The Impacts of Post-TRIPS Patent Reforms on the Structure of Exports

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Abstract

Implementation of the TRIPS Agreement in the WTO ushered in a period of major reforms in patent laws. We study the effects of reforms in the legal scope of patent rights (PRs) on the international pattern of sectoral exports. Adopting a generalized factor-proportions framework, we interact a measure of patent intensity across industries with national variables capturing the strength of PRs. We find that, conditional on factor endowments and intensities, a country with stronger PRs tends to have greater exports to the United States in patent-intensive sectors. These effects are significantly positive throughout the sample but are considerably larger in the post-TRIPS era. Further, the impacts are greater in developed countries than in developing countries, and in high-technology industries in comparison with low-technology industries. There is also evidence that changes over time in national PRs positively affect growth in exports. These results hold even after controlling for alternative determinants of international trade and correcting for endogeneity.

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1. Introduction

The period since 1990 has seen major reforms in patent laws throughout much of the developing world, because of both emerging domestic commercial interests in protecting innovation and the demands of technologically advanced nations for stronger protection in their export markets (Maskus, 2012). The primary vehicle carrying the latter process is the TRIPS Agreement at the World Trade Organization, which required significant changes in minimum patent norms, especially in developing countries. The ultimate impacts of this change on such elements as access to affordable medicines, the costs of reverse engineering, and the prospects for technology transfer remain controversial.

One central analytical question is how these changes might affect the pattern and volume of trade among countries. Indeed, a much-studied issue is whether cross-country variations in the strength of patent rights (PRs) have impacts on international trade. Since the initial paper by Maskus and Penubarti (1995), several authors have investigated this question, using various measures of PRs. Among the more prominent are Smith (1999, 2001), Co (2004) and Park and Lippoldt (2003). Most recently, Ivus (2010) found convincing evidence that patent reforms required in 18 developing countries by the TRIPS Agreement significantly raised imports of high-technology products from developed countries to these reforming nations.

All of this literature considers the impacts of domestic patent reforms on merchandise imports, arguing that such reforms should alter the demand for imported goods and technologies. However, it misses the important point that strengthening PRs has the potential to expand export capacity in developing countries that can absorb and even improve upon inflows of technical information (Yang and Maskus, 2009; He and Maskus, 2012). The essential reason is that patent reforms should expand inward technology transfer via trade and foreign direct investment (FDI), a proposition with considerable empirical support (Branstetter, et al, 2006). In turn, countries undertaking reform should achieve greater export capacity after some adjustment period, at least to the extent that the productivity of domestic firms and subsidiaries expands. Indeed, Branstetter, et al (2011) find evidence in detailed U.S. import data that countries increase the number of categories in which they export in the years after a basic patent reform. However, this question has not been investigated systematically in the empirical literature.

Thus, we study this issue by adapting the empirical approach pioneered by Romalis (2004), in which bilateral exports at the industry level are a function of industry factor intensities and interactions between factor intensities and exporter factor endowments. Our innovation is to consider the degree of patent rights to be an institutional "endowment" in the same manner as Nunn's (2007) interpretation of a country's contracting environment and Essaji's (2008) use of the extent of technical regulations governing product quality. We interact these PRs with a measure of industry patent intensity to investigate their contribution to sectoral specialization and export performance.

In this framework it is possible to examine whether countries with stronger patent rights export more in patent-intensive industries and whether changes in those

PRs over time have detectable impacts on sectoral export growth. We correct for the possibility of omitted-variable bias by including alternative determinants of the pattern of specialization. We also correct for the potential reverse causality from exports to PRs with instrumental variables and also an analysis of matched country pairs. Further, PRs may have different impacts on domestic innovation and technology transfer in developed countries than in developing countries. Accordingly, we examine the pattern of effects on trade among nations broken into these two groups. We also explore whether stronger PRs have differential impacts on exports in high-technology and medium-technology industries in relation to low-technology industries. Finally, we estimate the basic specification in first differences to see if countries with relatively larger growth in PRs experienced relatively greater expansion in exports in patent-intensive goods.

The empirical evidence we unearth broadly confirms our expectations. We find with both IV estimation and matched country pairs that stronger patent rights boost exports. Moreover, the effects of stronger PRs on exports in patent-intensive sectors are larger in developed countries than in developing countries, though significantly positive in both groups. Next, strengthening patent rights strongly encourages export specialization in high-technology industries. Last, there is evidence that countries adopting greater patent reforms over time registered larger export growth.

This paper contributes to the literature by establishing an empirical linkage between legal patent rights, sectoral patent intensity and export performance. Our work departs from previous studies in three ways. First, as noted above, prior literature has not addressed the impacts of domestic patent reforms on export performance and we offer the first systematic empirical evidence about this linkage. Second, we apply an augmented factor-proportions model, which permits studying the impact of stronger PRs on the pattern of exports by combining country characteristics and industry characteristics. Third, we find that stronger PRs have different implications for exports from developed and developing countries, while further varying between high-technology and low-technology industries.

2. Analytical Background

Patent rights are an important subject for study due to their potential effects on innovation and technology transfer, which affect prospects for economic development. At a general level, Hall and Jones (1999) argue that differences in social infrastructure across countries cause large differences in capital accumulation, educational attainment and productivity. More specifically, PRs are society's legal means of providing exclusivity rents to inventors as compensation for their investment, making such laws a form of institutional endowment.

One channel through which patents affect development is inward technology transfer, which can arrive via trade, foreign direct investment, and licensing. The basic idea stems from Vernon’s (1966) explication of the product life cycle. A series of theoretical papers in various analytical frameworks have sharpened this notion. For example, in a North-South dynamic model of endogenous FDI, stronger patents in the developing world can encourage inward investment through making multinational firms more willing to transfer production to lower-wage locations in response to a diminished imitation threat (Lai, 1998; Branstetter, et al., 2006). In a similar general-equilibrium, quality-ladders approach, Yang and Maskus (2001) show that to the extent patent reforms cut the costs of technology transfer by reducing problems of contracting under asymmetric information, the steady-state flow of licensing is also increased. Finally, He and Maskus (2012) explicitly model spillovers from Northern firms exporting and engaging in FDI in the South. Through imitation and learning by doing, Southern firms become sufficiently productive to innovate new products, which they export back to the North in a "reverse spillover", fully completing a product cycle.

Static models with strategic behavior support similar conclusions, depending on market circumstances. For example, stronger patent and trademark laws may limit the need for global firms to expend resources in sustaining proprietary knowledge, which would increase inward trade and FDI (Taylor 1994). The relative strength across locations of intellectual property protection also positively encourages technology transfer in complex products because it enhances the degree to which knowledge is shared across distance (Keller and Yeaple, 2009). This finding is consistent with the notion that intellectual property protection is important for enforcing contracts across borders, which matters for the technology content of trade and FDI (Antras, 2005).

Because strengthened patent rights can expand technology transfer, such reforms could in turn improve a country's export performance by enhancing the productivity of local firms and affiliates. An initial theoretical treatment by Yang and Maskus (2009) shows this outcome in a strategic model of two-firm, two-country competition for export markets. However, the idea is implicit in numerous papers analyzing productivity spillovers from FDI and trade as they are affected by local intellectual property protection (Markusen, 2001; Javorcik, 2004).

To the extent that there are such spillovers from inward technology transfer to domestic productivity, local enterprises should become more likely to enter export markets. Indeed, numerous studies find a positive relationship between the exporting status of firms and productivity, reflecting the importance of product quality and cost competitiveness in export markets. Bernard and Jensen (1997) review the characteristics of U.S. exporting plants and firms relative to non-exporters, finding that more productive firms become exporters, which grow faster than non-exporters. This may be because more productive enterprises find it profitable to incur the fixed costs of exporting, as emphasized by Roberts and Tybout (1997), Melitz (2003) and Yeaple (2005).

Beyond these impacts associated with technology transfer is the potential for stronger patent rights to induce more domestic innovation. The evidence on this point is mixed (Park, 2008), though work by Chen and Puttitanun (2005) and Qian (2009) suggests that domestic patent reforms are associated with the filing of more patent applications at the United States Patent and Trademark Office by enterprises in middle-income nations above certain income and education thresholds. In a historical study, Moser (2005) found that inventors in countries without patent laws in the 19th

century focused on inventions with returns that could be appropriated by other means, such as trade secrecy. This result implies that patents may affect the sectoral distribution of R&D investments in addition to overall inventiveness.

3. Empirical Specification and Data

Basic specification

With this background, consider how we might test the hypothesis that reforms in patent rights expand exports. In countries where patents are weak *ex post* there should be *ex ante* underinvestment in sectors where intellectual property protection (and perhaps adequate contract enforcement) is important for bringing in technologies, absorbing them into production, and developing local improvements. This underinvestment implies, in turn, that countries will have smaller production and exports in sectors that rely relatively more on protection, other things equal. Put differently, countries with stronger patent rights should have relatively lower prices, and relatively more output, in patent-intensive goods. This difference should show up in the structure of comparative advantage in trade.

