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CESIFO WORKING PAPER NO. 3441
CATEGORY 11: INDUSTRIAL ORGANISATION
MAY 2011

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Abstract

Generic competition in the pharmaceutical market is an effective cost-containment mechanism that improves static efficiency and stimulates pharmaceutical innovation. There is no prior study that has empirically analysed the relative delays in adoption of generic competition. This paper aims to investigate how price regulations in the OECD affect the adoption of generic competition following the first global generic launch of each molecule. Drawing upon data from 1999 to 2008, we estimate the impact of ex-ante price and market size expectations on the probability of generic launch using discrete-time duration modelling with cloglog and logit regressions. The econometric strategy employs both parametric and non-parametric duration dependence and includes controls for generic competition in each country, firm characteristics and molecule heterogeneity. Ex-ante profit expectations result in faster adoption; both expected price and market size increase the probability of launch. Our findings suggest that neither molecule nor firm characteristics have a significant effect on generic adoption across different specifications. Instead, evidence indicates that generic competitors follow a locally oriented strategy in contrast to research-intensive pharmaceutical firms.

JEL-Code: I110, L510.

Keywords: generic competition, regulation, adoption, discrete-time duration analysis.

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1 INTRODUCTION

A generic drug is chemically bioequivalent to the originator reference product with the same qualitative and quantitative composition in active ingredients, same form, route of administration, safety, and efficacy (Scott Morton 1999; Lichtenberg and Philipson 2002; Scottorn 2009). Generics that are almost by definition cost-effective alternatives to branded medicines offer the most visible source of savings and efficiency gains. Hence, delays in the entry of generic competition following patent expiry imply substantial opportunity costs for the sustainability of healthcare systems. Delays are due to exogenous reasons, such as the timing of the corresponding brand-name's patent expiration and the degree of administrative delay, but in part due to companies' strategic entry in specific market and therapeutic groups where the probability of profiting from lower priced products is higher. Paradoxically, despite the increasing economic importance of generic competition, there is surprisingly little empirical evidence on generic adoption and drivers of delays across major pharmaceutical markets. The purpose of this paper is to empirically examine how different pricing regulations influence the adoption of generic competition using price and volume data from 1999 to 2008 in the OECD market.

Given the lower potential for product differentiation, generics predominantly engage in price competition resulting in a significant pressure on branded price levels and market competition. Branded share of market revenues in the US within 2 yrs of patent expiration generally falls by 50% (Griliches and Cockburn 1994). Similarly, average prices in Europe appear to drop by 25% after the second year exclusivity is lost (DG Competition 2009). Generic competition, therefore, improves equity of access to pharmaceutical treatment. Timely generic entry is important not only from a static efficiency perspective but also from a dynamic perspective. Incentives to invest in future innovation are higher when branded manufactures face generic competition[1]. Furthermore, resources saved by payers due to early generic adoption can be transferred to stimulate future innovation in the branded sector.[2] From a strategic perspective,

[1] Consistently, the economics literature defines strategies of monopolists that have little incentive to develop new products that will compete directly against their products as the *replacement effect* (Tirole 1990).

[2] Given aging demographic profiles, growing trend towards chronic life-style diseases, and expected patent expiries, policy measures conducive to fast generic adoption and diffusion offer significant savings in the near future Gorka, E. (2009). "Generics at the crossroads: Will Europe lead the way forward." Journal of Generic Medicines 6(3): 193-205.

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timing to market is a key dimension of competition in the generic sector. Legislations in some markets grant market exclusivity to the first generic company that files for authorization (e.g. in the US exclusivity is 180 days). More specifically, first generics are expected to launch at higher prices and maintain generic market leadership as the demand-side may be reluctant to switch across alternative generics. Pharmacies, for instance, would avoid stocking multiple generics for a given molecule due to efficiency concerns (Competition Bureau Canada 2007).

Regulatory and financial barriers to market entry in the generic sector are highly asymmetric compared to the branded sector. Sunk costs are much lower in the generic sector since substantial R&D outlays for drug discovery and clinical trials to prove safety and efficacy are not required[3]. The cost of a bioavailability test has been estimated to be 18 times cheaper than the average costs of safety and clinical evaluation, which allows generics prices to be 20-80% cheaper than originators (Pharmaceutical Manufacturers Association 1993; Simoens S and de Coster S 2006). Canadian Generic Drug Sector Study (2007) estimates bioequivalence study costs in the range of $1-1.5m per product. Second, the technical and market risks faced by generic manufacturers are much lower as the therapeutic and commercial success of the originator has been tested by the time of patent expiry. Third, countries in the OECD have adopted several measures to further ease generic entry: generic substitution, Bolar provisions[4], market exclusivity grants to first generics (US), and generic reference pricing. Overall, the time it takes a generic drug from the research lab to the patient is 3-5 years, whereas branded drugs take about 12 years. On the other hand, generics may be subject to behavioural barriers to adoption and diffusion as a result of virtual perceived quality differences between branded and generic products. In particular, price-insensitive consumers or physicians may show a strong loyalty for brand-name drugs (Frank and Salkaver 1992), and physicians may have sticky prescribing habits that hamper switching to generic drugs (Hellerstein 1998; Coscelli 2000).

Bolar provisions allow generic manufacturers to experiment with a drug before the expiry of the patent and apply for market authorization (MA). Bolar provisions were granted in the US by the Hatch Waxman Act in 1984, and Europe followed with a delay of twenty years in 2004. In countries such as the US, UK and Germany, generic medicines obtain immediate price and reimbursement approval following MA. In contrast, most markets that require price and

[3] Entry costs are greatest for the first generic due to legal challenges and costs fall for follower generics.
[4] Bolar provisions allow generics to obtain marketing approval prior to the patent expiry of the originator molecule and thus virtually immediate entry upon patent expiry

reimbursement approval may delay market access of generic products. Time delays for generics following MA were on average 153 days in the EU, with a significant variation across Member States depending on local pricing and reimbursement (P&R) regulations (Bongers and Carradinha 2009). Generic price may be established as a percentage of the reference product, as the average price in reference countries, as a maximum (index) price or negotiation-based price (price-volume trade-off).

