^k \ln(E^k/E^*)\Delta PR_j + S^k + \epsilon_j^k; \end{aligned} \tag{16}$$

where I^k is a vector of industry indicator variables and γ^k measures the industry-specific impacts

[36]If both ΔPR_j and $\ln(E^k/E^*)\Delta PR_j$ are included in (15), then the coefficient on ΔPR_j is positive and significant and the coefficient on $\ln(E^k/E^*)\Delta PR_j$ is insignificant in all three specifications (variety, price, and quantity). This finding implies that once the cross-country variation in U.S. relative export growth is explained by the changes in PRs, additional variation in relative patent effectiveness across patent-relying industries within a country group does not help explain export growth.

of strengthening PRs. The results are reported in Table 6, where industries are ranked by patent effectiveness. It is apparent that the direction of the impact of stronger PRs on export components is not skewed by grouping of industries, as even at the industry-level the results persist. Across a wide range of industries, U.S. export variety rose while quantity and unit prices fell in response to the strengthening of PRs. It is apparent that industries were affected differently. The variety expansion, for example, is primarily observed in Pharmaceuticals and Medicinals, Special Purpose Machinery, General Purpose Machinery, Plastic Resins, Rubber and Plastics Products, and Precision Instruments.

B. Time

In the previous sections, PRs chnages over the 1990-2000 period were related to the changes in export components over the same period. In this section, I investigate whether the impact of the PRs strengthening changes over time. I redefine the outcome variable as the average annual growth rate of an export component over the 1990-2006 period and re-estimate (14). The new results, reported in Table (7), confirm the previous findings of positive differential impact on variety and unit prices and negative differential impact on quantity. The results also suggest that the impact of strengthened PRs on product variety is short-lived, since the coefficient on PRs change is smaller for the longer period. The impact of strengthened PRs on unit prices and quantities is also reduced over time, but the precision of the coefficients rises.

Table 7—**Time period**

Relative growth in:	Variety		Unit Prices		Quantities	
	OLS	St.Er.	2SLS	St.Er.	2SLS	St.Er.
1990-2000	0.757***	(0.412)	11.493*	(6.317)	-10.966*	(6.515)
1990-2006	0.344*	(0.177)	7.773**	(3.476)	-7.079**	(3.503)

Note: See the notes to Tables 2 and 3. In the first row, the average annual log change in a given export component is taken over the 1990-2000 period. In the second row, the average annual log change in a given export component is taken over the 1990-2006 period. In the variety model, the null hypothesis that ΔPR_j is exogenous cannot be rejected at 10 percent level of significance. In the price and quantity models, the null hypothesis that ΔPR_j is exogenous is rejected at 5 percent level of significance.

C. Countries

In the previous sections, PRs changes in 64 developing countries were examined. This sample of countries excludes the NICs to ease concerns that PRs changes in these countries (the majority of which are non-colonies) were determined as a function of U.S. export growth in patent-relying industries.[37] In this section, I seek to verify that the results are not unduly influenced by my choice of country sample. I first perform the following sensitivity test. I further modify my country sample to exclude six countries that were reportedly influenced by the USTR's intervention—namely Argentina, Chile, Ecuador, Egypt, Indonesia, and Jamaica—and then check the sensitivity of my results to the exclusion of these countries.[38] Table (8) presents

[37] See Section I.A. for details.

[38] All the excluded countries but Egypt and Jamaica are non-colonies. Indonesia signed a bilateral copyright agreement with the U.S. in 1989, enacted its first patent law in 1991, and was carrying out "important elements of the 1992 understanding" with the U.S. when it was implementing regulations for its patent law in 1994 (Source: 1994 Special 301 Report, Office of the USTR). Next, Ecuador and Jamaica signed comprehensive bilateral intellectual property agreements with the U.S. in 1993 and 1994 respectively. Chile's progress in strengthening its PRs was closely monitored by the U.S. to ensure conformity of the new laws with NAFTA. Finally, Argentina and Egypt were the only two countries from my sample that were put on the "Priority Watch List" of the Special 301 report in before 1994.

the results, with the previous findings from the full sample of countries reproduced in the first row and the restricted sample of 58 countries considered in the second. As can be seen, the coefficients are of similar magnitude.[39] While the impact on variety is less precisely estimated, the precision of the impact on unit prices and quantities is noticeably higher.