Nunn (2007) made a similar point regarding the effectiveness of contract enforcement in determining comparative advantage. In this context, he viewed the adequacy of contracts as a national endowment, similar to the capital stock. Countries with larger contract "endowments" should have relatively more exports in sectors where legal security is important. Indeed, he found that countries with strong contracting environments specialize in industries where relationship-specific investments are important. Similarly, Essaji (2008) studied the impact of technical product regulations, viewed as an endowment of regulatory safety. He found that developing countries are more specialized in sectors with greater technical regulation intensity. This seems a surprising result given the ostensibly inferior capacity of developing nations to specify and enforce technical regulations.

Our argument is that patent rights may similarly be considered a national institutional "endowment" of enforceable security regarding investments in technology transfer and innovation. This idea has a clearer theoretical foundation than the main alternative empirical-trade approach – the gravity model – because it is based on the traditional Heckscher-Ohlin model modified for transport costs and monopolistic competition. A further advantage is that the factor-proportions model allows us to study the impacts of patent reforms on exports in different industries, depending on their patent intensities, using industry-level data.

Thus, we follow Nunn's (2007) approach in adopting the following specification, which relates exports to determinants of comparative advantage.[2]

$$\ln(X_{cjt}) = \alpha_{ct} + \alpha_{jt} + \theta_1 \ln(capital_{ct}) * k_{jt} + \theta_2 \ln(skill_{ct}) * s_{jt} + \theta_3 \ln(PR_{ct}) * r_{jt} + \gamma Z + \varepsilon_{cjt}$$

Here, X_{cjt} is the total export of country *c* in industry *j* at time *t* to the world or a particular market, which we take here to be exports to the United States. Capital is the country's capital stock (relative to its labor force), while skill is each country's relative skilled-labor endowment. The variables k_{jt} and s_{jt} are measures of the physical-capital intensity and skilled-labor intensity of each industry, assumed to be

[2] This approach modifies Romalis (2004), which set out a many-country, general-equilibrium trade theory combining the continuum-of-goods, factor-proportions model with monopolistic competition. The interaction terms between industry and country characteristics were first introduced by Rajan and Zingales (1998) to test whether manufacturing industries that tend to use more external financing develop faster in countries with deeper financial markets.

the same across countries. The variable PR_{ct} is each nation's "patent rights endowment" as defined below, while r_{jt} is a sectoral patent intensity. This specification includes control variables Z and country-year and industry-year fixed effects, which account for any unmeasured country-specific and industry-specific changes, such as trade policy, openness to FDI, preferences, and technological change.

To reiterate, this approach is inspired by an underlying factor-proportions explanation of comparative advantage. Thus, if any of the θ coefficients is positive it indicates that the country tends to have greater exports in industries that intensively use the corresponding factor endowment: physical capital, human capital, and patent rights. Our basic test focuses on whether θ_3 is positive and significant, which would imply that countries with stronger PRs specialize in more patent-intensive sectors. We also consider changes in this coefficient before and after the implementation of TRIPS.

Data and variables

The empirical analysis is carried out using a balanced panel of data covering 82 countries and 136 three-digit SIC manufacturing industries every five years from 1985 to 2005. Following Romalis (2004), we use U.S. imports from country *c* in industry *j* as a proxy for total exports by country and industry. Note that the Romalis predictions on trade pattern are valid for both bilateral trade and multilateral trade. Thus, we use U.S. trade data, measured in thousands of U.S. dollars (in year 2000 prices) because they are the most complete and easily available. Further, import data are generally more reliable than export figures from individual countries. U.S. import data are from the University of California at Davis's Center for International Data.[3] To match these figures with other data, we aggregate them from the 1987 4-digit U.S. SIC to the 1987 3-digit U.S. SIC.

To test the model we need measures of patent-rights endowments by country and patent intensities by industry. Considering patent intensity first we adopt two different variables. First is a time-varying indicator of patent grants by industry, which we compile at the 2-digit industry level. We construct our measure as the ratio of U.S. patent grants to the value of shipments in each U.S. industry. Data on the numbers of utility patent grants are from the U.S. patent and trademark office public website.[4] The original patent data exist under the U.S. Patent Classification (USPC). To match these data with other factor intensity data, we develop a basic concordance from the USPC to the 2-digit U.S. SIC, 1987 version.[5] Data on the value of shipments are from the U.S. Census of Manufactures, available from the National Bureau of Economic Research.[6] Thus, this measure of patent intensity, which we label r_2, exists for data classified into 20 manufacturing industries and is based on American industrial data. We assume these time-varying intensities hold for the same industries in all countries.

Our second measure is taken from Hu and Png (2009).[7] Those authors employed data on U.S. patent grants from the NBER Patent Database (Hall, et al.,

[3] http://www.internationaldata.org.
[4] http://www.uspto.gov/web/offices/ac/ido/oeip/taf/reports.htm.
[5] This concordance is available on request.
[6] http://www.nber.org/data/nbprod2005.html.
[7] That paper lists patent intensities at the two-digit level. We are grateful to Albert Hu for sharing the underlying three-digit data.

2001) to enterprises in the COMPUSTAT database. Sales and patents were aggregated to the three-digit SIC level, from which patent intensities were computed as sectoral patent grants divided by real industry sales. Because there was considerable variability in these ratios over time and across industries the authors took the average for each sector over 1979-2000. Thus, this measure exists at the more disaggregated 3-digit level but is constant over time. We label it r_3 in our analysis.

Turn next to the endowment of patent rights in each country. Initially this is measured by the Ginarte and Park (1997; GP) index of patent laws, which exists for five-year intervals from 1960 through 2005. The GP index takes on values between zero and five, with higher numbers reflecting stronger levels of protection. The index consists of five categories: coverage of fields of technology, membership in international patent agreements, provisions for loss of protection, legal enforcement mechanisms, and patent duration. Each category takes a value between zero and one and their sum gives the overall value of the PRs index for a particular country.

The GP index has been used widely to measure the strength of patent laws and their changes over time. However, it suffers from one clear shortcoming. The index focuses strictly on the presence or absence of particular legal provisions and does not account for the efficacy of administrative and judicial enforcement mechanisms. Thus, some countries may have relatively high GP indexes but the effective enforcement of patents is weak. Indeed, in 1990 Malawi had a substantially higher index than Singapore, despite the latter nation's superior investment environment.

To deal with this issue we follow Hu and Png (2009) in combining GP with the Fraser Institute's index of legal systems and property rights.[8] This index exists for all countries in our sample at five-year intervals from 1970 to 2005 and ranges from zero to ten. After 1980 it was revised and based on three aspects of protection: legal security from confiscation of property rights, viability of contracts, and rule of law. Because of this change in definition we begin our analysis with 1985 data. Note that these components are subjective because they are compiled from surveys of international business executives published in the *International Country Risk Guide*.

Our second measure of patent-rights endowments, and the one we focus our analysis on, is then the product of the two variables: PR = GP x Fraser. As Hu and Png (2009) argue, it is reasonable to multiply these variables. A country with zero contract enforcement really has no patent rights, regardless of its legal rules. On the other hand, patent laws do matter and are likely complementary to enforcement efforts in their overall effects.

Following Romalis (2004), the skill intensity of an industry is measured as the ratio of non-production workers to total employment in each industry. Data on nonproduction workers and total employment are from the U.S. Census of Manufactures, aggregated to the 3-digit level. We compute skilled-labor endowments for each country based on measures of average educational attainment for the population aged 25 and over, as reported initially by Barro and Lee (2000).

[8] Available at http://www.freetheworld.com/release.html.

These figures, including updates to 2005, are available from the Center for International Development at Harvard University.[9] In the estimation we define the relative human capital stock as the ratio of the population over 25 that completed at least a secondary education to the population in this group that did not complete high school.

Following Nunn (2007), we define the ratio of capital stock in industry *j* to value added as the measure of capital intensity. We estimate capital stock figures in each U.S. industry from 1985 to 2005 by the perpetual inventory method using capital expenditure data from the U.S. Census of Manufactures. The current physical capital stock of industry j, $K_{j,t}$, is determined as follows:

$$K_{j,t} = I_{j,t-1} + (1-\delta)K_{j,t-1},$$

where δ is the depreciation rate, assumed to be 6 percent. The variables $I_{j,t-1}$ and $K_{j,t-1}$ are, respectively, capital expenditures and capital stocks in the previous year. The initial capital stock of each industry, K_{j0}, is estimated by

$$K_{j0} = I_{j0} / (g_j + \delta),$$

where g_j is the average annual growth rate of capital expenditure in sector *j*. The initial year is 1970.

National capital endowments are estimated by the perpetual inventory method using the investment data of each exporting country. The procedure for calculating capital stocks at the national level is identical to those for industry stocks outlined above. In this case the initial year is 1972. Investment data for each country from

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9 See www.cid.harvard.edu/ciddata/ciddata.html. The Barro-Lee data have been updated to 2010 and are available at this site also.

