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

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

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## Abstract

We study the effects of reforms in the legal scope of patent rights (PRs) on the international pattern of sectoral exports, before and after implementation of the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement at the World Trade Organization (WTO), in a generalized factor-proportions framework. 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. These impacts grow over time in developing economies, roughly in line with the implementation of TRIPS obligations. There is also evidence that changes over time in national PRs positively affect growth in exports. These results hold after controlling for alternative determinants of international trade and correcting for endogeneity.

*JEL Classification*: D23, F13, F14, O34
*Keywords*: Patent rights; Factor proportions; Exports



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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. 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 may be larger in middle-income countries than in developed countries, though significantly positive in both groups. Finally, 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 estimate that stronger PRs have positive effects on exports from developed and emerging countries, with the impacts being greater in the latter group.

## 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) and Melitz (2003).

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 (2007) 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 $19^{th}$ 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

### *3.1 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, Levchenko (2007) found that the quality of contracting institutions was a significant determinant of bilateral sectoral exports to the United States. 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.[1]

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

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 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

[1] 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.

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 $\theta$ 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 $\theta_3$ 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.

*3.2 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) and Levchenko (2007), 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.[2] 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. We do not include in our regressions cases where sectoral exports from a particular country to the United States are recorded as zero or missing.

To test the model we need measures of patent-rights endowments by country and patent intensities by industry. To capture patent intensity we adopt a measure from Hu and Png (2009).[3] Those authors employed data on U.S. patent grants from the NBER Patent Database (Hall, et al., 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 disaggregated 3-digit level, consistent with our trade data, but is constant over time for each industry. We label it $r$ 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

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2 http://www.internationaldata.org.

3 That paper lists patent intensities at the two-digit level. We are grateful to Albert Hu for sharing the underlying three-digit data.

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.[4] 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*.

Thus, our second measure of patent-rights endowments, and the one upon which we focus our analysis, is 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.

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

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 (2001). These figures, including updates to 2005, are available from the Center for International Development at Harvard University.[5] 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 $\delta$ 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

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

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 1972 to 2005 are derived by multiplying real GDP at PPP (constant 2000 U.S. 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.[6] Data on gross fixed capital formation (constant 2000 U.S. 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

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

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 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. imports and exports 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.

*3.3 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*, the 3-digit sectoral patent intensity, vary over time. Thus, the average number of patents per million dollars of shipments is around 0.01, 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 patent intensity is 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.[7] Both groups saw a rise in this index but there was a much larger increase among developing countries (97 percent) versus developed countries

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

(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 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 index. 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 GP and PR patent-endowment measures. Thus, the raw data demonstrate that countries with stronger patent rights tend to specialize their exports in industries with greater patent intensities.

### *4.1 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. In the first pair of regression columns the patent-interaction term is GP* *r*, while in the second pair it is PR* *r*. 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 positive and significant coefficients on patent rights. Using GP the coefficient is 0.11. Since these are beta coefficients the results imply that a one-standard-deviation increase in ln[GP]* *r* is associated with a 0.11 standard-deviation rise in the log of sectoral exports. Using PR interacted with patent intensity this coefficient is somewhat larger, at 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*, with the beta coefficient 0.19. In order to focus on policy change, hold *r* 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.[8] 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.

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 0.33. 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.

[8]The level coefficient implied by the standardized OLS coefficient is 19.38. The initial mean of ln(PR)*r 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.

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 judicial 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 and are time-invariant, they are likely exogenous to country-industry trade flows. Thus, the instrumental variables we include in the first-stage estimation are $B_c r_j$, $F_c r_j$, $S_c r_j$ and $G_c r_j$, 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. The F-tests strongly reject irrelevance of the instruments. 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 consistent with OLS. In particular, the coefficients of the interaction terms of patent rights and patent intensity remain positive and significant. In fact, they are larger in the IV cases compared with OLS. In the case with PR, 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.

As a first step in examining the robustness of these results, we re-estimate the basic equations using data averaged for each country-industry pair over the five sample years, retaining the industry and country fixed effects. The resulting IV regressions are in the final column pair of Table 5. As might be expected, this procedure reduced somewhat the magnitudes and significance levels of many of the interaction terms. However, it had virtually no impact on the patenting variable.