We argue that the variation in the timing of first generic availability for a given molecule can be explained by both ex-ante price and volume expectations. More specifically, free-priced markets not only avoid additional delays due to P&R approval but also offer higher incentives to market entry as a result of higher generic prices and higher generic penetration. Generic volumes are expected vary significantly across countries due to different demand-side policies, consumer attitudes and healthcare infrastructures. Hence, we examine whether ex-ante volume expectations affect the of probability of a generic product launch given lower profit margins No study in the literature has empirically analysed the existing differentials in launch for first generics across a comprehensive set of markets. This paper aims to provide preliminary evidence to fill this gap in the literature. Our empirical strategy uses discrete-time duration analysis to estimate the impact of regulation on the probability of launch across twenty pharmaceutical markets controlling for market size, expected competition, molecule and firm heterogeneity.

The remaining of the paper is structured as follows: Section 2 discusses the literature and sets the theoretical framework; Section 3 describes the methodology used; Section 4 presents estimation results and finally Section 5 discusses findings and policy implications.

2 GENERIC ENTRY: EVIDENCE FROM THE LITERATURE

2.1 Regulation as a Barrier to Generic Entry

Generic Entry in the North American Market

Most of the evidence on generic entry is from the North American market. This is partially because the generic sector has matured faster in the US as a response to provisions of the Hatch-Waxman Act in 1984. Empirical studies on generic entry have demonstrated that pre-entry market size and expected profits (Grabowski and Vernon 1992; Scott Morton 1999; Scott Morton 2000; Reiffen and Ward 2005; Saha, Grabowski et al. 2006); firm and drug

characteristics (Bae 1997; Scott Morton 1999), brand-name drug's goodwill stock (Hurwitz and Caves 1988; Hudson 2000); market structure and competition (Bae 1997) are important factors in the generic firms' entry decision. Moreover, entry dynamics differ strongly across therapeutic-classes (Saha, Grabowski et al. 2006).

Bae (1997) investigates the speed of generic entry post-patent expiry in the US market using a proportional hazard model with continuous failure times (Bae 1997). Higher revenues before patent expiry, proxied by the sales revenue of the brand-name manufacturers before patent loss, are associated with higher generic entry. Bae (1997) finds that the higher the degree of competition as proxied by the number of brand-name competitors, the slower the generic entry. The number of new generic entrants decreases as the number of generic incumbents increases (Saha, Grabowski et al. 2006). There also exists direct evidence which shows that revenue and the extent of entry are positively related for off-patent molecules during 1984-1987 (Frank and Salkever 1997). Similarly, Hudson (2000) identifies market size (original brand sales, deflated by the consumer price index) at patent expiration as the most significant determinant of generic entry in the US, the UK, Germany, and Japan. Increases in sales reduces the generic entry lag after patent expiration in these markets (Hudson 2000).

According to evidence from the US market during 1984-1994, generic firms enter markets with similar operating conditions to the drugs they already produce (Scott Morton 1999). Generic entry rates are also affected by the proportion of hospital sales. Drugs with higher hospital sales and drugs that treat chronic conditions exhibit higher entry rates in the US during 1986-1991. The number of brand-name competitors reduce generic entry whereas no significant evidence is found regarding the number of off-patent brands in the same therapeutic-group (Scott Morton 2000). In contrast to findings from the US studies by Bae (1997) and Scott Morton (2000), a more recent study by Magazzini et al observes that different brand names have a positive effect on generic entry in USA, UK, Germany, and France (Magazzini, Pammolli et al. 2004).

Generic Entry in Regulated Markets

Several studies have identified pharmaceutical price regulation (Danzon and Chao 2000b; Ekelund and Persson 2003; Moreno-Torres, Puig-Junoy et al. 2007) as a significant factor in generic firms' entry decision. The evidence on the impact of different regulations on generic entry, however, is limited.

Evidence from the Swedish market in 1972-1996 suggests that expected profits are associated with higher generic entry in a regulated environment too. The shorter the patent protection for the branded product, the higher the number of generic entrants (Rudholm 2001). Subsequent evidence from the Spanish market suggests that drivers of generic entry in a market with tough price regulations are similar to those in less regulated markets. Moreno-Torres et al (2009) estimate the number of generic firms that enter into different active ingredient markets during 1999-2005[5], ignoring firm's follow-on launches with different forms and doses. Both a higher number of generic incumbent firms and a higher number of molecules per therapeutic group decrease the average number of generic entries. This study concludes that reference pricing squeezes the potential market for generics by lowering branded drug prices (Moreno-Torres, Puig-Junoy et al. 2009). Generic use is discouraged if originator prices cluster around the reference price level as potential profits for generics are reduced (Simoens S and de Coster S 2006). Findings from a Swedish study confirm that the reference price system on average decreases the probability that generics are launched (Ekelund and Persson 2003).

Contrary to findings from the US market, evidence from Japan indicates that fewer generics enter if the drug is more frequently prescribed in large hospitals. This is predominantly due to behavioural reasons as doctors keep strong connections with medical schools where professors have high-level involvement in developing brand-name drugs and treatment guidelines. A more competitive branded sector in Japan, proxied by the number of brand name drugs already in the market, negatively affects generic entry. Economies of scope in entering multiple markets and brand revenues are important determinants that explain generic entry in the Japanese market (Iizuka 2009). Furthermore, as Iizuka (2009) notes, in Japan, due to government regulations, new generics can enter the market only once a year in July. This means that there is almost always a delay in generic entry after a brand-name's patent expiration.

Higher price regulation (as in Austria, Belgium, France, Italy, Portugal, Spain) is not only associated with reduced incentives for generic entry but also with limited diffusion of generics (Danzon and Chao 2000a; Garattini and Ghislandi 2006; Simoens S and de Coster S 2006). Free priced markets (US, Germany, the Netherlands and the UK) generally have higher drug prices and a higher originator-generic price differential, increasing incentives for generic entry. Some authors found that generics enter more quickly into countries where

[5] Market definition is at the molecule level

"expected" generic prices are higher. According to the authors, this is because these markets are more profitable for generic firms. Kyle (2007) find that brand-name drugs enter earlier into non-price-regulated markets than regulated markets. If so, patents will expire more quickly in non-price-regulated countries, and thus generics can enter into these markets earlier.