TABLE 8—**Countries**

Relative growth in:	Variety		Unit Prices		Quantities	
	OLS	St.Er.	2SLS	St.Er.	2SLS	St.Er.
64 countries	0.757***	(0.412)	11.493*	(6.317)	-10.966*	(6.515)
58 countries	0.749**	(0.293)	10.780***	(3.394)	-10.012***	(3.597)

Note: See the notes to tables 2 and 3. The sample of 58 countries includes 20 non-colonies. In the variety model, the null hypothesis that ΔPR_j is exogenous cannot be rejected at 10 percent level of significance. In the price and quantity models, the null hypothesis that ΔPR_j is exogenous is rejected at 5 percent level of significance.

How justified are the concerns that PRs changes in the NICs were influenced by U.S. relative growth in patent-relying industries? To shed light on this question, I examine whether the impact of PRs changes on U.S. relative export growth differs across the NICs and the other developing countries in my sample. The instrumental variable method does not allow consistent estimation of this differential impact since the number of NICs is small. I therefore focus on the variety component model, for which the OLS estimator is consistent, and estimate the following specification:

$$\Delta EM_j^k - \Delta EM_j^* = \beta_0 + \beta_1^k \Delta PR_j + \beta_2^k \Delta PR_j \times NIC + \beta_3 NIC + S^k + \epsilon_j^k, \tag{17}$$

where NIC is the indicator variables for the 8 newly industrialized developing countries and $\Delta PR_j \times NIC$ is its interaction term with PRs changes.

TABLE 9—**The NICs**

Relative growth in variety	Column 1		Column 2	
	OLS	St.Er.	OLS	St.Er.
PRs changes	0.477**	(0.191)	0.495**	(0.199)
PRs changes×NICs	0.362**	(0.149)	-0.204	(0.252)
NICs			0.030*	(0.016)
Constant	-0.167***	(0.019)	-0.168***	(0.019)
Industry fixed effects (n=24)	Yes		Yes	
Number of observations	1492		1492	
R^2	0.16		0.16	

Note: ***, **, and * denote 1, 5, and 10 percent significance level respectively. Robust standard errors clustered by country (72 clusters) are in parentheses. *EM relative growth* ($\Delta EM_j^k - \Delta EM_j^*$) is the outcome variable.

[39]This is in line with the findings in Lee G. Branstetter, Raymond Fisman, and C. Fritz Foley (2006) that the timing of patent reforms is not correlated with U.S. pressure, as measured by the placement of a country on the 301 Report.

VI. Conclusion

This paper analyzed the trade impact of PRs in terms of variety, price and quantity components by estimating the response of U.S. exports to the strengthening of PRs in 64 developing countries from 1990 to 2000. While the practical implications of these issues has been recognized for more than 20 years, our lack of understanding of these matters persists, as does the international debate over the advantages and disadvantages of strengthening PRs in developing countries. Several studies have measured the impact of PRs on the value of trade, but it remains unclear whether that impact is driven by changes in prices, quantities, or new products.

The individual components of exports were analyzed using U.S. export data organized by 10-digit product categories. An instrumental variable approach in which colonial origin was used to explain changes in developing countries' PRs was implemented. Twenty-four developing countries which were not colonized by Britain or France are classified as treated, while forty developing countries formerly colonized by Britain or France are non-treated. To control for unobserved measures of exports correlated with colonial origin, the growth rate of an export component in a given industry was measured relative to that in the group of industries with the lowest patent effectiveness. The approach was designed to address potential endogeneity bias due to systematic measurement errors, confounding factors, and reverse causality.

The findings indicate that the strengthening of PRs in developing countries under the TRIPs agreement increased the value of U.S. exports in industries that rely most heavily on patent protection by 7.87 percent. About 75 percent of this increase in exports was driven by an expansion in product variety. The quantities of already exported products fell and their unit prices rose. Patent-relying U.S. exports into the average developing country increased by $317 million (1990 US dollars), totalling a remarkable $7.6 billion (1990 US dollars) of additional patent-relying U.S. exports to 24 patent-reforming countries over the 1990-2000 period. This is an economically large effect, and its positive impact on trade flows is dominating. The strengthening of PRs affected industries differently, with the strongest impact observed in industries which rely most on patent protection. The impact of PRs is most pronounced among countries which had weak PRs in 1990, but managed to sufficiently improve their PRs by 2000 so as to compensate for the initially weak levels.