We next explore the question of how variations in effective patent rights affect bilateral exports to the United States among countries broken down by development levels. For this purpose, we incorporate interaction effects between patent rights and indicator variables for middle-income (MI) economies and small and poor developing countries (SM), which together make up our group of developing nations.[9] As noted by others (Maskus, 2012; Smith, 1998), it is in the MI group of nations where we might expect the largest impacts of patent reforms on competition. However, presumably countries in the SM group are less affected by IPRs in their trade.

As may be seen in Table 6, the coefficients on the patent rights variable remain significantly positive in this sample, with a large increase in moving from the OLS to the IV cases.[10] Thus, in the reference group of developed economies the impact of patent rights on export specialization is clearly positive. An interesting difference emerges for the other groups, however. Specifically, for both MI and SM the OLS coefficients on the patent-interaction variable are negative and significant, perhaps as anticipated. Still, the sum of these coefficients is significantly positive. However, once we instrument for prior legal origins these development-related interaction variables become significantly positive, particularly for the middle-income countries.[11]

The fact that the IV coefficients are larger than their OLS counterparts for patent rights may seem problematic given the notion that two-way causality would

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[9] The Appendix table lists this categorization.
[10] To conserve space from this point forward we do not list the first-stage results.
[11] Results for the small and poor countries should be treated with considerable caution because a large proportion of the bilateral sectoral trade flows between these nations and the United States are not reported (presumably indicating zero trade). There are far fewer missing trade flows among the middle-income economies.

generally support the opposite ranking.[12] 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 positive IV coefficients on the interaction variables for the developing-country groups in Table 6 are consistent with this notion.

It may seem counterintuitive that our interaction results find a larger impact of patent rights on specialization in patent-intensive goods in small and, especially, middle-income economies than in developed countries. Upon reflection, however, 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 might be expected to be

[12] Nunn (2007) similarly found larger IV coefficients with respect to contract enforcement and trade.

particularly sensitive to variations in patent rights in those countries. In developing countries, however, there is a greater relative presence of local firms that learn technology through simple imitation of foreign products and processes. In that context, 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. However, there are reasons to anticipate that the responsiveness could in fact be greater in emerging economies. First, patent reforms could attract enough technology transfer through FDI and licensing to effect a substantial transformation in local productivity (Maskus, 2012). Second, the elasticity of innovation to stronger IPRs in middle-income countries could be greater than in technologically advanced economies. The reason is that the former are not competing to advance the technological frontier, while the latter may be closer to diminishing returns to policy change. This would be the case, for example, if a one-unit rise in patent rights in developing countries encourages more transition to R&D investments than the same rise would in developed countries.[13] Overall, this is an interesting empirical question, with our results suggesting a greater stimulus to exports in

[13] A third explanation could be advanced, which is simply that the United States may, under Section 337 of its trade law, ban imports that infringe US patents, as may other developed nations under corresponding laws. Patent reforms in developing countries could then meet more open markets abroad, an issue that has not been studied in the literature.

middle-income economies than in developed countries.

While these findings are suggestive, it must be noted that the Sargan over-identification tests also reject the null hypothesis that the results are not over-identified (Table 5). Thus, while we believe the IV estimates are more reliable than the OLS findings, there is some ambiguity about this point. In either case, however, the impacts of patent rights on export specialization are clearly positive and significant.

*4.2 Robustness*

Before continuing, consider some basic robustness exercises.[14] First, it may be that our results are dominated by Hong Kong, South Korea and Singapore, all of which considerably expanded the scope of legal patent rights over the period. They also 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 are that the coefficients on the interaction term between PRs and patent intensity remain essentially unchanged, as do the other interaction coefficients.

Similarly, in our data period China rapidly expanded its share of U.S. imports in a number of sectors, while significantly increasing its legal protection of IPRs, in part due to its accession to the WTO in 2001. For these reasons one might wonder if the results are heavily influenced by the inclusion of China. Thus, we also re-estimate the basic IV equations, excluding China, finding that the results are

[14] All regressions are available on request.

virtually unchanged. For example, the coefficient of 0.39 in the fourth column of Table 5 becomes 0.40 and remains highly significant with the exclusion of China.