1972 to 2005 are derived by multiplying real GDP at PPP (constant 2000 US dollars) and the national investment share in GDP, both taken from Penn World Table 6.2. For some countries we use data on gross fixed capital formation at PPP rates as the investment measure because the underlying variables are not available from that source.[10] Data on gross fixed capital formation (constant 2000 US dollars) and PPP conversion factors are both from the *World Development Indicators* of the World Bank. We use these capital stocks divided by country labor forces in the estimation. Data on labor forces are from the World Bank also.

It is possible that other factors also affect the pattern of specialization and trade. Thus, we follow Nunn (2007) by including as control variables two additional interaction terms. The first is the product of the log of per-capita real income in each country and the share of value added in the total value of shipments in each industry using U.S. data. We label this variable $income_{ct}*v_{jt}$. This interaction accounts for the possibility that high-income countries may specialize in high-value-added industries. National income levels are measured by real GDP per capita at PPP rates, taken from Penn World Table 6.2. GDP per capita for 2005 is from Penn World Table 6.3 and GDP deflators are from the *World Development Indicators*. Data on value added and the value of shipments are from the U.S. Census of Manufactures, again aggregated to the 3-digit SIC.

The second control variable is an interaction of the log of per-capita real income

[10] These countries are Bangladesh, Bolivia, Colombia, Egypt, Guatemala, India, Iran, Jordan, Kenya, Malaysia, Panama, Peru, Sri Lanka, Thailand and Trinidad and Tobago.

and the Grubel-Lloyd index, which measures the level of intra-industry trade in each industry. This index is defined as $GLI_{jt} = 1 - \frac{|IMP_{jt} - EXP_{jt}|}{IMP_{jt} + EXP_{jt}}$, where IMP_{jt} and EXP_{jt} are U.S. exports and imports of industry *j*. We label this variable $income_{ct}*gl_{jt}$ and it accounts for the possibility that high-income countries tend to specialize in industries with high levels of intra-industry trade.

To summarize briefly, each of our explanatory variables consists of an interaction term between a national variable (endowments or average income) and an industry variable (factor intensities, value-added intensity, or the intra-industry trade index). The industry variables are all computed with U.S. data, which is not an exporter in our analysis.

Summary statistics

The data are summarized in Tables 1-4. In Table 1A we list the summary statistics for the industry-level intensity measures. All but r_3, the 3-digit patent intensity, vary over time. Thus, the average number of patents per $million of shipments is around 0.01 to 0.03, with a large variation across sectors. Capital stock in the average industry is about 66 percent of value added while the mean ratio of skilled labor to other labor is 0.28. The average Grubel-Lloyd index is 0.60, attesting to the high degree of two-way trade among U.S. industries. In Table 1B we offer correlations among these intensity measures. The two patent intensities are highly correlated with each other and reasonably highly correlated with skill intensity. The other variables are only modestly correlated. There is essentially no correlation between patent intensity and capital intensity.

In Table 2A we list statistics for the endowments. The GP index averaged 3.01 (of a potential maximum of 5.0) across time and countries. Our PR index, which is the product of GP and the Fraser Institute index, averaged 20.23 (of a potential maximum of 50.0). The mean capital stock was approximately $49,000 per worker (in 2000 prices), while the average ratio of those graduating high school to others was 0.58. The figures in Table 2B show that GP and PR are highly correlated, while there are strong positive correlations between these institutional endowments and the physical-capital and human-capital stocks.

Before turning to the econometric results, note in Table 3 that there has been a considerable increase in legislated and effective patent rights over time. The first two columns track the average GP index in the developed (M) and developing (D) countries in our sample.[11] Both groups saw a rise in this index but there was a much larger increase among developing countries (97 percent) versus developed countries (32 percent). The bulk of the developing-country increase came after 1990, attesting to the significant policy changes required by the TRIPS Agreement. The composite PR indexes rose by 66 percent (M) and 146 percent (D). With such significant policy shifts we might well expect an impact on economic activity, including exports.

4. Empirical Results

As an initial descriptive matter, we explore whether countries that tend to specialize in high-patent-intensity industries have stronger patent rights. For this

[11] The countries are listed in an appendix table.

purpose we calculate for each country, in each year, its direct "patent intensity of trade," which we define as the share of each sector's exports in country *c* to the United States in total exports of that country to the United States, weighted by that sector's patent intensity indexes. We then regress these specialization indexes on measures of patent rights over the entire sample, expressing the results as standardized beta coefficients. As shown in Table 4, there are strong positive correlations between the protection of patents and export specialization in patent-intensive goods across countries. The coefficients are similar for both the time-invariant 3-digit patent intensity r_3 and the time-varying 2-digit intensity r_2. In both cases the raw data demonstrate that countries with stronger patent rights tend to specialize their exports in industries with greater patent intensities.

4a. Full-sample results

Turn next to the primary regression specification, which explains trade specialization by the interactions of factor endowments and factor intensities. The basic prediction to test is that export volumes in patent-intensive sectors increase with the strength of patent rights in the country. In Table 5 we present results for both ordinary least squares (OLS) and instrumental-variables (IV) estimation (see below), using the entire sample over the period. As an initial robustness test we include regressions in which the endowment-patent-intensity interaction is specified with GP or PR (endowment) and r_2 or r_3. For example, in the first column the patent-interaction term is GP* r_2, while in the seventh column it is PR* r_3. In each case we include the other endowment interactions and the control variables, along with country-year fixed effects and industry-year fixed effects. In order to permit comparisons across variables all results are presented as standardized beta coefficients.

Comparing the OLS regressions first, we find a positive and significant coefficient on patent rights throughout. Using GP and r_2 (r_3), the coefficient is 0.21 (0.11). Since these are beta coefficients the results imply that a one standard deviation in ln[GP]* r_2 (ln[GP]* r_3) is associated with a 0.21 (0.11) standard-deviation rise in the log of sectoral exports. Using PR interacted with patent intensities these coefficients are somewhat larger with OLS, at 0.38 and 0.19.

These results imply that countries have greater exports in relatively patent-intensive industries as they strengthen the scope of their exclusive patent rights. In terms of economic significance, consider the impact of ln[PR]* r_3, with the beta coefficient 0.19. In order to focus on policy change, hold r_3 fixed at its mean (0.014). Consider a one standard deviation (11.92) rise in patent rights, from the sample average of 20.23 (about the level of South Africa in 1995) to 32.15 (about the level of Singapore in 1995). In turn, the average of bilateral exports by sector would increase from \$1.086 million to \$1.231 million.[12] Put differently, a near-doubling of patent rights would expand average sectoral exports by about 13.4 percent. In this regard, changes in the scope of patent protection have significant impacts on the volume and pattern of exports.

[12]The level coefficient implied by the standardized OLS coefficient is 19.38. The initial mean of ln(PR)*r_3 is 0.014*ln(20.23) = 0.0421, while the new mean becomes 0.014*ln(20.23+11.92) = 0.0486, for a change of 0.0065. The average of ln(X) is 6.99, making average bilateral exports exp(6.99) = 1086. Predicted average bilateral exports after the increase in PR become exp(19.38*0.0065+6.99) = 1231, implying an increase of 145.

As for the other variables, their impacts are quite consistent across the OLS regressions. The beta coefficient on interacted capital stock is about 0.04, while that on human capital is about 0.11. From these results it appears that specialization in exports is driven significantly by the joint impact of endowments and intensities, as predicted by the modified factor-proportions model. Both the income interactions are highly significant as well. In the OLS regressions the beta coefficient on the interaction between per-capita GDP and the Grubel-Lloyd index is the largest of all impacts, at around 0.31. Thus, changes in sectoral propensities to engage in two-way trade have a pronounced impact on the structure of exports to the United States as real incomes rise in exporting nations.

An obvious difficulty here is potential endogeneity of patent rights to trade flows. Countries with more exports in patent-intensive industries may choose to adopt a stronger policy on intellectual property protection. To correct for this problem, we adopt an instrumental-variables approach. Candidates to be valid instrumental variables should be correlated with patent rights but uncorrelated with unobserved errors in exports.

A natural candidate for this purpose is the colonial or historical origin of a country's legal system. La Porta et al. (1998) showed that a country's legal origin affects the protection of corporate shareholders and creditors and the quality of its enforcement. La Porta et al. (1999) provided further evidence that legal origin plays an important role in explaining the variation in government performance across countries. For this reason, Nunn (2007) used their data to instrument his contract enforcement measures. Intellectual property protection, as part of the legal system, likely is similarly affected by legal origin (Maskus and Penubarti, 1995; Ivus, 2010). It follows that the extent to which different countries have adopted different patent protection is partially related to the origins of their legal system, in itself surely a pre-determined variable with regard to trade in recent decades.