The potential increase in product prices and corresponding decrease in unit sales have been repeatedly recognized as the most troubling aspects of developing countries adopting and expanding strong intellectual property rights. While the results of this paper do not rule out these effects, they indicate that developing countries' access to high-tech products may rise as the variety of products imported from the U.S. expands in response to strengthening PRs. Due to this expansion in export variety, developing countries' overall imports from the U.S. also rise. The results also confirm the importance of breaking down the trade impact of PRs into individual components. If the impact of PRs was measured only in terms of overall export value, the role of PRs in encouraging exports of new products would have been underestimated and the contraction in the quantity of products exported already would have not been observed.

Appendix

A. Country Groups

Formerly colonized by Britain or France (40)			Not colonized by Britain or France (24)	
Algeria	Guyana	Nigeria	Angola	Honduras
Bangladesh	Haiti	Senegal	Argentina	Indonesia
Benin	Ivory Coast	Sierra Leone	Bolivia	Mozambique
Burkina Faso	Jamaica	Somalia	Burundi	Nepal
Burma	Jordan	Sri Lanka	Chile	Nicaragua
Cameroon	Kenya	Sudan	Colombia	Panama
Central African Rep.	Madagascar	Syria	Congo Dem. Rep.	Papua New Guinea
Chad	Malawi	Tanzania	Costa Rica	Paraguay
Congo Rep.	Mali	Togo	Ecuador	Peru
Dominican Rep.	Mauritania	Tunisia	El Salvador	Rwanda
Egypt	Mauritius	Uganda	Ethiopia	Uruguay
Fiji	Morocco	Zambia	Guatemala	Venezuela
Gabon	Niger	Zimbabwe		
Ghana				

Notes: Data for colonization origin is taken from the CIA World Factbook: `https://www.cia.gov/library/publications/the-world-factbook/index.html`.

ISIC rev.3 (1)	Manufacturing industries (2)	Patent effectiv. (3)	Number. of categ. (4)	Growth in the number of categ.		
				Total (5)	Non-colon. (6)	Colonies (7)
3311	Medical & Surgical Equipment	54.70	53	0.0	0.0	6.0
2423	Pharmaceuticals, Medicinal Chemicals, & Botanical Products	50.20	138	-1.5	-1.6	0.0
2920	Special Purpose Machinery	48.83	393	0.0	0.3	6.2
3430	Autoparts	44.35	32	0.0	0.0	14.3
3010	Office, Accounting & Computing Machinery	41.00	17	0.0	0.0	6.3
2429	Miscellaneous Chemicals	39.66	118	1.7	1.7	4.7
2800	Fabricated Metal Products	39.43	279	0.4	0.4	14.0
3410	Car & Truck	38.89	53	-1.9	-1.9	2.0
2411	Basic Chemicals	38.86	585	0.7	1.1	7.4
2910	General Purpose Machinery	38.78	333	1.5	1.5	8.3
3230	TV & Radio Receivers, Sound & Video Reprod. Apparatus	38.75	34	-5.9	-5.9	0.0
2400	Other Chemical Products	37.46	119	1.7	1.7	8.0
2100	Paper & Paper Products	36.94	147	1.4	0.7	7.9
2922	Machine Tools	36.00	230	3.6	5.5	9.2
3100	Electrical Machinery & Apparatus	34.55	149	0.0	0.0	7.2
2320	Petroleum	33.33	14	0.0	0.0	-7.1
2413	Plastics in Primary Forms & of Synthetic Rubber	32.96	80	0.0	0.0	-4.0
3530	Aerospace	32.92	67	1.7	3.7	-4.0
2500	Rubber & Plastics Products	32.71	156	1.3	2.0	3.4
2610	Glass	30.83	68	0.0	3.1	15.8
2695	Concrete, Cement, & Plaster	30 12	0.0	0.0	9.1	-9.1
3312	Precision Instruments	25.86	112	0.9	1.8	5.8
3220	**Communications Equipment**	25.74	11	0.0	0.0	0.0
3110	**Electric Motors, Generators, Transformers**	25.23	82	1.2	1.2	9.5
2710	**Basic Iron and Steel**	22.00	217	1.5	3.1	12.7
3210	**Electronic Components**	21.35	85	2.5	2.6	32.1
2600	**Non-metallic Minerals**	21.11	99	1.0	1.1	3.4
1700	Textiles	20.00	712	6.4	8.8	3.2
2700	**Basic Metals**	20.00	201	10.6	9.6	25.6
1500	Food Products	18.26	109	0.0	2.3	5.3
2200	Publishing & Printing	12.08	45	-2.2	-4.4	4.9