Another potential concern is that the positive results might be dominated by expanded exports from affiliates in countries where U.S.-based multinational corporations have significant investments. To control for this we again run the basic regressions in Table 5 and add a variable capturing the real U.S. foreign investment position in each country, using data from the Bureau of Economic Analysis. Coefficients on this variable are insignificantly different from zero, while its inclusion has only minor impacts on any of the endowment-intensity interactions. Thus, even conditioning for U.S. investment presence in a country the role of patent rights on export specialization is highly significant.

A final 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. Note also that the patent-intensity variable *r* is not time-varying and therefore not likely to depend on variations in sector-country exports to the United States across many nations. Nevertheless, to correct further for this possibility, we re-estimate the basic equation using data on factor intensities lagged for 5 years. The estimation findings, again not shown, are that the coefficients on the interaction term of PRs remain essentially unchanged in magnitude and significance, as do the other results.

*4.3 The effects of TRIPS*

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) and incorporate a post-TRIPS dummy into the patent-interaction variable. In Table 7 we present IV results from this procedure, initially for all countries and then broken down by country groups. In the sample with all countries the coefficients on the basic interactions (pre-TRIPS) are around 0.2 to 0.3 and highly significant. However, the coefficients on the interactions in the later years are significantly higher, at around 0.4 to 0.5 and also highly significant. Thus, in the era since TRIPS was introduced it appears the sensitivity of sectoral exports to patent rights increased sharply in this comprehensive sample.

The results for the developed countries are somewhat anomalous in this context. Using just the GP index, the IV regression suggests that the impact of patent rights actually fell for those countries after the implementation of TRIPS. This finding is certainly possible in theory, particularly if patent-intensive exports from those countries were crowded out by trade from the developing world. It is counterintuitive, however, and does not hold up when *PR*, the broader measure of patent rights, is incorporated. Thus, in the fourth column the same pattern emerges as for the full sample: a significantly positive coefficient early and a markedly higher impact late. It should be noted also that using the time-related patent interactions has a substantial impact on the capital, Grubel-Lloyd, and value-added coefficients.

For the developing economies as a whole, the coefficients of interacted patent rights prior to TRIPS are insignificant, which may accord with expectations. Interestingly, however, the estimated impacts after TRIPS was implemented are positive and significant, suggesting a substantial increase in the responsiveness of exports to patent reforms and enforcement conditions. It is noteworthy that, when the middle-income group is broken out separately the coefficient pre-TRIPS is significantly positive but rises considerably after 1995, particularly using the PR measure.

We provide additional perspective on the issue of how these impacts changed over time in Table 8, where we incorporate a series of variables in which year dummies for 1990, 1995, 2000, and 2005 are interacted with the product of patent rights and patent intensities. Looking first at the full sample of countries, the coefficient of patent rights is significantly positive in the reference year (1985). There was no change by 1990 but these coefficients are positive and increasing in magnitude from 1995 through 2005. In this context, it seems the effects of strengthened patents on exports, as set out largely by TRIPS, grew stronger over time. Looking at the developed nations, the large impact seemed to come only in 1995, which was the year those countries implemented any changes required of them, though all the year coefficients are positive. It is interesting that, for both the developing countries as a whole and the group of middle-income economies, the stronger impacts came late in the period in 2000 and

2005. Within the MI group these results suggest that reforms in PR were more significant than those in GP alone, underscoring the importance of contract enforcement in this regard. In any case, the results suggest a lagged response that largely tracked the delayed implementation of TRIPS obligations in many of these countries.

*4.4 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 9. Recall that our measure of patent intensity by industry 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).[15] Each set of three columns lists three regressions, covering the full set of countries and the breakdown between developed and developing 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 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.

[15] Results using GP 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.

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 10. Controlling for country-year effects the results are virtually identical to the short-run impacts in Table 9, 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.