2.2 Strategic Barriers to Generic Entry

Economic theory predicts that generic entry should lead to a sharp decline in the price and market power of the originator molecule. To counteract market erosion induced by generic entry, innovator companies have developed several strategies for product life-cycle management to counteract the combined impact of increasing patent losses over time and the decrease in pharmaceutical R&D efficiency (Karwal 2006). A significant body of literature analyzes the dynamics of branded-generic competition after patent expiry and strategies originators pursue to minimize the impact of generic entry on life-cycle profits (Caves, Whinston et al. 1991; Grabowski and Vernon 1992; Frank and Salkever 1997; Suh, Schondelmeyer et al. 1998; Aronsson, Bergman et al. 2001; Magazzini, Pammolli et al. 2004; Lexchin 2006).

Traditionally, innovators have defended market shares through patent protection strategies that include patent clusters and patent litigations to restrict generic penetration. Other common strategies are reformulation of the original molecule to shift demand; switching from prescription to OTC[6] status (that allows direct to consumer marketing in the US) and defensive pricing. Reformulation may involve combining the active ingredient with another molecule; changing the dosage, route of administration or creating controlled release versions. Defensive pricing involves lowering the price of the originator molecule for certain formulations or doses or discounts for repeat prescriptions. Another pricing strategy to maintain market share is based on market-segmentation by consumer brand loyalty. In free-priced markets, the originator may increase off-patent molecule prices to capture more revenue from the insensitive segment of the market and retain shares, which is known as the "generic paradox"

[6] Over the counter medicine

(Frank and Salkaver 1992; Frank and Salkever 1997; Regan 2007; Schweitzer and Comanor 2007), (Regan 2007; Schweitzer and Comanor 2007)[7].

More recently branded manufacturers have shifted from defence strategies to strategies that allow value creation from generics such as alliances with generic companies, authorized and in-house generics strategies (Business Insights 2009c). Authorized generics include agreements between branded and generic manufacturers that allow generic manufacturers to produce and market the active pharmaceutical ingredient before any generic competitor enters the market. Authorized generics may block competition and dissipate the first mover advantage that grants 180-day market exclusivity provisions to the first generic entrant in the US (Peny and Covilard 2007). The branded manufacturers can avoid litigation costs and utilize their advantage in manufacturing and marketing by in-house manufacturing of generics.

A summary of the findings from the literature is presented in Table A.1 in the Appendix. The majority of the studies have focused on the extent of generic entry rather than the timing of generic adoption. The literature offers very limited evidence on determinants of generic entry lags across markets with different pricing mechanisms. This study aims to provide the first comparative analysis of generic adoption across 20 markets in the OECD[8] by incorporating local expected generic price, extent of generic penetration, concentration of the generic sector in each market, and firm and molecule heterogeneity.

3 METHODS

3.1 Data

IMS data used in this study contains quarterly MIDAS sales data for the period 1999 Q1 – 2008 Q3 in 20 major pharmaceutical markets. The data includes USD ($)[9] and standard unit (SU) sales for each pharmaceutical product by quarter, molecule name, IMS generic classification, global and local launch dates, therapeutic class (ATC4), and sales by distribution channel (retail versus hospital). The ex-manufacturer price level for molecules is calculated by dividing the ex-manufacturer retail USD sales by volume in SU. Marketing

[7] Frank and Salkaver (1992) develop a segmented market model with one branded producer and a competitive fringe producing the generic version and find conditions under which the branded price increases.

[8] The country set in alphabetical order is: Australia, Austria, Belgium, Canada, Finland, France, Germany, Greece, Italy, Japan, Netherlands, Poland, Portugal, South Africa, Spain, Sweden, Switzerland, Turkey, the UK and US (South Africa is an enhanced engagement country of the OECD).

[9] Sales figures in USD dollars were deflated by IMF GDP deflators for each country-year. Observations with negative sales were dropped. These represent products that have been returned to the manufacturer after the product has been withdrawn from the market, and account about 5% of total observations.

discounts and margins along the distribution chain are ignored. Launch in Spain, Turkey, Belgium, Greece, Portugal, Spain, South Africa represents launch in the retail sector; for Sweden launch could be either in the retail or hospital sector. Launch in the US market could be in the retail sector (drugstores, foodstores and mail service) or non-retail sector (clinics, federal facilities, HMOs, home health care, long term care, non-federal hospitals and other miscellaneous channels)

The unit of analysis is molecule-country pairs. Once the generic version of a given molecule launches in one of the twenty markets, the remaining countries get under risk for the launch of the first generic version of the same molecule. This definition allows analyzing differentials in relative adoption speed with reference to the first global generic availability. Although we cannot control for delay following patent protection expiry, all regressions control for the delay of the originator entry following the first global launch of the new molecule. Failure time for the first generic product of molecule *j*-country *k* pair is defined as the difference between the first global generic launch date of molecule *j* and the local launch date of the generic in country *k*. Missing launch dates are approximated by period of first positive sales for molecules with the first generic launch after 1999 Q1.

The molecule set is restricted to those molecules that have a generic alternative both in the UK and the US to avoid potential bias from generics launched exclusively in one market. Also, we consider molecules that launched following the establishment of a single European market in 1993, which account for different dynamics in the pharmaceutical sector. Combination molecules composed of several active ingredients are ignored. With all these restrictions, the total number of molecules analyzed is 349.

Discrete time periods are defined in months as failure times (launch dates) are grouped into months[10]. The dataset is expanded for each subject, i.e. molecule-country pair, such that each subject contributes one row of data for each time period that the molecule is under risk of launching in the destination country. The subject gets under risk after first global launch date of the generic copy, and in the final time period the subject fails or is censored. A binary indicator is associated with each observation such that a value of 0 is assigned until the last observation which is 1 if the molecule launches and 0 if it is censored. Other time varying (e.g. price) and fixed (destination country) explanatory variables are accommodated in this data structure.

[10] Maximum117 month-periods from January 1999 till September 2008

3.2 Model

Entry of the first generic product in a given country is considered as a binary-outcome model defined as unity if entry occurs at time *t* and zero otherwise. The first generic alternative of molecule *j* launches in country *k* if expected profits are positive. Let Π_{jkt} represent the discounted post-entry profits for the generic of molecule *j* in country *k*. The entry decision d_{jkt} observed at time *t* is:

$$d_{jkt} = \begin{cases} 1 & \text{if } \Pi_{jkt} > 0 \text{ and } d_{jkn} = 0, \text{for all } n \leq t\text{-}1 \\ 0 & \text{otherwise} \end{cases}$$

The profit Π_{jkt} depends on the discounted future revenue stream net of entry costs and potential spillovers to markets that reference market *k* for generic price setting. The discounted future profit stream at time *t* ignoring marginal costs can be expressed as:

$$\Pi_{jkt} = \sum_{l=1}^{LT_{jk}} \delta^l \left\{ P_{jkl} \cdot Q_{jkl} - \sum_{r \neq k} L_{jkrl} \right\} - E_{jkt} + \nu_{jkt} \text{ , where}$$

P is the expected generic price. *Q* is the expected market size for the generic alternatives of molecule *j* in country *k*; *E* is the fixed cost of entry; *LT* is the expected life-time of the generic product in the destination market; δ is the discount factor and *L* is the extent of price spillover to market *r* due to external price referencing.