Notes: **In bold**: industries in the comparison group. The Communications Equipment industry contains television and radio transmitters and apparatus for line telephony and line telegraphy. *Column* (3): Patent effectiveness is defined as a mean percentage of product innovation for which patenting has been effective in protecting the "firm's competitive advantage from those innovations." Source: Wesley M. Cohen, Richard R. Nelson, and John P. Walsh (2000). *Column* (4): Number of categories is the number of distinct HS codes within a given ISIC code over the 1990-2006 period. *Column* (5): Growth (%) in the total number of categories in 1990-2006. *Column* (6): Growth (%) in the number of categories exported into non-colonies in 1990-2006. *Column* (7): Growth (%) in the number of categories exported into colonies in 1990-2006.

C. The Outcome Variable

The relative growth in	Obs.	Mean	St. deviation	Min	Max
Overall Exports	1293	-.0192869	.1722277	-.6374803	.7506918
Extensive Margin	1293	-.0769573	.1469316	-.8781295	.7204171
Intensive Margin	1293	.0576704	.1714288	-.611806	.7442099
Unit Prices	1213	.1276374	.8841372	-1.959996	4.120159
Quantities	1213	-.1246519	.9216348	-4.511651	2.078837
Non-colonies					
Overall Exports	525	-.000394	.1456723	-.53804	.7506918
Extensive Margin	525	-.0429843	.1034007	-.5700403	.4523145
Intensive Margin	525	.0425904	.1511326	-.5712678	.7442099
Unit Prices	505	.4301053	1.080977	-1.86321	4.120159
Quantities	505	-.4140671	1.123417	-4.511651	2.078837
Colonies					
Overall Exports	768	-.032202	.1872355	-.6374803	.7345546
Extensive Margin	768	-.100181	.1665286	-.8781295	.7204171
Intensive Margin	768	.0679789	.1834032	-.611806	.7215409
Unit Prices	708	-.088106	.6285682	-1.959996	1.896579
Quantities	708	.0817812	.6737489	-2.001561	2.014115

REFERENCES:

Blind, Knut, Jakob Edler, Rainer Frietsch, and Ulrich Schmoch. 2006. "Motives to patent: Empirical evidence from Germany." *Research Policy*, 35(5): 655-672.

Branstetter, Lee G., Raymond Fisman, and C. Fritz Foley. 2006. "Do Stronger Intellectual Property Rights Increase International Technology Transfer? Empirical Evidence from US Firm-Level Panel Data." *Quarterly Journal of Economics*, 121(1): 321-349.

Chin, Judith C., and Gene M. Grossman. 1990. "Intellectual property rights and North-South trade." In *The Political Economy of International Trade: Essays in Honor of Robert E. Baldwin*, ed. Ronald W. Jones and Anne O. Krueger, 90-107. Oxford: Basil Blackwell.

Co, Catherine Y. 2004. "Do Patent Rights Regimes Matter?" *Review of International Economics*, 12(3): 359-373.

Cohen, Wesley M., Richard R. Nelson, and John P. Walsh. 2000. "Protecting their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)." NBER Working Paper 7552.

Deardorff, Alan V. 1992. "Welfare effects of global patent protection." *Economica*, 59(233): 35-51.

Diwan, Ishac, and Dani Rodrik. 1991. "Patents, Appropriate Technology, and North-South Trade." *Journal of International Economics*, 30(1-2): 27-47.

Falvey, Rod, Neil Foster, and David Greenaway. 2009. "Trade, imitative ability and intellectual property rights." *Review of World Economics (Weltwirtschaftliches Archiv)*, 145(3): 373-404.

Feenstra, Robert C., and Hiau Looi Kee. 2004 "On the Measurement of Product Variety in Trade." *American Economic Review*, 94(2): 145-149.

Feenstra, Robert C., John Romalis, and Peter K. Schott. 2002. "U.S. Imports, Exports, and Tariff Data, 1989-2001." NBER Working Paper 9387.