*4.5 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 $\beta$ should be positive. Comparing all possible paired observations, without worrying about propensity matching, this regression yields a positive and highly significant coefficient on the sectoral patent-intensity measure, as shown in the first column of Table 11. 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),

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

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 (1983). 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 11. As may be seen the positive impact of patent intensity on export specialization remains intact in each case. The smaller coefficient 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. Moreover, we find that the effects of stronger PRs on exports in patent-intensive sectors are stronger in middle-income countries than in developed countries. However, they are significant in both cases and grew rapidly over time in the middle-income group, roughly following the implementation path of the TRIPS Agreement. 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 support 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. 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 (Maskus, 2012).

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**References**

Antras, P., 2005. Incomplete contracts and the product cycle. American Economic Review 95, 1054-1073.

Baier, S. L., Bergstrand, J. H., and Feng, M. 2011. Economic integration agreements and the margin of international trade. Notre Dame University, manuscript.

Barro, R. J. and Lee, J.-W., 2001. International data on educational attainment: updates and implications. Oxford Economic Papers 53, 541-563.

Bernard, A. and Jensen, B. J., 1997. Exceptional exporter performance: cause, effect, or both? Journal of International Economics 47, 1-26.

Branstetter, L., Fisman, R., and Foley, C. F., 2006. Do stronger intellectual property rights increase international technology transfer? empirical evidence from US firm-level panel data. Quarterly Journal of Economics 121, 321-349.

Branstetter, L., Fisman, R., Foley, C. F., and Saggi, K., 2011. Does intellectual property rights reform spur industrial development? Journal of International Economics 83, 27-36.

Chen, Y. and Puttitanun, T., 2005. Intellectual property rights and innovation in developing countries. Journal of Development Economics 78, 474-493.

Co, C., 2004. Do patent regimes matter? Review of International Economics 12, 359-373.

Essaji, A., 2008. Technical regulations and specialization in international trade. Journal of International Economics 76, 166–176.

Ginarte, J. C. and Park, W. G., 1997. Determinants of patent rights: a cross-national study. Research Policy 26, 283-301.

Grossman, G. M. and Lai, E. L-.C., 2004. International protection of intellectual property. American Economic Review 94, 1635-1653.

Hall, B. H., Jaffe, A. B., and Trajtenberg, M., 2001. The NBER patent citations data file: lessons, insights and methodological tools. Cambridge: National Bureau of Economic Research Working Paper 8498.

Hall, R. E. and Jones, C. I., 1999. Why do some countries produce so much more output per worker than others? Quarterly Journal of Economics 114, 83-116.

He, Y. and Maskus, K. E., 2012. Southern innovation and reverse knowledge spillovers: a dynamic FDI model. International Economic Review 53, 281-304.

Hu, A. and Png, I., 2009. Patent rights and economic growth: cross-country evidence. National University of Singapore Business School, manuscript.

Ivus, O., 2010. Do stronger patent rights raise high-tech exports to the developing world? Journal of International Economics 81, 38-47.

Javorcik, B. S., 2004. The composition of foreign direct investment and protection of intellectual property rights in transition economies. European Economic Review 48, 39-62.

Keller, W. and Yeaple, S. R., 2009. Gravity in the weightless economy. University of Colorado at Boulder, manuscript.

Lai, E. L-C, 1998. International intellectual property rights protection and the rate of product innovation. Journal of Development Economics 55, 115-130.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., and Vishny, R., 1998. Law and finance, Journal of Political Economy 106, 1113-1155.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., and Vishny, R., 1999. The quality of government, Journal of Law, Economics, and Organization 15: 222–279.

Levchenko, A., 2007. Institutional quality and international trade. Review of Economic Studies 74: 791-819.

Markusen, J. R., 2001. Contracts, intellectual property rights, and multinational investment in developing countries. Journal of International Economics 53, 189-204.

Maskus, K. 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.

Maskus, K. E., Neumann, R., and Seidel, T., 2012. How national and international financial development affect industrial R&D. European Economic Review 56, 72-83.

Maskus, K. E. and Penubarti, M., 1995. How trade-related are intellectual property rights? Journal of International Economics 39, 227-248.

Melitz, M. J., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica 71, 1695-1725.