Thus, we employ data on each country's legal origin taken from La Porta et al. (1998). They categorize nations as having legal traditions emanating from British common law, French civil law, Socialist law, German law and Scandinavian law. Taking the Scandinavian case as our reference group, define the dummy variables B_c, F_c, S_c, and G_c to account for the origins from, respectively, British, French, Socialist and German law. Next, since patent intensities are taken from U.S. industrial data they are likely exogenous, especially as regards the time-invariant version r_3. Thus, the instrumental variables we include in the first-stage estimation are $B_c r_{jt}$, $F_c r_{jt}$, $S_c r_{jt}$ and $G_c r_{jt}$, along with the control variables and fixed effects.

The columns labeled IV in Table 5 report the results, with the second-stage regressions at the top and first-stage regressions at the bottom. The first-stage estimation in each case suggests that the instruments are sound. An F-test for the irrelevance of the instruments is strongly rejected, with F-statistics ranging from 1438 to 2678. The coefficients indicate that, relative to countries with Scandinavian legal origins, effective patent rights are stronger in nations of German origin but weaker in the others, with French origins the weakest of all.

Turning to the second-stage estimation, the coefficients in the top panel are all significant and the signs are as predicted. In particular, the coefficients of the interaction terms of patent rights and patent intensity remain positive and significant. In fact, they are uniformly larger in the IV cases compared with OLS. In the case with PR and r_3, for example, the coefficient rises from 0.19 to 0.39. This suggests that the economic significance is larger than that estimated by OLS. In this case, the same change in the scope of patent rights considered above would raise average sectoral exports from $1.086 million to $1.406 million, or 29.5 percent. The coefficients on other interactions remain largely unchanged, though the IV estimates are generally somewhat smaller than OLS.

Table 6 explores the question of how variations in effective patent rights affect bilateral exports to the United States among the developing countries in the sample. We incorporate also an interaction effect between an indicator variable for small and poor developing countries, which are presumably less affected by IPRs in their trade. As may be seen, the coefficients on the patent rights variable remain significantly positive in this sample, with a large increase moving from the OLS to IV cases.[13] The coefficients on the small-and-poor interaction variable are negative and significant in most cases, which is as anticipated. Still, the sum of these coefficients is significantly positive in all cases. It is also interesting that for this sample of developing countries the coefficients on the physical-capital interaction become larger while those on skilled labor are generally negative.

The fact that the IV coefficients are larger than their OLS counterparts for patent

[13] To conserve space from this point forward we do not list the first-stage results.

rights may seem problematic given the notion that two-way causality would generally support the opposite ranking.[14] In this case, however, there is a good reason to expect the OLS coefficients to be biased downward. As the first-stage estimates suggest, countries with French and British colonial origins have patent rights (GP and PR) below what would be expected if legal origin did not matter. In the sample of 82 nations, there are 44 countries with French origin, 37 of them in the developing group (which arguably should capture also Greece and Portugal). There are 24 of British origin, 17 of them developing countries. To the extent our specification does not capture important development-related influences on trade, which is still possible despite the inclusion of country-year fixed effects, and those influences reduce exports to the United States, the OLS coefficients are biased downward. Indeed, the larger increase in the IV coefficients for the developing-country group in Table 6 is consistent with this notion.

At the same time, the Sargan over-identification tests also reject the null hypothesis that the results are not over-identified. Thus, while we believe the IV estimates are more reliable, there is some ambiguity about this point. In either case, however, the impacts of patent rights on export specialization are clearly positive and significant.

Before continuing, consider some basic robustness exercises. One possibility is that our results are dominated by Hong Kong, Korea and Singapore, all of which considerably expanded the scope of legal patent rights over the period. They also

[14] Nunn (2007) found the same results with respect to contract enforcement and trade.

experienced major increases in exports for many reasons, raising the risk that our results are spurious due to their inclusion. Thus, we drop these three countries and re-estimate the basic equation with instrumental variables. The results, not shown, are that the coefficients on the interaction term between PRs and patent intensity remain essentially unchanged, as do the other interaction coefficients.

A further possibility is that factor intensities are endogenous to trade, though the use of U.S. data to represent them for all countries should mitigate this problem considerably. To correct for this possibility, we next re-estimate the basic equation using data on factor intensities lagged for 5 years. The estimation results, again not shown, are that the coefficients on the interaction term of PRs remains essentially unchanged in magnitude and significance, as do the other results.

4b. Further results

We next address the basic question of whether the estimated impacts of patent rights are different prior to the implementation of TRIPS in 1995 compared to after that date. Recall from Table 3 that the bulk of the increase in patent protection happened in the latter period, especially among our sample of developing nations. Thus, we might expect a relatively larger increase in the sensitivity of trade flows to these more recent changes.

For this purpose, we split the sample into pre-TRIPS (1985 and 1990) and post-TRIPS (1995, 2000 and 2005). We find that this notion is borne out by the results in Table 7, which are all IV estimates using PR as the measure of patent rights, interacted with each of the patent intensities. The coefficient on the r_3 patent intensity essentially doubles from the earlier to the later period, which covers implementation of TRIPS.

We now extend this analysis by running IV regressions for samples with developing (D) and developed (M) countries, also broken down by time period. In the sample there are 54 developing countries and 28 developed countries. As an institutional endowment, domestic PRs may have different impacts on the pattern of exports for countries at varying development levels.

It is not obvious whether patent reforms should have a greater effect on exports in richer or poorer economies. An initial observation is that, given their presumed comparative advantage in higher-technology goods, developed economies are likely to adopt patent laws and standards that offer stronger exclusive rights in an attempt to support innovation and formal technology transfer (Grossman and Lai, 2004). In that context, productivity growth and export performance may be particularly sensitive to variations in patent rights. In developing countries, however, there is a greater relative presence of local firms that learn technology through simple imitation of foreign products and processes. The prospects for imitation are generally reduced as domestic patent laws are strengthened.

Thus, while formal means of inward technology transfer may be enhanced through patent reforms, as suggested by the results in Branstetter et al (2006), this effect has to be balanced against the loss of access through higher-cost imitation. By itself, this would suggest that patent reforms are likely to be less stimulative to productivity and export growth in the developing world. At the same time, however, it is possible that the local innovation returns to stronger IPRs are greater in developing economies, which are not competing to advance the technological frontier. Overall, this is an interesting empirical question.

In Table 8 the results are broken down by country group and by period prior to and since the implementation of TRIPS. As may be seen in the first and third columns, in the earlier period the beta coefficients were about the same for both country groups using the r_2 patent intensity. However, using r_3 (in Columns 5 and 7) the coefficient for the richer countries was larger than for the poorer countries, which had an insignificant estimate. The latter finding indicates a greater sensitivity of trade to patent reforms in the developed group.

However, all of these IV coefficients rose considerably in the latter period, suggesting a globally larger responsiveness. Further, there was substantial convergence of these coefficients between the M and D groups, with those in the developing countries rising relatively more sharply. Indeed, in the post-TRIPS period the effect is larger for developing nations using intensity r_2, though the impacts using r_3 remained larger for the developed economies.

In Table 9 we provide perspective on impacts by industry group. We break down our 136 three-digit industries into 12 high-technology (HT) sectors and 39 medium-technology (MT) sectors, with the balance of sectors labeled low-technology (LT). This categorization is based on the percentage of R&D expenditures in value of shipments in each sector in 1997, using U.S. data. For this purpose, we map the 1997 NAICS 4-digit industry classification into the 3-digit SIC, using a concordance from the U.S. Bureau of Economic Analysis. Figures on R&D are taken from the National Science Foundation's *Research and Development in Industry: 2000* and data on value of shipments are from the *Annual Survey of Manufactures: 2000*. We define high-technology sectors as those with R&D over sales ratios greater than 2.5 percent and medium-technology sectors as those with ratios between 0.9 percent and 2.5 percent. Note that in the NAICS categorization the mean ratio is 2.6 and the median is 1.2 for 1997. Our industry classification is given in the appendix table, where we list each of the 3-digit high-technology sectors and aggregated titles for the 3-digit medium-technology sectors.

To assess the impacts of patent rights on trade in this context, we regress bilateral exports by sector on our standard variables but add dummy variables for HT and MT industries, which we multiply by the PR interaction term. Thus, we test whether the effects are differentially higher in these industries in comparison with LT goods. The IV results are given in Table 9, broken down for the full sample and the groups of developing (D) and developed (M) nations. It is noteworthy that the coefficients for the basic patent-interaction terms (essentially capturing patent impacts for low-technology goods) are larger for the developing economies. Looking at the industry interactions, the impacts of PRs on exports are significantly higher in both MT and HT industries than in LT sectors for both groups of countries, though the coefficients are considerably higher for the developed nations. There is not much difference between the coefficients across the two industry groups. In these regressions the physical capital stock shows up as a significant determinant of export specialization, while the intensity of intra-industry trade remains highly influential.

The next natural step is to consider the breakdown by country group and industry group in the periods prior to TRIPS and after TRIPS, which we do in Table 10. Again, we see that the coefficients on patent rights are higher in all cases for MT and HT sectors than for the reference LT group. It is interesting that prior to TRIPS the coefficients on the MT group were somewhat higher than those on the HT group. This likely reflects the fact that local imitation of MT goods is generally less costly, leading to a higher dependence on patents to protect technology and exports. This difference generally evaporated with the stronger global protection after 1995.