The expected price *P* is a function of branded price levels in the local market and branded-generic price mark-up which is a function of regulation and competition in the therapeutic subgroup. In markets such as the US generic prices are determined freely. In the EU, on the other hand, generic prices are regulated in the majority of the countries (83% of European countries). Generic medicine prices can be set as a percentage below the originator price level, as the average of a selected number of European countries or as a combination of both. In markets with reference pricing, regulators set a common reimbursement level for a group of interchangeable medicines, which may constitute a barrier for further price competition beyond those imposed by regulation (Dylst and Simoens 2010).

The expected market size *Q* depends on total sales of the branded drug and the percentage of generic penetration in the given market. Penetration of generic medicines is more successful in

countries with free pricing than in countries with price regulation. Higher medicine prices achieved under free pricing facilitate market entry of generics (Schulz 2004; Martikainen, Kivi et al. 2005). In price controlled countries, regulation drives down the price of the originator medicine discouraging market entry of generics. Also, the price difference between originators and generics tends to be higher in free-priced countries, which results in higher incentives to switch to generic alternatives. Molecule's therapeutic importance increases branded market size and incentives to generic entry. Generic firms compete in price; hence, any scale effects that reduce costs will provide a competitive edge.

Defining row vectors of regulation ($\mathbf{R}$), competition ($\mathbf{C}$), molecule ($\mathbf{M}$), firm characteristics ($\mathbf{F}$), the additive reduced-form profit function can be specified as:

$$\Pi_{jkt} = \mathbf{R}_{jkt}\boldsymbol{\beta}_R + \mathbf{C}_{jkt}\boldsymbol{\beta}_C + \mathbf{M}_{jk|t}\boldsymbol{\beta}_M + \mathbf{F}_{jk|t}\boldsymbol{\beta}_F + \gamma_t + u_{jkt} = \mathbf{z}_{jkt}\boldsymbol{\beta} + \gamma_t + u_{jkt}, \text{ where}$$

$\boldsymbol{\beta}_R$, $\boldsymbol{\beta}_C$, $\boldsymbol{\beta}_M$, and $\boldsymbol{\beta}_F$ represent corresponding column vectors of parameters to be estimated.

γ_t is a function of time since global launch *t* of molecule *j* and u_{jkt} is a random error term.

Let $\mathbf{z}_{jk}(t)$ be a $1 \times p$ matrix defined as: $\mathbf{z}_{jkt} = \left[\mathbf{R}_{jkt}, \mathbf{C}_{jkt}, \mathbf{M}_{jkt}, \mathbf{F}_{jkt}\right]$.

Given that launch has not occurred up to time interval *t*, the conditional probability of launch during interval *t*, i.e. the interval hazard rate is:

$$\Pr(d_{jkt} = 1 \mid T_{jk} \geq t) = h_{jk}(t) = \Pr(\Pi_{jkt} > 0)$$

$$= \Pr\left(\mathbf{R}_{jkt}\boldsymbol{\beta}_R + \mathbf{C}_{jkt}\boldsymbol{\beta}_C + \mathbf{M}_{jk|t}\boldsymbol{\beta}_M + \mathbf{F}_{jk|t}\boldsymbol{\beta}_F + \gamma_t + u_{jkt} > 0\right)$$

$$= \Pr\left(\mathbf{z}_{jkt}\boldsymbol{\beta} + \gamma_t + u_{jkt} > 0\right)$$

$$h_{jk}(t) = \Pr\left(u_{jkt} > -\mathbf{z}_{jkt}\boldsymbol{\beta} - \gamma_t\right) = 1 - F\left(-\mathbf{z}_{jkt}\boldsymbol{\beta} - \gamma_t\right) = F\left(\mathbf{z}_{jkt}\boldsymbol{\beta} + \gamma_t\right),$$

where *F*(.) is the cumulative distribution function of *u* and T_{jk} is the launch time of molecule *j* in country *k*. We estimate the results using the two most common link functions: *complementary log-log* (*cloglog*) and *logit* link functions. Cloglog transformation is the discrete-time implementation of the Cox proportional hazard (PH) model that assumes continuous failure-times. It is typically used when survival times are measured continuously

but grouped on a discrete time scale (e.g. months in this study). It has been shown that the discrete-time implementation of the PH model with a cloglog link function results in parameter estimates that are equivalent to the population parameters of the PH model that generates the data (Prentice and Gloeckler 1978). The logistic model, on the other hand, interpreted in terms of the proportional odds of failure (Singer and Willett 1993).

For the cloglog model $F(\mathbf{z}_{jkt}\boldsymbol{\beta}+\gamma_t)=1-\exp\left\{-\exp(\mathbf{z}_{jkt}\boldsymbol{\beta}+\gamma_t)\right\}$, which gives the hazard rate:

$$h_{jk}(t)=1-\exp\left(-\exp\left(\mathbf{z}_{jkt}\boldsymbol{\beta}+\gamma_t\right)\right) \text{ or } \operatorname{cloglog}(h_{jkt})=\mathbf{z}_{jkt}\boldsymbol{\beta}+\gamma_t .$$

Using the logistic cumulative function the hazard is parameterized as follows:

$$h_{jk}(t)=\frac{1}{\left[1+\exp(-(\mathbf{z}_{jkt}\boldsymbol{\beta}+\gamma_t))\right]},$$

where γ_t is the vector of duration dependence. Transforming the hazard using a logit link function gives the following proportional odds model (Xie, McHugo et al. 2003):

$$\ln\left(\frac{h}{1-h}\right)=\mathbf{z}_{jkt}\boldsymbol{\beta}+\gamma_t .$$

For small hazard values, cloglog and logit regressions for discrete survival analysis yield similar estimates (see Appendix, Table A.2). However, in general the estimated coefficients in the logit model will be larger than the coefficient estimates in the cloglog model (Abbott 1985). The logit model has the proportional odd assumption; as such it might be the appropriate model if the proportional odd assumption is correct in instances when the hazard rates are not "small".

