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Effects of Regulation on Drug Launch and Pricing in Interdependent Markets

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Abstract

This study examines the effect of price regulation and competition on launch decisions and pricing of new drugs. Our data cover launch experience in 15 countries of drugs in 12 therapeutic classes that experienced significant innovation over the decade 1992-2003. We find that launch timing and prices of innovative drugs are related to prices of competitor products, with greater effects within-subclass than between-subclass. Controlling for domestic market conditions, we find that new drug launch hazards and launch prices are affected by launch experience in other countries, especially within the EU. Manufacturers rationally delay launch in low-price markets that could undermine higher prices in other markets that are linked through regulatory referencing or parallel trade. By undermining market segmentation, these policies may have contributed to launch lags and price convergence, leading to welfare loss in lower price countries. These findings have implications for US proposals to constrain pharmaceutical prices in the US through external referencing and drug importation.

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I. Introduction

New drugs contribute importantly to health outcomes and health expenditures; hence the launch and pricing of new drugs is important to consumers and health payers. Prompt launch is also critical for drug manufacturers, given the fixed patent life over which to recoup the high costs of R&D.[1] In fact, in a study of the 1990s launch experience of 85 drugs in 25 industrialized countries, only roughly half the potential country-compound launches occurred, and many of the eventual launches involved months or years of delay (Danzon, Wang and Wang, 2005).

Regulatory requirements for proof of safety and efficacy ("registration") are an intended hurdle to new drug launch, and earlier studies (e.g., Peltzman, 1973; Grabowski and Vernon, 1978) found that increased stringency of these requirements contributed to launch lags in the US in the 1960s and 1970s. However, in the 1990s the US and the EU harmonized data requirements and adopted measures to accelerate review. Consequently, differences in registration requirements can no longer explain differences in launch delays, especially between EU countries, at least for drugs that meet strict registration requirements. By contrast, price regulation remains country-specific and has become more complex. Both theory and evidence suggest it plays a role in cross-national differences in new drug launch timing and pricing.

If price regulation reduces the manufacturer's expected price and NPV, it could lead directly to non-launch, especially for drug-country pairs with small sales potential. Launch delay is harder to explain, however, because NPV decreases with launch delay, given fixed patent terms. Of course, regulation may entail bureaucratic delay or encourage strategic delay by firms

[1] Pharmaceutical R&D takes on average 8-12 years and costs roughly $802m. (in 2001 US dollars) per new compound approved in the US (DiMasi, Hansen and Grabowski, 2003).

or regulators to influence the ultimate price.[2] Under this model of regulation-induced delay, welfare effects are not necessarily negative, provided that regulators weigh any loss of health benefit to citizens against any savings from lower prices that result from their regulatory system.[3]

More problematic from a social welfare perspective is the increasingly common regulatory strategy of "external referencing," whereby one country references a drug's price in foreign markets in setting its domestic prices. For example, Canada caps the price of innovative new drugs at the median price in seven countries, while some EU countries use the mean or minimum price in a group of referenced countries, or cross-national comparisons in *ad hoc* evaluations of their regulatory regimes, as in the UK. In addition, the EU permits parallel trade (drug importation by third parties) between EU countries. External referencing and parallel trade undermine a firm's ability to segment markets and sustain price discrimination. With interdependent markets, a firm's optimal strategy may be to delay or not launch in low-price countries that are linked through referencing or parallel trade to potentially higher price countries, even if expected net revenue in the low price countries is positive, absent spillovers.

This paper examines the relative contribution to drug launch lags and pricing of a country's own regulatory and market environment (direct effects) vs. spillovers (indirect effects) from other countries. Understanding the contribution of regulation and other factors to launch patterns is important for understanding the diverse launch experience of new drugs in different countries. Estimating the impact of external referencing and parallel trade is particularly important given the recent US proposals to legalize drug importation and reference drug prices in

[2] Delay could also reflect launch budget constraints faced by firms, in which case a rational strategy may be to launch first in the most profitable markets and use the revenues generated to cover launch in less profitable markets.
[3] Negative external effects may accrue to other countries if the regulated prices result in suboptimal contribution to joint costs of R&D (Danzon, 2003).

other countries as a mechanism to limit US drug prices.[4] Adoption of such policies could impose significant welfare loss on consumers abroad if creating interdependence between the US and foreign markets leads to launch delay, non-launch or higher prices in other countries to avoid spillover effects to the large, higher-price US market which currently accounts for over 45 percent of global pharmaceutical sales.

In addition to direct and indirect effects of regulation, we also examine the role of static (within-subclass) and dynamic (between-subclass) competition on launch timing and pricing. Pharmaceuticals are subject to both static and dynamic competition, as drugs with new mechanisms and potentially improved efficacy and safety profiles replace older drugs. We examine how competitor prices in new vs. old subclasses affects launch delay and launch prices, and test for first mover advantage.

Previous studies of launch experience for new drugs (Danzon, Wang and Wang, 2005; Lanjouw, 2005; Kyle, 2006, 2007) have generally concluded that price regulation contributes to launch delay. However, these studies lacked product-specific data on prices of newly launched drugs and competitor products; they estimated effects on launch lags but not launch prices; proxy measures for regulation were at best rough and sometimes inaccurate; and none clearly distinguished between the direct (own-country) and the indirect (spill-over) effects of regulation.

This paper analyzes launch timing and launch prices using quarterly sales data, by drug, from IMS Health[5] from 1992-2003 for 12 major therapeutic classes in 15 countries: four relatively high price EU markets (Germany, the UK, the Netherlands and Sweden) and five lower-price EU markets (France, Italy, Spain, Portugal and Greece); four large high-price non-

[4] Regulating US prices based on external referencing to foreign prices has been proposed but so far not enacted. Drug importation has been approved but so far is not implemented, because the Secretary of Health and Human Services has been unwilling to certify that safety and cost reduction requirements have been met.
[5] IMS Health Inc. is a market research company that collects data on sales of pharmaceuticals in all significant world markets.

EU markets (the US, Japan, Switzerland and Canada) and two middle income, Latin American countries (Brazil and Mexico). The 12 classes are: asthma, antiulcerants, antidepressants, epileptics, antihypertensives, antinausea, Parkinsons, anti-psychotics, lipid lowering (statins), migraine, osteoporosis, and anticlotting. All of these classes experienced dynamic entry of a new subclass during our study period. For example, in the antiulcerant class, the proton pump inhibitors (PPIs) displaced the H2-antagonists; in the antidepressant class, the selective serotonin and neurotonic reuptake inhibitors (SSRIs and SNRIs) displaced the tricyclates. We refer to new and old subclasses as "superior" and "inferior", but intend no judgment about their relative value.

We estimate a two-equation model of launch hazard and launch price for superior and inferior subclasses separately, to permit comparison between them. The launch hazard equation is estimated using a complementary log-log (hereafter "clog-log") specification with time-varying covariates. To control for unobserved molecule-level heterogeneity, we also estimate a random effects estimator. We also estimate a split population model (Schmidt and Witte, 1989) to test the restriction implicit in the clog-log duration model that the ultimate probability of launch as time goes to infinity is unity for all drugs in all countries. The launch hazard results are robust to specification, although both the split population and the random effects hypotheses are confirmed. For the launch price equation, we report OLS estimates of price conditional on launch and random effects models. We also tested for selection bias, using a two-step Heckman selection estimator (Heckman, 1979). Although we lack strong identification and rely largely on functional form, the Mills ratio is sometimes significant. The launch price results are also robust to specification.

Our results confirm that country-specific prices of competitor products are positively associated with launch hazards and prices. Although cross-price effects are more significant

within classes than between classes, the material differences in launch experience of drugs in the superior subclass vs. late-launching drugs in the inferior subclasses suggest strong, non-price dynamic competition. The own-price effects imply that to the extent that regulation reduces drug prices, it contributes to launch delay/non-launch. Spillover effects from foreign countries also play a role, especially in low-price EU countries. We find no evidence that manufacturers delay launch as a bargaining strategy to obtain a higher price; rather, launch delay more likely reflects firms' strategic decisions to accept a low price only after higher prices have been established for the drug in other countries. Launch by local corporations increases launch probabilities but not launch prices, and these effects are confined to a subset of countries.

The remainder of the paper is organized as follows. Section II reviews the relevant literature, Section III outlines regulatory regimes and expected effects, and Section IV describes the theoretical model. Section V details the data and empirical methods, Sections VI-VIII describe the results, and Section IX concludes.

II. Literature

Several recent studies have examined effects of price regulation on lags in new drug launch. Danzon, Wang and Wang (2005) studied the launch experience of 85 new drugs in the 25 leading markets in the 1990s, focusing on drugs that had met registration requirements of one of the two strictest agencies (the US Food and Drug Administration [FDA] and the UK Medicines Agency) and hence could potentially meet registration requirements in other countries. This analysis used the average price of all competitor products at global launch as a proxy for the direct regulatory effect on expected price. It concluded that price regulation that leads to low

prices deters launch and that the potential for price spillovers to higher-price markets exacerbates launch lags in low price markets. Launch by a local firm increased launch probability.

Kyle (2007) used a larger, more heterogeneous sample of compounds and countries, a longer time period (1980-1999), and a vector of dummy variables for types of regulation and price rank.[6] She concluded that price controls reduced launch probability in countries that impose them. However, the estimated effects may be biased because the regulatory indicators from 2000/2002 sources incorrectly classify some countries, do not reflect changes over the 20-year analysis period, and are missing for several countries.[7] More fundamentally, indicators for regulatory type imperfectly capture the multidimensional and heterogeneous detail of price control regimes across countries and over time. Country-specific price data were not available, except for a 2002 indicator for a country's price rank. This was negatively related to launch probability prior to 1995 and insignificant after 1995, which seems inconsistent with the conclusion, that price controls delay or reduce launch probabilities. Indicators for prior launch in a high price or low price country were positively associated with launch probabilities in other countries, consistent with price spillovers. However, differential effects across countries were not

[6]The large and heterogeneous sample probably includes some drugs that could not meet requirements of the strictest agencies, such as the US FDA, the UK Medicines Agency and the EMEA. A count of Medline citations is included as a control for product quality; however, this US-centric measure may be a biased proxy for quality as perceived by non-US countries, especially for drugs not launched in the US.

[7] Several examples can illustrate the measurement error that results from applying the 2000/2002 listing of regulatory indicators to the 1980-1999 data. In the paper, "price controls refer to a cap on either the ex-manufacturer price or the amount a national health service pays for a pharmaceutical product." By this definition, therapeutic reference pricing should count as a form of price control, because the reference price is a cap on reimbursement for all drugs in a class. In fact, therapeutic reference pricing is included as a separate dummy variable and has a coefficient that is positive and sufficiently large (0. 854) to dominate the negative price control coefficient (-.418). But this effect appears to be spurious due to measurement error: although 7 countries are classified as having therapeutic reference pricing, in fact only the Netherlands had comprehensive therapeutic referencing, and this was only introduced in 1991. Similarly, 6 countries are categorized as "Pharmacoeconomic evidence recommended," but in fact pharmacoeconomic evidence was used informally to support price negotiations in many countries from the early 1990s. In the late 1990s, both the UK and Canada required pharmacoeconomic evidence, but neither of these countries are categorized recommending use of pharmacoeconomic evidence. Given this measurement error, the large negative coefficient on this variable is unlikely to provide an accurate measure of the effect of requiring pharmacoeconomic evidence. Germany is listed as having a Prescribing budget, but in fact it was only in place from 1993-2000, and never enforced.

estimated; thus, spillovers related to regulatory regime cannot be distinguished from other unobserved factors that could lead to closely sequenced launches, such as coordinated regulatory filings.[8] Kyle (2006) performs a similar analysis focusing on the role of firm characteristics on launch in the G7 countries. A binary indicator for drug price controls is negatively associated with launch probability, but is significant only in some specifications.

Lanjouw (2005) examined first launch of a large, heterogeneous sample of new drugs in 68 countries between 1982 and 2002, using covariates measured at first global launch. She also used binary indicators for price regulation regimes that are invariant across the 20-year study period and lacked data on prices. She concluded that even moderate price controls in high income countries reduced the long-run likelihood of drug launch, while price controls in less wealthy countries reduced launch probability in the short-run but not the long-run. Spillover effects are not addressed.

Our study adds to this literature in several ways. We have detailed, product-specific data on prices and volumes over time for competitor products, categorized into new ("superior") and old ("inferior") subclasses. These data on competitor prices provide a more accurate measure of the net effect of regulation on prices. Separate analysis of launches in new vs. old subclasses provides evidence on the nature of dynamic (between subclasses) vs. static (within subclass) competition in this industry. Our analysis is the first to examine launch prices, to shed light on determinants of launch prices and validate findings from the launch hazard estimates. We distinguish carefully between direct effects of regulation vs. indirect effects through cross-national spillovers, since welfare implications are very different. Our more detailed analysis

[8] High (1%) significance levels for most explanatory variables are surprising and may be upward biased by including multiple indications for the same compound. Since follow-on indications are usually not subject to separate price regulation and simply receive the same price as previous indications, with minimal price regulatory delay, including them could bias coefficient estimates.

shows that the benefits of launch by a domestic corporation is confined to a few countries and are not general, as suggested by previous studies. Our findings are robust to estimation methods, including controls for within-molecule correlation and unobserved heterogeneity.

III. Pharmaceutical Regulation: Registration and Price/ Reimbursement

New drugs face two possible regulatory hurdles, registration and price approval.