Moser, P., 2005. How do patent laws influence innovation? Evidence from nineteenth-century world's fairs. American Economic Review 94, 1214-1236.

Nunn, N., 2007. Relationship-specificity, incomplete contracts and the pattern of trade. Quarterly Journal of Economics 122, 569-600.

Park, W. G., 2008. Intellectual property rights and international innovation, in: Maskus, K. E., (Ed.), Intellectual Property, Growth and Trade, Elsevier, Amsterdam, pp. 289-328.

Park, W. G. and Lippoldt, D., 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, OECD, Paris.

Qian, Y., 2007. Do national patent laws stimulate domestic innovation in a global patenting environment? Review of Economics and Statistics 89, 436-453.

Rajan, R. G. and Zingales, L., 1998. Financial dependence and growth. American Economic Review 88, 559-586.

Roberts, M. J. and Tybout, J. R., 1997. The decision to export in Colombia: an empirical model of entry with sunk costs. American Economic Review 87, 545-564.

Romalis, J., 2004. Factor proportions and the structure of commodity trade. American Economic Review 94, 67-97.

Rosenbaum, P. R. and Rubin, D. B., 1983. The central role of the propensity score in observational studies for causal effects. *Biometrika* 70, 41-55.

Smith, P. J., 1999. Are weak patent rights a barrier to U.S. exports? Journal of International Economics 48, 151-177.

Smith, P. J., 2001. How do foreign patent rights affect U.S. exports, affiliate sales, and licenses? Journal of International Economics 5, 411-440.

Taylor, M. S., 1994. TRIPS, trade, and growth. International Economic Review 35, 361-381.

Yang, G. and Maskus, K. E., 2001. Intellectual property rights, licensing, and innovation in an endogenous product-cycle model. Journal of International Economics 53, 169-187.

Yang, L. and Maskus, K. E., 2009. Intellectual property rights, technology transfer and exports in developing countries. Journal of Development Economics 90, 231-236.

**Appendix: Countries in the Sample**

| Developed (28) | Middle-Income (34) | Low-Income (20) |
|---|---|---|
| Australia | Algeria | Bangladesh |
| Austria | Argentina | Benin |
| Belgium | Bolivia | Burundi |
| Canada | Brazil | Cameroon |
| Cyprus | Chile | Central African Republic |
| Denmark | China | Congo |
| Finland | Colombia | Gabon |
| France | Costa Rica | Ghana |
| Germany | Dominican Republic | Jamaica |
| Greece | Ecuador | Malawi |
| Hong Kong | Egypt | Mauritius |
| Hungary | Guatemala | Nicaragua |
| Iceland | Honduras | Niger |
| Ireland | India | Paraguay |
| Israel | Indonesia | Senegal |
| Italy | Iran | Sierra Leone |
| Republic of Korea | Jordan | Sri Lanka |
| Japan | Kenya | Togo |
| Netherlands | Malaysia | Zambia |
| New Zealand | Malta | Zimbabwe |
| Norway | Mexico | |
| Poland | Pakistan | |
| Portugal | Panama | |
| Singapore | Peru | |
| Spain | Philippines | |
| Switzerland | Romania | |
| Sweden | South Africa | |
| UK | Syria | |
| | Thailand | |
| | Trinidad & Tobago | |
| | Tunisia | |
| | Turkey | |
| | Uruguay | |
| | Venezuela | |

Notes: Middle-income developing economies are indicated by the letter M. 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 | 0.014 | 0.01 | 0.0008 | 0.08 |
| k | 0.66 | 0.42 | 0.10 | 4.00 |
| s | 0.28 | 0.12 | 0.07 | 0.85 |
| v | 0.50 | 0.12 | 0.07 | 0.90 |
| gl | 0.60 | 0.29 | 0.00 | 1.00 |