The second empirical issue is the appropriateness of the duration-dependence specification for the baseline hazards. The empirical strategy in the regressions assumes two different duration specifications: i) a parametric specification $\gamma_t = f(t)$; and ii) a semi-parametric specification that includes dummies for each month following risk onset, i.e. first global generic adoption. This approach provides a robustness check on parametric estimates and helps avoid potential bias if the duration dependence is incorrectly specified.

3.3 Variables

We define our independent variables based on findings in industrial organization and strategy literature regarding the drivers of market entry (Chryssochoidis and Wong 1998; Wong 2002). Variables used account for: i) firm's external environment, i.e. regulation (**R)**, market size and competition (**C**) and ii) firm's internal environment, i.e. firm economies of scale and scope (**F**) and molecule heterogeneity (**M**). A list of descriptive statistics for the control variables used in the empirical analysis is provided in the Appendix (Table A.3).

3.3.1 External Environment

Identification of Regulation

Expected Generic Prices

Regulatory complexity and diversity is captured through expected generic prices of the launching molecule. This approach has not been used before for the analysis of generic adoption, and is a natural extension of the recent studies that use price information to measure the impact of regulation on the timing of new patent-protected molecules. As lower prices squeeze the market for generics, it is expected that higher generic prices will increase hazard of launch, controlling for market size and structure as well as firm and product characteristics.

When the first generic is about to enter the market, there are no generic products for the same active ingredient. The price of branded products defines price reference for generic copies that compete in the market based on price. Regulations in some countries may link generic prices to the originator price by setting the generic price a certain percentage (i.e. 30-35%) lower than branded products. Several studies have identified that the market share captured by generics depends on the relative prices of the generic and originator product. Anis (2003) uses the generic-branded price ratio, Pg/Pb, as a measure of how regulation affects generic prices and competitiveness (Anis, Guh et al. 2003). This ratio (Pg/Pb) is observed to decrease significantly over time as new generics enter the market (Caves, Whinston et al. 1991; Grabowski and Vernon 1992). Therefore, we proxy the expected generic price by the product of the average branded price for the launching active ingredient and the median generic-branded price ratio in the local market. Non-generic product prices in each country are calculated as a volume-weighted average price of products that have the same active ingredient. Lagged or moving average prices are used to avoid problems of endogeneity.

Treatment Dummies for Regulation

Dummies for the existence of a reference price system (RPS) and generic substitution are used as an additional control for the impact of regulation. Although the sign of the parameter estimates for these variables indicates their impact on relative speed of adoption for the first generic, there is considerable uncertainty regarding these measures. The estimates for RPS and generic substitution are presented in the robustness tests. However, regulation is mainly identified through its effect on prices due to the significant heterogeneity in the definition of RPS and generic substitution incentives.

Each country employs different criteria to set the reference groups and reference prices. 71% of European countries use RPS to control the reimbursement level of medicines (Perry 2006). The reference groups can be defined at three levels: 1) the active ingredient (e.g. Belgium, France, Italy and Portugal); 2) pharmacological class (e.g. in Poland); 3) therapeutic subgroup (e.g., Germany and Netherlands). The reference price can be set at the price of the cheapest generic (e.g. Italy and Poland); at the median price of all medicines in the group (e.g. Netherlands); highest price of available generic medicines (e.g. Portugal). RPS is more successful in promoting generic use if the price difference between generics and branded drugs is high; RPS is less effective in generic promotion when prices of the originators are reduced to reference price levels (Simoens S and de Coster S 2006).

Similarly, generic substitution is mandatory in some countries whereas it is promoted in others, and the incentives for substitution at the pharmacist level vary greatly across countries. For example, pharmacists' remuneration in Portugal and Spain is set as a fixed percentage of the public prices; whereas in Italy and Poland the percentage remuneration decreases as prices increase. In France and Belgium the absolute pharmacist margin is the same for originators and generics. In France, higher discount-levels for generic medicines offer generic substitution incentives to pharmacists who capture the discount benefits.

Market Characteristics and Competition

Expected Market Size

Generics have lower profit margins compared to non-generic products and are subject to intense price competition. The sustainability of the generic business, therefore, depends on capturing a high market share. Ex-ante expected generic sales are a function of branded molecule sales prior to launch and expected generic penetration following market entry. Therefore, we estimate the expected generic market size as the product of total molecule sales prior to generic entry and the average market share captured by generics, where the average is calculated over all off-patent molecules with. Previous studies have ignored the differentials in

generic market penetration and have predominantly used branded sales as a proxy for expected sales. Market size is estimated both in USD($) and IMS standard units (SU[11]).

Market Structure and Competition

Once manufacturing infrastructure is established, the marginal cost of producing generic drugs is relatively low and switching to another molecule is relatively easy (except for certain formulations that are difficult to manufacture). Therefore, ex-ante expectations for market competition are proxied by the number of generic manufacturers in the destination country. In addition, to incorporate relative firm sizes and account for heterogeneity in competition at the therapeutic subgroup (ATC4), we define the Herfindahl-Hirschman Index (IHH) in each ATC4 as the sum of squared market shares of individual generic firms. A high IHH value is an indication of little potential competition in the generic sector, assuming the most imminent competitors of the first generic entrant are incumbents of other active ingredients in the same therapeutic subgroup.

3.3.2 Internal Environment

Firm Characteristics

In a fierce price-competition environment, lower costs result in higher profit margins. Globalization of generic firms, especially from emerging markets, is increasing the pressure for lower costs. Achieving economies of scale through consolidation of manufacturing, administrative and marketing functions across firms helps reduce unit costs and improve profit margins. Mergers and acquisitions reduce firm volatility by complementing product lines with new medicines; also, scale economies or higher firm size reduce the financial risks associated with litigation and launch risk. Geographical diversification spreads out business and regulatory risks across markets reducing business volatility (Karwal 2006). We control for heterogeneity in firm size by quarterly local and global firm sales, and global reach of the firm proxied by the number of markets in which the firm has sales (across the 20 countries in the dataset). Economies of scope in the pharmaceutical industry exist when it is more efficient to develop or commercialize a drug by one firm rather than several different firms because of knowledge spillovers across different products.

