Intellectual Property Rights and Access to Innovation: Evidence from TRIPS*

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Abstract

Intellectual property rights (IPRs) attempt to balance long-run incentives for innovation and short-run access to innovation. The market power granted by IPRs allows innovators to charge higher prices, potentially reducing access to patented products. However, the existence of IPRs may make a market more attractive for innovators, leading to country-specific investments in marketing and distribution. Such investments may result in quicker launch of new products, increased marketing of older products, and greater availability of treatments. We examine the consequences of stronger pharmaceutical patent protection on the speed of drug launch, price, and quantity in 59 countries from 2000-2011. The World Trade Organization required its member countries to implement a minimum level of patent protection within a specified time period as part of the TRIPS Agreement, and we use these deadlines as natural experiment for the strengthening of IPRs. Our results suggest that patents are generally associated with faster launch, higher prices, and higher sales, and that the importance of patents varies across country income groups.

1 Introduction

Intellectual property rights (IPRs) require a tradeoff between static and dynamic efficiency. By allowing innovators to block competition and therefore appropriate a greater share of the value of their ideas, IPRs can create incentives for investment in research and development (R&D). However, IPRs can also lead to static inefficiencies in the form of monopoly prices. This tradeoff is especially

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acute in the case of pharmaceuticals for developing countries. Incentives for drug development are critical, since many diseases prevalent in developing countries lack appropriate treatments, but the prices of innovative drugs in the absence of generic competition make them unaffordable to most people there.

IPRs have expanded considerably in recent years as a consequence of the 1994 Trade-Related Intellectual Property Rights Agreement (TRIPS), negotiated at the end of the Uruguay Round of the General Agreement on Tariffs and Trade (GATT). TRIPS requires members of the World Trade Organization (WTO) to implement minimum standards for intellectual property (IP) protection. For most developing countries, complying with TRIPS involved substantial changes to their IPR policies, especially for pharmaceuticals. Supporters of TRIPS asserted that IPRs should benefit developing countries in several ways. First, IPRs create incentives for innovation that can benefit both rich and poor countries. Second, IPRs can promote domestic innovation in developing countries. And third, IPRs may increase the availability of new drugs, if innovative pharmaceutical companies find markets with IPRs more attractive for launch. The Office of the Trade Representative of the United States explicitly states the "Stronger patent and data protection increases the willingness of companies to release innovative drugs in free trade partners markets, potentially increasing, rather than decreasing, the availability of medicines."[1] However, developing and least-developed countries have argued that patents reduce access to new drugs, since IPRs grant monopolistic positions to pharmaceutical companies and allow them to charge higher prices.

If IPRs make a market more attractive to innovators, either through increased pricing power or because they do not share the market with imitators, then we should observe an increase in launch speed following a country's introduction of patents. In the presence of competitors, firms may fear creating spillover benefits for their rivals; a monopoly position would therefore increase investment in country-specific marketing and distribution channels. These investments may have implications for all products the firm sells within a country, regardless of their individual patent protection status. However, we should observe an effect on pricing only for those drugs eligible for patent protection in the country, i.e. those with a patent priority date post-TRIPS compliance. Higher prices would also be expected to reduce quantities sold.

This paper examines how IPRs have affected new drug launches, prices and sales across 28 developing and 31 high income countries. We explain why IPRs may shift the equilibrium speed of launch, price and quantity. We then empirically examine these outcomes using data that allows us to compare pre- and post-IPR regimes in developing countries with outcomes in high income countries. Though the introduction of IPRs is an endogenous decision taken by policy makers, developing countries were required by WTO rules to implement a minimum level of patent protection within a specified time period, and we argue that this requirement creates a natural experiment. In addition, we exploit the fact that these policy changes did not affect all drugs in the same way.

[1] http://www.ustr.gov/about-us/press-office/fact-sheets/archives/2004/july/us-morocco-free-trade-agreement-access-medicine

Drug development has a large random component in the time between discovery (or initial patent date) and completion of clinical trials and regulatory requirements (or initial launch date). Within a country and year, we can compare the outcomes of products invented in a year prior to the adoption of TRIPS, and hence not eligible for patent protection, with those invented just after TRIPS compliance. This allows us to control for unobservable country characteristics that affect an innovator's expected profitability and that vary over time.

This paper is the first to address these questions using data that covers all disease areas and at least six years post-treatment in a large cross-section of countries. Our results suggest that the consequences of TRIPS on access have not been as negative as predicted by many in the global health community. The post-TRIPS era is in fact associated with a decrease in the price premium enjoyed by drugs with product patents, although prices in countries where the drug has a product patent are higher than where no such patent exists. Patents are generally associated with earlier launch of new products and higher sales, conditional on price. We cannot rule out the possibility that countervailing policies such as price controls or the threat of compulsory licensing induced different pricing behavior from originators, which is an extension we are currently pursuing.

We summarize related literature in the next section, with a discussion of important institutional details and existing theory to motivate our empirical study. Section 3 explains our empirical model, and Section 4 describes the data. Results are presented in Section 5, and we conclude in Section 6.

2 Background and Literature

2.1 The Impact of Intellectual Property Protection

IPRs potentially have both static and dynamic effects. Standard theory models predict negative static effects, as patents allow inventors to block imitation. This monopoly position usually leads to higher prices and lower consumption. However, these static losses can be offset by increased incentives for inventors, leading to higher rates of innovation in the long run. There are some notable exceptions to these predictions, including Boldrin & Levine (2002) and others who are critical of IPRs as a mechanism to induce innovation. We focus here on the empirical evidence, and specifically the pharmaceutical sector.

A number of papers have examined the effect of IPRs on pharmaceutical innovation, an industry setting in which patents are especially important (Cohen et al. (2000)). In a study of 26 countries, Qian (2007) suggested that IP implementation increased domestic innovation only if accompanied by high levels of development, educational attainment, and economic freedom. Arora et al. (2008) found that patent applications associated with process innovations increased in India after its compliance with TRIPS in 2005. Lanjouw & Cockburn (2001) investigated the impact of TRIPS on pharmaceutical innovations for diseases most prevalent in developing countries, but concluded that too little time had elapsed by the time of their study to observe large changes. Ten years later,

Kyle & McGahan (2012) examined whether TRIPS compliance stimulated R&D activities for new drugs across the world. They found that TRIPS has strengthened research on global diseases that affect both high-income as well as developing countries, but it has not increased R&D activities for diseases that almost exclusively affect low-income countries.

Other papers have focused on how IPRs have affected access to new treatments. In a study covering a large number of developed as well as developing countries, Lanjouw (2005) found that stronger patent protection increased the speed of new drug launches in rich countries, but the effect in lower income countries was ambiguous. She suggested that this finding may be the result of "spillover" effects of external reference pricing and parallel trade, as described in Section 2.3. Kyle (2007) and Danzon & Epstein (2008) presented evidence of such spillovers as well, in studies that used smaller samples of relatively rich countries. Borrell (2005), examining HIV treatments, found that patents were associated with faster launch in developing countries with relatively low levels of income inequality.

The most important study in this area is Chaudhuri et al. (2006), who focused on a single category of pharmaceuticals in India prior to the introduction of pharmaceutical product patents. Using counterfactual welfare calculations derived from structural estimation, they concluded that the introduction of IPRs would reduce social welfare, because of the increase in price a reduction in generic competition would cause both for new treatments and their older substitutes. Given the importance of Indian generic firms in supplying low-cost treatments for HIV in developing countries (Waning et al. (2010)), the Chaudhuri et al. (2006) results have important implications for other countries as well.

2.2 The TRIPS Agreement

The TRIPS Agreement specifies the minimum levels and enforcement of IPRs, including patents, trademarks and copyright, that are a condition of membership in the World Trade Organization (WTO). TRIPS compliance requires patent terms of at least 20 years for products and processes. Two features of TRIPS are of particular importance here.

First, the introduction of product patents for pharmaceuticals was a major change for many countries. Product patents on pharmaceuticals allow the originator to protect the active chemical ingredient in a drug. This is considered the strongest form of protection, because no other firm can produce or import that chemical during the period of patent protection. LaCroix & Liu (2008) note that in 1960, very few countries allowed pharmaceutical product patents, but more than 95% did so by 2005; TRIPS is responsible for much of this shift.

Second, the WTO established a process of dispute resolution between member states. If a country fails to comply with TRIPS, other member states may use this process to impose trade penalties on the offending country. To the extent that this gave patentholders (or at least their representatives in the governments of member states) greater enforcement power, we would expect

TRIPS to strengthen patent protection in practice, even in the absence of a legislative change to patent law.

Developing and least-developed countries generally objected to some terms of TRIPS, and particularly to pharmaceutical product patents. To alleviate their concerns, poorer countries were permitted a transition period to comply with TRIPS. While developed countries had one year after joining the WTO to conform, most developing countries were required to implement TRIPS by 2000, and least-developed countries (LDCs) by 2006. However, countries that did not grant patents in a particular technology area in 1995 were given 10 years to comply. India, for instance, had until 2005 to introduce pharmaceutical product patents. The transition period for LDCs was later extended to 2016 for pharmaceutical product patents. Further details are provided in Section 4.3.

Several other exemptions that weaken the strength of pharmaceutical patents were included in TRIPS to accommodate the concerns of developing countries as well as developed countries.[2] The 2002 Doha Declaration first outlined the conditions under which countries may issue compulsory licenses; these conditions include limiting the use of the licensed product to the domestic market, restricting the use of compulsory licenses to cases of national health emergencies and providing "reasonable" compensation to the patent holder. Since many countries lack domestic manufacturing capacity and were therefore unable to use compulsory licenses, they negotiated the ability to import compulsory-licensed products from foreign markets (parallel imports) in 2003. Several countries have issued compulsory licenses, mainly for HIV treatments, although Thailand and India have also done so for other diseases such as hypertension and cancer. Several developed countries, including the United States, threatened compulsory licensing during public health scares such as flu outbreaks (Beall & Kuhn (2012)).

2.3 Pharmaceutical Regulation

The pharmaceutical sector is highly regulated. Most developed countries require proof of safety and efficacy before permitting a drug to be sold, and many also regulate the prices that firms can charge for pharmaceuticals; see Scott Morton & Kyle (2012) for an overview. In developing countries, there is more variation in the regulation of market entry and in the use of price controls. Price controls may offset the expected effects of IPRs, since patent holders may be forced to charge lower prices (thus reducing the incentives for innovation) and access may be higher as a result (thus reducing the static inefficiencies associated with patents).

Most previous work on price regulation has focused on relatively rich markets. For example, Danzon et al. (2005), Kyle (2006), Kyle (2007) and Danzon & Epstein (2008) all examine the relationship between price controls and the speed of access to new drugs. If country markets were

[2]For example, many developed countries include a "Bolar provision," which permits research using a patented product during the term of patent protection. This exemption is particularly relevant for the development of generic drugs.

completely independent and firms faced no capital constraints in product launch, we would expect firms to launch a new drug in all markets immediately (especially with a patent clock ticking). In general, marginal costs of production are fairly low relative to the fixed cost of developing a drug, at least for small molecule drugs. So long as a firm can cover the marginal cost of producing the drug, the firm should be willing to sell. However, all these papers find that the reality is more complicated.

First, firms must incur country-specific entry costs. In countries such as the US and EU member states, the first firm to introduce a new chemical entity must document the drug's safety and efficacy through clinical trial evidence. Most developing countries have regulatory agencies charged with granting marketing authorizations, though some allow firms to rely on dossiers provided to other countries. The process of price negotiation with particular governments can be time-consuming, generating launch delays. This is a purely bureaucratic delay, although it may be increasing in regulators' preferences for low prices.

In addition, country markets are not in fact independent. Many governments use "external reference pricing" when setting the local price, meaning that they base the local price on that observed in other countries. Thus, launching a new drug at a very low price in one country can reduce the price the firm receives in other countries, if they reference that initial low price. Country markets can also be linked through parallel trade, which is legal between European Union member states and has been considered by the US. Parallel trade amounts to arbitrage of price differences between countries, which again means that launch in a low-price market is less attractive than would be the case with independent country markets. The general finding from the literature cited above is that price controls are associated with launch delays. Whether the cost-savings generated by the use of price controls outweigh the delay in access is unresolved, as is the effect on dynamic incentives for investment in innovation.