Looking between the periods, it is interesting that the sensitivity of low-tech exports (the reference group) to patent rights went up for the developing countries but diminished for the richer economies, even becoming negative and significant with patent intensity measure r_2.

4c. First-differences regressions

The results above suggest that current levels of trade are strongly influenced by the exporting-nation's scope of patent rights and that this effect grew stronger in the post-TRIPS era. The IV regressions included a full set of country-year and industry-year fixed effects, along with controls for other endowment-intensity interactions and income-product differentiation interactions. That specification seems sufficiently comprehensive to limit concerns about the possibility of spurious relations associated with some omitted variable.

Nevertheless, to address such concerns and consider a more rigorous question we turn next to a first-differenced version of the primary equation. Thus, we ask whether sectors in which there were larger increases in the home-country's effective patent rights generated larger growth in exports to the United States. We consider this question first in a short-run specification, in which we simply take first differences of all variables between each five-year period. We then compute long-run effects using first differences from 1985 to 2005 to determine the cumulative impact over the full timeframe.

The short-run results, stated as beta coefficients from second-stage IV regressions, are presented in Table 11. To save space we report only the results for the 3-digit patent intensity r_3.[15] Recall that this intensity does not vary over time so the changes in effective patent rights refer to the mix of legislative changes (captured by GP) and judicial enforcement quality (captured by the Fraser Institute index). Each set of three columns lists three regressions, covering the full set of countries and the breakdown between developing and developed economies.

The difference between column sets relates to the treatment of fixed effects in the first differencing. In an initial specification (not shown) we incorporate first differences of both the country-year and industry-year fixed effects.[16] With this approach we do not observe any impacts of growth in patent rights on growth in export specialization. This likely is due to the multicollinearity between the many country-year and industry-year fixed effects. For example, it could be that changes

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[15] Results for r_2 are available on request.

[16] First differences in country-year fixed effects may be represented as (c, t-(t-5)) and similarly for industry-year effects. This approach has been used in Baier, et al (2011) in a gravity estimation of the trade effects of regional integration agreements.

in country-specific unobservables, such as trade policy, are associated with shifts in industry-specific unobservables in a given time period. Indeed, there is a high variance inflation factor between the country-year and industry-year fixed effects.

For this reason we present the results with just first differences in country-year effects in the first block of three regressions and just those in industry-year effects in the second block. Here we find evidence that growth in effective patent rights increases exports. Thus, controlling for changes in country-year effects we observe that the beta coefficients on both developing-country and developed-country patent rights are significantly positive, with the latter being over twice the former. Alternatively, controlling for changes in industry effects there is no impact of growth in patent rights on exports in developing countries but a highly significant and positive one in developed economies. Thus, in these short-run five-year periods there is some ambiguity about the impacts overall but evidence does exist of positive influences.

Results for the long-run case, using growth in exports and the right-hand-side variables over the full period, are in Table 12. Controlling for country-year effects the results are virtually identical to the short-run impacts in Table 11, with the notable exception of a larger positive effect of growth in skills on export growth. With industry-year effects included the story is the same as in the short-run, except the significant coefficient for the developed economies is somewhat larger in the long-run case.

4d. A further look at causality: matched country pairs

We noted above that there remains some ambiguity about how effectively our instrument set deals with endogeneity problems. One potential difficulty is that while a country's legal origin is useful for isolating changes in PRs that are not caused by current trade flows, that origin could affect comparative advantage through other unmeasured channels, making it correlated with residuals in the second-stage exports equation. For example, La Porta et al (1998) find that legal origins also affect measures of financial development and investor protection. These variables may affect comparative advantage, a factor that may not be sufficiently controlled in our exports equation.[17]

To approach this problem we follow Nunn (2007) in developing matched country pairs based on propensity scores. For this purpose consider the set of countries with either British or French legal origins. Rather than using legal background as an instrument, we estimate the following reduced-form equation:

$$\ln\left(\frac{X_{jB}}{X_{jF}}\right) = \alpha_{BF} + \beta r_j + \varepsilon_{jBF}$$

The left-hand side is the ratio of sectoral exports from any British-origin nation over the same sector's exports from any French-origin nations. As noted in La Porta et al (1998) and Nunn (2007), countries with British origins tend to have stronger current legal systems, other things equal. This is true as well with respect to patent rights. To the degree that this difference influences export specialization in more patent-intensive goods, the coefficient β should be positive. Comparing all possible paired observations, without worrying about propensity matching, this regression yields a

[17] Maskus et al (2012) show that financial-market development affects sectoral R&D intensities within OECD countries.

positive and highly significant coefficient on both sectoral patent-intensity measures, as shown in the first two columns of Table 13. Thus, without conditioning the country pairs the evidence suggests that British-origin nations export relatively more than French-origin nations in sectors with higher patent intensities.

However, this result may simply pick up other channels through which legal origins could affect such specialization. To control for such factors we select country pairs (by year) that are most alike on a set of other key variables. The candidates we select are overall development (measured by log real GDP per capita), a measure of financial development (log of private bank credit divided by GDP), our set of factor endowments (capital per worker and the skills ratio), trade openness (log of exports plus imports divided by GDP), and all of these variables together.

The matching algorithm follows Rosenbaum and Rubin (1984). Specifically, we estimate a probit model where the dependent variable is one for a British-origin country and zero for a French-origin country, with this variable regressed on the matching country characteristics. From the probit model we calculate the predicted propensity score $\hat{P}_B$ and then for each British common-law country we select the French civil-law country that has the closest propensity score. That is, for each B select a country F that minimizes the absolute difference $|\hat{P}_B - \hat{P}_F|$.

The results from estimating the relative exports equation on these matched countries are in the remaining columns of Table 13. As may be seen the positive impact of patent intensity on export specialization remains intact in each case. The smaller coefficients on per-capita GDP suggests that failing to control for these national channels of influence tends to bias upwards the earlier coefficients relating patent rights (PRs) to exports. Note, however, that matching by both financial development and trade openness generates relative export advantages that are as large as those in the unmatched cases.

From these results it follows that, even controlling for other influences, legal origins exert a causal impact on relative export specialization in sectors with greater patent intensities. The coefficients from the matching procedure are somewhat lower than the implied effects from the IV estimation, suggesting that the latter are biased upward. In all approaches, however, the evidence points toward a positive causal impact of stronger PRs on export specialization, including in developing countries.

5. Summary and Conclusions

In this paper we provide an initial empirical assessment of the effects of patent reforms and enforcement norms on the pattern of the reforming nations' exports, using the factor-proportions model. We study this question first with regressions of the levels of sectoral trade performance (exports to a single market, the United States) on effective patent rights, controlling for other determinants of trade and fixed effects for country-year and industry-year pairs. To correct for potential endogeneity bias, we use legal origins as instrumental variables for the various PRs indexes. We also perform a number of robustness tests and supplement the basic specifications with first-differences regressions.

The empirical results conform broadly with the underlying hypothesis that reforms in PRs can boost export performance in sectors that rely relatively more on patent protection. More generally, the extent of this impact differs across industries that vary in their technology content as measured by R&D as a percentage of sales. Moreover, we find that the effects of stronger PRs on exports in patent-intensive sectors are stronger in developed countries than in developing countries, but there was some convergence in these rankings late in the period. The estimation also suggests that the impacts of PRs changes are heightened in high-technology and medium-technology industries relative to low-technology industries.
First-differences regressions find evidence of relatively greater export growth in nations with bigger patent reforms. Finally, analysis of matched country pairs based on several characteristics confirms the positive causal impacts of PRs on export specialization.

Overall, we find the scope of PRs to be an important determinant of the pattern of trade, with a larger set of effects after implementation of TRIPS. The findings also lend some support to the view that stronger patent protection in developing nations is likely to expand their exports of patent-sensitive goods in international markets.

We emphasize that a positive impact on exports, while suggestive of structural transformation in the economy, is not an indication of national welfare gains. Our analysis is restricted to the simple positive question of trade impacts and, therefore, does not address such fundamental questions as variety changes in trade, price impacts from stronger patents, or effects of patent reforms on domestic innovation and profits. Put differently, our findings say little about whether the policies adopted in response to TRIPS are likely to raise welfare overall. Thus, while policymakers in developing countries should find the present findings of interest, they need to think more broadly about how to meet development challenges arising from their intellectual property policies.

References

Antras, Pol. 2005. Incomplete Contracts and the Product Cycle. *American Economic Review* 95: 1054-1073.

Baier, Scott L, Jeffrey H. Bergstrand and Michael Feng. 2011. Economic Integration Agreements and the Margin of International Trade. Notre Dame University, manuscript.

Barro, Robert J. and Lee, Jong-Wha, 2001. International Data on Educational Attainment: Updates and Implications. *Oxford Economic Papers* 53, 541-563.