Molecule Characteristics

[11] IMS standard unit is the smallest dose for each form, for example, one tablet, one capsule, or 5 ml of liquid

Therapeutically important molecules diffuse internationally quicker and to a wider set of markets. These molecules offer a higher market potential for generic entrants not only because of the volume effect but also because of price mark-ups offered to innovative products. The total number of markets in which the molecule has launched is used as a proxy for relative therapeutic importance. In addition, median sales over 1999-2008 and annual sales of the molecule (USD$) are used as additional proxies to control for molecule heterogeneity.

The evidence regarding brand loyalty on generic entry is mixed. Rudholm (2001) finds that a longer monopoly period reduces entry whereas Grabowski and Vernon (1992) found no significant effect of patent protection duration. Due to lack of information about protection expiry dates of molecules, this study cannot directly control for the exclusivity period in each market. However, launch delays (time elapse between the first global launch date and local launch date) of originator products are used as a control for the monopoly period loss in each market. The higher the delay, the shorter is the period available for building brand loyalty.

4 EMPIRICAL RESULTS

The empirical strategy adopts different economic specifications to detect potential bias in parameter estimates and test for the robustness of estimates under different assumptions regarding the underlying hazard. Regressions are estimated by two most-commonly used discrete-time duration analysis methods: i) cloglog regression, and ii) logit regression. Duration dependence is specified parametrically as a function of time *t* elapsed since risk onset, and semi-parametrically by including monthly interval dummies following risk onset.

We estimate the hazard of generic adoption in each market following the first global launch of a generic copy with the same active ingredient. All regressions control for the lag of the originator molecule as well as heterogeneity in anatomic therapeutic categories (ATC4s) and country of launch. Time trends are captured by including dummies for calendar years. Errors are clustered by molecule-country to account for correlation between the errors of the same molecule-country pair. All molecules used have launched for the first time after 1993, which accounts of changing dynamics after the creation of the European Union. The hypotheses tested in the empirical analysis are summarized in Table A.4.

4.1 Parametric Duration Dependence

Table 1 presents the marginal effects (*dy/dx*) for the parametric duration dependence specification $h_0(t) = t + \ln(t^2)$. Marginal effects and coefficient estimates are very close or identical across *cloglog* and *logit* parameter estimates. The coefficient estimates for *cloglog*

and *logit* (not reported for brevity) are very close to each other, implying that the hazard of launch on average is small. As expected, in cases where the coefficients are not exactly identical, logit estimates are marginally higher than the cloglog estimates.

Estimates suggest significant generic price effect on the hazard of generic adoption; the higher the expected generic price the higher the hazard of first generic adoption in individual markets. This effect is robust across different model specifications and to the inclusion or exclusion of calendar year dummies. The significance of the price effect is higher when calendar year dummies are excluded, which could be an indication of the fact that calendar year dummies capture some of the variation in expected generic prices (generic prices are pushed downward over time either due to competition or regulation).

The marginal effect of log expected generic prices on the hazard of first generic launch is on the order of 0.002. Considering the average price level of 21.13 $/SU across markets, an increase of one standard deviation (86.73 $/SU) in expected generic prices increases probability of launch by approximately 0.8% [12]. Similarly, the marginal effect of log average branded prices is 0.002. Increase of one standard unit in branded prices increases probability of launch by 0.8%[13] (mean branded price is 28.97 $/SU and standard deviation is 119.65 $/SU).

Expected market size in dollars is significant across all specifications. The marginal effect of log expected market size for generics (in USD$) varies from 0.002 to 0.004 depending on whether calendar year dummies are included or not. Overall, an increase of one standard deviation in the expected generic market size increases hazard of launch by 1.4%-2.8%[14] (the mean of the expected market size of observations used in the regressions is 472,723.3$ with a standard deviation of 3,255,101$). Expected market size in SUs, on the other hand, is only significant when calendar year dummies are excluded.

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[12] $(86.728)\frac{\partial y}{\partial p} = (86.728)\frac{\partial y}{\partial \ln p}\cdot\frac{\partial \ln p}{\partial p} = (86.728)\frac{\partial y}{\partial \ln p}\cdot\frac{1}{p} = (86.728)(0.002)\frac{1}{21.125} = .008 \sim 0.8\%$

[13] $(119.646)\frac{\partial y}{\partial \ln p_b}.\frac{1}{p_b} = (119.646)(0.002).\frac{1}{28.971} = 0.008 \sim 0.8\%$

[14] $(3255101)\frac{\partial y}{\partial \ln MSize}.\frac{1}{MSize} = (3255101)(0.002).\frac{1}{472723.3} = 0.014 \sim 1.4\%$

$(3255101)\frac{\partial y}{\partial \ln MSize}.\frac{1}{MSize} = (3255101)(0.004).\frac{1}{472723.3} = 0.028 \sim 2.8\%$

The parameter estimate for the effect of generic competition is also highly sensitive to the inclusion or exclusion of calendar year dummies. When macro trends are incorporated with calendar year dummies, the higher the number of competitors the higher is the hazard of launch. On the other hand, the number of competitors significantly increases hazard of launch when calendar year dummies are excluded. This switch in the sign of coefficients suggests that there could be multicollinearity problems with this variable, which is addressed in Section 4.3.

Surprisingly, molecule and firm effects show no robust statistical significance. Marginal effects of global molecule sales alternate from positive to negative values, which could again be an indication of issues with multicollinearity. On the other hand, marginal effects of global firm sales is consistently positive across different specifications, which suggests that firm scale positively affects the speed of adoption (significance level is 0.075).

There is robust evidence that the hazard of launch is concave in the number of months elapsed since risk onset. The variable *t* indicates the number of months elapsed since the first global generic launch of the originator molecule. Overall, comparing the information criteria statistics across different specifications indicates that specifications with calendar year dummies provide a better fit compared with the specifications that exclude calendar year dummies.