With patent protection, the innovator may block entry by generic firms. Without patent protection, both innovators and generic firms are eligible to launch a new drug. Their incentives to do so depend on other policies, in particular regarding data exclusivity and the requirements for subsequent entrants. For example, many countries (including the US) allow generic firms seeking regulatory approval to rely on the clinical data provided by the first entrant. They need only demonstrate that their product is bioequivalent to that of the first entrant's. The difference in regulatory treatment of first entrants and subsequent entrants is considered vital for assuring generic competition, since it drastically lowers the entry costs for followers.[3] However, the first entrant is granted a period of data exclusivity over its clinical trial evidence, during which time generic firms must either independently provide similar evidence to the regulator or wait for its expiration.

[3]The 1984 Hatch-Waxman Act established the regulatory pathway for generic approval, after which generic entry increased substantially.

2.4 Summary of theoretical predictions

We assume firms (either innovators or generic producers) launch products when they expect positive expected profits. If subsequent entrants can rely on the clinical trial evidence of the first entrant and there is no period of data exclusivity, the first entrant may not be able to recoup the fixed costs of launch. In this case, even without a patent barrier, no firm may launch. With a period of data exclusivity, both the innovator and generic firms may be willing to launch. If it has already conducted clinical trials for regulatory approval in other countries, the innovator may have a cost advantage. With patent protection and no data exclusivity, then only the innovator has the right to launch the product. The innovator may choose not to launch because of the regulatory spillovers discussed above.

In the absence of price regulation, the theoretical effect of IPRs on price, conditional on launch, is fairly clear: the price with IPRs should be at least as high as that without IPRs, if firms have constant marginal costs of production and there are no other large frictions in the market such as asymmetric information. With price regulation, the theoretical effect is less obvious, and depends on regulators' willingness to reward innovators, attract entry, control expenditures, etc.

In the case of total quantity sold (conditional on launch and price), the expected effect of IPRs depends on the importance of country and product specific investments. Examples of such investments include educating medical professionals about the existence, use and benefits of a new drug; establishing distribution networks; ensuring the provision of complements such as diagnostics, etc. If competitors can free-ride on those investments, then generic competition in the absence of IPRs might result in lower levels of investment and lower quantities sold.

To summarize, the theoretical impact of IPRs on launch, price and quantity is ambiguous. Under commonly observed regulatory conditions, IPRs are likely to result in faster launch. In markets with free pricing, IPRs are likely to result in higher prices, but such markets are rare. For products that require substantial country-level investment in education and infrastructure, IPRs may encourage such investments and lead to higher quantities sold. However, conditions vary substantially across countries and products.

3 Empirical model

In this section, we describe our estimation methods for evaluating the effects of IPRs on the time to launch, price and quantity sold. We use data at the country-molecule-quarter level, which allows us to control for molecule and country effects and to use within-molecule, between-country or within-country, between-molecule comparisons in evaluating the effects of IPRs. We estimate separate regressions for each of our dependent variables of interest, i.e. the speed of launch, price, and quantity sold. With this approach, we are assuming that firms first choose whether (and how quickly) to launch, which may depend on the existence of IPRs. Given launch, we examine

whether prices are higher in the presence of IPRs. Given price, we estimate whether the quantity sold changes in the presence of IPRs. To be clear, we are not estimating structural demand and supply equations. Our claim is only that IPRs may shift the equilibrium levels of these dependent variables.

IPRs exist at the country level, and change for a subset of countries as a result of the TRIPS Agreement. One estimation of the effect of IPRs is a comparison of the overall launch speed, price level and quantity sold within countries following the introduction of IPRs, compared with those that did not. This approach is not ideal, however, because the adoption of IPRs by a country does not grant generally retroactive patent rights to existing products.[4] A drug first patented in 1999 in the US, for example, is not eligible for a product patent in a country that only adopted product patents in 2000 to comply with TRIPS. We would not expect to see an effect of TRIPS on that drug. A standard difference-in-difference estimation approach would have difficulty identifying the effect of IPRs because it doesn't distinguish between outcomes for products without TRIPS patents in a post-TRIPS year from those for products that have the stronger protections granted by TRIPS.

An alternative estimation approach takes advantage of the fact that IPRs also exist at the country-molecule level to provide a much cleaner estimate of the effect of IPRs on the profits derived from a particular product. Thus, following the implementation of patent rights, only a subset of products qualifies for protection and any associated pricing power, and this subset is exogenously determined. We therefore consider an additional set of specifications that includes a "Post-TRIPS treated" group of products within a country, defined as those with patent priority dates after compliance with TRIPS. If the patent priority date determining whether a product qualifies for a Post-TRIPS patent in a country is exogenous, then the difference in outcomes between products with pre-TRIPS patents and those with Post-TRIPS patents captures the effect of strengthened IPRs.[5] To put it another way, the countries for which a drug qualifies for product patents is exogenously determined by the year in which its priority patent application was filed.

We use a discrete-time model of firms' launch decisions, assuming that we observe launch if firms expect positive profits from market entry. The latent variable for profit Π_{ijt} denotes the profit from the launch of drug j in country i and in quarter t, and we specify the following reduced-form profit function conditional on drug launch:

[4] In countries that used the mailbox provision of TRIPS, the situation is somewhat more complicated.

[5] In many countries, a patent system existed prior to official TRIPS compliance, but may not have offered the same level of protection.

$$
\begin{aligned}
\Pi_{ijt} &= \alpha_1 TRIPSCountry_i \\
&+ \alpha_2 PostTRIPS_{it} \\
&+ \alpha_3 PatentedDrug_{ijt} \\
&+ \alpha_4 PostTRIPSPatentedDrug_{ijt} \\
&+ \alpha_5 IncomeGroup_i \\
&+ \alpha_6 IncomeGroup_i * PatentedDrug_{ijt} \\
&+ \alpha_7 IncomeGroup_i * PostTRIPSPatentedDrug_{ijt} \\
&+ \alpha_8 \tau_{ijt} + X_{ijt}\mu + \phi_j + \epsilon_{ijt},
\end{aligned}
$$

where $TRIPSCountry_i$ is a dummy variable equal to one if country i was required by TRIPS to adopt pharmaceutical product patents (the most important legislative change in this context), and $PostTRIPS_{it}$ is a dummy variable equal to one if quarter t is later than country i's compliance deadline with TRIPS, regardless of whether country i was required to change its product patent law. $PatentedDrug_{ijt}$ is a dummy variable equal to one if drug j has patent protection in country i in quarter t, and $PostTRIPSPatentedDrug_{ijt}$ is a dummy variable equal to one if drug j has a post-TRIPS patent (i.e., a patent applied for following country i's compliance with TRIPS) in quarter t. These are both interacted with country i's World Bank income classification in order to allow the coefficients to vary across types of countries. τ_{ijt} is the time elapsed since the first international launch for drug j in country i at time t, X_{ijt} is a vector of other variables that may affect the launch probability (market size, GDP levels, previously launched substitute treatments for drug j in country i, etc.), ϕ_j is the drug fixed effect, and ϵ_{ijt} is the unobserved error term. We estimate this using a discrete-time hazard with a logit link.

The effect of IPRs is theoretically ambiguous in the launch equation. We simply estimate whether countries have earlier access to innovations when patent protection exists there, either from the originator or from generic imitators, without distinguishing whether the originator or imitators enter first. Originators may be more likely to launch when they have strong IPR protection, but international reference pricing may cause strategic delays in the launch. Generics may be quicker to market if no IPRs exist, but if they rely on entry by an originator to reduce their imitation costs, they may not necessarily enter the market before the originator. The sign on the post-TRIPS variables indicates the net impact of IPRs on speed of access.

We next examine the relationship between IPRs and price by estimating the following equation, conditional on launch:

$$
\begin{aligned}
P_{ijt} &= \beta_1 TRIPSCountry_i \\
&+ \beta_2 PostTRIPS_{it} \\
&+ \beta_3 PatentedDrug_{ijt} \\
&+ \beta_4 PostTRIPSPatentedDrug_{ijt} \\
&+ \beta_5 IncomeGroup_i \\
&+ \beta_6 IncomeGroup_i * PatentedDrug_{ijt} \\
&+ \beta_7 IncomeGroup_i * PostTRIPSPatentedDrug_{ijt} \\
&+ X_{ijt}\mu + \phi_j + \epsilon_{ijt},
\end{aligned}
$$

where the variables are defined as in the launch model. Generally, we expect IPRs to give originators some market power, and for this to be reflected in higher prices. However, the use of price controls by countries may limit those price increases. In this equation and the sales equation below, we include drug fixed effects for the following important rationale: if patents are more likely to be granted on novel drugs and novelty is positively correlated with a drug's quality or effectiveness, then controlling for the drug fixed effects is necessary for deriving unbiased estimates.

Finally, we turn to quantity. It is possible that originators may be more willing to undertake investments in education and advertising if they are able to appropriate most of the benefits, which is more likely in the absence of generic competition. In that case, quantity sold may be higher with IPRs, conditional on higher prices. We estimate the following equation:

$$
\begin{aligned}
Q_{ijt} &= \gamma_1 TRIPSCountry_i \\
&+ \gamma_2 PostTRIPS_{it} \\
&+ \gamma_3 PatentedDrug_{ijt} \\
&+ \gamma_4 PostTRIPSPatentedDrug_{ijt} \\
&+ \gamma_5 IncomeGroup_i \\
&+ \gamma_6 IncomeGroup_i * PatentedDrug_{ijt} \\
&+ \gamma_7 IncomeGroup_i * PostTRIPSPatentedDrug_{ijt} \\
&+ X_{ijt}\mu + \phi_j + \epsilon_{ijt},
\end{aligned}
$$

where variables are defined as earlier, and price P_{ijt} is included as an explanatory variable. Omitting it would mean that the estimated coefficients on the treatment variables would confound the effect of price and IPRs. If price is simultaneously determined with quantity, we cannot give any structural interpretation to its coefficient; it is merely a control variable. Alternatively, one

could assume that price is pre-determined, which may be the case if price controls are in use (as they are in many countries).

We also estimate the equations above with the addition of a country fixed effect, δ_i. This fixed effect will absorb differences across countries in, for example, the efficiency of bureaucracies in approving new drugs. Since there is no within-country variation in its status as a TRIPS-affected country, the variable $TRIPSCountry$ drops out, as do the dummy variables for income group. However, there may also be time-varying unobservables that drive the adoption of IPRs that are correlated with the expected profits of an innovator. The endogeneity of this policy choice has been a challenge for earlier papers that examined the effect of IPRs. Developing countries generally opposed the requirements of TRIPS, so there is a case to be made that the policy was exogenously imposed on many of them (Hamdan-Livramento (2009), LaCroix & Liu (2008)). That said, some countries resisted more than others, and some complied early. A possible instrument is for the year of actual compliance is the year by which a country was *required* to implement TRIPS under WTO rules, which we describe in more detail in 4.3. Implementation of this instrumental variables estimation is rather difficult in practice, however. First, the deadlines themselves were negotiated and may not be truly exogenous. Second, the endogenous variable $PostTRIPS$ and its interaction are binary, which suggests using a control function approach. However, this technique requires extra assumptions and is less robust than two-stage least squares. Therefore, we prefer to emphasize the advantage of the triple-difference.

We include several other controls. The number of other sellers of the same drug, the number of substitute drugs sold locally, the number of substitute drugs sold abroad (all lagged one period) capture the effect of competition. For the price and quantity regressions, we also include a lagged price index that tracks changes in the price of other drugs in the same ATC3 therapeutic class. Market size is approximated by country level variables such as the disease burden associated with each drug's primary therapeutic class, population, GDP per capita and life expectancy.

We repeat the analysis using the existence of any patent and the number of patents associated with a drug in each country-quarter. While product patents have received the most attention and were the most contentious legislative change, researchers and policymakers have also focused on the use of follow-on patents to extend market exclusivity. The latter specifications provide some insight into whether such additional patents affect originator incentives to launch and market their products.

This analysis does not permit us to calculate welfare effects. It is important to note that we also do not estimate changes in the prices and quantities of older drugs that result from any IPR-related changes for newer drugs.