Ferrantino, Michael J. 1993. "The Effect of Intellectual Property Rights on International Trade and Investment." *Weltwirtschaftliches Archiv*, 129: 300-333.

Fink, Carsten, and Carlos A. Primo Braga. 1999. "How Stronger Protection of Intellectual Property Rights Affects International Trade Flows." Policy Research Working Paper Series 2051, The World Bank.

Ginarte, Juan C., and Walter G. Park. 1997. "Determinants of Patent Rights: A Cross-national Study." *Research Policy*, 26(3): 283-301.

Glass, Amy Jocelyn, and Kamal Saggi. 2002. "Intellectual Property Rights and Foreign Direct Investment." *Journal of International Economics*, 56(2): 387-410.

Glass, Amy Jocelyn, and Xiaodong Wu. 2007. "Intellectual property rights and quality improvement." *Journal of Development Economics*, 82(2): 393-415.

Helpman, Elhanan. 1993. "Innovation, Imitation, and Intellectual Property Rights." *Econometrica*, 61(6): 1247-1280.

Hummels, David, and Peter J. Klenow. 2005. "The Variety and Quality of a Nation's Exports." *American Economic Review*, 95(3): 704-723.

Ivus, Olena. 2010. "Do Stronger Patent Rights Raise High-Tech Exports to the Developing World?" *Journal of International Economics*, 81(1): 38-47.

Ivus, Olena. 2011. "Trade-Related Intellectual Property Rights: Industry Variation and Technology Diffusion." *Canadian Journal of Economics*, 44(1): 201-226.

Lai, Edwin L.-C. 1998. "International Intellectual Property Rights Protection and the Rate of Product Innovation." *Journal of Development Economics*, 55(1): 133-153.

Keenan, Michael, Saritas, Ozcan, and Kroener, Inga 2004. "A Dying Industry - Or Not? The Future of the European Textiles and Clothing Industry." *Foresight - The journal of future studies, strategic thinking and policy*, 6(5): 313-322.

Maskus, Keith E. 2006. "Intellectual Property Rights in Agriculture and the Interests of Asian-Pacific Economies." *The World Economy*, 29(6): 715-742.

Maskus, Keith E. 2000. *Intellectual Property Rights in the Global Economy.* Institute for International Economics, Washington, DC.

Maskus, Keith E., and Mohan Penubarti. 1997. "Patents and International Trade: An Empirical Study." In *Quiet Pioneering: Robert M. Stern and His International Economic Legacy*, ed. Keith Maskus, Peter M. Holland, Edward E. Leamer, and J. David Richardson, 95-118. University of Michigan Press, Ann Arbor, MI.

Park, Walter G. 2008. "International patent protection: 1960-2005." *Research Policy*, 37: 761-766.

Park, Walter G., and Douglas C. Lippoldt 2008. "Transfer and the Economic Implications of the Strengthening of Intellectual Property Rights in Developing Countries." *OECD Trade Policy Working Papers*, 62.

Pierce, Justin R., and Peter K. Schott 2011. "Concording U.S. Harmonized System Catogories Over Time." *Journal of Official Statistics*, forthcoming.

Rafiquzzaman, Mohammed. 2002. "Impact of Patent Rights on International Trade: Evidence from Canada." *Canadian Journal of Economics*, 35(2): 307-330.

Smith, Pamela J. 1999. "Are Weak Patent Rights a Barrier to U.S. Exports?" *Journal of International Economics*, 48(1): 151-177.

Smith, Pamela J. 2001. "How Do Foreign Patent Rights Affect U.S. Exports, Affiliate Sales, and Licenses?" *Journal of International Economics*, 55: 411-439.

Stegemann, Klaus. 2000. "The Integration of Intellectual Property Rights into the WTO System." *The World Economy*, 23(9): 1237-1267.

Stock, James H., Jonathan Wright, and Motohiro Yogo. 2002. "A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments." *Journal of Business & Economic Statistics*, 20(4): 518-29.

Taylor, M. Scott. 1993. "TRIPS, Trade, and Technology Transfer." *Canadian Journal of Economics*, 26(3): 625-638.

Taylor, M. Scott. 1994. "TRIPS, Trade, and Growth." *International Economic Review*, 35(2): 361-382.

Yang, Guifang, and Keith E. Maskus. 2001. "Intellectual property rights, licensing, and innovation in an endogenous product-cycle model." *Journal of International Economics*, 53(1): 169-187.