Bernard, Andrew, and Bradford J. Jensen, 1997. Exceptional Exporter Performance: Cause, Effect, or Both? *Journal of International Economics* 47, 1-26.

Branstetter, Lee, Ray 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, no. 1: 321-349.

Branstetter, Lee, Ray Fisman, C. Fritz Foley and Kamal Saggi. 2011. Does Intellectual Property Rights Reform Spur Industrial Development? *Journal of International Economics* 83, no. 1: 27-36.

Chen, Yongmin and Thitima Puttitanun. 2005. Intellectual Property Rights and Innovation in Developing Countries. *Journal of Development Economics* 78: 474-493.

Co, Catherine, 2004. Do Patent Regimes Matter? *Review of International Economics* 12, 359-373.

Essaji, Azim, 2008. Technical Regulations and Specialization in International Trade. *Journal of International Economics* 76, 166–176.

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

Grossman, Gene M. and Edwin L-.C. Lai, 2004. International Protection of Intellectual Property. *American Economic Review*, 94, 1635-1653.

Hall, Bronwyn H., Adam B. Jaffe, and Manuel Trajtenberg. 2001. The NBER Patent Citations Data File: Lessons, Insights and Methodological Tools. NBER Working Paper 8498.

Hall, Robert E. and Charles I. Jones, 1999. Why Do Some Countries Produce So Much More Output per Worker than Others? *Quarterly Journal of Economics* 114, 83-116.

He, Yin and Keith E. Maskus, 2012. Southern Innovation and Reverse Knowledge Spillovers: A Dynamic FDI Model, *International Economic Review* 53, 281-304.

Hu, Albert and Ivan Png. 2009. Patent Rights and Economic Growth: Cross-Country Evidence. National University of Singapore Business School, manuscript.

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

Javorcik, Beata Smarzynska. 2004. The Composition of Foreign Direct Investment and Protection of Intellectual Property Rights in Transition Economies. *European Economic Review* 48, 39-62.

Keller, Wolfgang and Stephen R. Yeaple, 2009. Gravity in the Weightless Economy. University of Colorado at Boulder, manuscript.

Lai, Edwin L-C, 1998. International Intellectual Property Rights Protection and the Rate of Product Innovation. *Journal of Development Economics* 55, 115-130.

La Porta, Rafael, Florencio Lopez-de-Silanes, Andrei Shleifer, and Robert Vishny. 1998. Law and Finance, *Journal of Political Economy* 106: 1113-1155.

La Porta, Rafael, Florencio Lopez-de-Silanes, Andre Shleifer, and Robert Vishny. 1999. The Quality of Government, *Journal of Law, Economics, and Organization* 15: 222–279.

Markusen, James R. 2001. Contracts, Intellectual Property Rights, and Multinational Investment in Developing Countries. *Journal of International Economics* 53, 189-204.

Maskus, Keith E. 2012. *Private Rights and Public Problems: The Global Economics of Intellectual Property Rights in the 21st Century* (Washington, DC: Peterson Institute for International Economics), in process.

Maskus, Keith E., Rebecca Neumann and Tobias Seidel. 2012. How National and International Financial Development Affect Industrial R&D. *European Economic Review*, forthcoming.

Maskus, Keith E. and Mohan Penubarti, 1995. How Trade-Related are Intellectual Property Rights? *Journal of International Economics* 39, 227-248.

Melitz, Marc J., 2003. The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity, *Econometrica* 71, 1695-1725.

Moser, Petra. 2005. How do Patent Laws Influence Innovation? Evidence from Nineteenth-Century World's Fairs. *American Economic Review* 94: 1214-1236.

Nunn, Nathan, 2007. Relationship-Specificity, Incomplete Contracts and the Pattern of Trade. *Quarterly Journal of Economics* 122, 569-600.

Park, Walter G. 2008. Intellectual Property Rights and International Innovation. In Keith E. Maskus, ed., *Intellectual Property, Growth and Trade* (Amsterdam: Elsevier), 289-328.

Park, Walter G. and Douglas Lippoldt, 2003. The Impact of Trade-Related Intellectual Property Rights on Trade and Foreign Direct Investment in Developing Countries," *OECD Papers: Special Issue on Trade Policy* 4. Issue 294.

Psacharopoulos, George, 1994. Returns to Investment in Education: A Global Update. *World Development* 22, 1325-1343.

Qian, Yi. 2007. Do National Patent Laws Stimulate Domestic Innovation in a Global Patenting Environment? *Review of Economics and Statistics* 89: 436-453.

Rajan, Raghuram G. and Luigi Zingales. 1998. Financial Dependence and Growth. *American Economic Review* 88: 559-586.

Roberts, Mark J. and James R. Tybout, 1997. The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs, *American Economic Review*, 87: 545-564.

Romalis, John. 2004. Factor Proportions and the Structure of Commodity Trade. *American Economic Review* 94, 67-97.

Rosenbaum, Paul R. and Donald B. Rubin. 1983. The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika* 70, 41-55.

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

Smith, Pamela J., 2001. How Do Foreign Patent Rights Affect U.S. Exports, Affiliate Sales, and Licenses? *Journal of International Economics* 5, 411-440.

Taylor, M. Scott., 1994. Trips, Trade, and Growth. *International Economic Review* 35, 361-381.

Yang, Guifang and Keith E. Maskus, 2001. Intellectual Property Rights, Licensing, and Innovation in an Endogenous Product-Cycle Model. *Journal of International Economics* 53, 169-187.

Yang, Lei and Keith E. Maskus, 2009. Intellectual Property Rights, Technology Transfer and Exports in Developing Countries. *Journal of Development Economics* 90, 231-236.

Appendix: Countries and Industries in the Sample

Developed (28)	Developing (54)		High-Tech (n=12)	Medium-Tech (n=39)
Australia	Algeria	Pakistan	Medicinal Chemicals	Paper Products (5)
Austria	Argentina	Panama	Plastics Materials	Printing (5)
Belgium	Bangladesh	Paraguay	Communications Equip	Other Chemicals (6)
Canada	Benin	Peru	Electronics Parts	Rubber & Plastics (5)
Cyprus	Bolivia	Philippines	Motor Vehicles & Parts	Engines & Turbines (1)
Denmark	Brazil	Romania	Aircraft	Industrial Machinery (8)
Finland	Burundi	Senegal	Missiles & Aerospace	Power Equipment (3)
France	Cameroon	S. Leone	Navigation Systems	Appliances (1)
Germany	C. Afr. Rep.	S. Africa	Measuring & Testing Equip	Other Transport Equip (4)
Greece	Chile	Sri Lanka	Medical Instruments	Photographic Equip (1)
Hong Kong	China	Syria	Optical Goods	
Hungary	Colombia	Thailand	Watches & Clocks	
Iceland	Congo	Togo		
Ireland	Costa Rica	T. & Tobago		
Israel	Dom. Rep.	Tunisia		
Italy	Ecuador	Turkey		
Korea, Rep.	Egypt	Uruguay		
Japan	Gabon	Venezuela		
Netherlands	Ghana	Zambia		
New Zealand	Guatemala	Zimbabwe		
Norway	Honduras			
Poland	India			
Portugal	Indonesia			
Singapore	Iran			
Spain	Jamaica			
Switzerland	Jordan			
Sweden	Kenya			
UK	Malawi			
	Malaysia			
	Malta			
	Mauritius			
	Mexico			
	Nicaragua			
	Niger			

Note: the number of 3-digit sectors in each medium–technology category is listed in parentheses.

Table 1A. Summary Statistics for Intensity Measures

	Mean	**Std. Dev.**	**Min**	**Max**
r_2	0.03	0.03	0.0007	0.13
r_3	0.01	0.01	0.0008	0.08
K	0.66	0.42	0.10	4.00
S	0.28	0.12	0.07	0.85
VA	0.50	0.12	0.07	0.90
GL	0.60	0.29	0.00	1.00

Table 1B. Correlations among Intensity Measures

	r_2	r_3	k	s	va	gl
r_2	1					
r_3	0.66	1				
K	-0.04	-0.02	1			
S	0.42	0.36	-0.12	1		
VA	0.23	0.18	-0.38	0.28	1	
GL	0.25	0.23	0.15	0.22	-0.06	1

Table 2A. Summary Statistics for Endowments

	Mean	**Std. Dev.**	**Min**	**Max**
PR	20.23	11.92	1.30	44.83
GP	3.01	1.16	0.33	4.67
K stock	49.35	43.50	0.74	172.53
H stock	0.58	0.54	0.004	3.57

Table 2B. Correlations among Endowments

	GP	PR	K stock	H stock
GP	1			
PR	0.91	1		
K stock	0.64	0.78	1	
H stock	0.60	0.68	0.62	1

Table 3. Average Patent Protection and Law Enforcement Measures

	GP(M)	GP(D)	PR(M)	PR(D)
1985	2.96	1.61	21.34	6.79
1990	3.22	1.64	24.71	7.40
1995	4.02	2.17	33.07	10.96
2000	4.30	2.81	36.08	13.79
2005	4.38	3.17	35.50	16.73
Percentage change	32	97	66	146

Table 4. Export Specialization and Patent Rights

VARIABLES	(1) Σ_j(exp share$_{cjt}$)* r_2	(2) Σ_j(exp share$_{cjt}$)* r_3	(3) Σ_j(exp share$_{cjt}$)* r_2	(4) Σ_j(exp share$_{cjt}$)* r_3
GP	0.33***			
	(0.047)			
GP		0.37***		
		(0.046)		
PR			0.38***	
			(0.046)	
PR				0.39***
				(0.046)
R^2	0.11	0.14	0.13	0.12
# obs	410	410	410	410

Results are standardized beta coefficients. Robust standard errors are in parentheses. Coefficients are significant at 1% (***), 5% (**) or 10% (*).