Registration: In all countries, drug registration and market access require proof of safety, efficacy and manufacturing quality. In the 1990s, the US FDA and counterpart agencies in Europe and Japan harmonized some requirements while retaining autonomy in data evaluation and decision-making. The FDA adopted user fees to hire more reviewers and created fast track and priority review procedures. Since 1995, the newly-created European Medicines Agency has offered both centralized and mutual recognition procedures that can lead to simultaneous registration of new drugs in all EU countries, as an alternative to the traditional country-by-country review through national drug approval agencies.[9] Thus cross-national differences in drug registration regulation cannot explain large systematic differences in launch lags among EU countries or between the US and EU. Japan is an exception in retaining special requirements, including clinical trials on Japanese citizens.

Price/Reimbursement Regulation: Once a new drug clears registration hurdles, most countries with national health insurance systems require price approval as a condition of reimbursement.[10] Countries use one or both of two criteria to set launch prices: (a) "internal referencing" to prices of competitor products in the same therapeutic class, with potential for

[9] Under the mutual recognition procedure, a manufacturer selects one rapporteur country to review the application; other countries have 90 days in which to challenge the approval, otherwise it takes effect automatically. The centralized procedure is mandatory for biologics and optional for other innovative drugs.

[10] Price approval is generally not required if the drug is launched without reimbursement, but such unreimbursed launch is rare, except for "lifestyle" drugs.

mark-ups for superior efficacy based on pharmacoeconomic data, etc.,[11] or (b) "external referencing" to the minimum, median or mean of prices of the same drug in specified comparator countries. Most price regulatory regimes disallow post-launch price increases, and price cuts are sometimes mandated; hence the launch price is critical to the life-cycle price profile. Internal referencing may entail bureaucratic delay and possibly strategic delay if firms (regulators) hold out to achieve a higher (lower) price. However, regulators should have incentives to weigh any costs associated with launch delay against the benefits in lower prices, with no significant spillover to other countries.

By contrast, because external referencing regimes benchmark their price to the price of the same drug in other countries, they create incentives for firms to delay launch in low price countries until prices have been established in potentially higher price countries that reference to or are referenced by these lower price countries. To the extent that referencing-induced delay accrues in a country that is referenced, associated costs are not born by the referencing country. For example, suppose that in the absence of referencing, drug prices would be roughly proportional to GDP per capita. If high income countries then cap their prices by referencing low income countries' prices, this may lead to launch delay and welfare loss in low income countries. Of course, because some low income countries cap their prices at the minimum price in a group of similar countries, this could lead to launch delay and welfare loss in the referring low income country that would be internalized. Thus referencing is predicted to lead to delays in lower-price

[11] Internal benchmarking may involve informal negotiations between the manufacturer and the regulator, as in France, or a more mechanistic reference price (RP) reimbursement system as in the Netherlands. Under therapeutic RP, drugs are classified based on mechanism of action and indication; generic RP only groups drugs with the same molecule, hence mainly off-patent drugs with generic equivalents. All drugs in a group receive the same reimbursement or reference price. A manufacturer may in theory charge a higher price, but the patient must pay any excess over the RP.

countries, regardless of who does the referencing, but effects are external to the regulator's calculus when higher price countries reference lower price countries.

Identifying the contribution of these regulatory regimes to drug launch experience across countries is complex because some countries use multiple forms of regulation, including both internal and external referencing; details of each regulation type differ across countries; and external referencing webs are complex, sometimes informal and could extend transitively to unrelated countries. For example, the effects in country A of being referenced by country B depend on the other countries in B's reference set and whether B references the mean, median or minimum of prices, whether an initial regulated price in B is updated if launch in A occurs after launch in B, and whether other countries reference B. The effects of internal referencing depend on whether the regulator is aggressive in using older products as the benchmark and disallowing product improvements claimed by the firm.

Of the countries in our data and study period, France and Japan used both internal and external referencing. Canada used external referencing for "innovative" (first in class) drugs and internal referencing for "me-too" (late entrant) drugs. The Netherlands adopted a comprehensive but largely ineffective internal reference price reimbursement system in 1991; in 1996 it added price controls based on external referencing.[12] Italy used a cost plus system until 1993; since then it has used variants of external referencing. Canada, Japan, Greece and Portugal also used externally referenced price controls for most of the period.[13]

[12] Many other countries, including most US health plans, the UK, Sweden, Italy, Germany and Spain used RP reimbursement for generically equivalent, off-patent compounds for at least part of our period. However, because these generic RP systems apply to off-patent drugs only, they are unlikely to affect launch decisions for new drugs, unless inter-brand effects are significant due to either competition or informal referencing.

[13] The EU countries that used external reference pricing include Denmark (since April 1997, up to 10 EU countries excluding Greece and Italy), Greece (lowest in the EU), Ireland (lower of UK or the average in Denmark, France, Germany, the Netherlands, and the UK), Italy (average of up to 12 EU countries, must be on market for 4 countries and at least 2 with direct price controls), the Netherlands (since June 1996, average price in Belgium, France, Germany, and the UK), and Portugal (lowest in France, Italy, and Spain)..

Free Pricing: In the US, Germany and the UK, a new drug could be launched and reimbursed without prior price approval, although other control mechanisms applied. In the US, multiple private health plans negotiate discounts in return for preferred formulary status and Medicaid requires discounts off the price charged to private payers. These mechanisms may delay drug diffusion but not launch. In Germany, the reference price reimbursement system adopted in 1989 excluded new on-patent drugs, which could be launched and reimbursed without price approval, at least until 2005.[14] The UK permits free pricing of individual drugs, subject to a rate of return constraint on each firm's portfolio of drugs. Since 1999 the National Institute of Clinical Excellence (NICE) has reviewed cost-effectiveness as a condition of reimbursement for most new drugs. This could slow new drug launch or lead to non-launch if the review were negative for drugs launched after 1999.

Parallel Trade: Parallel trade can potentially occur between all EU countries, but in our data is present only in the high price EU countries (Germany, the Netherlands, Sweden, and the UK) that also have incentives for pharmacists to substitute parallel imports for higher-priced, locally sourced products. Parallel exporting countries are mainly the lower price EU countries (France, Spain, Italy, Greece, and Portugal) (Burstall, 1998). Parallel trade risk is an additional reason a firm may opt to incur costs of delay or non-launch in countries whose low prices might erode potentially higher prices in other countries.

Given the heterogeneity of each regulatory type and each country's price regulatory system, categorizing countries by one or more regulatory indicator variables is unlikely to accurately measure even the direct effect of the regulation on prices and hence expected NPV. For example, although France, Japan and Canada all use both internal and external referencing,

[14] From 1993-2000 Germany had a national drug budget with physicians at risk for budget overruns. In 2005 on-patent drugs were added to the reference pricing system for reimbursement.

weighted price indexes for 1999 show Canadian and French prices roughly 30 percent lower than the US, whereas Japan's prices were over 20 percent higher than the US (Danzon and Furukawa, 2008). Moreover, an indicator that country A uses external referencing cannot capture the external effects that accrue as launch delay in the referenced, lower price countries. Rather than use binary indicators, we therefore use average prices of competitor products as the most accurate measure of the net direct effect of regulation on expected prices for new drugs. We measure parallel trade risk and the indirect, spillover effects of regulation using a set of indicators described below.

IV. Theoretical Model

If markets were separable and prices were unregulated, profit-maximizing firms would set prices independently for each country and would launch promptly after registration in all markets where the expected net present value of revenues exceeds country-specific fixed launch costs. With price regulation and potential spillovers, a necessary condition for launch of drug *s* in country *j* is that expected net present value of revenues exceeds country-specific costs plus any revenue loss in other countries due to spillovers:

$$E\{\int_{t=1}^{T}\left\{\left[P_{sjt}\left(P_{bjt}(R),P_{gjt}(N_{gjt}),Y_j;P_{skt}\right)-C_{sjt}\right]\times Q_{sjt}\left(Q_{jt},N_{bjt},N_{gjt}\right)-\sum_{k\neq j}X_{jkt}\left(P_{sjt},R_{kt},I_{kt}\right)\right\}e^{-rt}dt > F_{jt}(H\} \quad (1)$$

where E is the expectations operator, P_{sjt} is the expected price of product s; P_{bjt}, and P_{gjt} are prices of competitor brand and generic products, which depend on regulatory regime R and number of generic competitors N_{gjt}, respectively; Y is per capita income; C is average variable cost; P_{skt} is the price of drug s in countries $k \ldots K \geq 0$ that are referenced by j; Q is unit sales volume, which depends on aggregate sales in the class Q_{jt}, and on the number of brand and

generic competitors;[15] $X_{jk} = \partial(P_k Q_k)/\partial P_{sj}$ is the effect of P_{sj} on revenues in country k, which either references to j or derives parallel imports I from j; $F_j = F_R + F_P$ is total fixed cost of drug launch, including registration cost F_R and price approval cost F_P, which may be lower if the launching corporation is home-based H; T is the duration of the economic life of the drug indexed by t; and r is the discount factor.

Equation 1 can be rewritten to yield the firm's reservation price for launch in country j, which is increasing in X_{jk} , the potential revenue loss in country k due to spillovers from country j ($\partial P_{sj}^{Ask}/\partial X_{jk} > 0$) and decreasing in market size in j ($\partial P_{sj}^{Ask}/\partial Q_{sj} < 0$), because the foregone sales cost of launch delay increases with market size, unless export risk increases with market size. If F is invariant across countries and compounds, firms are less likely to seek launch in country-compound pairs with low expected sales, due to low prices or small volume. Price regulation can reduce launch probabilities directly by reducing comparator prices P_{bjt} and hence expected prices for new drugs, or possibly by adding fixed costs. External referencing of country j or parallel importing by countries $k \ldots K$ that results in negative spillovers can undermine incentives to launch in country j, even if the NPV of within-country sales is positive.

The regulator's reservation or maximum offer price depends on the regulatory regime. Under internal referencing, the regulator's offer depends directly on prices of substitute products ($\partial P_{sj}^{Offer}/\partial P_{bj} > 0$). Under external referencing, although the regulator's offer derives from a formula based on prices in comparator countries, prices of existing products may serve as an empirical proxy for achievable price levels under the referencing formula. Regulatory offers may be related to per capita income ($\partial P_{sj}^{Offer}/\partial Y_j \geq 0$), given the political pressures on regulators to constrain health spending growth to per capita income growth. Concern for budgetary impact

[15] Number of competitors is treated as exogenous because of the 6-12 year lead time required for R&D and regulatory approval of new compounds. Entry delay is shorter for generics, but is still several years from starting compound formulation to regulatory approval.

may lead regulators to offer lower prices for drugs with relatively large potential volume, Q_{sj}, other things equal ($\partial P_{sj}^{Offer} / \partial Q_{sj} \leq 0$). If $P_{sj}^{Offer} - P_{sj}^{Ask} \geq 0$ and a launch price can be agreed within this range, launch occurs. If not, negotiations may continue and launch may ultimately occur if either P_{sj}^{Offer} increases, P_{sj}^{Ask} falls, or some mechanism can be negotiated to adjust for the difference, such as a price-volume offset.[16]

In our data, we observe only the launch date and launch price conditional on launch, not the dates of registration, price submission, or negotiation details. We therefore estimate reduced-form equations for the launch hazard and launch price as a function of the determinants of the firm's ask price and the regulator's offer price. The reduced form launch hazard equation is:

$$h_{sjt} = h\{P_{bjt}, P_{gjt}, Q_{jt}, X_{jt}, N_{bjt}, N_{gjt}, I_{jt}, Y_j; P_{sKt}; H\} \quad (4)$$

Measurement and predicted signs of variables are discussed below.

Because the bargaining range $P^{Offer} - P^{Ask} > 0$ also defines the range of launch price, the reduced form launch price equation includes the same variables as the launch hazard equation:

$$P_{sj} = f\{P_{bj}, P_{gj}, Q_j, X_j, I_j, Y_j; P_{sKt}; H\} \quad (5)$$

In theory, expected price and market size at global launch t_0 influence the decision to seek registration and hence the launch hazard, and hence could identify the launch hazard equation, whereas launch price depends only on competitor price values at launch. In practice, because both pre-launch values and change over time of the expected price and quantity variables were insignificant in the launch equation, after controlling for contemporaneous values, identification in the two-stage selection models relies mainly on functional form, as discussed below.

We estimate separate models for drugs launching in superior vs. inferior subclasses. Coefficient differences between these equations are expected due to dynamic competition and

[16] In addition to internal and external referencing, France applies company-specific and therapeutic class spending limits that result in price cuts if volume sold exceeds target levels.

other factors. For example, a drug that is a late entrant in an old subclass with declining sales may not be worth launching unless it has unusually high efficacy/safety or the firm expects favorable treatment by local regulators and/or markets.

V. Data and Methods

Data

We use data from IMS Health's Midas database on drugs in 15 countries for 12 therapeutic classes, all of which experienced the launch of a new subclass shortly before or during our study period, 1992-2003. The data for each molecule include active ingredient, originator corporation(s) and marketing companies, pack description, launch date, therapeutic class, etc., and quarterly data on outpatient sales at manufacturer prices (revenue in local currency) and unit volume (IMS standard units)[17] from 1Q 1992 through 4Q 2003. After the data were screened for internal consistency, revenue was adjusted for inflation using country-quarter-specific Producer Price Indexes available from the International Monetary Fund, with 2003 as the base year, and converted to US dollars using the average 2003 country-specific exchange rate. Brazil and Mexico sales were reported in our IMS data only in US dollars. Price per dose for each drug was calculated on a quarterly basis as the ratio of total revenues to standard units sold.[18]

Of the 375 molecules in the dataset, 116 are classified as superior and 221 of their potential 1,740 drug-country launches had occurred prior to our study period; 259 are classified

[17] The IMS standard unit is a proxy for a dose for each formulation e.g. one tablet or capsule, 5ml. for liquids etc. The IMS price data for the US do not reflect off-invoice discounts given by manufacturers to pharmacy benefit managers and HMOs, hence the US prices are upward biased for manufacturer net revenues.