4 Data

4.1 Market outcome data

Our data on key market outcomes of interest – the speed of launch, price, and units sold – comes from the MIDAS dataset produced by IMS Health. We have quarterly data on prices and units sold from 2000-2011 and on launch from 1990-2011, a time period that allows us to examine several years pre- and post-TRIPS implementation for many developing countries. The original data is provided at the package level, i.e. bottles of 30 10mg tablets. For drugs sold in multiple packages and presentations, we aggregate the revenues and number of "standard units" (smallest dose) up to the level of a molecule or combination. Although there is some price discrimination across packages within a country, this aggregation facilitates comparisons across countries. Each drug is assigned to a therapeutic class (at the ATC3 level); for drugs with sales in multiple classes, we use the class with the highest level of sales as its primary disease market.

The IMS data includes a total of 28,813 unique molecules or combinations of molecules, many of which are quite old. We focus on drugs first launched anywhere in the world after 1990, since it is this set for which TRIPS is most relevant. Drugs that are unique to one country, a set that includes many homeopathic products in India and China, are dropped from our analysis. In addition, we exclude diagnostic agents (ATC class T) and drugs that cannot be easily assigned to a disease (ATC class V). Finally, we restrict our sample to drugs that we could match to patent information. This leaves us with a total of 516 drugs.

For each molecule-country pair, we observe launch date, the total sales in nominal local currency, and the number of units sold. We convert nominal sales to real values using the country's GDP deflator. We calculate price as total sales divided by the total number of standard units sold.[6] Thus, within-country price changes do not reflect exchange rate fluctuations or inflation. For cross-country comparisons, we express prices in constant US dollars using the average exchange rate for 2011Q4.

We keep one observation per country and quarter for each drug starting from its initial launch. A drug is considered launched in a country once positive sales are observed; prior to its launch in a country but following its first launch elsewhere, launch is coded as zero and price and sales are coded as missing. Ultimately, this dataset includes 48 quarters, 60 countries, and 516 unique molecules, amounting to 1,139,275 molecule-country-quarter observations.

4.2 Firm-level data

We distinguish between originators, or firms that invest in the development of a new drug, and generic firms. Originators generally own patent rights on the molecule or a license to those rights.

[6] Some observations have negative values for sales, which reflect the return of products to the manufacturer. We set price to missing in these cases.

Many drugs are developed and/or marketed under license by multiple firms. For example, several firms could collaborate in the development, with one firm responsible for marketing the drug globally, or one firm might develop the drug and license it out to other firms for marketing in North America, Europe, etc. We use two approaches to identify these firms. First, the MIDAS dataset includes some information on the licensing status of each firm generating sales of a molecule in a country. If the licensing status is available and listed as either "original brands" or "licensed brands", we treat the observation as an originator sale, since the originator receives some payment for the sale of a licensed brand, even if the marketing firm was not the firm responsible for the innovation.[7] For the remaining cases, we use the R&D Focus database provided by IMS Health, which tracks drug development projects and includes information on the drug, its intended uses, and the firms participating in its development or marketing. We designate any firm listed as a co-developer or licensee on a drug project that is also selling the product in one of our sample countries as originators. All other producers of that drug are considered generic firms. Sometimes, generic competition occurs despite the existence of a patent in a country because either the originator or the regulatory authorities do not enforce the patent.

4.3 Country-level data

Summary information for the countries in our sample, including the dates of TRIPS deadlines, World Bank income grouping, and region, is provided in 1. More than half of the countries are considered high income, though the non-OECD high income countries include some with very high levels of income inequality (Saudi Arabia, Kuwait, and the United Arab Emirates) and the OECD group includes many transition countries in Eastern Europe. Our sample includes the major emerging markets of Brazil, Russia, India, and China, as well as Indonesia, Malaysia, Thailand, and South Africa.

One possible instrument for IPRs at the country-year level is the WTO's deadline for TRIPS compliance. At the time of the WTO's establishment, member countries that declared themselves as "developed" had one year to bring their IPRs up to the minimum standards specified by TRIPS. Developed countries that joined after 1995 were required to be compliant at the date their WTO membership began. Original WTO members that declared themselves as "developing" were permitted a transition period for TRIPS implementation, with a deadline of 2000. A longer transition period, until 2005, was permitted for countries that did not grant pharmaceutical product patents, such as India. These countries were required to provide a "mailbox provision" until then, i.e. accept patent applications even while deferring decisions until 2005, and to grant applicants five years of

[7] The set of originator firms we identify for a product also includes parallel importers, which are firms that arbitrage price differences between countries but which do not produce drugs themselves. Parallel importers sell the originator's own products in a country, but without a license. Parallel trade is reasonably widespread within the European Union and is thought to be important in some developing countries.

marketing exclusivity during the transition period.[8] Least- developed countries, designated as such by the United Nations, had the longest transition period: initially the deadline was January 1, 2006, and this was extended to 2016 as a result of the Doha round of negotiations in 2002. Thirty of our sample countries had TRIPS compliance dates in 2000 or later (see 1). Many countries had adopted pharmaceutical product patent legislation prior to their official compliance deadlines.

A limitation of all variables based on TRIPS is that they do not capture expectations that firms may have about the state of future patent protection in a country, or effective enforcement. A number of compulsory licenses have been issued under the TRIPS exemptions – or the threat of a compulsory license resulted in a substantial discount or voluntary license – mostly for HIV treatments (by Brazil, South Africa, Thailand, Malaysia and Indonesia). Thailand issued a compulsory license for a cardiovascular treatment, and Canada and the US threatened compulsory licensing of the anthrax treatment Cipro in 2001. While relatively rare events, the threat of compulsory licensing may undermine the expectations of profits associated with drug launch and lead firms to set prices low enough to avoid triggering such policies. Failure to account for this would probably underestimate the true effect of IPRs on price; one interpretation of our results, therefore, is the effect of IPRs with TRIPS-permitted exemptions or flexibilities rather than the effect of full IPRs.

To control for the impact of economic development or income level, we use the World Development Index (WDI) dataset from the World Bank. It includes GDP per capita, population, the Gini coefficient of income inequality, health expenditures per capita, life expectancy, out-of-pocket health expenditures, poverty rates, and GDP deflators across the sampled countries. Our source of information on quarterly exchange rates between the local currency and the US dollar is the Pacific Exchange Rate Service for most countries, and individual central banks otherwise.

Finally, IPRs may have been affected by trade agreements other than TRIPS. For example, the United States signed 11 free trade agreements that included so-called "TRIPS plus" requirements related to IPRs. These additional requirements often cover issues such as data exclusivity and compulsory licensing. We include a dummy variable for years following when US bilaterial agreements were signed. However, we do not yet have a comprehensive measure of other trade pacts executed during our study period.

4.4 Disease data

Our empirical approach requires information about total market size. In our setting, a market can be defined as a country-disease pair. Regulatory approval is required at the country level in order to market a drug, and gaining regulatory approval in one country does not generally allow a firm to access other countries.[9] In addition, demand for a drug that treats a particular disease is limited

[8] The US challenged India's compliance with these terms in a WTO trade dispute.

[9] Within the European Union, a firm can use a centralized approval process handled by the European Medicines Agency to win approval among all member states. Alternatively, a firm can apply for regulatory approval in one member state and use this member state as a reference for approval in other EU countries. However, in order to have

to the population affected by that disease. For example, we would not expect demand for an HIV antiviral drug to be very high among those who are HIV-negative. Therefore, we need information on disease prevalence, incidence, or burden at the country level. Since the burden of disease can change over time for any number of reasons (aging of the population, spread of infectious diseases, changes in risky behaviors, etc.), our ideal measure would capture such changes.

One measure, used by Danzon et al. (2005) among others, is the lag of total sales in each therapeutic class-country. A disadvantage of this measure is that it reflects demand for older products, rather than potential market size. This is especially problematic where previous treatments were unavailable or inadequate: the sales of HIV treatments in 1990 would be a massive underestimate of the potential market size. A new drug that represents a major therapeutic advance would expect to sell to the untreated population. In addition, historical sales of unpatented drugs with aggressive price competition may not be an accurate forecast of the potential market for a new treatment with patent protection.

The second measure is the number of deaths due to a disease from the WHO's mortality data, which has the advantage of covering most countries at annual intervals. This measure of disease burden has several limitations, however. Coverage of poorer countries is incomplete, and likely to include significant measurement error; the WHO cautions against making cross-country comparisons since there are differences in how deaths are recorded across countries. In addition, mortality is not the preferred measure of disease burden. For example, hypertension or diabetes might increase the probability of death, but may not be recorded as the direct causes of death. The mortality measure tends to underestimate the true burden of many chronic diseases that take a long time to kill, but that take a toll during the affected person's lifetime.

A third measure of disease burden is known as "disability-adjusted life years," or DALYs. This measure is also available from the WHO, but only for a single cross-section of countries in 2004. For diseases with considerable variation over time, such as HIV, this will again introduce measurement error. However, it is considered more appropriate for cross-country comparisons than mortality. We matched each drug's ATC classification to its DALY code, using fairly aggregate disease definitions (e.g., infectious and parasitic diseases are matched to ATC codes J and P).[10]

Finally, we can allow for each country to have a specific disease effect by including country-ATC fixed effects. This avoids any issues in matching ATC codes to disease-level information from other sources. However, it does require us to assume that the relative importance of diseases within a country is stable during our study period.

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the product reimbursed, the firm must negotiate with different (country specific) regulators over the price.

[10] see `http://www.who.int/entity/healthinfo/statistics/gbdestimatescauselist.pdf`

4.5 Patent data

Information on drug-specific patents comes from IMS R&D Focus and Patent Focus, which we match to the MIDAS data described above using the generic or chemical name. Of the 2,369 drugs launched since 1990, we were able to identify patents for 517. The unmatched drugs are usually new versions or combinations of old molecules, for which originators rely on country-specific data exclusivity protection in lieu of patents.[11]

We use the first application date for any patent associated with a molecule across all countries as an approximation of its priority date.[12] Originators generally must apply for protection in other countries within one year of the priority date.[13] Because of the lengthy period of clinical trials, the patent priority date is usually at least 5 years before the launch date of a new drug.

There are a number of complications in using pharmaceutical patent data. The first is that most molecules have multiple associated patents, covering a use of the molecule, manufacturing processes, etc. Despite a move towards harmonization of IP laws, the same molecule might be eligible for a different number of patents in different countries, or different breadth of coverage. For example, there is an ongoing dispute between pharmaceutical firms and the Indian Patent Office regarding the standards used to assess novelty. Where possible, we code whether a product patent (considered stronger than a process patent in general) existed in a country and the earliest year of all product patents associated with the molecule in that country, and whether any patent existed and the earliest year of any patent for that molecule in that country. Although post-TRIPS, patents have a duration of 20 years from the date of application, this is often adjusted for delays in the patent examination process, and in some countries molecules may be protected by "supplementary protection certificates" that allow additional years of market exclusivity.

When a molecule is protected by multiple patents, it is not straightforward to determine which patent is most important for blocking competition. Based on the expiry and SPC information in Patent Focus, we count the number of active patents in each country and each quarter, and distinguish between those with application dates pre and post-TRIPS. We use the expiration of a product patent to determine whether a drug is likely to be vulnerable to legal generic competition. Prior to that, any generic competition we assume to be a result of lax enforcement of IPRs. That is, generic competition in the US may legally occur despite some remaining patents on a molecule, because remaining patents cover a manufacturing process that generics have worked around after the patent has expired. In other countries, such as India, generic competition may also occur

[11] The two data sources do not use common identifiers. Where possible, we matched on chemical or molecule names. For vaccines and patents on drug delivery technologies, and for patents identified only by the name of the branded product, additional work is required to find the corresponding product in the other dataset.

[12] The filing date and priority date can be different, particularly when a patent application is derived from a parent application. We do our best to deal with this by selecting the earliest filing date for all patents associated with a molecule.

[13] Under the Paris Convention, inventors have 12 months to apply in other countries. Under the Patent Cooperation Treaty, inventors may wait up to 30 months.

because no patent exists, or because patents are not enforced. We use three different measures of patent protection in the empirical analysis: the existence of an active patent (post-grant date and pre-expiration date); the total number of active patents; and the existence of an active *product* patent.

In addition to the priority date, we observe in which countries the inventor sought protection. The introduction of patents may not always lead to the use of patents. If a market is very small or cannot support prices that allow the firm to recover variable costs and the fixed costs of launch, then a firm may not bother to apply for a local patent. Similarly, we may not observe patent applications when a firm expects lax enforcement of the patent or a negative decision from the patent office. In our sample, molecules had product patents in 41 countries on average, with the top decile at 68 and the bottom decile at 20.