Table 1. Parametric Duration Dependence : Marginal Effects for Base Case Cloglog and Logit Estimates for First Generic Launch

Variables	*With Calendar Year Dummies*						*No Calendar Year Dummies*					
	CLOGLOG			LOGIT			CLOGLOG			LOGIT		
	1	2	3	1	2	3	1	2	3	1	2	3
Expected Generic Price												
LMAvgExpPg	0.002*	0.002*		0.002*	0.003*		0.002**	0.004***		0.002**	0.005***	
(log expected generic prices)	[0.0006]	[0.0011]		[0.0007]	[0.0011]		[0.0007]	[0.0013]		[0.0007]	[0.0013]	
LMAvg_Pb			0.002*			0.002*			0.002**			0.002**
(log branded prices, $/SU)			[0.0006]			[0.0007]			[0.0007]			[0.0007]
medRatioPgPb			0.007			0.008			-0.018			-0.02
(generic-branded price ratio)			[0.0155]			[0.0160]			[0.0190]			[0.0192]
Expected Market Size												
ExpMarketSizeUSD	0.002**			0.002**			0.004***			0.004***		
(expected market size, in $)	[0.0008]			[0.0008]			[0.0010]			[0.0010]		
ExpMarketSizeSU		0.001			0.001			0.002*			0.003**	
(expected market size, SUs)		[0.0008]			[0.0008]			[0.0010]			[0.0010]	
LMAvg_USD_molCtr_			0.002*			0.002**			0.003***			0.003***
(molecule sales in country, $)			[0.0008]			[0.0008]			[0.0009]			[0.0009]
avgGenShare_USD_			0.000			0			0.002***			0.002***
(avg Generic Share in $)			[0.0003]			[0.0003]			[0.0003]			[0.0003]
Competition												
NumGenFirmMed	-0.032	-0.032	-0.031	-0.029	-0.029	-0.029	0.127***	0.131***	0.100***	0.129***	0.133***	0.101***
(number of Generic Firms)	[0.0175]	[0.0176]	[0.0175]	[0.0180]	[0.0180]	[0.0179]	[0.0184]	[0.0185]	[0.0169]	[0.0186]	[0.0187]	[0.0170]
Molecule Characteristics												
ln_lag_yrs	0.002*	0.002	0.002*	0.002*	0.002	0.002*	0.001	0	0.001	0.001	0	0.001
(launch delay of originator)	[0.0011]	[0.0011]	[0.0011]	[0.0011]	[0.0011]	[0.0011]	[0.0012]	[0.0013]	[0.0012]	[0.0013]	[0.0013]	[0.0012]
ln_MolGlobalUSDAnnual_	-0.001	0.000	-0.001	-0.001	0	-0.001	-0.002	0	-0.001	-0.002	0	-0.001
(log global molecule sales, $)	[0.0010]	[0.0010]	[0.0010]	[0.0010]	[0.0011]	[0.0010]	[0.0012]	[0.0012]	[0.0011]	[0.0012]	[0.0012]	[0.0011]
Firm Characteristics												
ln_globalFirmSales	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
(log global firm sales in $)	[0.0003]	[0.0003]	[0.0003]	[0.0003]	[0.0003]	[0.0003]	[0.0004]	[0.0004]	[0.0004]	[0.0004]	[0.0004]	[0.0004]
Time Since Risk Onset												
t	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]
$\ln(t^2)$	-0.006***	-	-	-	-	-	-	-	-	-0.009***	-0.009***	-0.008***

		0.006***	0.006***	0.006***	0.006***	0.006***	0.009***	0.009***	0.008***			
	[0.0007]	[0.0007]	[0.0007]	[0.0007]	[0.0007]	[0.0007]	[0.0007]	[0.0007]	[0.0007]	[0.0008]	[0.0008]	[0.0007]
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
ATC1 Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Model Stats												
Number of Observations	19698	19698	19698	19698	19698	19698	19698	19698	19698	19698	19698	19698
Log Likelihood	-2218.21	-2221.42	-2218.47	-2220.04	-2223.32	-2220.28	-2326.57	-2332.77	-2306.01	-2327.9	-2334.26	-2307.48
chi2	737.92	736.01	749.44	681.63	681.78	687.45	418.16	406.76	447.5	380.01	371.24	413.37
P value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Akaike Info Criteria	4530.422	4536.85	4534.93	4534.08	4540.65	4538.56	4731.13	4743.53	4694.02	4733.79	4746.53	4696.95
Bayesian Info Criteria	4901.17	4907.59	4921.46	4904.83	4911.4	4925.08	5038.77	5051.17	5017.44	5041.44	5054.17	5020.37

Note: *p<0.05, **p < 0.01, ***p<0.001. Standard errors clustered at molecule-country level (standard errors in brackets). Marginal effects (dy/dx) reported .
Year, ATC1 and Country Dummies not reported.

4.2 Non-Parametric Duration Dependence

Non-parametric approach to duration dependence obviates the need for prior assumptions regarding the functional form of the hazard with respect to time. Estimation is carried out by including dummies for each month following the risk onset and specifying *noconstant* option in Stata. This approach essentially assumes a constant hazard rate during each monthly interval. As a robustness check, all non-parametric specifications were also estimated with cloglog and logit regressions.

Parameter estimates using non-parametric duration dependence are presented in Table A.5 in the Appendix. The signs of the coefficients are on broadly consistent with results of the corresponding parametric specification. The higher the expected generic price and market size, the higher is the hazard of adoption. In regression runs with no calendar year dummies, a higher *Pg/Pb* ratio is significantly associated with a lower hazard rate. This is expected because once generic prices are controlled for; a wider price differential between generic and branded alternatives gives a competitive edge to the generic manufacturer due to significantly lower prices. This effect, however, is not significant when macro time trends are incorporated by calendar year dummies. Similarly, the higher the aggregate generic share in the destination country the higher is the hazard of adoption; however, the effect is significant when year dummies are excluded.

The impact of competition, proxied by the number of generic firms, is not robust and shows the same trend as in the parametric duration specification. Launch hazard is decreasing in the number of generic firms, as expected, when calendar year dummies are included. Excluding year dummies reverses the effect of potential competition. The signs of the coefficients for molecule and firm effects are robust in the non-parametric specification results. The coefficients of therapeutic importance (global molecule sales) are positive and statistically significant in the second specification whereas the coefficients of global firm sales (scale effect) are consistently positive across different specifications, however, not statistically significant.