[18] We combined multiple form-3 level formulations (e.g. tablets and capsules, possibly of different strength) in a given country and quarter into a single observation and defined the price as the volume-weighted average price per unit. Identical forms that were launched by different co-marketing companies were also averaged.

as inferior and 1,276 of their potential 3,885 drug-country launches had occurred prior to our period.[19] During our 12-year study period, we observe 885 of the 1,519 potential superior drug-country launches and 390 of the 2,609 potential inferior drug-country launches. For 91 country-molecule pairs, two distinct formulations (form 2-level, such as an oral solid and a liquid) of a molecule launched simultaneously, and in 4 country-molecule pairs three distinct formulations launched simultaneously, implying there were 1,367 country-molecule-product launches (946 superior and 421 inferior) in our study period.

Launch Estimation

Because our data are on a quarterly basis, the launch hazard equation was modeled using a maximum likelihood discrete time implementation of a proportional hazards model based on complementary log-log regression,[20] which readily accommodates right censoring, late entry into the risk set, estimation of a flexible baseline hazard, and time-varying covariates. In the clog-log analysis, each drug was considered eligible for launch in all countries starting from its quarter of first launch in any country in our sample ("global launch"), and remained eligible until it launched. Thus each drug s in each country j contributes t_{sj} observations, the number of quarters from product s's global launch through either first launch in country j or 4Q 2001, the end of our study period. To account for multiple observations per drug resulting from potential launch in multiple countries, we use robust standard errors or molecule random effects to account for intra-molecule clustering.

[19] Five superior molecules and 20 inferior molecules were diffused to all our countries prior to our period. These are included as competitor products but are not in the sample of potential launches.

[20] A clog-log specification is preferred to logit in this context because of the clog-log's underlying assumption that the launch decision process is continuous (Allison, 1995).

The hazard of launch is $h_{sjt} = \Pr[\tau = t \mid \tau \geq t]$, i.e., the probability that drug *s* launches in country *j* in period *t* conditional on not having previously launched, where τ indicates the quarter of launch. Using a clog-log specification implies that

$$\log\{-\log(1-h_{sjt})\} = \lambda(t) + \beta\Gamma_{sjt} \tag{6}$$

where Γ_{sjt} is a vector of explanatory variables as outlined above. To facilitate tests of duration dependence, we specified $\lambda(t)$ to be quadratic in the number of quarters since global launch. The clog-log specification can be rearranged to yield an expression for the launch hazard:

$$h_{sjt} = 1 - \exp\{-\exp(\lambda(t) + \beta\Gamma_{sjt})\} \tag{7}$$

This in turn leads to a log likelihood function:

$$\ln L = \sum_{s=1}^{n}\sum_{j=1}^{m}\sum_{k=1}^{t_{sj}}\{d_{sjk}\log(h_{sjk}) + (1-d_{sjk})\log(1-h_{sjk})\} \tag{8}$$

where *d* is an indicator for whether launch occurs.

There are two limitations of this basic specification that we address with alternate estimators. First, like other standard duration models, it assumes that the probability of failure goes to unity as time goes to infinity; however, some of the molecules in our sample might not meet drug approval requirements and/or would have limited market potential in some countries. We therefore also estimate a discrete-time split-population model with time-varying covariates (Schmidt and Witte, 1989; Jenkins, 1995). This specification allows for some empirically-estimated sample-wide proportion of drugs, *c*, never to launch.[21] The log likelihood function for this model is

$$\ln L = \sum_{s=1}^{n}\sum_{j=1}^{m}\sum_{k=1}^{t_{sj}}\{d_{sjk}\log[(1-c)h_{sjk}] + (1-d_{sjk})\log[c + (1-c)(1-h_{sjk})]\} \tag{9}$$

[21] This feature is especially relevant for analysis of molecules in inferior subclasses, in which 116 of the 259 molecules did not experience a new launch during the study period (compared with two of the 116 molecules in superior subclasses).

The second term of equation (9) accounts for the possibilities that drugs not observed to launch in the data either (a) never launch, or (b) launch after the end of the study period. Note that when *c* is zero, the split-population model log likelihood reverts to the standard clog-log model in equation (8).

A second limitation of standard duration models is that they do not account for unobserved heterogeneity. We suspect that there are time-invariant unobserved characteristics common to a molecule across countries that influence the probability of launch. Failure to account for unobserved heterogeneity in the estimation, may lead to coefficient attenuation, and may overstate the degree of negative duration dependence and understate the degree of positive duration dependence (Heckman and Singer, 1984; Lancaster, 1990). The most straightforward way to address this issue is to augment the hazard specification with a term for the drug-level heterogeneity ν_s:

$$h_{sjt} = 1 - \exp\left\{-\exp\left(\lambda(t) + \beta\Gamma_{sjt} + \nu_s\right)\right\} \tag{10}$$

We estimated ν_s with a Normal, and an empirically-derived finite discrete distribution. As results were robust and there are no *ex ante* reasons to prefer one, we report results for the Normal distribution.

Launch Price

We use ordinary least squares to model the log of launch price of drug *s* in country *j*, conditional on launching. We use molecule-clustered standard errors in the OLS estimation, and to account for unobserved molecule characteristics we also report results with a GLS random effects estimator. To account for the potential selection bias produced by the correlation between the propensity to launch and the launch price, we also estimate a Heckman selection model with

a first-stage clog-log regression which, as described above, is equivalent to a proportional hazards model of new drug launch.[22]

Variable Definitions

Regulation/Expected Price: We use the (log lagged) average price of competitor brand (including originator and licensed) products in the same therapeutic class, as a comprehensive measure of the direct effect of price regulations on expected price for new entrants. Average prices for superior and inferior subclasses are distinguished, to test for differential effects within vs. between subclasses, as proxies for static vs. dynamic competition. Average price of competitor brands is the relevant regulatory benchmark for internal referencing regimes and should be a rough proxy for the effects of the referencing formula even in external referencing regimes. Prices of competitor products are also a measure of the expected price of a new drug in free pricing countries, assuming competition constrains similar products to have similar prices. This approach is based on the premise that if price regulation leads to delay/non-launch due solely to its direct effect on expected price, measuring the effect of actual prices, as a proxy for expected price, is the best approach to measuring the likely effects of regulation that reduces prices.[23]

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[22] The clog-log-based Heckman model is estimated following a two-step procedure that ensures consistent standard errors (Heckman, 1979). Following Lee (1983) and Greene (1992), the inverse Mills ratio for drug *s* in country *j* and time *t*, M_{sjt}, is calculated using the predicted probability of launch $\hat{p}_{sjt}$ from a clog-log regression as

$$M_{sjt} = \frac{\phi\left[\Phi^{-1}\left(\hat{p}_{sjt}\right)\right]}{\Phi\left[\hat{p}_{sjt}\right]}$$

where $\phi[\cdot]$ is the standard Normal density function and $\Phi[\cdot]$ is the standard Normal distribution function. As a check of sensitivity we also estimated a traditional maximum-likelihood Heckman model based on a probit in the first stage that offers robust, clustered standard errors.

[23] In theory, we could identify the effects of regulation on launch experience using difference-in-difference analysis applied to countries that adopted price regulatory regimes relative to those that did not. In practice, most countries experienced gradual evolution of regulatory regimes over the period, with too few clear changes to permit difference-in-difference estimation.

To further isolate the effects of regulation on launch timing, we control for other factors that may influence price levels, including therapeutic category indicators, per capita income and the extent of generic competition.

The price equation includes product characteristics that affect price per dose, including pack size, pill strength (grams per unit), and indicator variables for specialized formulations (oral delayed and non-oral solids), with oral solids (basic tablets and capsules) as the referent formulation.

Expected Sales Volume: The (log lagged) total number of doses sold in the same therapeutic class as the new drug is included as a measure of expected volume.[24] It is expected to be positively related to launch hazard, if the firm's opportunity cost of delay dominates the regulator's concern over budget impact.

Spillovers: To test for indirect effects in low-price countries of regulatory referencing by high-price countries, we include three count variables that measure the number of countries a molecule has already launched in, categorized by low price EU countries (, France, Italy, Spain, Portugal, Greece), high price EU countries (Germany, the Netherlands, Sweden and the UK) and high-priced non-EU countries (the US, Japan and Canada). Categorization of low and high price EU countries is supported by actual average prices (see below). These variables are also interacted with indicators for whether the potential launch is in a low vs. high price EU country. These interactions test whether spillover effects are greater for launches in low-price EU countries, which are referenced by and are the main sources of parallel trade to higher-price EU countries, and whether spillovers are greater within the EU than from non-EU to EU countries, as expected.

[24] We tried distinguishing volume by subclass and including number of competitor firms, but these were not significant and were dropped.

In the price equation, we include similar interactions, except that we use the Minimum Own Price in high-price EU, low-price EU and high-price non-EU countries, defined as the lowest price received for the molecule in any country where launch has already occurred, for each country group, rather than simple count variables for number of prior launches. Estimates using Maximum Own Price were similar to those reported here using Minimum Own Price. Both variables could not be included together due to collinearity.

We also include a dummy variable Any PI Share in Subclass, to test whether risk of competition from parallel import reduces the propensity to launch and/or reduces launch prices.[25] The IMS data do not identify the country from which PIs originate. Thus we cannot directly test whether propensity to be a parallel exporting country reduces the launch hazards in the exporting country. Rather, the propensity to parallel export is subsumed in the country fixed effects.

First Mover and Timing: To test for first mover incentives for launch, the launch equation includes an indicator variable for quarters in which there are no molecules in the country-subclass. To test for first mover advantage on price, we include indicator variables for first, second and third entrants in country-subclass.

A quadratic in years since global launch is included to control for the decline in incentives for launch with time lapsed since global launch, because patents run regardless of launch and compounds may undergo obsolescence due to entry of newer compounds. An indicator for molecules launched before 1990 controls for both their relatively old age and missing launch data. An indicator for molecules launched since 1996 tests for effects of the EMEA regime. It is expected to be positive if the cost-reducing effects of the EMEA coordinated registration process outweighed the increased risk of spillovers. Molecules launched during 1990-1995 are the referent category.

[25] We tried including the average price of parallel imports, but this was not significant.

Country of Domicile: Previous studies have found that new drugs launch more quickly in the home country of the originator firm, attributed to greater experience or favor with domestic regulatory agencies (Danzon, Wang and Wang, 2005; Kyle, 2006, 2007). To control for this, we include an indicator for launch by a Local Corporation. This includes both originator firms and local licensed partners, to test the conventional wisdom that originator firms sometimes outlicense a compound to local firms to gain local expertise and/or influence in dealing with regulators.

Country and Year Effects: We include country fixed effects to capture other country-specific factors that may affect launch delay and launch prices (controlling for expected price, volume and per capita income), in particular, pure bureaucratic delay and parallel export risk. Germany is excluded as the referent country.

The dollar-euro/ecu exchange rate and the PPI are included to control for exchange rate and indexing trends that could bias our dollar-denominated estimates of competitor prices and launch prices. Year effects were included in some specifications but were generally insignificant and are not reported here.

VI. Descriptives

Table 1 reports the total number of molecules ever launched, the number launched in our time period, and mean and median launch lags, by country and subclass. For the superior subclasses, Germany and the US (two free pricing countries) have the most molecules ever launched (88 and 86) and launched during our period (72). Sweden, the US, the Netherlands, Germany, and the UK (all higher price, less strictly regulated) also have the shortest median launch delay (17.4-18.7 months). Japan, Portugal and France (all price-regulated countries) have

the fewest superior molecules (53, 62 and 69 respectively) and the longest mean launch lags (41, 31, and 37).

For the inferior subclasses, Japan leads in number of inferior molecules (158) ever launched, followed by Germany (131), and even Portugal (113) has more than the US (97). The number of inferior molecule launches during our period is highest in three regulated markets (Japan [43], Brazil [40] and Greece [47]) whereas most other countries have fewer than 27. Mean launch lags are generally much longer for inferior than for superior molecules. These differences in launch experience in the superior vs. inferior subclasses confirms that the older subclasses may be more heterogeneous, including some molecules that could not meet strict regulatory requirements and/or have limited sales potential in some markets.

Table 2 reports the mean number of manufacturers per molecule in 2003 by country, subclass and license type, to illustrate differences in market structure that may influence outcomes across countries. The expected number of originator/licensees per molecule is 1-2, assuming that an originator's profit-maximizing strategy is usually to launch alone or with at most one co-marketing partner. Consistent with this, the mean number of originator/licensees per superior molecule is 1.0 in the US, the UK, and the Netherlands, and only slightly higher in most other countries. However, licensees are more common in Italy (1.8), Spain (1.7) and Japan (1.3), suggesting that having a local co-marketing partner may be particularly valuable in these markets.

Parallel imports are found only in the four higher priced EU countries—Germany, the Netherlands, Sweden and the UK—and the majority of molecules in these countries have some PI presence by 2003. This concentration of PIs in a few countries may provide insufficient variation to accurately estimate PI effects, as noted below.

Unbranded generics are more numerous for molecules in older subclasses, which is unsurprising because these are generics that enter after patent expiry and compete on price. Unbranded generics are most common in the US. By contrast, Other Brands, which includes branded generics and copy products that compete mainly on brand, are most numerous in Germany, Japan, and Brazil.

Table 3 reports mean prices by country-subclass-license type. Each mean price is the unweighted mean of prices for all products in that country-subclass-license type. These means thus reflect differences in molecules and formulations, in addition to price differences for similar products, and hence are not valid indexes of cross-national price differences for a standardized basket of drugs.[26] However, these unweighted mean prices provide a rough measure of benchmark competitor prices used by regulators and firms in forming price expectations, except that in practice, regulators and firms may focus on a narrower subset of close substitute products within these broad subclass averages.