Table 5. Impacts of Patent Rights on Export Specialization, Full Sample

Dependent variable is log exports to US								
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	GP& r_2	GP& r_2	GP& r_3	GP& r_3	PR& r_2	PR& r_2	PR& r_3	PR& r_3
$PR_{ct}*r_{jt}$	0.21***	0.63***	0.11***	0.33***	0.38***	0.78***	0.19***	0.39***
	(0.011)	(0.029)	(0.010)	(0.026)	(0.016)	(0.035)	(0.015)	(0.032)
$Capital_{ct}*k_{jt}$	0.04***	0.02**	0.04***	0.03***	0.03***	0.02*	0.04***	0.03***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
$Skill_{ct}*s_{jt}$	0.10***	0.03***	0.12***	0.09***	0.09***	0.04***	0.11***	0.09***
	(0.010)	(0.011)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
$Income_{ct}*gl_{jt}$	0.31***	0.25***	0.33***	0.29***	0.29***	0.25***	0.32***	0.29***
	(0.011)	(0.012)	(0.011)	(0.012)	(0.011)	(0.012)	(0.011)	(0.012)
$Income_{ct}*v_{jt}$	0.18***	0.07***	0.21***	0.17***	0.16***	0.07***	0.20***	0.17***
	(0.018)	(0.020)	(0.018)	(0.019)	(0.018)	(0.020)	(0.018)	(0.019)
C-Y FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
I-Y FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.65	0.63	0.64	0.64	0.65	0.64	0.65	0.64
#obs	36594	36594	36594	36594	36594	36594	36594	36594
First-Stage Regressions								
B_c*r_{jt}		-0.13***		-0.16***		-0.12***		-0.16***
		(0.004)		(0.005)		(0.003)		(0.003)
F_c*r_{jt}		-0.25***		-0.30***		-0.23***		-0.28***
		(0.005)		(0.006)		(0.003)		(0.004)
S_c*r_{jt}		-0.07***		-0.09***		-0.07***		-0.08***
		(0.003)		(0.003)		(0.002)		(0.002)
G_c*r_{jt}		0.02***		0.03***		-0.01***		-0.00**
		(0.003)		(0.003)		(0.002)		(0.002)
F-stats first stage		404.8		362.9		1101.0		953.6
F-stats instruments		1438		1654		2579		2678
Over-id test		0.00		0.00		0.00		0.00

Results are standardized beta coefficients. Robust standard errors are in parentheses. Coefficients are significant at 1% (***), 5% (**) or 10% (*).

Table 6. Impacts of Patent Rights on Export Specialization, Developing and Small-Poor Countries

Dependent variable is log exports to US								
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	GP& r_2	GP& r_2	GP& r_3	GP& r_3	PR& r_2	PR& r_2	PR& r_3	PR& r_3
$Small*PR_{ct}*r_j$	-0.01**	-0.04***	-0.02**	-0.04***	-0.01	0.01	-0.02**	-0.02**
	(0.007)	(0.008)	(0.008)	(0.010)	(0.007)	(0.008)	(0.008)	(0.008)
$PR_{ct}*r_{jt}$	0.07***	0.84***	0.06***	0.22**	0.23***	1.61***	0.18***	0.67***
	(0.018)	(0.143)	(0.017)	(0.105)	(0.032)	(0.171)	(0.030)	(0.127)
$Capital_{ct}*k_{jt}$	0.19***	0.18***	0.19***	0.19***	0.18***	0.17***	0.19***	0.18***
	(0.023)	(0.024)	(0.023)	(0.023)	(0.023)	(0.024)	(0.023)	(0.023)
$Skill_{ct}*s_{jt}$	-0.02	-0.08***	-0.02	-0.03*	-0.02	-0.07***	-0.02	-0.03**
	(0.016)	(0.020)	(0.016)	(0.017)	(0.016)	(0.018)	(0.016)	(0.017)
$Income_{ct}*gl_{jt}$	0.15***	0.10***	0.15***	0.14***	0.14***	0.06**	0.14***	0.12***
	(0.022)	(0.024)	(0.022)	(0.022)	(0.022)	(0.025)	(0.022)	(0.023)
$Income_{ct}*v_{jt}$	0.11***	0.00	0.12***	0.10***	0.10***	-0.06	0.11***	0.07*
	(0.036)	(0.041)	(0.036)	(0.037)	(0.037)	(0.042)	(0.036)	(0.038)
C-Y FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
I-Y FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.61	0.57	0.61	0.61	0.61	0.57	0.61	0.60
#obs	19866	19866	19866	19866	19866	19866	19866	19866

Results are standardized beta coefficients. Robust standard errors are in parentheses. Coefficients are significant at 1% (***), 5% (**) or 10% (*).

Table 7. Impacts of Patent Rights on Export Specialization, Pre- and Post-TRIPS (IV Estimation)

Dependent variable is log exports to US; measure of patent rights is PR				
	Pre	Post	Pre	Post
	r_2	r_2	r_3	r_3
$PR_{ct}*r_{jt}$	0.60***	0.83***	0.27***	0.55***
	(0.044)	(0.053)	(0.039)	(0.051)
$Capital_{ct}*k_{jt}$	0.03*	0.02	0.04**	0.03*
	(0.018)	(0.017)	(0.018)	(0.017)
$Skill_{ct}*s_{jt}$	0.05***	0.04**	0.08***	0.09***
	(0.014)	(0.016)	(0.014)	(0.015)
$Income_{ct}*gl_{jt}$	0.21***	0.28***	0.27***	0.31***
	(0.019)	(0.015)	(0.018)	(0.015)
$Income_{ct}*v_{jt}$	0.15***	0.05**	0.26***	0.12***
	(0.031)	(0.025)	(0.030)	(0.024)
C-Y FEs	Yes	Yes	Yes	Yes
I-Y FEs	Yes	Yes	Yes	Yes
R^2	0.64	0.63	0.64	0.63
#obs	14747	21847	14747	21847

Results are standardized beta coefficients. Robust standard errors are in parentheses. Coefficients are significant at 1% (***), 5% (**) or 10% (*). Pre-TRIPS is 1985-90; post-TRIPS is 1995-2005.

Table 8: Impacts of Patent Rights on Export Specialization by Country Group, Pre- and Post-TRIPS (IV Estimation)

Dependent variable is log exports to US; measure of patent rights is PR								
	Pre D(r_2)	Post D(r_2)	Pre M(r_2)	Post M(r_2)	Pre D(r_3)	Post D(r_3)	Pre M(r_3)	Post M(r_3)
$PR_{ct}*r_{jt}$	0.53***	1.35***	0.52***	0.82***	0.21	0.76***	0.33***	0.92***
	(0.150)	(0.240)	(0.109)	(0.192)	(0.142)	(0.248)	(0.098)	(0.205)
$Capital_{ct}*k_{jt}$	0.22***	0.13***	0.20***	0.15**	0.22***	0.14***	0.20***	0.14**
	(0.031)	(0.035)	(0.052)	(0.066)	(0.031)	(0.034)	(0.052)	(0.066)
$Skill_{ct}*s_{jt}$	-0.02	-0.12***	0.05**	0.04*	-0.03	-0.06*	0.05**	0.04*
	(0.024)	(0.032)	(0.023)	(0.024)	(0.024)	(0.031)	(0.023)	(0.024)
$Income_{ct}*gl_{it}$	0.10***	0.10***	0.54***	0.46***	0.12***	0.13***	0.59***	0.46***
	(0.034)	(0.033)	(0.063)	(0.058)	(0.034)	(0.032)	(0.061)	(0.058)
$Income_{ct}*v_{jt}$	0.12**	-0.06	0.15	0.30***	0.15***	0.04	0.24**	0.30***
	(0.057)	(0.057)	(0.097)	(0.091)	(0.057)	(0.053)	(0.094)	(0.090)
C-Y FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
I-Y Fes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.59	0.58	0.68	0.70	0.59	0.60	0.68	0.70
#obs	7921	11945	6826	9902	7921	11945	6826	9902

Results are standardized beta coefficients. Robust standard errors are in parentheses. Coefficients are significant at 1% (***), 5% (**) or 10% (*). Pre-TRIPS is 19785-90; post-TRIPS is 1995-2005.