It is important to note that we observe patenting activity in many countries prior to their required compliance with the TRIPS Agreement. Some complied early, and others maintained a pre-TRIPS patent system that provided weaker protection than TRIPS required. We test for a difference between pre-TRIPS patents and post-TRIPS patents in the empirical analysis below.

4.6 Summary of data

Our sample includes 27 high income OECD, 5 high income non-OECD, 21 upper-middle and 6 lower-middle income countries (see Table 1). Most non-OECD countries faced TRIPS deadlines of 2000 or 2005. The distribution of broad disease areas for the molecules in our regression sample is listed in Table 2. Cancer, cardiovascular treatments, and anti-infectives have the highest number of molecules. Table 3 shows the distribution of first patent priority dates and first global launch dates for our sample of drugs. The list of countries included, along with their required TRIPS compliance dates and dates of pharmaceutical product patent legislation, is contained in Table 15.

Country-specific information is presented in the 7. There is wide variety across countries in the fraction of molecules with product patents. For example, there are very few with product patents in the United Arab Emirates, but more than 70% of the drugs launched since 1990 in the United States had a product patent. Those without product patents in the US are generally old drugs for which a new use has been discovered, or combinations of drugs that may not always qualify for product patents. The share of products for which originators beat generics to market also varies substantially. The originator is first more than 90% of the time in most countries. However, Middle Eastern and Eastern European countries, in addition to India, often see generics first. Some of these countries only recently implemented product patents, but others may have weak patent enforcement. This suggests that generic firms often rely on local entry by originators, perhaps because obtaining regulatory approval is easier once the originator has provided clinical data or because originators invest in advertising that generic firms can benefit from. It also underscores the importance of patents in India compared with other developing countries. The impact within

India of introducing patent protection is likely to be larger than anywhere else, and may have consequences for the supply of generic drugs to countries where IPR remains weak.

Table 4 presents simple means of several key variables by income group and patent status. Not surprisingly, the fraction of product launched is increasing in country income, with 49% of eligible treatments available at some point during 1990-2011 in high income OECD countries, but only 27% for lower middle income countries. Launch by originators is faster in high income countries, and originators are quicker to markets than generics in every income group. However, originators enjoy a longer period of market exclusivity in high income countries (7.63 years) than elsewhere (5.64-6.92 years). Differences between income groups, and between drugs with patents in a country versus those without, are more stark for the subset of drugs launched since 2000. This table also includes a column indicating the fraction of products with generic competition despite the presense of an unexpired product patents, i.e. "illegal" generics.[14] This is a rare event, which indicates the importance of a product patent. Of course, this also reflects that product patents were unavailable or unenforced in many countries prior to TRIPS, so that there was a smaller IPR-related barrier to legal generic competition. In the appendix, we provide examples of launch and pricing patterns by income level and patent status for three drugs.

Trends in patenting activity are shown in Table 5, first by the year of first global launch and then by the year of first patent application. The top panel shows a clear increase in patenting over time. The total number of patents across all countries and the number of countries with product patents have grown by more than 70%. The number of launch countries has not seen the same increase, which likely reflects the long lags in product launch documented elsewhere. Similar trends (and similar truncation) are evident when the data is broken down by the year of first patent application.

Summary statistics for variables used in the regression analysis are presented in Tables 6 and 7. Table 6 contains the sample used for the launch regression, which runs from 1990-2011; only observations up to and including the quarter of launch are included for this analysis. Table 7 corresponds to the sample used for the price and quantity regressions, for which data is available from 2000-2011. Only observations post-launch are included.

5 Results

Tables 8-13 contain the results of estimating the "triple difference" specifications, in which we distinguish between the set of products that qualify for stronger patent protection, i.e. those first patented during the post-TRIPS period for a country. This allows us to disentangle changes in a country's overall business environment that may have been concurrent with the adoption of stronger IPRs (or the effect of stronger trademarks and copyrights) from the effect of having stronger patent

[14] We use the term "illegal" loosely here, since the product patent may be invalid or unenforced by the originator.

protection on a particular product. Standard errors are clustered by country. Year-fixed effects are included in all specifications, drug fixed effects are included in the price and quantity regressions, and therapeutic-class fixed effects are included in the launch regressions.[15] The inclusion of drug-fixed effects is important if patents are more likely to be granted on novel drugs and novelty is positively correlated with a drug's quality or effectiveness. We focus our discussion on the variables related to IPRs, since the coefficients on other explanatory variables are generally in line with expectations.

Table 8 presents results from specifications without country-fixed effects, where the patent dummy variable is defined as the existence of a granted product patent that has not yet expired. Note that this means the comparison group includes drugs with no patent as well as drugs protected by process or other types of patents. The TRIPS interaction picks up any increase in patent protection beyond the introduction of product patents alone. (A comparison of product patents to no patents is presented in Table 14.)

As expected, launch speed, price and sales are highest in high-income OECD countries (the omitted category) and lowest in lower middle income countries. Prices fall with a drug's age, while quantities sold increase. This pattern is typical for innovative products, which are introduced at high prices that decline over time while adoption increases. Drugs with higher prices sell in lower quantities, all else equal. As explained earlier, we cannot interpret the coefficient on price in the reduced-form quantity regression as an elasticity, but it does have the expected sign.

Ten high-income OECD countries in our sample adopted product patent legislation between 1990 and 1995, soon before the TRIPS compliance deadline of 1995. We find that drugs are launched more quickly when protected by a product patent in high-income OECD countries (the omitted category). The marginal effect on the probability of launch is .001, which is an increase of 15% over the mean of the dependent variable. Product patents granted post-TRIPS compliance are associated with even faster launch. Within the set of high income OECD countries, prices are about 28% higher in countries where a drug has a product patent than in countries without a product patent, and total sales that are about 29% higher. The coefficient on the dummy variable for a product patent granted post-TRIPS is negative in both the price and quantity regressions in almost all specifications. However, the coefficient for the post-TRIPS period is positive. Since any drug with a post-TRIPS product patent is sold during the post-TRIPS period, these results indicate a smaller price premium post-TRIPS and lower sales on net. However, the TRIPS dummy variable may reflect changes associated with WTO membership and freer trade in addition to changes in IPRs.

Product patents and the TRIPS Agreement were more contentious for countries in other income groups. To examine whether product patents have different effects in these countries, we interact the patent dummies with income groups. Though overall, launch is slower in high income non-

[15] Including drug-fixed effects in the launch equation is computationally demanding.

OECD countries, the increase in launch speed associated with product patents granted prior to TRIPS compliance is higher than in OECD countries and slightly slower for post-TRIPS product patents. The difference between the effect of patents is most apparent for prices. The gap between prices of drugs in countries where they are protected by post-TRIPS product patents and countries where they do not have product patent protection is significantly higher in high income non-OECD countries than in their OECD counterparts. Product patents are also associated with higher quantities sold, although this difference is not statistically significant. For upper middle income countries, we find no significant difference for the effect of product patents on launch compared to high income OECD countries. As in high income non-OECD countries, the patent premium associated with post-TRIPS product patents is much larger, and sales of drugs with post-TRIPS product patents is also much higher. Thus, for high income non-OECD and upper middle income countries, TRIPS appears to have increased the value of a product patent through higher prices and higher sales.

For lower middle income countries, most of which faced TRIPS compliance deadlines of 2005, it is harder for us to identify the importance of post-TRIPS patents with any statistical precision. Because of the lengthy drug development cycle, very few drugs first patented after 2005 have been brought to market by 2011, when our sample ends. However, we find no statistically different effect of post-TRIPS product patents on launch or price, and the estimated coefficients are very small. Thus, drugs are more expensive in lower middle income countries where they have a product patent, but have not become relatively more expensive with post-TRIPS product patents. Quantity sold is significantly higher for drugs with post-TRIPS product patents, suggesting some benefits for lower middle income countries.

When country-fixed effects are included, we again find that product patents are associated with faster launch, higher prices and higher sales within the set of high income OECD countries. In these specifications, the patent premium is higher for post-TRIPS product patents ($\approx$15% versus $\approx$10%), but prices for non-patented products are $\approx$14% lower during the post-TRIPS period as well. It is harder to identify differences in the effects of patents within income groups once country fixed effects are included, but it is worth noting that we again find the patent premium for drugs with post-TRIPS product patents is smaller (in fact, negative) in lower middle income countries, and quantities sold are higher. We interpret these results with caution, since they are driven by a small number of drugs.

We plot the predicted margins of the income interaction effects from the three estimation equations in Figures 1-3 (based on the specifications in Table 9, with 95% confidence intervals indicated). It is clear that stronger patent protection generally increases the probability of launch, price, and quantity sold: post-TRIPS patents are associated with higher levels of all three relative to having no product patent. The launch probability associated with post-TRIPS witnessed the largest upward jump in the high-income OECD countries. For prices and quantities sold, there is

little difference between pre and post-TRIPS patented drugs for high income countries. Since most of these countries had strong IPRs prior to TRIPS, the latter result is not particularly surprising. In contrast, post-TRIPS patents are associated with lower prices than pre-TRIPS patents in lower middle income countries, and higher quantities for a given price. Pre-TRIPS patents yield almost the same prices and quantities in middle income countries as drugs without a product patent. This may indicate weak IPR enforcement in these countries.

Results are reasonably similar when we used alternative definitions of patent protection. Tables 10- 11 contain specifications that use the existence of any patent, and those in Tables 12- 13 use the number of patents. In general, the patent premium for prices in high income non-OECD and upper middle income countries appears to be converging to that observed in high-income OECD countries, while lower middle income countries see relatively lower prices. These patterns are also evident from the figures for several drugs in the appendix.

As an additional robustness check, we estimate Seemingly-Unrelated Regressions to account for the correlations among the errors of the three equations (launch, price, and sale quantity). Because price and sales are observed only for products that were launched, the launch equation cannot be jointly estimated unless price and quantity are imputed for the non-launched drugs. We do so through a simple imputation using the price and quantity of the drug sold in neighboring countries (geographically close countries with similar income levels). In addition, we construct an alternative proxy for launch delays, defined as the number of years since to the first global launch of the drug. We can jointly estimate this equation together with the price and quantity equation instead of the launch equation, without the need for imputation. Results are robust to those from the main specifications, with much enhanced statisticaly significance. We therefore report the main specifications above as "conservative" estimates.

5.1 Discussion

We expected patents to be associated with increased prices, if patent holders are able to exploit their market power. Though the price of a drug is generally higher when there is a product patent, TRIPS has actually been associated with a smaller price difference attributable to patent protection in the poorest countries in our sample. While drugs with many local producers (i.e., generics) sell in higher quantities, drugs eligible for post-TRIPS patents have much higher sales for a given price. This suggests that originators invest efforts to shift out demand when IPRs protect them from generic competition. Since advertising and investments in educating patients or health care practioners would generally spill over to competitors, it makes sense that originators underinvest in them when facing generic imitation. We did not have a clear prediction for the effect of patents on launch, but we find across all specifications that launch of new products is faster in the presence of stronger patents. As was evident from the summary statistics, patents are not the only barrier to generic entry in practice: even when patents do not exist, generics may not enter, and they rarely

enter first in most markets.

One explanation for the observed reduction in price in lower middle income countries is that these countries exercised more stringent price controls on pharmaceuticals at the same time they introduced stronger patents. India established a panel to examine regulating the price of patented medicines in 2007, for example, shortly after its TRIPS compliance deadline in 2005. Originators may still expect higher profits with profits and price controls if they are not sharing the market with generic imitators, so launch would be more attractive. We find some evidence for this. Countries may also have issued compulsory licenses, which are permitted under the TRIPS Agreement in cases of a public health emergency. So far, the use of compulsory licensing has been limited. Beall & Kuhn (2012) identified only 34 potential compulsory licenses in 26 countries by 2011. Of course, originators may have started to reduce prices post-TRIPS or to use voluntary licensing in order to make compulsory licensing less attractive to governments, or perhaps due to increased attention to corporate social responsibility. For example, to encourage innovators to increase the availability of their products in developing countries, accesstomedicines.org produces an annual index of pharmaceutical firms based on their pricing, licensing, R%D investments, and other dimensions. Merck and GlaxoSmithKline announced a large price cut on their cervical cancer vaccines for developing countries in May 2013.