These unweighted mean prices show that, for originator/licensee superior products in the EU, the price-regulated regimes (France, Spain, Portugal, Greece, Italy) have relative low prices, and we classify them as "low price EU markets;" the countries with freer pricing, reimbursement regulation and/or late adoption of price regulation (Germany, the UK, the Netherlands, Sweden) have higher mean prices and we classify them as "high price EU markets." The US has the highest prices, followed closely by Canada; we also classify Switzerland and Japan as "non-EU high price markets" based on other price index comparisons (Danzon and Furukawa, 2003), although Japan's unweighted mean prices are quite low in Table 3. Originator prices are lower in inferior than superior subclasses, and country rankings are similar but with smaller differentials.

[26] Danzon and Furukawa (2003, 2008) report weighted price indexes, based on standardized market baskets, for originator and generic products in 1999 and 2005

Other Brand prices are generally higher than for Unbranded generics, as expected.[27] For unbranded generics, the relatively high mean US price is surprising and reflects its larger number of superior products, whereas volume-weighted price indexes for standardized products show generic prices relatively low in the US (Danzon and Furukawa, 2003). PI prices generally fall between generic and originator prices, as expected; again, these differentials are not based on a standardized product mix and are not intended to provide an accurate measure of originator/PI price differentials or the impact of PIs on firms or consumers/payers.

Table 4 shows, for each country, the number of molecules that had a Local Corporation, originator or licensee, associated with launch in this country. In future work, we plan to report originators and licensees separately, since preliminary analysis suggests significant differences by license type and subclass. On average, superior molecules diffuse to more countries than inferior molecules.

Means and standard deviations for all variables in the launch and price equations are reported in Appendix Tables A1 and A2.

VII. Determinants of Launch

Table 5 reports coefficients and marginal effects from our basic launch specification, using clog-log estimates with both robust, clustered standard errors and molecule-level Normal random effects, to control for unobserved molecule characteristics.[28] Our discussion focuses on results for the superior subclasses, noting differences for the inferior subclasses where relevant.

Domestic Market Conditions: Expected Price and Quantity

[27] Some of the PI, Unbranded Generic and Other Brand means include very few products, hence are less robust than the originator means, because most molecules have at least one originator/licensee product.

[28] The standard errors of the marginal effects are calculated using the delta method; see Bartus (2005) for more details. Parallel specifications using a clog-log split population model and REs with a discrete distribution were also estimated. Results were generally consistent with those reported here.

Launch hazards of superior products are significantly related to mean prices of competitor brand products in the superior subclass: a 10 percent increase in competitor prices is associated with a 0.047 percentage point increase in the launch hazard, which seems reasonable given the 3.8% average launch hazard for superiors molecules per quarter.[29] Thus to the extent that regulation reduces prices, it reduces incentives to launch. These estimates may underestimate the magnitude of effects, if our broad measures of competitor brand prices, which are based on all originator or licensee products in the subclass, imperfectly measure the prices of the most relevant comparator products. For the inferior subclass, prices of competitor products in the same subclass are positive but not significant. Overall, these results indicate that competitive and/or regulatory price effects operate primarily within rather than between subclasses, and that dynamic competition is driven by other product characteristics, not price.

Launch of superior and inferior products is negatively related to the number of generic competitors, but effects are small and statistically insignificant. This suggests that availability of older, cheaper therapeutic substitutes is not a significant deterrent to the launch of new brand products, even in older subclasses where generics are more numerous. This may reflect the fact that late launches of inferior products occur mainly in countries where most generics are branded generics that do not compete aggressively price.

Unit volume for the therapeutic class[30]—whether measured as contemporaneous, at global launch or as growth—was not on significantly positive for superior or inferior products, even when country and class effects are omitted. Thus on average potential market size is not a

[29] Since average prices of competitor products vary mainly by class and country, we estimated specifications without controls for country and class fixed effects, to show maximum potential impact of competitor prices. In fact, results for the price variables were either insignificant or negative, suggesting uncontrolled heterogeneity. We therefore report here the specifications that include country and class fixed effect, such that identification is based on variation within country-class over time. Results for other variables are robust to excluding class fixed effects.

[30] Volume is measured here as total volume in the relevant inferior and new subclasses; separate subclass measures were also insignificant.

significant launch determinant for this sample of drugs-countries, possibly because regulators monitor prices more stringently for larger classes, which offsets incentives of firms to launch more rapidly in large classes. More detailed country-class interactions would be needed to determine whether small expected volume is an issue specifically for drugs in small classes in small countries.[31]

Launch Timing and Sequence

For both superior and inferior products, launch hazards appear to first decrease then increase with time since global launch, reaching a minimum at 13.5 yrs from global launch for superior drugs and 49.1 years for inferiors.[32] These average quadratic specifications reflect the diverse launch patterns in Table 1, which shows a fairly clear pattern for superior drugs, with median launch lags of less than one year in the high-price EU countries and the US, followed by launch within the second year for all other countries except Portugal and Japan, where launch typically occurs only in the third year from global launch. For inferior drugs, median launch lags are much longer, which the other evidence suggests is only partly explained by the fact that we observe them later in their life-cycle.

Inferior drugs launched before 1990 are more likely to launch than later entrants in the same subclass, possibly due to accumulated global brand capital of these earlier entrants and despite their presumably shorter remaining patent life.[33] The poor launch performance of late

[31] The insignificant effects of expected volume on launch of new products found here contrasts with significant positive effects in Danzon, Wang and Wang (2004). These different findings may reflect differences in sample countries and drugs, in addition to our use here of more detailed measures of country-class prices and other characteristics.

[32] The minimums from the split population estimates are 11.0 years for superior and 49.3 years for inferiors. The evidence from the descriptive tables, significance of REs and split population results suggest considerable unobserved molecule heterogeneity. Since this is known to bias estimates of time dependence, these quadratic estimates should be interpreted with caution.

[33] Patent expiry is less critical to expected sales in countries with few generics or primarily branded generics that do not compete aggressively on price. This includes all the low price EU countries during our time period.

entrants in older subclasses is consistent with the hypothesis that dynamic competition from the newer subclass disadvantages late entrants to an inferior subclass.

The post-1996 global launch dummy is positive but insignificant for superior drugs. Taken at face value this suggests that on average the EMEA process did not affect speed of diffusion, possibly because price approval was the rate-limiting regulatory hurdle and any cost-reducing effect of accelerated approval was offset by increased risk of spillovers. However, our analysis period ends too early to observe full effects of the EMEA, because it initially focused on biologics and truly innovative drugs; hence many of the drugs in our sample may not have qualified.

Indirect Regulatory Effects: Cross-National Spillovers

The evidence is strongly consistent with the hypothesis that launch in low-priced EU countries is adversely affected by the risk of spillover to higher-price EU countries through external referencing. For superior drugs, the coefficients on number of countries in which launch has already occurred are all positive, with the exception of prior launch in the three lowest price EU countries, Spain, Portugal and Greece. The marginal effect of prior launch in the UK or Germany is 0.027 and 0.023 for Sweden or the Netherlands. By contrast the marginal effect of prior launch in Italy or France is 0.012, and for high price non-EU countries the marginal effect is only 0.009.[34] This pattern confirms that launch in high-price EU countries is associated with a larger increase in launch hazard than launch in other countries, as expected if firms delay launch in low-price EU countries until launch has occurred in higher-price EU countries, to avoid negative spillovers. Moreover, since Spain, Portugal and Greece reference the lowest prices in a group of relatively low-price countries, including France and Italy, a firm's optimal launch

[34] The p-values for Wald tests comparing these marginal effects are as follows: UK/Germany vs. Italy/France, p=0.019; UK/Germany vs. high-price non-EU countries, p=0.008; Sweden/Netherlands vs. Italy/France, p=0.067; Sweden/Netherlands vs. high-price non-EU countries, p=0.004.

strategy plausibly leads to launching last in these three countries, after higher prices have been established in the countries that they reference. For inferior drugs, marginal effects are much smaller and generally insignificant, consistent with other evidence that these late launching drugs in older subclasses reflect either delayed launches of previously launched drugs or atypical drugs.

To explore further the spillover effects for superior drugs, we estimated a specification that includes counts of prior launches in high-price EU, low-price EU and other high-price countries (Canada, Japan, Switzerland and the US), together with interactions between these launch counts and indicators for whether the current observation is a low or high price EU country (results available from authors on request). Marginal effects of these interactions are reported in Table 6. The marginal effect of a prior launch (zero to one) in a high-price EU country on launch in a low-price EU country is 0.0018, whereas the effect of a prior launch in another low-price EU country is only 0.0005, and the difference is statistically significant. Similarly, the marginal effect on launch in a low-price EU country is greater from a prior launch in a high-price EU country than from launch in a high-price non-EU country, as expected because referencing and parallel trade within the EU is only to EU countries. This evidence is thus consistent with the hypothesis that the observed pattern reflects spillovers, not simply some unobserved factor that leads to correlation in launch times across countries.

Parallel import presence in the class is not associated with launch hazard in the importing country, after controlling for country fixed effects. This may simply reflect the high correlation between the PI indicator and the country indicators for the four countries with PI presence – Germany, Sweden, the Netherlands and the UK – and the high PIs presence across classes in those countries. But it is also likely that parallel trade risk primarily leads to launch delay in the

parallel export countries, not in the importing countries. This effect cannot be identified directly because our data do not report PI country of origin; hence it is subsumed in country effects.[35]

Country Fixed Effects

For superior drugs, compared to Germany, the referent country, other country effects are all negative except for the UK. Marginal effects are smallest for the US (-0.02) and other relatively free pricing countries; marginal effects are largest for Japan (-0.04), reflecting its unique registration requirements; and the major EU parallel export countries (Spain, France, Greece, Portugal and Italy) are all significantly negative, as are several other countries. For inferior drugs, none of the country marginal effects is significant in the basic clog-log estimation, possibly due to within-class heterogeneity. However, with the random effects and split population estimators, the US coefficient is significantly negative, implying that late launching inferior drugs are less likely to launch in the US than in other countries.

Launch by a Local Corporation

Launch is more likely for both superior and inferior molecules that are launched by a local corporation, either as originator or marketing partner, possibly due to regulatory experience and/or preferential treatment. Although absolute marginal effects are larger for superior than inferior drugs, the increase relative to baseline hazard is larger for inferiors, implying that home advantage is relatively more important for late entrants in older subclasses.

In order to test whether these local corporation effects differ across countries, we estimated specifications with interactions between the Local Corporation indicator and country fixed effects (results available from authors on request). Marginal effects of these interactions are

[35] We also tried including the average price of PIs, but this was not significant after controlling for country fixed effects. It is also possible that parallel trade has modest incremental effects compared to external referencing, because external referencing reduces prices on all units whereas parallel trade affects only the fraction of sales that are imported.

reported in Table 7. Once country interactions are included, the Local Corporation coefficient becomes insignificant for the referent, Germany, and for most other countries, except that France, Italy, Switzerland and Japan have significant positive effects. The marginal effects of launch by a local corporation in these four countries are roughly twice as large as for Germany and other countries, although the differences are not statistically significant due to large standard errors. Although Japan's marginal effect is the smallest of these four countries, it is the largest relative to Japan's very low baseline hazard. Moreover, after controlling for launches by its domestic corporations through this interaction, Japan's country effect for launches by non-Japanese corporations becomes even more negative. Overall, this evidence suggest that the large average Local Corporation effect on launch timing observed in previous studies and in our baseline specifications reflects bias towards domestic companies in just a few countries, with no significant domestic bias evident in other countries.

Split Population and Random Effects Estimators

The split population and random effects estimates are generally consistent with the clog-log estimates. However, the split population estimates imply that the probability of never launching is highly significant for 8.7 percent of inferior molecule-country pairs, compared with only 4.4 percent of the superior molecules (results available from author). This provides further evidence that certain molecules, especially late entrants in inferior classes, are not marketable in certain countries. Whether this reflects inability to meet regulatory or market requirements cannot be determined with our data.

VIII. Determinants of Launch Price

Table 8 reports the OLS estimates of determinants of (log) launch price, with robust, clustered standard errors, and random effects estimates to control for unobserved molecule heterogeneity. Equations reported here include country fixed effects. Year fixed effects were also included, to control for any bias in our inflation and exchange rate adjusters, but coefficients are not reported because they were generally insignificant. Class effects are omitted because they are highly collinear with the variables measuring competitor prices and order of entry within class. Our discussion focuses on estimates that include GDP per capita; excluding GDP changes primarily the country fixed effects, as reported below.

Because our observed launch prices are conditional on launch, we estimated a two-stage Heckman selection correction model that includes as a regressor the Mills ratio from a clog-log first stage hazard equation (results available on request). The Mills ratios are larger for the inferior drugs, but are only significant for the superior drugs; otherwise results are generally similar to the conditional estimates. These results are broadly consistent with the findings from the split population estimates, that at least some molecules do not have global launch potential. Because the first stage launch equation is identified primarily off functional form, we focus our discussion on the conditional estimates in Table 8 and do not attempt to draw inferences about differences between conditional and unconditional estimates.

Competitor Prices and Product Characteristics

For both superior and inferior products, launch prices are significantly positively related to prices of competitor products in the same subclass (elasticity of 0.12 for superiors and 0.17 for inferiors). The cross-subclass elasticities are positive, smaller in magnitude and significant only in the RE estimates. This confirms the earlier evidence, that launch probabilities are influenced

mainly by prices of competitors within subclass, implying that dynamic competition between subclasses is based on non-price product attributes.[36] Generic prices have no significant effect on launch prices of new superior brands, suggesting weak price competition between new brands and old generics. Launch prices of new inferior products are negatively related to generic prices in the class (elasticity -0.08), which may reflect a selection effect, that late entrants in inferior subclasses only launch if they expect to receive high prices relative to competing generics.