**Table 1B. Correlations among Intensity Measures**

| | r | k | s | va | gl |
|---|---|---|---|---|---|
| r | 1 | | | | |
| k | -0.02 | 1 | | | |
| s | 0.36 | -0.12 | 1 | | |
| v | 0.18 | -0.38 | 0.28 | 1 | |
| gl | 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**

| *Patent Endowment* | $\Sigma_j$(exp share$_{cjt}$)* $r_j$ | $\Sigma_j$(exp share$_{cjt}$)* $r_j$ |
|---|---|---|
| *GP* | 0.37*** | |
| | (0.046) | |
| *PR* | | 0.39*** |
| | | (0.046) |
| $R^2$ | 0.14 | 0.12 |
| # observations | 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, All Countries**

| | *OLS: GP* | *IV: GP* | *OLS: PR* | *IV: PR* | *IV: GP (avg)* | *IV: PR (avg)* |
|---|---|---|---|---|---|---|
| $Patent_{ct}*r_j$ | 0.11*** | 0.33*** | 0.19*** | 0.39*** | 0.30*** | 0.38*** |
| | (0.010) | (0.026) | (0.015) | (0.032) | (0.040) | (0.052) |
| $Capital_{ct}*k_{jt}$ | 0.04*** | 0.03*** | 0.04*** | 0.03*** | -0.01 | -0.01 |
| | (0.012) | (0.012) | (0.012) | (0.012) | (0.020) | (0.020) |
| $Skill_{ct}*s_{jt}$ | 0.12*** | 0.09*** | 0.11*** | 0.09*** | 0.02 | 0.03** |
| | (0.010) | (0.010) | (0.010) | (0.010) | (0.017) | (0.017) |
| $Income_{ct}*gl_{jt}$ | 0.33*** | 0.29*** | 0.32*** | 0.29*** | 0.21*** | 0.20*** |
| | (0.011) | (0.012) | (0.011) | (0.012) | (0.017) | (0.017) |
| $Income_{ct}*v_{jt}$ | 0.21*** | 0.17*** | 0.20*** | 0.17*** | 0.10*** | 0.09*** |
| | (0.018) | (0.019) | (0.018) | (0.019) | (0.028) | (0.028) |
| C-Y Fes | Yes | Yes | Yes | Yes | Yes | Yes |
| I-Y Fes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.64 | 0.64 | 0.65 | 0.64 | 0.69 | 0.69 |
| # obs | 36594 | 36594 | 36594 | 36594 | 9529 | 9529 |
| | | | | | | |
| 1st stage | | *GP* | | *PR* | *GP(avg)* | *PR(avg)* |
| $B_c*r_j$ | | -0.16*** | | -0.16*** | -0.20*** | -0.18*** |
| | | (0.005) | | (0.003) | (0.010) | (0.007) |
| $F_c*r_j$ | | -0.30*** | | -0.28*** | -0.37*** | -0.32*** |
| | | (0.006) | | (0.004) | (0.012) | (0.008) |
| $S_c*r_j$ | | -0.09*** | | -0.08*** | -0.09*** | -0.08*** |
| | | (0.003) | | (0.002) | (0.006) | (0.004) |
| $G_c*r_j$ | | 0.03*** | | -0.00** | 0.03*** | -0.00 |
| | | (0.003) | | (0.002) | (0.007) | (0.004) |
| F 1st stage | | 362.9 | | 953.6 | 413.1 | 1091.2 |
| F instruments | | 2564 | | 2678 | 530 | 780 |
| Overid test | | 0.00 | | 0.00 | 0.19 | 0.02 |

Results are standardized beta coefficients. Robust standard errors are in parentheses. Coefficients are significant at 1% (***), 5% (**) or 10% (*). All regressions include country-year and industry-year fixed effects.