Patent challenges, or attempts to invalidate pharmaceutical patents, may also play a role. Such challenges exist in both developed countries (indeed, the Hatch-Waxman Act in the US provides clear incentives for such challenges) and increasingly in developing countries as well. In addition, countries vary in the definition of the inventive step required to patent an innovation. Sampat et al. (2012) describe the case of India, whose Patent Act does not allow patents on variants of existing pharmaceuticals without proof of increased effectiveness. Garrison (2006) provides a detailed description of other exceptions used by developing countries to limit scope of patent protection.

There are alternative explanations for a change in prices unrelated to non-IP policy shifts or political pressures. First, if originators are more willing to launch new products when they are protected by IPRs, the set of products available in a market will expand. This larger set of products may include those for which patents shifted the expected quantity sold by the innovator more than the price commanded (especially in relatively poor countries, where demand may be more elastic). In other words, the adoption of patents may have encouraged the launch of products with lower prices, for which innovators could not cover the fixed costs of launch without the assurance of 100% market share. Another explanation is related to the form of competition in developing markets. While generic products in developed countries are usually considered (nearly) perfect substitutes for the original product, emerging markets often see competition between "branded" generics, where real or perceived quality may vary across firms. In these environments, firms may incur some costs to develop and protect their brand names, or use price to signal quality. It is possible that by

allocating the entire market to the originator, TRIPS-related IPRs have eliminated the need to differentiate from other producers of the same molecule; lower costs allow lower prices.

Whether the price changes are voluntary responses by firms or result directly from other policy instruments, our estimates reflect the "net" effect of TRIPS rather than the effect of IPRs alone, and there may be substantial heterogeneity in the outcomes across countries. However, the results suggest that developing countries may have succeeded in negotiating sufficient exemptions to largely offset the negative impact of stronger IPRs. It is worth noting that the Office of the US Trade Representative has usually sought to reduce the use of these exemptions when negotiating bilateral trade agreements since the years since TRIPS. Our results indicate an increase in price and a reduction in quantities sold following the signature of such bilateral treaties. While these findings are only suggestive at this point, since the decision to sign such treaties is endogenous, they do provide some support for opponents of the "TRIPS-plus" terms that these agreements include.

6 Conclusion

Our results suggest several points about the relationship between IPRs and access. First, the existence of IPRs is neither necessary nor sufficient for the launch of pharmaceutical innovations at the country level. That is, the existence of patents on a molecule in a country does not always block generic imitation, nor does the lack of patents always deter an originator from making a product available. This suggests substantial heterogeneity in the value of IPRs, both across countries and across drugs. IPRs that are not enforced are worth very little. IPRs on molecules with very high imitation costs or low potential for profit in a country are also not particularly important. While patented products generally command higher prices, we find that the price premium for patent products is smaller following TRIPS compliance. This may reflect the greater use of pharmaceutical price controls, bargaining power of government purchasers or the threat of compulsory licensing in order to offset some of the market power granted by IPRs. Controlling for price, patented drugs enjoy higher sales. Thus, while the potential for patents to limit access is often emphasized in policy discussions, it appears that increased marketing efforts by originators may increase the availability of new treatments to populations in developing countries.

The TRIPS Agreement, which generally strengthened and harmonized IPRs across countries, does appear to have changed market outcomes. On average, access to new pharmaceuticals has increased with TRIPS: the probability of new product launch increased, as did quantities sold, conditional on price. While patents are also associated with higher prices, there is some evidence that prices in poorer countries have fallen, though not to the level of off-patent products. However, the effect of IPRs may be confounded by other policy changes. It is certainly possible that in the absence of countervailing policies, stronger IPRs would have resulted in a larger increase in prices. It is also likely that IPRs have very different implications for countries with a large generic sector, such as India, than for most of the developing countries we examine.

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Table 1: Distribution of country characteristics

Product patent legislation	**N**
1980	12
1983	1
1986	1
1987	2
1990	1
1991	4
1992	6
1993	4
1994	4
1995	1
1997	2
1998	2
1999	3
2000	7
2002	1
2003	1
2004	3
2005	3
Total	58
TRIPS deadline	**N**
1995	25
1996	1
1999	1
2000	16
2001	2
2005	12
2012	1
Total	58
Income group	**N**
High OECD	27
High nonOECD	5
Upper middle	21
Lower middle	6
Total	59
Region	**N**
East Asia & Pacific	10
Europe & Central Asia	27
Latin America & Caribbean	9
Middle East & North Africa	8
North America	2
South Asia	2
Sub-Saharan Africa	1
Total	59

Disease	**N**
Infectious and parasitic	87
Respiratory	30
Nutritional deficiencies	2
Neoplasms	91
Diabetes	23
Endocrine	9
Neuropsychotic	62
Sense organ	5
Cardiovascular	101
Digestive	27
Genitourinary	25
Skin	30
Musculoskeletal	24
Oral	1
Total	517

Table 2: Distribution of molecules across diseases

Table 3: Distribution of molecule characteristics

Year of first patent	**N**	**Year of first launch**	**N**
1969	1		
1980	10		
1981	11		
1982	14		
1983	22		
1984	29		
1985	25		
1986	26		
1987	20		
1988	36		
1989	26		
1990	36	1990	18
1991	26	1991	26
1992	26	1992	23
1993	31	1993	26
1994	22	1994	24
1995	23	1995	26
1996	22	1996	28
1997	19	1997	22
1998	15	1998	29
1999	13	1999	26
2000	12	2000	34
2001	6	2001	30
2002	13	2002	25
2003	8	2003	23
2004	7	2004	16
2005	5	2005	25
2006	4	2006	25
2007	5	2007	25
2008	2	2008	18
2009	1	2009	18
2010		2010	15
2011		2011	14

Table 4: Access and price by income group and patent status

	Mean					
	Fraction launched	N local patents	Fraction illegal generics	Years to originator entry	Years to generic entry	Price per unit
Income group						
High OECD	0.50	3.70	0.02	2.70	7.69	150.84
High nonOECD	0.30	0.31	0.01	4.32	5.86	30.50
Upper middle	0.31	0.71	0.01	4.43	7.21	23.89
Lower middle	0.27	0.36	0.00	5.46	6.51	17.86
Protection						
No product patent	0.32	0.75	0.00	4.28	6.95	65.60
Product patent	0.55	5.00	0.04	2.38	7.94	155.49
Total	0.39	2.01	0.01	3.40	7.20	107.37

Table 5: Patenting and launch activity over time

	Mean		
	N global patents	N launch countries	N countries with product patent
First global patent application			
Pre-1995	151.51	28.00	20.47
1995-1999	175.14	30.04	24.28
2000-2004	165.36	24.19	31.23
Post-2005	99.76	16.94	15.59
First global launch			
Pre-1995	109.36	29.87	15.69
1995-1999	140.33	29.66	19.56
2000-2004	175.16	28.94	22.57
Post-2005	188.71	22.99	28.64
Total	155.27	27.66	21.96

Table 6: Summary statistics for launch data

Variable	Mean	Std. Dev.	N
Launch in quarter	0.006	0.080	828963
Fraction launched	0.063	0.243	828963
Originator 1st to market	0.895	0.307	112878
Active product patent	0.143	0.350	828963
Number of granted patents on drug in country	0.672	1.917	828963
Any active patent	0.264	0.441	828963
Active product patent granted post-TRIPS	0.005	0.068	828963
Number of granted patents on drug in country during post-TRIPS era	0.036	0.404	828963
Any active patent granted post-TRIPS	0.016	0.125	828963
Post TRIPS compliance deadline	0.735	0.441	828963
Country permits product patents	0.852	0.355	828963
TRIPS country	0.449	0.497	828963
Log(DALY)	3.418	1.996	822816
Ln(GDP per capita)	1.806	1.196	828963
Life expectancy	73.780	5.281	828963
Ln(population)	2.988	1.621	828963
Post US-FTA signing	0.892	0.311	828963
Number of local substitutes	7.188	7.578	828963
Number of global substitutes	65.753	105.048	828963

Table 7: Summary statistics for price and quantity data

Variable	Mean	Std. Dev.	N
Ln(price per unit in US dollars)	1.718	2.508	337806
Ln(quantity)	3.513	2.913	337806
Active product patent	0.359	0.480	337806
Number of granted patents on drug in country	2.686	5.728	337806
Any active patent	0.616	0.486	337806
Active product patent granted post-TRIPS	0.009	0.094	337806
Number of granted patents on drug in country during post-TRIPS era	0.062	0.471	337806
Any active patent granted post-TRIPS	0.031	0.172	337806
Post TRIPS compliance deadline	0.950	0.218	337806
Country permits product patents	0.980	0.139	337806
TRIPS country	0.288	0.453	337806
Log(DALY)	3.400	1.862	336459
Ln(GDP per capita)	2.369	1.116	337806
Life expectancy	76.364	5.390	337806
Ln(population)	3.245	1.533	337806
Post US-FTA signing	0.936	0.245	337806
Number of local producers	1.629	2.387	337806
Number of local substitutes	8.887	7.162	337806
Number of global substitutes	49.100	62.308	337806
Price index of ATC class	1.508	4.265	337806

Table 8: Single equation estimation results using active product patent

	Launch b/se	Price b/se	Quantity b/se
TRIPS country	−0.1133	−0.3601*	0.0607
	(0.1370)	(0.2027)	(0.2204)
Post TRIPS compliance deadline	−0.0453	0.3312**	0.0011
	(0.1031)	(0.1378)	(0.2042)
Country permits product patents	−0.1692**	0.1813	0.4518*
	(0.0771)	(0.2783)	(0.2506)
Patent	0.4064***	0.1828***	0.2926***
	(0.0699)	(0.0504)	(0.0744)
Post-TRIPS patent	0.3226***	−0.4706***	−0.9296**
	(0.1107)	(0.1581)	(0.4183)
High nonOECD	−0.2749*	−0.3345**	−1.0949***
	(0.1551)	(0.1623)	(0.3039)
Upper middle	−0.3867***	−0.8724***	−1.5890***
	(0.1331)	(0.2559)	(0.3620)
Lower middle	−0.5742**	−0.8293**	−2.2409***
	(0.2503)	(0.4071)	(0.5222)
High nonOECD*patent	0.2971***	−0.0015	0.4820
	(0.0898)	(0.1484)	(0.3016)
High nonOECD*Post-TRIPS patent	−0.5538***	0.6166***	0.6263
	(0.1783)	(0.2183)	(0.4864)
Upper middle*patent	0.0068	0.0587	−0.3828**
	(0.1576)	(0.1119)	(0.1555)
Upper middle*Post-TRIPS patent	0.1080	0.6920***	1.3419***
	(0.2509)	(0.2568)	(0.4756)
Lower middle*patent	0.1058	0.3535	−0.3548**
	(0.2117)	(0.2287)	(0.1504)
Lower middle*Post-TRIPS patent	−0.5329	−0.0986	1.5973***
	(0.6184)	(0.2481)	(0.4777)
Log(DALY)	−0.1324***	−0.0446	0.1864***
	(0.0278)	(0.0393)	(0.0501)
Ln(GDP per capita)	−0.1024	0.2115**	0.4298***
	(0.0683)	(0.0889)	(0.1457)
Life expectancy	0.0148	−0.0196	−0.0001
	(0.0118)	(0.0141)	(0.0203)
Ln(population)	0.0344	0.1159***	0.7761***
	(0.0257)	(0.0305)	(0.0667)
Post US-FTA signing	0.1383	−0.1847	0.6076***
	(0.1231)	(0.2949)	(0.1751)
Number of local producers	1.6617***	−0.0370***	0.0979***
	(0.2963)	(0.0123)	(0.0144)
Number of local substitutes	0.0254***	0.0097	0.0171**
	(0.0042)	(0.0068)	(0.0068)
Number of global substitutes	−0.0059***	0.0001	−0.0017**
	(0.0004)	(0.0004)	(0.0008)
Years since first global launch		−0.0232***	0.0450***
		(0.0056)	(0.0093)
Price index of ATC class		−0.0153	0.0105
		(0.0100)	(0.0089)
Intercept	−5.1876***	2.7102**	−1.5585
	(0.9612)	(1.1576)	(1.4028)
N	822816	336459	336459
Pseudo or Adj. R^2	.244	.843	.763
Fixed effects	Year ATC	Year Drug	Year Drug

* p<0.10, ** p<0.05, *** p< .01. Standard errors are clustered by country. The omitted income group is High income OECD.