Product characteristics have expected effects. Price per unit is significantly negatively related to pack size, particularly for pack size over 100 units, possibly indicating economies of scale in packaging and/or the competitive use of large packs to give discounts to pharmacies in countries such as the US, that permit pharmacists to dispense from large packs. Price is unrelated to strength (grams of active ingredient per unit) in the RE estimates, suggesting that the positive coefficient in the OLS results for superiors reflects between- rather than within-molecule effects. Compared to the oral solid formulations (the omitted category), price per dose is significantly higher for injectable and non-oral forms (liquids, creams etc).

Launch Timing and Sequence

For superior drugs, the country-specific producer prices indexes (our price deflator) is significantly negative, indicating that launch prices of drugs on average have not kept pace with economy-wide inflation. The US dollar per Ecu/Euro exchange rate, which declined from a high of 1.38 in 1992 to a low of .83 in 2000, is insignificant for superior products but large and significant for inferior products. This suggests that cross-national differences in launch prices for the more broadly diffused superior products were constrained by exchange rates, whereas launch

[36] When therapeutic class indicators are included, they are significant for superior drugs in all 11 classes, compared to anti-hypertensives, the referent category. For inferior drugs, class effects are significant for only 4 classes. After including the class FEs, such that estimation is within country-class-year, the competitor price variable for superiors becomes insignificant, and the coefficient for inferiors is significant, consistent with greater within-class heterogeneity for this subclass.

prices for inferior products, which were less likely to launch in the US, were priced independent of the USD/Euro exchange rate.

Controlling for inflation and exchange rates, launch prices for superior products decline 3.1% per year elapsed since global launch.[37] This contradicts the hypothesis that manufacturers would rationally delay launch in the expectation of receiving a higher price purely due to delay.

For superior products, there is no evidence of first-mover advantage in prices, although second and third entrants do receive higher prices relative to later entrants in a class. For inferior products, the first or second entrants in the subclass appear to receive a price premium relative to other inferior drugs; however, this conclusion is tentative because it is based on a very small number of inferior subclasses for which first and second launches occur in our time period.

Cross-national Spillovers

For both superior and inferior products, launch prices are positively related to the lowest price previously received in other high-price EU countries, whereas effects of launch in low-price EU countries is insignificant. The minimum own price received in non-EU countries is significantly positive for superior molecules, but insignificant for inferior molecules, possibly because they are less likely to launch in high-price non-EU countries such as the US and Canada.

The indicator for PI presence is insignificant for superior drugs but significantly negative for inferior drugs, indicating that PI presence reduces launch prices mainly for late entrants in older subclasses.

We also estimated equations with interactions to test the hypothesis that spillovers to low-price EU countries are largest from high-price EU countries (detailed estimates available on request). Marginal effects of the interactions are reported in Table 9, which parallels Table 6 for

[37] The net impact of time since global launch (a quadratic) was calculated as $\beta_{tsgl} + 2\beta_{tsgl^2}\bar{t}$, where the mean value of time is 2.16 years. The estimate from the random effects model is -4.2%.

the launch model in structure and results. We find that the effect on launch price in a low-price EU country is larger for a 10% increase in a drug's minimum own price in high-price EU countries than from a 10% increase in minimum own price in other low-price EU countries. Specifically, the difference in the marginal effects in the minimum own price elasticity based on the OLS model is 0.3928, and based on the RE model is 0.2625. Similarly, the effect on launch price in a low-price EU country is substantially larger for a 10% increase in a drug's minimum own price in high-price EU countries than it is for a 10% increase in minimum own price in high-price non-EU countries. The differences in the own price elasticity are 0.3748 from the OLS model and 0.2530 for the RE model. This supports the hypothesis that launching first in high-price EU markets can influence prices in low-price EU markets.

Country Fixed Effects

The country fixed effects in Table 8 are dramatically different, depending on whether GDP per capita is included. Based on the RE estimates, without GDP controls, prices in Switzerland, the US and Japan are higher than Germany, whereas prices in Brazil and all other EU countries are lower, except the Netherlands and Sweden which are similar to Germany. However, after controlling for GDP per capita, Brazil, Mexico, Spain, Portugal and Greece have prices significantly higher, and Switzerland, the UK and Sweden have prices significantly lower than Germany.

Although these are not pure hedonic country effects, taken at face value they imply that the prevailing spread in drug prices across EU countries is compressed relative to the counterfactual of differentials based on per capita income. This may explain at least in part why Spain, Portugal and Greece, the lowest-price EU countries in our sample, adopt more stringent price controls than the higher, price northern countries. However, these low-price EU countries

appear to be constrained in their ability to keep price differentials in line with income differentials, in part due to spillovers that result from external referencing by and parallel importing to higher income countries. The evidence here confirms that the resulting interconnectedness across countries contributes to delay or non-launch of new drugs in these lower price EU countries, as firms seek to avoid spillovers to prices in higher-price EU countries.

Local Corporations

For superior drugs, launch by a local corporation is not significantly associated with launch price on average. For inferior drugs, the average effect is negative in OLS but insignificant with random effects, suggesting that any effects are confined to specific molecules that on average have low prices. Tests for country-specific differences (results available from authors) are significant only for inferior molecules in Greece, which should be interpreted with caution due to small samples. This lack of evidence of a price premium for drugs launched by local firms, despite a significant advantage in the launch equation for a subset of countries, suggests that the launch advantage reflects favoring by the registration authorities rather than by pricing authorities.

IX. Conclusions

The evidence here confirms that launch timing and launch prices of new drugs are related to prices of competitor products in the same subclass, with smaller cross-subclass effects. This implies that price competition, whether implemented through regulation or through markets, is primarily within-subclass, with weaker constraints from older, cheaper drugs. However, we find strong evidence suggesting dynamic competition on non-price product attributes in pharmaceutical markets. Late entrants in older subclasses diffuse less broadly than newer drugs

and these late inferior launches are at lower prices, linked to the lower prices in these older subclasses.

The evidence here confirms that launch delay and/or non-launch are more likely where expected launch prices are low, as measured by prices of established, competitor products in the subclass. Thus to the extent that strict price regulation reduces price levels, it contributes directly to the longer average launch delays observed in low-price countries. Our estimates suggest that the magnitude of these direct effects is quite small, although downward bias due to measurement error is certainly possible. Regardless of the magnitude of these direct effects, welfare conclusions are ambiguous, assuming that regulators weigh the benefits of lower prices against any welfare loss from reduced access to new drugs for their citizens.

However, we also find significant evidence that regulatory referencing to lower foreign prices creates incentives for manufacturers to delay launch in low price countries until higher prices have been established in other countries. Consistent with such strategies, launch in higher-price EU countries is associated with increased launch hazard in lower-price EU countries, and launch prices in low-price EU countries are directly related to prior launch prices in high-price EU markets. This evidence, that spillover effects are greatest from high-price EU to low-price EU countries, in both launch and price models, supports the hypothesis that they are attributable to referencing and parallel trade, not other unmeasured factors that may lead to closely sequenced launches across countries. To the extent that referencing or parallel importation by higher-price countries leads to launch delay and/or higher prices in lower-price countries than would otherwise occur, a welfare loss is imposed on low-priced countries by the higher-price countries that adopt these regulatory strategies.

Although these low-price countries regulate their drug prices, their low drug prices also reflect their relatively low per capita income. In fact, despite price regulation, Spain, Portugal and Greece had relatively high drug prices given their income, whereas high-price EU countries had lower drug prices relative to their per capita GDP. How far external referencing and parallel trade have contributed to this convergence of pharmaceutical prices relative to GDP among EU countries is beyond the scope of this paper. Both theory and the evidence here suggest that parallel trade is less important than external referencing. We do find that the parallel import threat reduces launch prices of late launching inferior products, and that country fixed effects are negative for countries that are significant parallel exporters. This rather weak evidence on effects of parallel trade may simply reflect measurement challenges, in particular, concentration of parallel imports in four of our countries and lack of data on country of export for parallel imports.

This evidence, that policies of external referencing (and, with weaker evidence, parallel importing) impose an external cost on the referenced or exporting countries, is based on the EU where such policies already exist. However it has important implications for the US debate over drug price controls through external referencing and drug importation. Theory suggests that the launch lag externality will be greater if referenced countries that are small and low price, compared to a much larger, higher price referencing or importing country. Since the US has both higher brand prices and much higher total volume than most potential reference or exporting countries, the impact on these countries if the US were to adopt referencing or importing would potentially be much larger than the EU effects documented here.

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Table 1. Launch and Molecule Count and Mean and Median Launch Delay by Country and Subclass

	Superior Subclasses				Inferior Subclasses			
Country	Molecules	Launches	Mean Launch Delay	Median Launch Delay	Molecules	Launches	Mean Launch Delay	Median Launch Delay
High-Price EU Countries								
Germany	88	72	18.5	9.5	131	18	30.4	17.5
UK	80	58	18.7	6.5	116	24	69.2	41.5
Netherlands	73	56	18.1	10	112	21	43.7	15
Sweden	77	62	17.4	7	82	19	49.9	18
Low-Price EU Countries								
France	69	53	30.9	29	105	19	87.6	59
Greece	72	55	30.1	22	107	37	116.8	54
Italy	76	61	24.8	21	127	26	74.7	48.5
Portugal	62	48	37.0	33.5	113	26	85.8	67
Spain	76	62	28.1	21	112	23	43.9	31
High-Price non-EU Countries								
Canada	73	62	25.6	16	98	22	91.9	66.5
Japan	53	42	41.0	40	158	43	63.3	28
Switzerland	78	63	23.9	18	111	21	55.5	47
USA	86	72	17.9	8	97	23	86.4	62
Low-Price non-EU Countries								
Brazil	71	60	31.2	20.5	92	40	107.1	90.5
Mexico	72	59	28.6	17	105	28	84.0	55

Note: Launch delays measured in months

Note: Sample includes all molecules present and new launches occurring in our data during 1992-2003

Note: Launch delays are calculated only for country launches that occurred during 1992-2003 (regardless of when the global launch occurred)

Table 2. Mean Number of Manufacturers per Molecule by Country, Subclass and License Type in 2003

	Superior Subclasses					Inferior Subclasses				
Country	Originator / Licensee	Unbranded Generic	Parallel Import	Other Brand	Molecules	Originator / Licensee	Unbranded Generic	Parallel Import	Other Brand	Molecules
High-Price EU Countries										
Germany	1.2	1.6	4.2	1.3	86	1.3	3.0	3.0	3.3	114
UK	1.0	0.3	0.1	0.0	79	1.1	1.0	0.3	1.1	103
Netherlands	1.0	0.0	5.5	0.0	68	1.1	0.0	6.1	0.1	97
Sweden	1.1	0.6	1.2	0.1	73	1.1	0.5	1.4	0.2	74
Low-Price EU Countries										
France	1.2	0.6		0.0	66	1.2	2.0		0.4	98
Greece	1.1	0.1		1.4	70	1.0	0.1		2.1	93
Italy	1.8	0.5		0.6	74	1.4	1.0		2.0	105
Portugal	1.3	1.1		1.1	61	1.1	0.4		0.8	101
Spain	1.7	2.2		1.1	73	1.4	0.9		1.3	100
High-Price non-EU Countries										
Canada	1.1	0.4		0.8	69	1.1	2.0		1.7	85
Japan	1.3	0.4		1.5	52	1.5	0.3		3.3	153
Switzerland	1.1	0.1		0.2	77	1.1	0.2		0.5	93
USA	1.0	1.4		0.0	85	1.2	7.0		0.3	91
Low-Price non-EU Countries										
Brazil	1.2	1.2		2.1	68	1.1	1.4		3.0	84
Mexico	1.1	0.3		0.9	70	1.1	0.7		1.9	90

Note: Sample includes all molecules present in IMS dataset in 2003

Table 3. Mean Price per Molecule by Country, Subclass and License Type in 2003

	Superior Subclasses				Inferior Subclasses			
Country	Originator / Licensee	Unbranded Generic	Parallel Import	Other Brand	Originator / Licensee	Unbranded Generic	Parallel Import	Other Brand
High-Price EU Countries								
Germany	30.31	0.49	9.23	0.94	2.56	0.32	0.33	0.75
UK	13.26	0.64	1.36	0.61	6.18	0.93	0.46	1.27
Netherlands	35.53	0.05	2.22	7.75	10.79	0.45	0.61	0.72
Sweden	24.41	0.34	1.79	0.45	13.08	0.26	0.42	0.98
Low-Price EU Countries								
France	6.52	0.41		0.89	0.28	0.39		0.75
Greece	12.84	1.11		0.56	6.26	0.45		0.80
Italy	2.24	0.41		0.77	0.30	0.31		0.61
Portugal	1.83	0.44		0.78	0.33	0.20		0.34
Spain	6.13	0.33		1.06	0.28	0.63		0.69
High-Price non-EU Countries								
Canada	49.30	0.57		0.60	1.03	0.93		0.57
Japan	12.27	0.44		0.73	2.62	1.26		0.59
Switzerland	34.64	0.81		0.76	5.81	0.37		1.43
USA	52.70	0.90		14.22	11.05	1.43		12.72
Low-Price non-EU Countries								
Brazil	2.34	0.39		0.95	4.21	0.21		0.35
Mexico	18.34	0.69		1.65	5.84	0.26		0.53

Note: All prices are ex manufacturer prices per standard unit in 2003 US Dollars
Note: Sample includes all molecules present in our dataset in 2003

Table 4. Number of Molecules Launched by a Local Corporation and Mean Number of Other Countries Launched in for Local Corporation Drugs