**Table 6. Impacts of Patent Rights on Export Specialization, by Country Group**

| | *OLS: GP* | *IV: GP* | *OLS: PR* | *IV: PR* |
|---|---|---|---|---|
| $Patent_{ct}*r_j$ | 0.10*** | 0.31*** | 0.16*** | 0.63*** |
| | (0.010) | (0.057) | (0.018) | (0.070) |
| $MI*Patent_{ct}*r_j$ | -0.04*** | 0.08** | -0.02*** | 0.14*** |
| | (0.006) | (0.030) | (0.007) | (0.023) |
| $SM*Patent_{ct}*r_j$ | -0.03*** | 0.02 | -0.01** | 0.07*** |
| | (0.005) | (0.012) | (0.006) | (0.014) |
| $Capital_{ct}*k_{jt}$ | 0.04*** | 0.04*** | 0.04*** | 0.04*** |
| | (0.012) | (0.012) | (0.012) | (0.012) |
| $Skill_{ct}*s_{jt}$ | 0.11*** | 0.10*** | 0.11*** | 0.11*** |
| | (0.010) | (0.010) | (0.010) | (0.010) |
| $Income_{ct}*gl_{jt}$ | 0.32*** | 0.31*** | 0.32*** | 0.31*** |
| | (0.011) | (0.011) | (0.011) | (0.011) |
| $Income_{ct}*v_{jt}$ | 0.02*** | 0.02*** | 0.02*** | 0.02*** |
| | (0.018) | (0.019) | (0.018) | (0.019) |
| C-Y Fes | Yes | Yes | Yes | Yes |
| I-Y Fes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.65 | 0.64 | 0.65 | 0.64 |
| # obs | 36594 | 36594 | 36594 | 36594 |

Results are standardized beta coefficients. Robust standard errors are in parentheses. Coefficients are significant at 1% (***), 5% (**) or 10% (*). All regressions include country-year and industry-year fixed effects.

**Table 7. Impacts of pre- and post-TRIPS Patent Rights on Export Specialization, by Country Group (IV Estimation)**

| | *All* | | *Developed* | | *Developing* | | *Middle-Income* | |
|---|---|---|---|---|---|---|---|---|
| | *GP* | *PR* | *GP* | *PR* | *GP* | *PR* | *GP* | *PR* |
| $Patent_{ct}*r_j$ | 0.20*** | 0.29*** | 0.25*** | 0.43*** | 0.06 | 0.17 | 0.33*** | 0.39*** |
| | (0.025) | (0.038) | (0.060) | (0.119) | (0.061) | (0.127) | (0.088) | (0.111) |
| $Post*Patent_{ct}*r_j$ | 0.48*** | 0.44*** | -0.62** | 0.70*** | 0.43*** | 0.52** | 0.04 | 0.77*** |
| | (0.054) | (0.062) | (0.273) | (0.268) | (0.164) | (0.262) | (0.198) | (0.271) |
| $Capital_{ct}*k_{jt}$ | 0.03*** | 0.03** | 0.24*** | 0.23*** | 0.13*** | 0.13*** | 0.17*** | 0.16*** |
| | (0.012) | (0.012) | (0.051) | (0.051) | (0.017) | (0.016) | (0.020) | (0.020) |
| $Skill_{ct}*s_{jt}$ | 0.06*** | 0.07*** | 0.05** | 0.04*** | -0.05** | -0.04** | 0.02 | -0.00 |
| | (0.011) | (0.010) | (0.013) | (0.013) | (0.020) | (0.019) | (0.023) | (0.021) |
| $Income_{ct}*gl_{jt}$ | 0.29*** | 0.29*** | 0.64*** | 0.59*** | 0.10*** | 0.09*** | 0.19*** | 0.17*** |
| | (0.012) | (0.012) | (0.046) | (0.048) | (0.015) | (0.016) | (0.020) | (0.020) |
| $Income_{ct}*v_{jt}$ | 0.15*** | 0.15*** | 0.28*** | 0.23*** | 0.07*** | 0.06** | 0.00 | -0.02 |
| | (0.019) | (0.019) | (0.052) | (0.054) | (0.026) | (0.027) | (0.031) | (0.031) |
| C-Y Fes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| I-Y Fes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.63 | 0.64 | 0.69 | 0.69 | 0.60 | 0.61 | 0.60 | 0.60 |
| # obs | 36594 | 36594 | 16728 | 16728 | 19866 | 19866 | 16024 | 16024 |

Results are standardized beta coefficients. Robust standard errors are in parentheses. Coefficients are significant at 1% (***), 5% (**) or 10% (*). All regressions include country-year and industry-year fixed effects.