Table 9: Single equation estimation results using active product patent, with country fixed effects

	Launch	Price	Quantity
	b/se	b/se	b/se
Post TRIPS compliance deadline	−0.1132	−0.1432***	−0.0225
	(0.0735)	(0.0144)	(0.1507)
Country permits product patents	−0.1767**	0.0464**	−0.2520*
	(0.0796)	(0.0199)	(0.1463)
Patent	0.4967***	0.0967***	0.1729***
	(0.0776)	(0.0053)	(0.0496)
Post-TRIPS patent	0.2795***	0.0544*	−0.3034*
	(0.0849)	(0.0303)	(0.1714)
High nonOECD*patent	0.1475	0.0419*	0.0792
	(0.1113)	(0.0247)	(0.0594)
High nonOECD*Post-TRIPS patent	−0.4626***	−0.0502	−0.2782
	(0.1071)	(0.0640)	(0.2861)
Upper middle*patent	−0.1552	−0.0293***	−0.2535***
	(0.1299)	(0.0110)	(0.0720)
Upper middle*Post-TRIPS patent	0.1580	0.0290	0.4024
	(0.2434)	(0.0403)	(0.2628)
Lower middle*patent	−0.1162	−0.0149	−0.3428***
	(0.2159)	(0.0238)	(0.1050)
Lower middle*Post-TRIPS patent	−0.4660	−0.2317***	1.1270***
	(0.6388)	(0.0601)	(0.2113)
Ln(GDP per capita)	−0.7665***	−0.3847***	0.7443***
	(0.2737)	(0.0263)	(0.2200)
Life expectancy	0.0087	−0.0079*	0.1236***
	(0.0254)	(0.0046)	(0.0416)
Ln(population)	−1.1458***	−0.2735***	1.3593***
	(0.3979)	(0.0473)	(0.4288)
Number of local producers	1.6916***	−0.0314***	0.1156***
	(0.2916)	(0.0008)	(0.0120)
Number of local substitutes	0.0210***	0.0127***	0.0299***
	(0.0035)	(0.0005)	(0.0064)
Number of global substitutes	−0.0056***	−0.0002	−0.0020**
	(0.0004)	(0.0002)	(0.0008)
Years since first global launch		−0.0081***	0.0042
		(0.0016)	(0.0149)
Price index of ATC class		0.0156***	0.0063
		(0.0008)	(0.0052)
Intercept	3.8745	3.9349***	−13.1773***
	(3.7833)	(0.3562)	(4.1800)
N	822816	336459	336459
Pseudo or Adj. R^2	.252	.870	.791
Fixed effects	Year Country ATC	Year Country Drug	Year Country Drug

* p<0.10, ** p<0.05, *** p< .01. Standard errors are clustered by country. The omitted income group is High income OECD.

Table 10: Single equation estimation results using any active patent

	Launch	Price	Quantity
	b/se	b/se	b/se
TRIPS country	−0.0946	−0.3691*	0.0531
	(0.1305)	(0.2042)	(0.2174)
Post TRIPS compliance deadline	−0.0662	0.3199**	0.0027
	(0.1015)	(0.1331)	(0.2014)
Country permits product patents	−0.1595**	0.1766	0.4117*
	(0.0750)	(0.2812)	(0.2346)
Patent	0.6156***	0.2950***	0.3160***
	(0.0700)	(0.0599)	(0.0945)
Post-TRIPS patent	0.3054*	−0.5796***	−0.7097
	(0.1850)	(0.1560)	(0.4456)
High nonOECD	−0.0814	−0.2153	−1.0749***
	(0.1540)	(0.1844)	(0.3121)
Upper middle	−0.2542*	−0.7720***	−1.5052***
	(0.1362)	(0.2463)	(0.3477)
Lower middle	−0.4432*	−0.7636*	−2.1504***
	(0.2483)	(0.4051)	(0.5018)
High nonOECD*patent	−0.0496	−0.1695	0.4621
	(0.1031)	(0.1594)	(0.3290)
High nonOECD*Post-TRIPS patent	−0.1940	0.7967***	0.7063
	(0.1881)	(0.1910)	(0.4711)
Upper middle*patent	−0.0549	−0.2194	−0.3850**
	(0.1327)	(0.1708)	(0.1742)
Upper middle*Post-TRIPS patent	−0.2992	0.9156***	0.8394*
	(0.2481)	(0.2466)	(0.4830)
Lower middle*patent	−0.0412	0.0555	−0.4572*
	(0.1749)	(0.2160)	(0.2338)
Lower middle*Post-TRIPS patent	−0.1410	0.2280	0.8441*
	(0.3421)	(0.2584)	(0.4583)
Log(DALY)	−0.1280***	−0.0411	0.1891***
	(0.0282)	(0.0392)	(0.0495)
Ln(GDP per capita)	−0.1434**	0.1980**	0.4249***
	(0.0680)	(0.0880)	(0.1416)
Life expectancy	0.0182	−0.0227	−0.0022
	(0.0117)	(0.0144)	(0.0196)
Ln(population)	0.0160	0.1146***	0.7793***
	(0.0257)	(0.0298)	(0.0669)
Post US-FTA signing	0.1138	−0.2257	0.5652***
	(0.1253)	(0.2771)	(0.1804)
Number of local producers	1.6661***	−0.0388***	0.0974***
	(0.2984)	(0.0124)	(0.0146)
Number of local substitutes	0.0251***	0.0092	0.0163**
	(0.0042)	(0.0068)	(0.0068)
Number of global substitutes	−0.0056***	0.0000	−0.0018**
	(0.0005)	(0.0004)	(0.0008)
Years since first global launch		−0.0218***	0.0455***
		(0.0055)	(0.0092)
Price index of ATC class		−0.0146	0.0113
		(0.0099)	(0.0089)
Intercept	−5.5369***	2.9003**	−1.4114
	(0.9389)	(1.1592)	(1.3516)
N	822816	336459	336459
Pseudo or Adj. R^2	.246	.844	.764
Fixed effects	Year	Year	Year
	ATC	Drug	Drug

* p<0.10, ** p<0.05, *** p< .01. Standard errors are clustered by country. The omitted income group is High income OECD.

Table 11: Single equation estimation results using any active patent, with country fixed effects

	Launch	Price	Quantity
	b/se	b/se	b/se
Post TRIPS compliance deadline	−0.1182	−0.1406***	−0.0247
	(0.0744)	(0.0144)	(0.1521)
Country permits product patents	−0.1728**	0.0528***	−0.2521*
	(0.0816)	(0.0199)	(0.1462)
Patent	0.6674***	0.1464***	0.0963**
	(0.0678)	(0.0063)	(0.0477)
Post-TRIPS patent	0.3253**	−0.0212	−0.1283
	(0.1320)	(0.0181)	(0.1954)
High nonOECD*patent	−0.1169	−0.0445**	0.0792
	(0.1118)	(0.0222)	(0.0668)
High nonOECD*Post-TRIPS patent	−0.1643	0.1142***	−0.0453
	(0.1576)	(0.0367)	(0.2051)
Upper middle*patent	−0.1909*	−0.1159***	−0.0951
	(0.1020)	(0.0108)	(0.0839)
Upper middle*Post-TRIPS patent	−0.2880	0.1641***	0.0752
	(0.2061)	(0.0241)	(0.2411)
Lower middle*patent	−0.2066	−0.1106***	−0.2893
	(0.1531)	(0.0184)	(0.1854)
Lower middle*Post-TRIPS patent	−0.1432	−0.0716**	0.4180*
	(0.3381)	(0.0336)	(0.2281)
Ln(GDP per capita)	−0.8411***	−0.4008***	0.7752***
	(0.2847)	(0.0263)	(0.2210)
Life expectancy	0.0020	−0.0085*	0.1214***
	(0.0278)	(0.0046)	(0.0418)
Ln(population)	−1.0667***	−0.2842***	1.3843***
	(0.4012)	(0.0473)	(0.4341)
Number of local producers	1.6977***	−0.0317***	0.1154***
	(0.2968)	(0.0008)	(0.0121)
Number of local substitutes	0.0213***	0.0126***	0.0297***
	(0.0035)	(0.0005)	(0.0064)
Number of global substitutes	−0.0053***	−0.0002	−0.0020**
	(0.0004)	(0.0002)	(0.0008)
Years since first global launch		−0.0079***	0.0030
		(0.0017)	(0.0150)
Price index of ATC class		0.0159***	0.0066
		(0.0008)	(0.0053)
Intercept	3.8428	3.9507***	−13.2300***
	(3.8255)	(0.3572)	(4.1978)
N	822816	336459	336459
Pseudo or Adj. R^2	.254	.870	.79
Fixed effects	Year Country ATC	Year Country Drug	Year Country Drug

* p<0.10, ** p<0.05, *** p< .01. Standard errors are clustered by country. The omitted income group is High income OECD.

Table 12: Single equation estimation results using number of active patents

	Launch b/se	Price b/se	Quantity b/se
TRIPS country	−0.1191	−0.3736*	0.0463
	(0.1349)	(0.2044)	(0.2189)
Post TRIPS compliance deadline	−0.0321	0.3308**	0.0099
	(0.1012)	(0.1372)	(0.2007)
Country permits product patents	−0.1440*	0.1899	0.4611*
	(0.0745)	(0.2843)	(0.2455)
Patent	0.0774***	0.0166**	0.0293***
	(0.0100)	(0.0076)	(0.0054)
Post-TRIPS patent	0.0187	−0.1428***	−0.1673*
	(0.0483)	(0.0391)	(0.0853)
High nonOECD	−0.2612*	−0.3550**	−1.1251***
	(0.1501)	(0.1629)	(0.2927)
Upper middle	−0.3661***	−0.8735***	−1.5944***
	(0.1363)	(0.2562)	(0.3576)
Lower middle	−0.5560**	−0.8213**	−2.2192***
	(0.2501)	(0.4096)	(0.5160)
High nonOECD*patent	0.1456**	0.0133	0.1719*
	(0.0601)	(0.0331)	(0.0870)
High nonOECD*Post-TRIPS patent	−0.1089*	0.1965***	0.0843
	(0.0615)	(0.0528)	(0.1108)
Upper middle*patent	0.0233	0.0047	−0.0583*
	(0.0252)	(0.0239)	(0.0297)
Upper middle*Post-TRIPS patent	−0.0785	0.2265***	0.2180**
	(0.0749)	(0.0676)	(0.1070)
Lower middle*patent	0.1196**	0.0862	−0.0986*
	(0.0528)	(0.0719)	(0.0531)
Lower middle*Post-TRIPS patent	−0.1098	−0.0612	0.2753***
	(0.1050)	(0.0830)	(0.0988)
Log(DALY)	−0.1400***	−0.0459	0.1797***
	(0.0276)	(0.0389)	(0.0500)
Ln(GDP per capita)	−0.1098*	0.2145**	0.4281***
	(0.0639)	(0.0896)	(0.1446)
Life expectancy	0.0149	−0.0209	−0.0002
	(0.0117)	(0.0145)	(0.0205)
Ln(population)	0.0257	0.1124***	0.7696***
	(0.0259)	(0.0309)	(0.0639)
Post US-FTA signing	0.1289	−0.1989	0.5894***
	(0.1269)	(0.2833)	(0.1755)
Number of local producers	1.6759***	−0.0374***	0.0984***
	(0.3026)	(0.0123)	(0.0143)
Number of local substitutes	0.0294***	0.0098	0.0172**
	(0.0039)	(0.0069)	(0.0067)
Number of global substitutes	−0.0061***	0.0001	−0.0017**
	(0.0005)	(0.0004)	(0.0008)
Years since first global launch		−0.0250***	0.0421***
		(0.0054)	(0.0093)
Price index of ATC class		−0.0158	0.0095
		(0.0100)	(0.0091)
Intercept	−5.1436***	2.8721**	−1.4399
	(0.9759)	(1.1807)	(1.4258)
N	822816	336459	336459
Pseudo or Adj. R^2	.247	.843	.764
Fixed effects	Year ATC	Year Drug	Year Drug

* p<0.10, ** p<0.05, *** p< .01. Standard errors are clustered by country. The omitted income group is High income OECD.