	Molecules in Superior Subclasses			Molecules in Inferior Subclasses		
Country	Total Molecules	Molecules Launched by Local Corporations	Mean # Other Countries Launched In for Local Corporation Drugs	Total Molecules	Molecules Launched by Local Corporations	Mean # Other Countries Launched In for Local Corporation Drugs
High-Price EU Countries						
Germany	88	15	10.4	131	32	7.7
UK	80	19	13.3	116	21	10.6
Netherlands	73	0	0.0	112	2	12.5
Sweden	77	4	11.3	82	0	0.0
Low-Price EU Countries						
France	69	20	11.0	105	26	7.9
Greece	72	0	0.0	107	1	4.0
Italy	76	21	9.9	127	19	5.0
Portugal	62	4	13.5	113	0	0.0
Spain	76	16	11.4	112	8	5.1
High-Price non-EU Countries						
Canada	73	2	7.0	98	3	7.7
Japan	53	29	7.5	158	62	3.0
Switzerland	78	16	10.7	111	27	10.7
USA	86	49	10.6	97	40	10.0
Low-Price non-EU Countries						
Brazil	71	2	13.5	92	6	6.5
Mexico	72	0	0.0	105	3	4.0

Note: Sample includes all molecules present and new launches occurring in IMS dataset during 1992-2003

Table 5. Coefficients and Marginal Effects for Launch Model (Standard Errors in Brackets)

	Coefficients				Marginal Effects			
	Clog-log with Robust Clustered SEs		Clog-log with Normal REs		Clog-log with Robust Clustered SEs		Clog-log with Normal REs	
Variables	Superior Subclasses	Inferior Subclasses	Superior Subclasses	Inferior Subclasses	Superior Subclasses	Inferior Subclasses	Superior Subclasses	Inferior Subclasses
Log Avg Price of Superior Brands (Lag 1Q)	0.1063*	-0.1098	0.1330***	-0.1166*	0.0047*	-0.0001	0.0075**	-0.0003
	[0.0558]	[0.0720]	[0.0475]	[0.0613]	[0.0026]	[0.0001]	[0.0029]	[0.0002]
Log Avg Price of Inferior Brands (Lag 1Q)	0.0418	0.1072	0.0610	0.0847	0.0018	0.0001	0.0034	0.0002
	[0.0624]	[0.0674]	[0.0497]	[0.0600]	[0.0027]	[0.0001]	[0.0028]	[0.0002]
Log Total Volume of All Drugs in Class (Lag 1Q)	-0.0758	0.0674	-0.0251	0.1085	-0.0033	0.0001	-0.0014	0.0003
	[0.0530]	[0.0995]	[0.0577]	[0.0862]	[0.0025]	[0.0001]	[0.0033]	[0.0002]
Num Generic Manufs per Molc in Superior Subclass (Lag 1Q)	-0.0022	0.0050	-0.0055	0.0104	-0.0001	0.0000	-0.0003	0.0000
	[0.0045]	[0.0081]	[0.0059]	[0.0083]	[0.0002]	[0.0000]	[0.0003]	[0.0000]
Num Generic Manufs per Molc in Inferior Subclass (Lag 1Q)	-0.0023	-0.0035	-0.0022	-0.0031	-0.0001	0.0000	-0.0001	0.0000
	[0.0020]	[0.0031]	[0.0017]	[0.0024]	[0.0001]	[0.0000]	[0.0001]	[0.0000]
No Molecules in Superior Subclass D.V.	0.2272	-0.2752	0.1113	-0.2612	0.0110	-0.0002	0.0065	-0.0006
	[0.1806]	[0.2533]	[0.1950]	[0.2352]	[0.0096]	[0.0002]	[0.0119]	[0.0005]
No Molecules in Inferior Subclass D.V.	-0.6650***	-0.3801	-0.6664	-0.2711	-0.0216***	-0.0003	-0.0285*	-0.0006
	[0.2013]	[0.8747]	[0.4646]	[0.5524]	[0.0066]	[0.0007]	[0.0156]	[0.0011]
Time Since Global Launch (Yrs)	-0.6223***	-0.2681***	-0.4643***	-0.2641***	-0.0273***	-0.0003**	-0.0260***	-0.0006***
	[0.0569]	[0.0320]	[0.0538]	[0.0277]	[0.0043]	[0.0001]	[0.0047]	[0.0002]
Time Since Global Launch Squared (Yrs)	0.0231***	0.0027***	0.0162***	0.0028***	0.0010***	0.0000**	0.0009***	0.0000***
	[0.0026]	[0.0004]	[0.0030]	[0.0004]	[0.0002]	[0.0000]	[0.0002]	[0.0000]
First Global Launch Before 1990 D.V.	0.0604	0.4759*	-0.1759	0.6729**	0.0027	0.0006*	-0.0092	0.0021*
	[0.1926]	[0.2464]	[0.2802]	[0.3347]	[0.0088]	[0.0004]	[0.0141]	[0.0011]
First Global Launch in [1996-end] D.V.	0.0080	-0.0932	-0.0421	0.0038	0.0004	-0.0001	-0.0023	0.0000
	[0.1463]	[0.2000]	[0.1855]	[0.3328]	[0.0065]	[0.0002]	[0.0102]	[0.0008]
Any PI Share in Subclass D.V.	0.0250	-0.2846	0.0803	-0.2639	0.0011	-0.0003	0.0046	-0.0006
	[0.1442]	[0.4814]	[0.1504]	[0.3562]	[0.0064]	[0.0005]	[0.0087]	[0.0009]
Num Already Launched (UK, Germany)	0.5878***	0.5417***	0.4793***	0.3894***	0.0270***	0.0006	0.0276***	0.0009*
	[0.0923]	[0.1877]	[0.0784]	[0.1464]	[0.0063]	[0.0004]	[0.0066]	[0.0005]
Num Already Launched (Sweden, Netherlands)	0.5090***	0.5767***	0.3944***	0.3602**	0.0231***	0.0006*	0.0225***	0.0009*
	[0.0712]	[0.1551]	[0.0745]	[0.1435]	[0.0050]	[0.0003]	[0.0055]	[0.0005]
Num Already Launched (Italy, France)	0.2708***	0.0940	0.3077***	0.1226	0.0120**	0.0001	0.0174***	0.0003

	[0.0949]	[0.1090]	[0.0833]	[0.1325]	[0.0049]	[0.0001]	[0.0055]	[0.0003]
Num Already Launched (Spain, Portugal, Greece)	0.0509	0.2353**	-0.0354	0.1306	0.0022	0.0002**	-0.0020	0.0003
	[0.0648]	[0.0966]	[0.0651]	[0.0937]	[0.0028]	[0.0001]	[0.0037]	[0.0002]
Num Already Launched (Canada, Japan, Switzerland, USA)	0.1943***	0.0071	0.1306**	-0.0867	0.0086***	0.0000	0.0073**	-0.0002
	[0.0620]	[0.0969]	[0.0557]	[0.0957]	[0.0028]	[0.0001]	[0.0033]	[0.0002]
Launch by Local Corporation D.V.	0.7369***	1.7172***	0.7217***	1.5415***	0.0443***	0.0043*	0.0532***	0.0068**
	[0.1235]	[0.2361]	[0.1061]	[0.1557]	[0.0111]	[0.0023]	[0.0130]	[0.0028]
USD to (ECU or Euro) Exchange Rate	0.0913	-0.0578	-0.2034	-0.7314	0.0040	-0.0001	-0.0114	-0.0017
	[0.4574]	[0.5770]	[0.4200]	[0.5681]	[0.0199]	[0.0006]	[0.0239]	[0.0015]
UK D.V.	-0.1709	0.1690	-0.1003	0.2779	-0.0069	0.0002	-0.0054	0.0007
	[0.2081]	[0.3027]	[0.1990]	[0.3515]	[0.0082]	[0.0003]	[0.0106]	[0.0009]
Netherlands D.V.	-0.8430***	0.4970	-0.7663***	0.6260	-0.0253***	0.0006	-0.0314***	0.0019
	[0.2455]	[0.3594]	[0.2184]	[0.3861]	[0.0077]	[0.0006]	[0.0099]	[0.0013]
Sweden D.V.	-0.6001**	-0.3079	-0.4402*	-0.1084	-0.0200**	-0.0003	-0.0205*	-0.0002
	[0.2673]	[0.4743]	[0.2262]	[0.4433]	[0.0090]	[0.0005]	[0.0110]	[0.0010]
France D.V.	-1.2696***	-0.9434	-1.2127***	-0.7951	-0.0320***	-0.0006	-0.0420***	-0.0014
	[0.2025]	[0.5779]	[0.2284]	[0.5126]	[0.0072]	[0.0005]	[0.0101]	[0.0011]
Greece D.V.	-1.2607***	0.5748	-1.0700***	0.7274	-0.0319***	0.0008	-0.0391***	0.0023
	[0.2522]	[0.5698]	[0.2480]	[0.5155]	[0.0079]	[0.0007]	[0.0108]	[0.0016]
Italy D.V.	-1.0092***	-0.1374	-0.9240***	0.0225	-0.0283***	-0.0001	-0.0356***	0.0001
	[0.2428]	[0.5561]	[0.2150]	[0.4838]	[0.0077]	[0.0005]	[0.0101]	[0.0012]
Portugal D.V.	-1.9216***	-0.1672	-1.7524***	-0.0259	-0.0382***	-0.0002	-0.0503***	-0.0001
	[0.2278]	[0.6001]	[0.2511]	[0.5292]	[0.0077]	[0.0006]	[0.0106]	[0.0013]
Spain D.V.	-0.8364***	-0.1242	-0.7237***	-0.0187	-0.0252***	-0.0001	-0.0302***	0.0000
	[0.1945]	[0.5521]	[0.2170]	[0.4984]	[0.0073]	[0.0005]	[0.0103]	[0.0012]
Canada D.V.	-1.0116***	-0.7627	-0.9052***	-0.5321	-0.0283***	-0.0005	-0.0352***	-0.0010
	[0.2309]	[0.5674]	[0.2095]	[0.4871]	[0.0078]	[0.0005]	[0.0100]	[0.0011]
Japan D.V.	-2.4194***	-0.2152	-2.4869***	-0.2343	-0.0408***	-0.0002	-0.0567***	-0.0005
	[0.2323]	[0.6296]	[0.2330]	[0.4530]	[0.0077]	[0.0006]	[0.0105]	[0.0010]
Switzerland D.V.	-1.0357***	-0.5329	-0.8541***	-0.3490	-0.0287***	-0.0004	-0.0338***	-0.0007
	[0.2582]	[0.5657]	[0.2519]	[0.5630]	[0.0082]	[0.0005]	[0.0111]	[0.0012]
USA D.V.	-0.6470**	-1.2809**	-0.6334***	-1.1638**	-0.0211**	-0.0007	-0.0274***	-0.0018*
	[0.2674]	[0.6408]	[0.2234]	[0.4760]	[0.0083]	[0.0005]	[0.0098]	[0.0010]
Brazil D.V.	-1.1472***	0.1306	-0.9745***	0.2805	-0.0304***	0.0001	-0.0369***	0.0007
	[0.2390]	[0.5753]	[0.2206]	[0.4818]	[0.0078]	[0.0006]	[0.0103]	[0.0012]
Mexico D.V.	-1.2726***	-0.1533	-1.0738***	0.0976	-0.0321***	-0.0001	-0.0391***	0.0002

	[0.2673]	[0.6160]	[0.2434]	[0.5280]	[0.0079]	[0.0006]	[0.0107]	[0.0013]
Anti-asthma D.V.	0.0746	0.5223*	-0.0788	0.1273	0.0034	0.0006	-0.0043	0.0003
	[0.3007]	[0.2803]	[0.3554]	[0.3977]	[0.0140]	[0.0005]	[0.0188]	[0.0010]
Anti-clotting D.V.	-0.8059**	-0.2655	-0.8125**	-0.2154	-0.0259***	-0.0002	-0.0343**	-0.0005
	[0.3205]	[0.4512]	[0.3896]	[0.4759]	[0.0094]	[0.0004]	[0.0137]	[0.0010]
Anti-depressants D.V.	0.1204	0.3712	0.2314	-0.0533	0.0055	0.0004	0.0141	-0.0001
	[0.1970]	[0.4103]	[0.2861]	[0.4540]	[0.0092]	[0.0006]	[0.0186]	[0.0010]
Epileptics D.V.	-0.0815	0.0056	-0.0825	-0.2466	-0.0035	0.0000	-0.0045	-0.0005
	[0.2051]	[0.7782]	[0.2830]	[0.8291]	[0.0086]	[0.0008]	[0.0152]	[0.0017]
Anti-nauseants D.V.	-0.8427***	-0.2181	-0.8515**	-0.4229	-0.0268***	-0.0002	-0.0356***	-0.0009
	[0.2958]	[0.4914]	[0.3821]	[0.7473]	[0.0088]	[0.0004]	[0.0137]	[0.0014]
Parkinsons D.V.	-0.4541	0.7312*	-0.1931	0.9571	-0.0165*	0.0011	-0.0101	0.0034
	[0.2994]	[0.4429]	[0.3786]	[0.6323]	[0.0098]	[0.0011]	[0.0185]	[0.0033]
Anti-psychotics D.V.	-0.1434	0.4097	0.0796	1.6619**	-0.0059	0.0005	0.0046	0.0080
	[0.3220]	[0.6167]	[0.3903]	[0.7094]	[0.0126]	[0.0009]	[0.0232]	[0.0060]
Anti-ulcerants D.V.	-0.3845	-0.3721	-0.5888*	-0.7576	-0.0147*	-0.0003	-0.0274**	-0.0014
	[0.2481]	[0.4731]	[0.3065]	[0.5332]	[0.0086]	[0.0004]	[0.0129]	[0.0010]
Lipid lowering D.V.	-0.0062	0.5170	0.1957	0.5508	-0.0003	0.0007	0.0119	0.0016
	[0.2381]	[0.4908]	[0.3259]	[0.5215]	[0.0104]	[0.0008]	[0.0213]	[0.0019]
Migraine D.V.	-0.5845*	-0.2452	-0.2020	-0.4930	-0.0199**	-0.0002	-0.0105	-0.0010
	[0.3405]	[0.6207]	[0.4239]	[0.8959]	[0.0102]	[0.0005]	[0.0205]	[0.0016]
Osteoporosis D.V.	-0.1224	0.6498*	-0.2250	0.4117	-0.0051	0.0008	-0.0116	0.0011
	[0.3198]	[0.3629]	[0.3149]	[0.3647]	[0.0127]	[0.0007]	[0.0151]	[0.0011]
Constant	-1.1848	-5.3671***	-1.6211	-5.2593***				
	[0.9823]	[1.6538]	[1.0147]	[1.6056]				
Num Observations	23,400	96,041	23,400	96,041	23,400	96,041	23,400	96,041
Number of Molecule-level Clusters	111	239	111	239	111	239	111	239
Model Log-Likelihood	-3088.4	-2033.3	-3067.4	-2003.9				
Mean of Dependent Variable	0.0378	0.0041	0.0378	0.0041	0.0378	0.0041	0.0378	0.0041

Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%
Note: All prices are ex manufacturer prices per standard unit in 2003 US Dollars

Table 6. Marginal Effects of Prior Foreign Launch on Launch Hazard in Low-Price EU Countries for Superior Subclasses (Standard Errors in Brackets)

Marginal Effects of Prior Foreign Launch in Low-Price EU Countries Clog-log with Robust Clustered SEs	
Net effect of a Single Prior Launch in a High-Price EU Country	0.0018*** [0.0004]
Net effect of a Single Prior Launch in a Low-Price EU Country	0.0005*** [0.0002]
Difference	0.0013*** [0.0003]
Net effect of a Single Prior Launch in a High-Price EU Country	0.0018*** [0.0004]
Net effect of a Single Prior Launch in a High-Price non-EU Country	0.0005*** [0.0002]
Difference	0.0012*** [0.0004]

Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 7. Marginal Effects of Launch by a Local Corporation (Standard Errors in Brackets)

	Superior Subclasses		Inferior Subclasses	
Country	Net Effect	Difference from Germany	Net Effect	Difference from Germany
Germany	0.0070	--	0.0033	--
	[0.0122]		[0.0024]	
UK	0.0340	0.0270	0.0034*	0.0000
	[0.0258]	[0.0278]	[0.0019]	[0.0025]
Sweden	-0.0106	-0.0176	N/A	N/A
	[0.0071]	[0.0148]		
Netherlands	N/A	N/A	0.0157	0.0124
			[0.0243]	[0.0241]
France	0.0145**	0.0074	0.0010	-0.0023
	[0.0066]	[0.0145]	[0.0008]	[0.3457]
Greece	N/A	N/A	0.0032	-0.0001
			[0.0062]	[0.0066]
Italy	0.0148**	0.0078	0.0052*	0.0018
	[0.0069]	[0.0136]	[0.0028]	[0.0039]
Spain	0.0143**	0.0073	0.0113	0.0080
	[0.0058]	[0.5939]	[0.0087]	[0.0095]
Portugal	0.0001	-0.0069	N/A	N/A
	[0.0010]	[0.0123]		
Canada	0.0059	-0.0011	0.0008	-0.0026
	[0.0075]	[0.0139]	[0.0006]	[0.0024]
Japan	0.0108***	0.0038	0.0085*	0.0052
	[0.0035]	[0.0130]	[0.0050]	[0.0058]
Switzerland	0.0217**	0.0147	0.0004	-0.0030
	[0.0097]	[0.0162]	[0.0009]	[0.0024]
USA	0.0118	0.0048	0.0010*	-0.0023
	[0.0099]	[0.0162]	[0.0006]	[0.0025]
Brazil	0.0045	-0.0025	0.0045	0.0012
	[0.0049]	[0.0130]	[0.0036]	[0.0043]
Mexico	N/A	N/A	0.0013	-0.0020
			[0.0019]	[0.0028]

Note: Effects for some countries were not estimated due to a lack of launches by local corporations in those countries

Table 8. Determinants of Launch Prices, OLS and Normal Random Effects Regressions (Standard Errors in Brackets)

	OLS w/ Robust Clustered SEs				Normal Random Effects			
Variables	Superior Subclasses	Inferior Subclasses	Superior Subclasses	Inferior Subclasses	Superior Subclasses	Inferior Subclasses	Superior Subclasses	Inferior Subclasses
Superior Brands' Price Missing D.V.	-0.0547	0.0165	-0.0567	0.0264	-0.0545	0.0410	-0.0592	0.0490
	[0.1888]	[0.1215]	[0.1896]	[0.1213]	[0.1124]	[0.1105]	[0.1127]	[0.1117]
Log Avg Price of Superior Brands (Lag 1Q)	0.1576***	-0.0024	0.1589***	0.0037	0.1220***	-0.0064	0.1252***	0.0065
	[0.0395]	[0.0462]	[0.0396]	[0.0475]	[0.0200]	[0.0336]	[0.0200]	[0.0336]
Inferior Brands' Price Missing D.V.	0.1106	-0.7399	0.1152	-0.7976	0.0105	-1.1929**	0.0222	-1.2387**
	[0.1527]	[0.6968]	[0.1544]	[0.7256]	[0.1109]	[0.4828]	[0.1111]	[0.4864]
Log Avg Price of Inferior Brands (Lag 1Q)	0.0372	0.2170***	0.0367	0.2154***	0.0800***	0.1733***	0.0786***	0.1732***
	[0.0400]	[0.0490]	[0.0398]	[0.0487]	[0.0203]	[0.0293]	[0.0204]	[0.0297]
Generics' Price Missing D.V.	0.0693	0.3715*	0.0707	0.3758*	0.0139	0.2413*	0.0160	0.2419*
	[0.1166]	[0.1990]	[0.1163]	[0.2001]	[0.0753]	[0.1238]	[0.0755]	[0.1255]
Log Avg Price of Generics in Class (Lag 1Q)	0.0289	-0.1213***	0.0290	-0.1227***	0.0155	-0.0852**	0.0146	-0.0824**
	[0.0294]	[0.0437]	[0.0294]	[0.0435]	[0.0193]	[0.0341]	[0.0194]	[0.0346]
Time Since Global Launch (Yrs)	-0.0447*	-0.0226	-0.0433	-0.0239	-0.0455*	-0.0032	-0.0431*	-0.0058
	[0.0264]	[0.0204]	[0.0265]	[0.0206]	[0.0258]	[0.0204]	[0.0258]	[0.0204]
Time Since Global Launch Squared (Yrs)	0.0029	-0.0006	0.0028	-0.0005	0.0008	-0.0013**	0.0006	-0.0012*
	[0.0018]	[0.0006]	[0.0018]	[0.0006]	[0.0018]	[0.0006]	[0.0018]	[0.0006]
First Brand Launch in Ctry-Subclass D.V.	0.1922	0.8617**	0.1957	0.8949**	0.1970	1.1693***	0.1991	1.2174***
	[0.1648]	[0.4028]	[0.1651]	[0.4329]	[0.1299]	[0.3532]	[0.1303]	[0.3576]
Second Brand Launch in Ctry-Subclass D.V.	0.3492***	0.6179**	0.3482***	0.6069*	0.2734***	0.6104***	0.2672***	0.6282***
	[0.0821]	[0.3114]	[0.0821]	[0.3254]	[0.0747]	[0.2302]	[0.0748]	[0.2315]
Third or Fourth Brand Launch in Ctry-Subclass D.V.	0.2443***	0.3213**	0.2429***	0.3163*	0.1832***	0.2095	0.1778***	0.2170
	[0.0612]	[0.1608]	[0.0614]	[0.1627]	[0.0553]	[0.1455]	[0.0554]	[0.1462]
Any PI Share in Subclass D.V.	0.0191	-0.5001**	0.0204	-0.4569**	0.0162	-0.4746***	0.0193	-0.4583***
	[0.0795]	[0.2013]	[0.0785]	[0.2139]	[0.0644]	[0.1711]	[0.0646]	[0.1737]
High-price EU Min Own Price Missing D.V.	0.2262***	-0.0567	0.2232***	-0.0485	0.0732	-0.0542	0.0709	-0.0652
	[0.0813]	[0.1352]	[0.0813]	[0.1361]	[0.0564]	[0.0951]	[0.0566]	[0.0962]
Log Min Own Price in Hi-Price EU (Lag 1Q)	0.2202***	0.3868***	0.2197***	0.3919***	0.1008***	0.2740***	0.1015***	0.2847***
	[0.0633]	[0.0892]	[0.0632]	[0.0901]	[0.0258]	[0.0585]	[0.0259]	[0.0590]
Low-price EU Min Own Price	-0.0197	-0.0941	-0.0173	-0.0951	0.0220	0.0357	0.0274	0.0269

Missing D.V.	[0.0525]	[0.1255]	[0.0529]	[0.1249]	[0.0479]	[0.1021]	[0.0480]	[0.1034]
Log Min Own Price in Low-Price EU (Lag 1Q)	-0.0257	-0.1035	-0.0249	-0.0935	-0.0229	-0.1007	-0.0195	-0.0993
	[0.0395]	[0.1174]	[0.0392]	[0.1159]	[0.0277]	[0.0782]	[0.0277]	[0.0790]
High-price non-EU Min Own Price Missing D.V.	0.1073	-0.3117***	0.1096*	-0.3208***	0.1003*	-0.1114	0.1030*	-0.1231
	[0.0656]	[0.1114]	[0.0659]	[0.1128]	[0.0550]	[0.0924]	[0.0551]	[0.0935]
Log Min Own Price in Hi-Price non-EU (Lag 1Q)	0.2666***	0.0473	0.2660***	0.0530	0.1366***	-0.0270	0.1348***	-0.0179
	[0.0525]	[0.0657]	[0.0523]	[0.0634]	[0.0250]	[0.0565]	[0.0250]	[0.0571]
Log GDP per Capita	0.8491	2.9423*			1.8249**	3.3683***		
	[0.9185]	[1.5670]			[0.7360]	[1.1556]		
Launch by Local Corporation D.V.	-0.0395	-0.2214**	-0.0380	-0.2323**	0.0000	-0.0977	0.0035	-0.1093
	[0.0610]	[0.1105]	[0.0611]	[0.1125]	[0.0441]	[0.0760]	[0.0442]	[0.0771]
USD to (ECU or Euro) Exchange Rate	-0.1372	2.5270**	-0.1266	2.3748**	-0.0282	1.8420**	0.0021	1.6395**
	[0.6306]	[1.0413]	[0.6204]	[1.0423]	[0.4490]	[0.8156]	[0.4501]	[0.8246]
Country-Specific Quarterly Producer Price Index	-0.0084*	0.0019	-0.0060	0.0103	-0.0083*	-0.0123*	-0.0033	-0.0014
	[0.0043]	[0.0082]	[0.0038]	[0.0064]	[0.0043]	[0.0067]	[0.0038]	[0.0056]
Avg Pack Size (Up to 100)	-0.0118***	-0.0104***	-0.0118***	-0.0102***	-0.0092***	-0.0094***	-0.0092***	-0.0094***
	[0.0017]	[0.0025]	[0.0017]	[0.0025]	[0.0010]	[0.0017]	[0.0010]	[0.0017]
Pack Size > 100 D.V.	-1.1981***	-1.6354***	-1.1999***	-1.6008***	-0.9742***	-1.4205***	-0.9755***	-1.4262***
	[0.1875]	[0.2150]	[0.1883]	[0.2095]	[0.1106]	[0.1759]	[0.1109]	[0.1781]
Avg Pill Strength (g)	0.4895**	0.0355	0.5030**	0.0273	0.0927	0.1731	0.1120	0.1656
	[0.2421]	[0.0690]	[0.2426]	[0.0685]	[0.2750]	[0.1425]	[0.2757]	[0.1421]
Form: Oral Solid Delayed D.V.	-0.1085	-0.1818	-0.1159	-0.1464	0.0990	0.0950	0.0873	0.0971
	[0.1948]	[0.1437]	[0.1944]	[0.1441]	[0.1811]	[0.1569]	[0.1815]	[0.1587]
Form: Injectable D.V.	2.0837***	1.7419***	2.0907***	1.7262***	1.7522***	1.9598***	1.7654***	1.9546***
	[0.3011]	[0.3526]	[0.3027]	[0.3517]	[0.0882]	[0.2161]	[0.0883]	[0.2183]
Form: Other	-0.0468	0.3395***	-0.0496	0.3412***	0.0987	0.0906	0.0944	0.0798
	[0.1677]	[0.1083]	[0.1657]	[0.1098]	[0.1697]	[0.1266]	[0.1702]	[0.1275]
UK D.V.	-0.3181***	-0.1837	-0.2720***	-0.0542	-0.2741***	-0.1424	-0.1772**	-0.0027
	[0.0953]	[0.1242]	[0.0826]	[0.1201]	[0.0865]	[0.1534]	[0.0774]	[0.1481]
Netherlands D.V.	-0.0681	-0.0192	-0.0709	-0.0696	-0.0572	-0.0285	-0.0615	-0.0809
	[0.1020]	[0.1426]	[0.1009]	[0.1359]	[0.0791]	[0.1573]	[0.0793]	[0.1589]
Sweden D.V.	-0.1720	-0.1988	-0.0535	0.1963	-0.3271**	-0.3940*	-0.0726	0.0468
	[0.1666]	[0.2770]	[0.0853]	[0.2120]	[0.1322]	[0.2221]	[0.0835]	[0.1667]
France D.V.	-0.1980*	-0.7234***	-0.2301**	-0.8020***	-0.1218	-0.6705***	-0.1895**	-0.7961***
	[0.1114]	[0.2689]	[0.1091]	[0.2679]	[0.0993]	[0.2279]	[0.0958]	[0.2276]