**Table 8. Impacts of Patent Rights by Year on Export Specialization, by Country Group (IV Estimation)**

| | *All* | | *Developed* | | *Developing* | | *Middle Income* | |
|---|---|---|---|---|---|---|---|---|
| | *GP* | *PR* | *GP* | *PR* | *GP* | *PR* | *GP* | *PR* |
| $Patent_{ct}*r_j$ | 0.16*** | 0.27*** | 0.20** | 0.36** | 0.04 | 0.04 | 0.32** | 0.26* |
| | (0.036) | (0.053) | (0.092) | (0.174) | (0.088) | (0.169) | (0.136) | (0.144) |
| $D90*P*r_j$ | 0.03 | 0.04 | 0.06 | 0.07 | 0.02 | 0.13 | 0.01 | 0.13 |
| | (0.023) | (0.042) | (0.068) | (0.140) | (0.041) | (0.125) | (0.057) | (0.108) |
| $D95*P*r_j$ | 0.14*** | 0.12** | -0.12 | 0.99*** | 0.08 | 0.15 | 0.02 | 0.30 |
| | (0.037) | (0.055) | (0.245) | (0.336) | (0.100) | (0.200) | (0.139) | (0.223) |
| $D00*P*r_j$ | 0.34*** | 0.16** | -0.22 | 0.42 | 0.32 | 0.63* | -0.30 | 0.89** |
| | (0.062) | (0.065) | (0.329) | (0.295) | (0.211) | (0.361) | (0.256) | (0.401) |
| $D05*P*r_j$ | 0.37*** | 0.27*** | -0.61* | 0.22 | 0.32* | 0.69** | 0.14 | 0.78** |
| | (0.072) | (0.070) | (0.337) | (0.280) | (0.163) | (0.304) | (0.214) | (0.317) |
| $Capital_{ct}*k_{jt}$ | 0.03** | 0.03*** | 0.24*** | 0.23*** | 0.13*** | 0.13*** | 0.17*** | 0.16*** |
| | (0.012) | (0.012) | (0.051) | (0.051) | (0.017) | (0.017) | (0.020) | (0.020) |
| $Skill_{ct}*s_{jt}$ | 0.07*** | 0.08*** | 0.05*** | 0.04*** | -0.04** | -0.05** | 0.03 | -0.01 |
| | (0.011) | (0.010) | (0.013) | (0.013) | (0.021) | (0.020) | (0.023) | (0.022) |
| $Income_{ct}*gl_{jt}$ | 0.30*** | 0.30*** | 0.64*** | 0.59*** | 0.10*** | 0.09*** | 0.20*** | 0.17*** |
| | (0.012) | (0.012) | (0.046) | (0.048) | (0.015) | (0.016) | (0.020) | (0.021) |
| $Income_{ct}*v_{jt}$ | 0.17*** | 0.17*** | 0.27*** | 0.23*** | 0.07*** | 0.05* | 0.01 | -0.03 |
| | (0.019) | (0.019) | (0.053) | (0.054) | (0.026) | (0.028) | (0.031) | (0.032) |
| C-Y FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| I-Y FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.64 | 0.64 | 0.69 | 0.69 | 0.60 | 0.61 | 0.60 | 0.60 |
| # obs | 36594 | 36594 | 16728 | 16728 | 19866 | 19866 | 16024 | 16024 |

Results are standardized beta coefficients. Robust standard errors are in parentheses. Coefficients are significant at 1% (***), 5% (**) or 10% (*). All regressions include country-year and industry-year fixed effects.

**Table 9: First-Difference Estimates of the Effects of Growth in PRs on Growth in Export Specialization, Full sample, Every Five Years (IV Estimation)**

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

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

**Table 10: First-Difference Estimates of the Effects of Growth in PRs on Growth in Export Specialization, Long Run, 1985-2005 (IV Estimation)**

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

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

**Table 11. Comparing Matched British Common Law and French Civil Law Countries**

| | *Not Matched* | *Per-Capita GDP* | *Financial Develop* | *Factor Endow* | *Trade Openness* | *All Variable* |
|---|---|---|---|---|---|---|
| $r_j$ | 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 |
| $R^2$ | 0.58 | 0.50 | 0.46 | 0.50 | 0.58 | 0.60 |
| #obs | 308634 | 8715 | 8657 | 7862 | 6579 | 6582 |

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