Table 13: Single equation estimation results using number of active patents, with country fixed effects

	Launch	Price	Quantity
	b/se	b/se	b/se
Post TRIPS compliance deadline	−0.0981	−0.1410***	−0.0142
	(0.0737)	(0.0144)	(0.1519)
Country permits product patents	−0.1526**	0.0511**	−0.2454
	(0.0778)	(0.0199)	(0.1476)
Patent	0.0857***	0.0085***	0.0179***
	(0.0120)	(0.0004)	(0.0026)
Post-TRIPS patent	0.0037	−0.0108*	−0.0339
	(0.0561)	(0.0059)	(0.0362)
High nonOECD*patent	0.1263**	0.0143**	0.0503***
	(0.0609)	(0.0068)	(0.0089)
High nonOECD*Post-TRIPS patent	−0.0871	0.0315**	−0.0500
	(0.0742)	(0.0134)	(0.0407)
Upper middle*patent	0.0015	0.0038*	−0.0368***
	(0.0198)	(0.0020)	(0.0102)
Upper middle*Post-TRIPS patent	−0.0479	0.0369***	0.0159
	(0.0767)	(0.0084)	(0.0526)
Lower middle*patent	0.0653	0.0007	−0.0922***
	(0.0424)	(0.0066)	(0.0334)
Lower middle*Post-TRIPS patent	−0.0767	−0.0631***	0.1726**
	(0.1200)	(0.0161)	(0.0791)
Ln(GDP per capita)	−0.6539**	−0.3599***	0.8152***
	(0.2640)	(0.0263)	(0.2252)
Life expectancy	0.0110	−0.0049	0.1226***
	(0.0237)	(0.0046)	(0.0428)
Ln(population)	−1.1102***	−0.2479***	1.4173***
	(0.3701)	(0.0473)	(0.4411)
Number of local producers	1.7097***	−0.0315***	0.1156***
	(0.2979)	(0.0008)	(0.0121)
Number of local substitutes	0.0258***	0.0127***	0.0297***
	(0.0032)	(0.0005)	(0.0064)
Number of global substitutes	−0.0059***	−0.0001	−0.0020**
	(0.0004)	(0.0002)	(0.0008)
Years since first global launch		−0.0107***	0.0009
		(0.0016)	(0.0154)
Price index of ATC class		0.0154***	0.0058
		(0.0008)	(0.0051)
Intercept	2.9442	3.6550***	−13.7172***
	(3.5488)	(0.3563)	(4.3071)
N	822816	336459	336459
Pseudo or Adj. R^2	.255	.870	.791
Fixed effects	Year Country ATC	Year Country Drug	Year Country Drug

* p<0.10, ** p<0.05, *** p< .01. Standard errors are clustered by country. The omitted income group is High income OECD.

Table 14: Single equation estimation results using active product patent vs. no patent, with country fixed effects

	Launch	Price	Quantity
	b/se	b/se	b/se
Post TRIPS compliance deadline	−0.0616	−0.1423**	−0.0483
	(0.0857)	(0.0593)	(0.1550)
Country permits product patents	−0.2091**	0.0467	−0.2611*
	(0.0871)	(0.0913)	(0.1518)
Patent	0.7751***	0.1727***	0.2016***
	(0.0865)	(0.0363)	(0.0683)
Post-TRIPS patent	0.2082**	0.0227	−0.3487
	(0.0971)	(0.0786)	(0.2160)
High nonOECD*patent	−0.0911	0.0020	0.0725
	(0.1222)	(0.0376)	(0.0771)
High nonOECD*Post-TRIPS patent	−0.3380***	−0.0405	−0.2391
	(0.1145)	(0.1128)	(0.3236)
Upper middle*patent	−0.3507**	−0.0944	−0.2453**
	(0.1411)	(0.0749)	(0.1027)
Upper middle*Post-TRIPS patent	0.2544	0.0715	0.3882
	(0.2537)	(0.1422)	(0.2986)
Lower middle*patent	−0.3230	−0.0673	−0.3486**
	(0.2156)	(0.1169)	(0.1423)
Lower middle*Post-TRIPS patent	−0.3449	−0.2012**	1.1127***
	(0.6550)	(0.0916)	(0.2509)
Ln(GDP per capita)	−0.7335***	−0.4330***	0.7475***
	(0.2768)	(0.1573)	(0.2126)
Life expectancy	0.0118	−0.0109	0.1150***
	(0.0274)	(0.0246)	(0.0407)
Ln(population)	−1.1153***	−0.3125	1.4935***
	(0.4079)	(0.2660)	(0.3578)
Number of local producers	1.7523***	−0.0366***	0.1297***
	(0.3000)	(0.0065)	(0.0122)
Number of local substitutes	0.0222***	0.0123**	0.0290***
	(0.0038)	(0.0050)	(0.0057)
Number of global substitutes	−0.0053***	−0.0002	−0.0009
	(0.0005)	(0.0004)	(0.0008)
Years since first global launch		−0.0080	0.0010
		(0.0091)	(0.0146)
Price index of ATC class		0.0106**	−0.0005
		(0.0044)	(0.0052)
Intercept	3.2261	7.2356**	−13.2234***
	(3.9428)	(2.7209)	(3.9082)
N	720872	249888	249888
Pseudo or Adj. R^2	.254	.870	.783
Fixed effects	Year Country ATC	Year Country Drug	Year Country Drug

* p<0.10, ** p<0.05, *** p< .01. Standard errors are clustered by country. The omitted income group is High income OECD.

Figure 1: Patent protection and launch

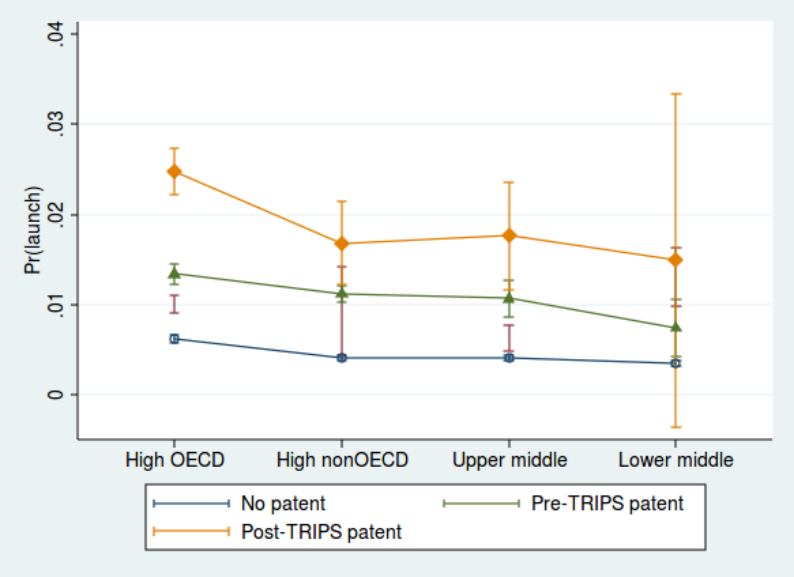


Figure 2: Patent protection and price

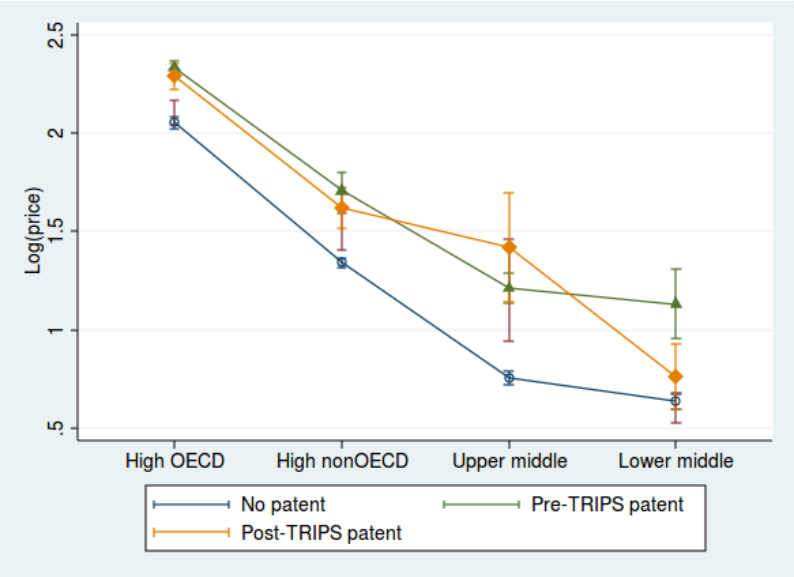
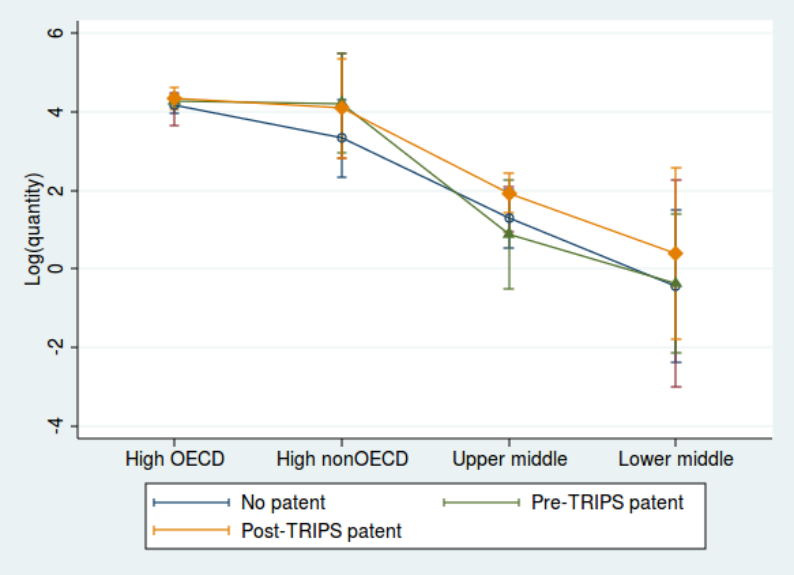