Greece D.V.	0.2751	1.3523	-0.3885***	-0.8714***	1.1963**	1.7931**	-0.2290**	-0.7859***
	[0.7164]	[1.2197]	[0.1190]	[0.2578]	[0.5841]	[0.9111]	[0.1038]	[0.2241]
Italy D.V.	-0.1888	-0.2666	-0.3447***	-0.7474***	0.0869	-0.0369	-0.2457***	-0.6109***
	[0.1956]	[0.3839]	[0.1057]	[0.2615]	[0.1644]	[0.2955]	[0.0953]	[0.2246]
Portugal D.V.	0.3684	1.5339	-0.3040***	-0.7830***	1.2180**	2.0567**	-0.2229**	-0.6173***
	[0.7247]	[1.2826]	[0.1097]	[0.2538]	[0.5908]	[0.9434]	[0.1065]	[0.2271]
Spain D.V.	0.1933	0.8711	-0.2439**	-0.6308***	0.7716**	1.0792*	-0.1671*	-0.6646***
	[0.4847]	[0.8654]	[0.1000]	[0.2366]	[0.3895]	[0.6375]	[0.0919]	[0.2234]
Canada D.V.	0.0457	-0.2775	0.0382	-0.2964	0.0386	-0.2199	0.0243	-0.2633
	[0.1076]	[0.2933]	[0.1051]	[0.2976]	[0.0914]	[0.2253]	[0.0915]	[0.2286]
Japan D.V.	0.1784	-0.9953	0.6090***	0.5184*	-0.3499	-1.1783*	0.5783***	0.5344**
	[0.4964]	[0.7901]	[0.2005]	[0.2843]	[0.3932]	[0.6362]	[0.1206]	[0.2477]
Switzerland D.V.	-0.1294	-1.6747**	0.2162**	-0.4406*	-0.5989*	-1.6100***	0.1470*	-0.2499
	[0.4024]	[0.6707]	[0.0919]	[0.2471]	[0.3133]	[0.5176]	[0.0876]	[0.2241]
USA D.V.	0.2007	-0.8430	0.5395***	0.3456	-0.3386	-1.0889**	0.3919***	0.2331
	[0.4023]	[0.6352]	[0.1332]	[0.2586]	[0.3099]	[0.5070]	[0.0962]	[0.2308]
Brazil D.V.	1.2609	4.8771*	-0.3138***	-0.5226**	3.1688**	5.7499***	-0.2112**	-0.4718**
	[1.6860]	[2.9072]	[0.1102]	[0.2442]	[1.3664]	[2.1448]	[0.0930]	[0.2209]
Mexico D.V.	0.9099	3.0603	-0.2478**	-0.9115***	2.3304**	3.7571**	-0.1537	-0.8177***
	[1.2575]	[2.1490]	[0.1203]	[0.2340]	[1.0064]	[1.5847]	[0.0950]	[0.2306]
Constant	-7.0024	-31.3603**	1.1664	-2.8290*	-16.7642**	-33.9512***	0.7869	-1.2879
	[8.7335]	[15.2202]	[0.8811]	[1.5154]	[7.1148]	[11.2780]	[0.7173]	[1.1971]
Year Fixed Effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	950	423	950	423	950	423	950	423
Number of Molecule-level Clusters	109	123	109	123	109	123	109	123
R-squared	0.89	0.79	0.89	0.79	0.87	0.76	0.87	0.76
Mean of Dependent Variable	0.74	-0.39	0.74	-0.39	0.74	-0.39	0.74	-0.39

Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%
Note: All prices are ex manufacturer prices per standard unit in 2003 US Dollars

Table 9. Spillover Effects of Own Price on Launch Price in Low-Price EU Countries for Superior Subclasses

Marginal Effects of Log Min Own Price on Launch Price in Low-Price EU Countries

	OLS w/ Robust Clustered SEs	Normal Random Effects
Net effect of Log Min Own Price in High-Price EU Countries (Lag 1Q)	0.4274***	0.2496***
	[0.0849]	[0.0829]
Net effect of Log Min Own Price in Low-Price EU Countries (Lag 1Q)	0.0346	-0.0129
	[0.0596]	[0.0424]
Difference	0.3928***	0.2625**
	[0.1101]	[0.1035]
Net effect of Log Min Own Price in High-Price EU Countries (Lag 1Q)	0.4274***	0.2496***
	[0.0849]	[0.0829]
Net effect of Log Min Own Price in High-Price non-EU Countries (Lag 1Q)	0.0526	-0.0034
	[0.0829]	[0.0763]
Difference	0.3748**	0.2530*
	[0.1620]	[0.1551]

Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%
Note: All prices are ex manufacturer prices per standard unit in 2003 US Dollars

Appendix Table A1. Descriptive Statistics for Launch Model Variables

Variable Description	Superior Subclasses Mean	Superior Subclasses Std. Dev.	Inferior Subclasses Mean	Inferior Subclasses Std. Dev.
New Launch D.V.	0.04	0.19	0.00	0.06
Log Avg Price of Superior Brand Drugs (Lag 1Q)	0.52	1.33	0.68	1.47
Log Avg Price of Inferior Brand Drugs (Lag 1Q)	-0.54	1.29	-0.48	1.46
Log Total Volume of All Drugs In (Lag 1Q)	12.68	1.75	12.94	1.69
Num Generic Manufs per Molc in Superior Sub (Lag 1Q)	5.08	10.30	4.41	9.27
Num Generic Manufs per Molc in Inferior Sub (Lag 1Q)	28.95	37.17	35.80	41.52
No Molecules in Superior Sub D.V.	0.05	0.22	0.05	0.23
No Molecules in Inferior Sub D.V.	0.01	0.07	0.01	0.07
Time Since Molecule Global Launch (Years)	4.41	3.97	14.70	11.88
Time Since Molecule Global Launch Squared	35.20	56.96	357.07	739.83
First Global Launch Before 1990 D.V.	0.21	0.40	0.72	0.45
First Global Launch In [1990-1995] D.V.	0.38	0.48	0.20	0.40
First Global Launch In [1996-2002] D.V.	0.42	0.49	0.08	0.26
Any PI Share In Subclass- D.V.	0.16	0.36	0.22	0.41
Num Already Launched (UK, Germany)	0.69	0.82	0.51	0.73
Num Already Launched (Italy, France)	0.51	0.72	0.48	0.70
Num Already Launched (Sweden, Netherlands)	0.56	0.78	0.30	0.61
Num Already Launched (Spain, Portugal, Greece)	0.58	0.94	0.58	0.91
Num Already Launched (Canada, Japan, Switzerland, USA)	1.18	0.94	1.01	0.95
Launch by Local Corporation D.V.	0.07	0.26	0.04	0.20
USD to (ECU or Euro) Exchange Rate	1.09	0.13	1.11	0.14
Germany D.V.	0.05	0.22	0.05	0.23
UK D.V.	0.06	0.23	0.06	0.25
Netherlands D.V.	0.06	0.25	0.06	0.25
Sweden D.V.	0.06	0.24	0.08	0.27
France D.V.	0.07	0.26	0.07	0.25
Greece D.V.	0.07	0.25	0.07	0.26
Italy D.V.	0.06	0.23	0.06	0.23
Portugal D.V.	0.09	0.28	0.07	0.25
Spain D.V.	0.06	0.24	0.06	0.25
Canada D.V.	0.07	0.25	0.07	0.26
Japan D.V.	0.10	0.30	0.05	0.21
Switzerland D.V.	0.06	0.24	0.07	0.25
USA D.V.	0.06	0.23	0.07	0.26
Brazil D.V.	0.07	0.25	0.08	0.27
Mexico D.V.	0.07	0.26	0.07	0.26
Anti-asthma D.V.	0.05	0.21	0.16	0.37
Anti-clotting D.V.	0.07	0.25	0.10	0.29
Anti-depressants D.V.	0.09	0.29	0.09	0.28
Epileptics D.V.	0.15	0.36	0.03	0.16
Anti-hypertensives D.V.	0.21	0.41	0.17	0.38
Anti-nausea D.V.	0.07	0.26	0.04	0.21
Parkinsons D.V.	0.05	0.22	0.01	0.11

Anti-psychotic D.V.	0.05	0.22	0.01	0.12
Anti-ulcerant D.V.	0.11	0.32	0.09	0.28
Lipid-lowering D.V.	0.04	0.20	0.05	0.22
Migraine D.V.	0.03	0.17	0.03	0.17
Osteoporosis D.V.	0.08	0.26	0.22	0.41
Sample Size	23,400		96,041	

Note: All prices are ex manufacturer prices per standard unit in 2003 US Dollars

Appendix Table A2. Descriptive Statistics for Price Model Variables

Variable Description	Superior Subclasses Mean	Superior Subclasses Std. Dev.	Inferior Subclasses Mean	Inferior Subclasses Std. Dev.
Log of Price in 2003 USD per SU	0.74	1.65	-0.39	1.31
Price in 2003 USD per SU	27.95	150.13	7.10	46.63
Superior Brands' Price Missing D.V.	0.08	0.28	0.13	0.33
Log Avg Price of Superior Brands (Lag 1Q)	0.66	1.39	0.29	1.27
Inferior Brands' Price Missing D.V.	0.02	0.14	0.01	0.11
Log Avg Price of Inferior Brands (Lag 1Q)	-0.53	1.41	-0.55	1.40
Generics' Price Missing D.V.	0.11	0.32	0.12	0.33
Log Avg Price of Generics In Class (Lag 1Q)	-1.23	1.05	-1.06	1.11
Time Since Global Launch (Years)	2.16	2.49	6.54	7.32
Time Since Global Launch Squared	10.87	30.65	96.22	211.51
First Brand Launch in Ctry-Subclass D.V.	0.11	0.31	0.01	0.12
Second Brand Launch in Ctry-Subclass D.V.	0.15	0.36	0.03	0.17
Third or Fourth Brand Launch in Ctry-Subclass D.V.	0.30	0.46	0.11	0.31
Fifth or Later Brand Launch in Ctry-Subclass D.V.	0.44	0.50	0.85	0.36
Any PI Share In Ctry-Subclass D.V.	0.16	0.36	0.18	0.38
High-price EU Min Own Price Missing D.V.	0.24	0.43	0.37	0.48
Log Min Own Price in Hi-Price EU (Lag 1Q)	0.41	1.33	-0.31	1.02
Low-price EU Min Own Price Missing D.V.	0.47	0.50	0.43	0.50
Log Min Own Price in Low-Price EU (Lag 1Q)	0.12	0.90	-0.55	0.72
High-price non-EU Min Own Price Missing D.V.	0.29	0.45	0.50	0.50
Log Min Own Price in Hi-Price non-EU (Lag 1Q)	0.60	1.45	-0.31	0.89
Log GDP per Capita (in 2000 USD 000s)	9.71	0.66	9.60	0.73
Launch by Local Corporation D.V.	0.19	0.39	0.26	0.44
USD to (ECU or Euro) Exchange Rate	1.12	0.13	1.15	0.13
Country-Specific Quarterly Producer Price Index	95.14	6.84	93.52	9.46
Avg Pack Size (Up to 100)	33.01	28.15	31.42	27.18
Avg Pack Size > 100 D.V.	0.05	0.23	0.15	0.36
Avg Pill Strength	0.08	0.13	0.09	0.29
Form Oral Instant D.V.	0.85	0.35	0.67	0.47
Form Oral Delayed D.V.	0.01	0.09	0.06	0.24
Form Injectable D.V.	0.11	0.31	0.05	0.23
Form Other D.V.	0.03	0.17	0.21	0.41
Germany D.V.	0.08	0.27	0.05	0.21
UK D.V.	0.07	0.25	0.10	0.31
Netherlands D.V.	0.06	0.24	0.05	0.22
Sweden D.V.	0.07	0.26	0.05	0.22
France D.V.	0.06	0.24	0.06	0.24
Greece D.V.	0.06	0.24	0.10	0.30
Italy D.V.	0.07	0.26	0.07	0.26
Portugal D.V.	0.05	0.22	0.07	0.25
Spain D.V.	0.06	0.23	0.05	0.22
Canada D.V.	0.07	0.25	0.05	0.22
Japan D.V.	0.05	0.21	0.11	0.31
Switzerland D.V.	0.07	0.26	0.06	0.24
USA D.V.	0.08	0.27	0.05	0.23

Brazil D.V.	0.07	0.25	0.05	0.23
Mexico D.V.	0.07	0.25	0.07	0.25
Year 1992 D.V.	0.07	0.25	0.13	0.33
Year 1993 D.V.	0.07	0.25	0.14	0.34
Year 1994 D.V.	0.07	0.25	0.09	0.29
Year 1995 D.V.	0.08	0.27	0.07	0.26
Year 1996 D.V.	0.08	0.28	0.11	0.32
Year 1997 D.V.	0.13	0.34	0.15	0.35
Year 1998 D.V.	0.15	0.36	0.07	0.25
Year 1999 D.V.	0.10	0.30	0.04	0.21
Year 2000 D.V.	0.09	0.28	0.07	0.25
Year 2001 D.V.	0.07	0.25	0.06	0.23
Year 2002 D.V.	0.05	0.22	0.05	0.23
Year 2003 D.V.	0.05	0.21	0.03	0.16
Sample Size	950		423	

Note: All prices are ex manufacturer prices per standard unit in 2003 US Dollars