Table 9. Impacts of Patent Rights on Export Specialization by Country and Industry Group, Full Sample (IV Estimation)

Dependent Variable is Log Exports to US; measure of patent rights is PR						
	All	D	M	All	D	M
	r_2	r_2	r_2	r_3	r_3	r_3
$D_{HT}*PR_{ct}*r_{jt}$	0.45***	0.35***	0.85***	2.14***	1.35***	2.91***
	(0.041)	(0.103)	(0.122)	(0.124)	(0.299)	(0.374)
$D_{MT}*PR_{ct}*r_{jt}$	0.46***	0.49***	0.83***	1.68***	1.54***	2.66***
	(0.033)	(0.073)	(0.095)	(0.093)	(0.205)	(0.271)
$PR_{ct}*r_{jt}$	0.34***	0.56***	-0.05	0.37***	0.56	0.29
	(0.043)	(0.152)	(0.135)	(0.123)	(0.503)	(0.401)
$Capital_{ct}*k_{jt}$	0.02	0.18***	0.17***	0.06	0.64***	0.60***
	(0.012)	(0.023)	(0.041)	(0.043)	(0.082)	(0.145)
$Skill_{ct}*s_{jt}$	0.04***	-0.04**	0.04**	0.17***	-0.10*	0.12**
	(0.010)	(0.017)	(0.017)	(0.037)	(0.059)	(0.059)
$Income_{ct}*gl_{jt}$	0.24***	0.10***	0.46***	0.92***	0.42***	1.57***
	(0.012)	(0.023)	(0.044)	(0.042)	(0.081)	(0.156)
$Income_{ct}*v_{jt}$	0.09***	0.04	0.20***	0.46***	0.31**	0.69***
	(0.019)	(0.039)	(0.068)	(0.067)	(0.135)	(0.237)
C-Y FEs	Yes	Yes	Yes	Yes	Yes	Yes
I-Y FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.65	0.61	0.70	0.65	0.61	0.69
#obs	36594	19866	16728	36594	19866	16728

Results are standardized beta coefficients. Robust standard errors are in parentheses. Coefficients are significant at 1% (***), 5% (**) or 10% (*). Pre-TRIPS is 1985-90; post-TRIPS is 1995-2005.

Table 10: Impacts of Patent Rights on Export Specialization by Industry Group and Country Group, Pre- and Post-TRIPS (IV Estimation)

Dependent variable is log exports to US; measure of patent rights is PR								
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
	D(r_2)	D(r_2)	M(r_2)	M(r_2)	D(r_3)	D(r_3)	M(r_3)	M(r_3)
$D_{HT}*PR_{ct}*r_{jt}$	0.17	0.51***	0.37***	1.89***	0.76*	1.91***	1.62***	5.63***
	(0.132)	(0.149)	(0.132)	(0.240)	(0.386)	(0.442)	(0.406)	(0.729)
$D_{MT}*PR_{ct}*r_{jt}$	0.39***	0.63***	0.45***	1.52***	1.26***	1.89***	1.79***	4.38***
	(0.092)	(0.117)	(0.105)	(0.190)	(0.259)	(0.324)	(0.306)	(0.523)
$PR_{ct}*r_{jt}$	0.29*	0.86***	0.18	-0.61**	0.12	1.50*	0.23	0.41
	(0.165)	(0.254)	(0.136)	(0.244)	(0.524)	(0.902)	(0.383)	(0.783)
$Capital_{ct}*k_{jt}$	0.22***	0.13***	0.19***	0.14**	0.77***	0.49***	0.66***	0.47**
	(0.031)	(0.034)	(0.052)	(0.066)	(0.111)	(0.121)	(0.185)	(0.236)
$Skill_{ct}*s_{jt}$	-0.02	-0.12**	0.04*	0.03	-0.09	-0.29**	0.15*	0.07
	(0.024)	(0.031)	(0.023)	(0.024)	(0.085)	(0.111)	(0.083)	(0.084)
$Income_{ct}*gl_{jt}$	0.10***	0.08**	0.51***	0.43***	0.40***	0.39***	1.86***	1.36***
	(0.034)	(0.032)	(0.064)	(0.058)	(0.120)	(0.114)	(0.222)	(0.209)
$Income_{ct}*v_{jt}$	0.12**	-0.04	0.13	0.27***	0.49**	0.10	0.58*	0.85***
	(0.057)	(0.056)	(0.097)	(0.091)	(0.202)	(0.190)	(0.337)	(0.324)
C-Y Fes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
I-Y Fes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.59	0.60	0.68	0.70	0.59	0.60	0.68	0.70
#obs	7921	11945	6826	9902	7921	11945	6826	9902

Results are standardized beta coefficients. Robust standard errors are in parentheses. Coefficients are significant at 1% (***), 5% (**) or 10% (*). Pre-TRIPS is 1985-90; post-TRIPS is 1995-2005.

Table 11: First-Difference Estimates of the Effects of Growth in PRs on Growth in Export Specialization, Full sample, Every Five Years (IV Estimation)

	All	D	M	All	D	M
$\Delta PR_{ct}*r_j$	0.08***	0.05***	0.12***	0.32***	-0.07	0.45***
	(0.015)	(0.019)	(0.024)	(0.042)	(0.087)	(0.063)
$\Delta Capital_{ct}*k_{jt}$	-0.06***	-0.04***	-0.08***	0.02	0.03	-0.20***
	(0.007)	(0.010)	(0.009)	(0.019)	(0.022)	(0.074)
$\Delta Skill_{ct}*s_{jt}$	0.03***	0.01	0.07***	0.01	0.02	-0.03***
	(0.009)	(0.012)	(0.015)	(0.007)	(0.012)	(0.010)
$\Delta Income_{ct}*gl_j$	-0.04***	-0.05***	-0.04***	-0.04**	0.04*	-0.12*
	(0.007)	(0.010)	(0.009)	(0.017)	(0.022)	(0.069)
$\Delta Income_{ct}*v_{jt}$	0.01	0.00	0.01	-0.01	0.03*	-0.14***
	(0.009)	(0.018)	(0.010)	(0.010)	(0.016)	(0.035)
C-Y FEs	Yes	Yes	Yes	No	No	No
I-Y Fes	No	No	No	Yes	Yes	Yes
R^2	0.084	0.090	0.051	0.065	0.122	0.129
#obs	25453	12803	12650	25453	12803	12650

Table 12: First-Difference Estimates of the Effects of Growth in PRs on Growth in Export Specialization, Long Run, 1985-2005 (IV Estimation)

	All 1985-2005	D 1985-2005	M 1985-2005	All 1985-2005	D 1985-2005	M 1985-2005
$\Delta PR_{ct}*r_j$	0.09***	0.05**	0.13***	0.45***	0.08	0.60***
	(0.017)	(0.021)	(0.026)	(0.047)	(0.092)	(0.058)
$\Delta Capital_{ct}*k_{jt}$	-0.03**	0.02	-0.06***	0.03	0.22***	-0.04
	(0.013)	(0.019)	(0.018)	(0.029)	(0.033)	(0.096)
$\Delta Skill_{ct}*s_{jt}$	0.13***	0.08***	0.24***	0.00	0.01	0.02
	(0.017)	(0.023)	(0.030)	(0.014)	(0.023)	(0.019)
$\Delta Income_{ct}*gl_j$	-0.08***	-0.12***	-0.06***	0.04	0.01	-0.07
	(0.013)	(0.021)	(0.017)	(0.029)	(0.037)	(0.108)
$\Delta Income_{ct}*v_{jt}$	-0.08***	-0.15***	-0.04**	-0.02	0.11***	-0.47***
	(0.022)	(0.044)	(0.022)	(0.020)	(0.029)	(0.053)
C-Y Fes	Yes	Yes	Yes	No	No	No
I-Y Fes	No	No	No	Yes	Yes	Yes
R^2	0.196	0.179	0.136	0.177	0.213	0.298
#obs	6438	3290	3148	6438	3290	3148

Table 13. Comparing Matched British Common Law and French Civil Law Countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Not Matched	Not Matched	Per-Cap. GDP	Per-Cap. GDP	Financial Develop	Financial Develop	Factor Endow	Factor Endow	Trade Openness	Trade Openness	All Variables	All Variables
r_{2t}	0.07***		0.02***		0.06***		0.03***		0.08***		0.04***	
	(0.001)		(0.008)		(0.008)		(0.008)		(0.008)		(0.008)	
r_{3t}		0.05***		0.02**		0.06***		0.03***		0.06***		0.04***
		(0.001)		(0.008)		(0.008)		(0.008)		(0.008)		(0.008)
C-Pair FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.58	0.58	0.50	0.50	0.46	0.46	0.50	0.50	0.58	0.58	0.60	0.60
#obs	308634	308634	8715	8715	8657	8657	7862	7862	6579	6579	6582	6582