Figure 3: Patent protection and quantity



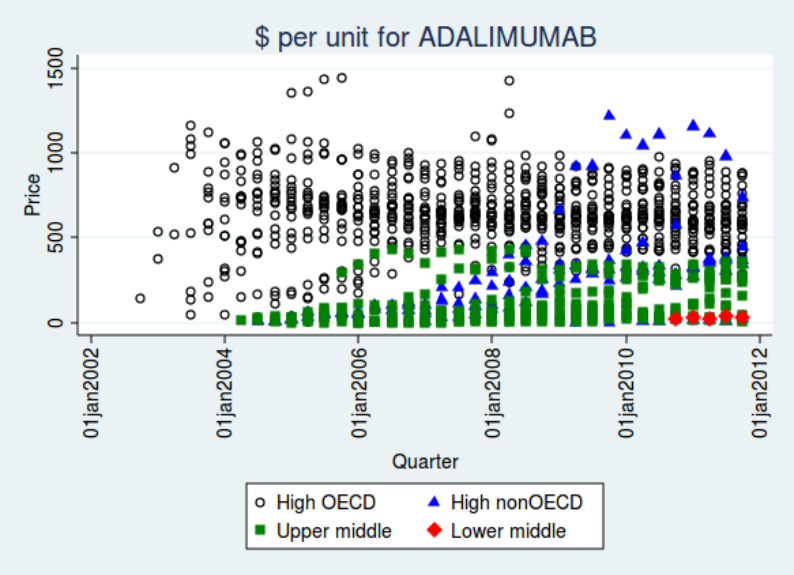
7 Appendix

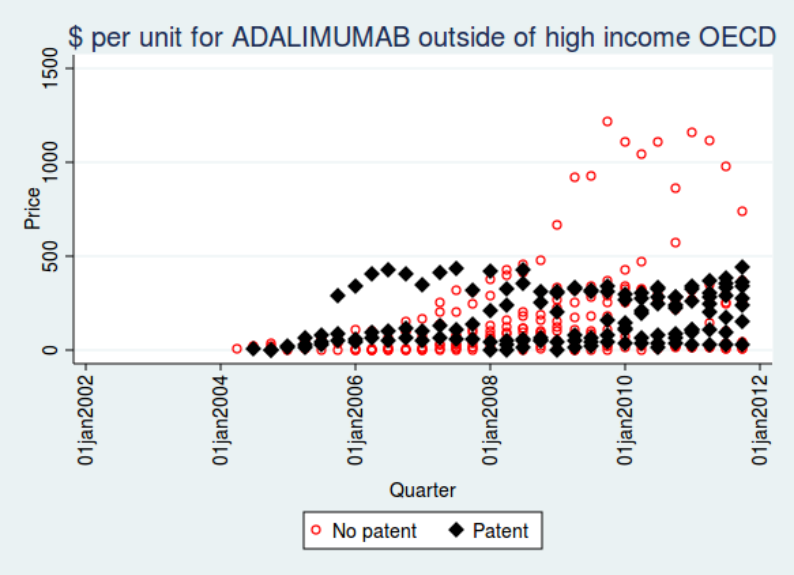
Country	Legislation	Deadline	Income Group	Originator first	Fraction product patent
ALGERIA	2003		Upper middle	0.13	0.00
ARGENTINA	2000	2005	Upper middle	0.95	0.12
AUSTRALIA	1990	1995	High OECD	0.94	0.62
AUSTRIA	1987	1995	High OECD	0.92	0.53
BELGIUM	1984	1995	High OECD	0.94	0.69
BRAZIL	2004	2005	Upper middle	0.93	0.37
BULGARIA	1993	1996	Upper middle	0.95	0.20
CANADA	1987	1995	High OECD	0.93	0.66
CHINA	1993	2001	Upper middle	0.90	0.33
COLOMBIA	2000	2000	Upper middle	0.97	0.05
CROATIA	2004	2000	High nonOECD	0.16	0.15
CZECH REPUBLIC	1991	1995	High OECD	0.94	0.32
DOMINICAN REPUBLIC	2000	2000	Upper middle	0.98	0.00
ECUADOR	1998	2000	Upper middle	0.94	0.03
EGYPT	2005	2005	Lower middle	0.90	0.06
ESTONIA	1994	2000	High OECD	0.27	0.11
FINLAND	1995	1995	High OECD	0.94	0.35
FRANCE	1978	1995	High OECD	0.96	0.70
GERMANY	1968	1995	High OECD	0.93	0.71
GREECE	1992	1995	High OECD	0.94	0.50
HUNGARY	1994	1995	High OECD	0.93	0.32
INDIA	2005	2005	Lower middle	0.17	0.12
INDONESIA	1997	2000	Lower middle	0.95	0.08

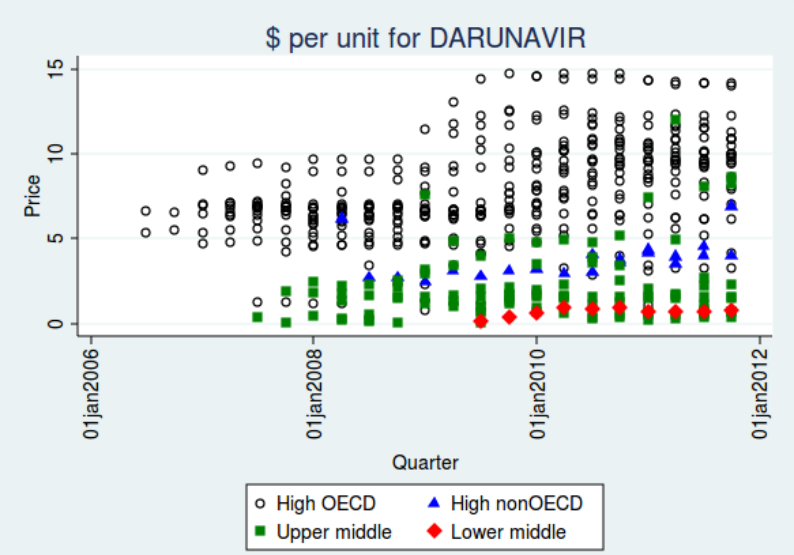
Country	Legislation	Deadline	Income Group	Originator first	Fraction product patent
IRELAND	pre-1980	1995	High OECD	0.95	0.54
ITALY	1978	1995	High OECD	0.94	0.68
JAPAN	1976	1995	High OECD	0.98	0.71
JORDAN	1999	2000	Upper middle	0.94	0.00
KOREA	1986	2000	High OECD	0.87	0.48
KUWAIT		2005	High nonOECD	0.22	0.01
LATVIA	1993	1999	Upper middle	0.20	0.24
LITHUANIA	1994	2001	Upper middle	0.17	0.19
LUXEMBOURG	1978	1995	High OECD	0.97	0.62
MALAYSIA	1983	2000	Upper middle	0.93	0.00
MEXICO	1991	2000	Upper middle	0.88	0.36
MOROCCO	2000	2005	Lower middle	0.92	0.05
NEW ZEALAND	pre-1980	1995	High OECD	0.93	0.49
NORWAY	1992	1995	High OECD	0.93	0.33
PAKISTAN	2005	2005	Lower middle	0.92	0.00
PERU	2000	2000	Upper middle	0.94	0.01
PHILIPPINES	1998	2000	Lower middle	0.98	0.22
POLAND	1993	2000	High OECD	0.92	0.22
PORTUGAL	1992	1995	High OECD	0.93	0.39
RUSSIA	1992	2012	Upper middle	0.90	0.27
SAUDI ARABIA	2004	2005	High nonOECD	0.92	0.01
SINGAPORE	1994	2000	High nonOECD	0.94	0.18
SLOVAKIA	1991	1995	High OECD	0.91	0.28
SLOVENIA	1992	1995	High OECD	0.95	0.24
SOUTH AFRICA	1997	1995	Upper middle	0.97	0.50

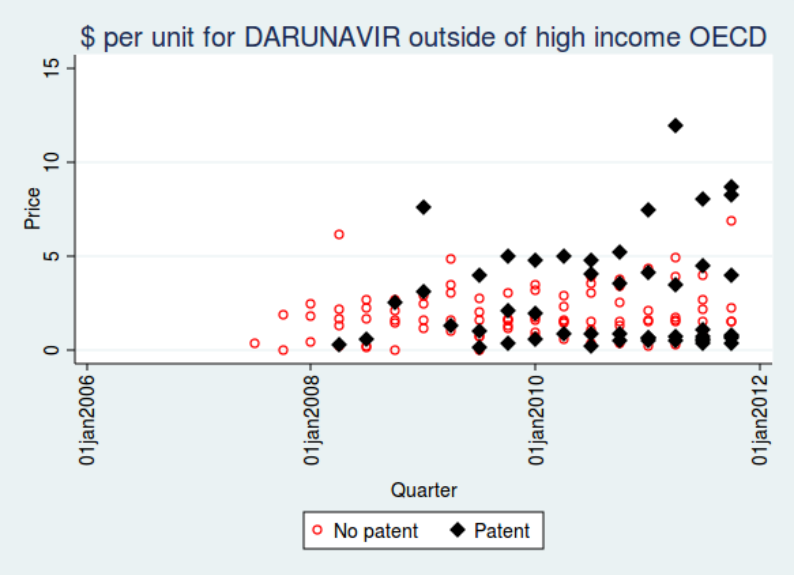
Country	**Legislation**	**Deadline**	**Income Group**	**Originator first**	**Fraction product patent**
SPAIN	1992	1995	High OECD	0.92	0.42
SWEDEN	1978	1995	High OECD	0.93	0.67
SWITZERLAND	1977	1995	High OECD	0.93	0.69
THAILAND	1999	2000	Upper middle	0.93	0.03
TUNISIA	2000	2005	Upper middle	0.95	0.00
TURKEY	1999	2005	Upper middle	0.94	0.18
UNITED ARAB EMIRATES	2002	2005	High nonOECD	0.94	0.01
UNITED KINGDOM	1949	1995	High OECD	0.92	0.71
UNITED STATES	1790	1995	High OECD	0.93	0.71
URUGUAY	1991	2005	Upper middle	0.94	0.04
VENEZUELA	2000	2000	Upper middle	0.98	0.01

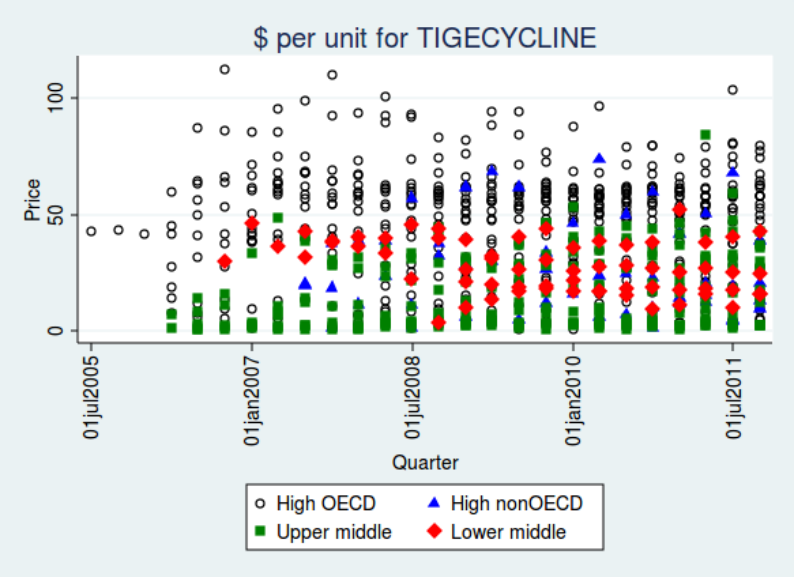
Table 15: Country data

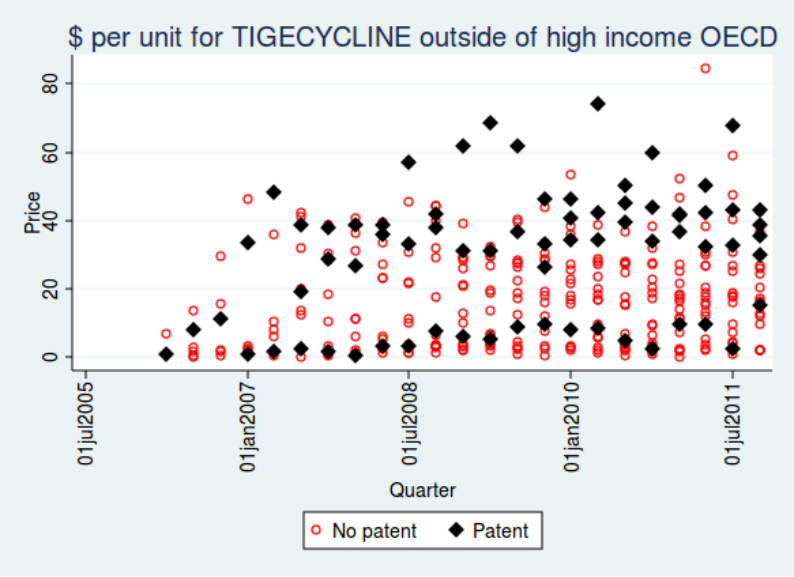

$ per unit for ADALIMUMAB
Price
0
500
1000
1500
01jan2002
01jan2004
01jan2006
01jan2008
01jan2010
01jan2012
Quarter
High OECD
High nonOECD
Upper middle
Lower middle


$ per unit for ADALIMUMAB outside of high income OECD
Price
0
500
1000
1500
01jan2002
01jan2004
01jan2006
01jan2008
01jan2010
01jan2012
Quarter
No patent
Patent


$ per unit for DARUNAVIR
Price
0
5
10
15
01jan2006
01jan2008
01jan2010
01jan2012
Quarter
High OECD
High nonOECD
Upper middle
Lower middle


$ per unit for DARUNAVIR outside of high income OECD
Price
0
5
10
15
01jan2006
01jan2008
01jan2010
01jan2012
Quarter
No patent
Patent


$ per unit for TIGECYCLINE
Price
0
50
100
01jul2005
01jan2007
01jul2008
01jan2010
01jul2011
Quarter
High OECD
High nonOECD
Upper middle
Lower middle


$ per unit for TIGECYCLINE outside of high income OECD
Price
0
20
40
60
80
01jul2005
01jan2007
01jul2008
01jan2010
01jul2011
Quarter
No patent
Patent