Akaike and Bayesian information criteria for non-parametric specifications are much higher compared to the parametric duration specifications. This can be explained by the fact that the number of estimated parameters increases considerably due to the inclusion of 117 dummies for each month (from 1999 Q1 to 2008 Q3) in the non-parametric specification, whereas the parametric specification requires the estimation of only two parameters for duration dependence, *t*

and $\ln\left(t^2\right)$. As in the cases with parametric estimation, information criteria are lowest in specifications where calendar year dummies are included. Overall, this suggests that parametric duration specification with calendar year dummies provides a better fit to the data. Small difference in parameter estimates and information criteria for cloglog and logit regressions suggests that both perform equally well because hazard of adoption is small.

4.3 Multicollinearity

Given the swings in some coefficient signs (e.g. number of generic firms) in the base case estimates, we tested for potential issues of multicollinearity by computing the variance inflation factors (*VIFs*). Ideally, *VIFs* should be smaller than 10[15]. Multicollinearity could result in several problems including: 1) wide swings in the parameter estimates with small changes in the data; 2) high standard errors and low significance; 3) wrong coefficients signs and implausible magnitudes.

VIFs were calculated by first running an ordinary least squares regression and then calculating the *VIF* by the Stata command *estat VIF*. *VIF* estimates are presented in Table A.6 in the Appendix. The variance inflation factor for the proxy of competition (number of generic firms) is 244.7 and the mean value is 16.6, which indicates as expected a severe multicollinearity problem. When the normalized Herfindahl-Hirshman Index within therapeutic categories is used instead of the number of generic firms as a proxy for competition the multicollinearity problem subsides and the mean *VIF* reduces to 2.9 (see Table A.7). It should be noted that although the *VIF* factors for calendar year dummies is less than 10, they remain predominantly above 5, which may further explain some of the sensitivity in the coefficients with respect to whether calendar year dummies are included in the regressions.

Marginal effects *dy/dx* for the base case specifications are re-estimated after changing the control for competition from number of generic firms to the normalized Herfindahl-Hirschman Index (*IHH*) (see Table 2). Akaike and Bayesian information criteria indicate that the new specification with *IHH* provide a better fit overall. Therefore, the robustness tests in Section 5 use *IHH* as the control variable for competition to avoid problems with multicollinearity.

[15] http://www.nd.edu/~rwilliam/stats2/l11.pdf

Table 2. Parametric Duration Dependence: Marginal Effects using Herfindahl Index as a proxy for competition

Variables	with calendar year dummies						no calendar year dummies					
	cloglog 1	cloglog 2	cloglog 3	logit 1	logit 2	logit 3	cloglog 1	cloglog 2	cloglog 3	logit 1	logit 2	logit 3
Expected Generic Price												
LMAvgExpPg	0.002***	0.003**		0.002***	0.003**		0.003***	0.005***		0.003***	0.005***	
	[0.0006]	[0.0010]		[0.0006]	[0.0010]		[0.0006]	[0.0012]		[0.0007]	[0.0012]	
LMAvg_Pb			0.002***			0.002***			0.002***			0.002***
			[0.0006]			[0.0006]			[0.0006]			[0.0006]
medRatioPgPb			0.000			0.004			-0.022			-0.022
			[0.0133]			[0.0136]			[0.0147]			[0.0151]
Expected Market Size												
ExpMarketSizeUSD	0.002*			0.002**			0.004***			0.004***		
	[0.0007]			[0.0007]			[0.0009]			[0.0009]		
ExpMarketSizeSU		0.001			0.001			0.003***			0.003***	
		[0.0007]			[0.0007]			[0.0009]			[0.0009]	
LMAvg_USD_molCtr_			0.002*			0.002**			0.003***			0.003***
			[0.0007]			[0.0008]			[0.0008]			[0.0008]
avgGenShare_USD_			0.000			0.000			0.001***			0.001***
			[0.0002]			[0.0002]			[0.0002]			[0.0002]
Competition												
norm_IHHatc4_gen	0.009***	0.009***	0.009***	0.009***	0.009***	0.009***	0.011***	0.011***	0.010***	0.011***	0.011***	0.011***
	[0.0008]	[0.0008]	[0.0008]	[0.0008]	[0.0008]	[0.0008]	[0.0009]	[0.0009]	[0.0008]	[0.0009]	[0.0009]	[0.0009]
Molecule Characteristics												
ln_MolGlobalUSDAnnual_	-0.001	0.000	-0.001	-0.001	0.000	-0.001	-0.002*	-0.001	-0.002	-0.002*	-0.001	-0.002
	[0.0009]	[0.0009]	[0.0009]	[0.0009]	[0.0009]	[0.0009]	[0.0010]	[0.0010]	[0.0010]	[0.0010]	[0.0011]	[0.0010]
ln_lag_yrs	0.001	0.001	0.001	0.001	0.001	0.001	-0.001	-0.001	-0.001	-0.001	-0.001	0
	[0.0010]	[0.0010]	[0.0010]	[0.0010]	[0.0010]	[0.0010]	[0.0011]	[0.0011]	[0.0010]	[0.0011]	[0.0011]	[0.0011]
Firm Characteristics												
ln_globalFirmSales	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	[0.0003]	[0.0003]	[0.0003]	[0.0003]	[0.0003]	[0.0003]	[0.0004]	[0.0004]	[0.0003]	[0.0004]	[0.0004]	[0.0003]
Time Since Risk Onset												
t	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]	[0.0001]
$Ln(t^2)$	-0.005***	-0.005***	-0.005***	-0.005***	-0.005***	-0.005***	-0.007***	-0.007***	-0.007***	-0.008***	-0.008***	-0.007***
	[0.0006]	[0.0006]	[0.0005]	[0.0006]	[0.0006]	[0.0006]	[0.0006]	[0.0006]	[0.0006]	[0.0006]	[0.0006]	[0.0006]

Heterogeneity												
ATC1 Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Calendar Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Model Stats												
Number of Observations	19698	19698	19698	19698	19698	19698	19698	19698	19698	19698	19698	19698
Log likelihood	-2083.37	-2086.36	-2083.47	-2082.67	-2085.94	-2082.87	-2192.41	-2199.68	-2170.06	-2194.79	-2202.22	-2172.71
chi2	798.35	798.11	817.25	668	669.02	682.63	617.43	604.45	615.58	521.4	510.85	530.79
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Akaike Info Criteria	4260.73	4266.72	4264.94	4259.34	4265.87	4263.75	4462.82	4477.37	4422.13	4467.58	4482.45	4427.42
Bayesian Info Criteria	4631.48	4637.47	4651.46	4630.09	4636.62	4650.28	4770.46	4785.01	4745.55	4775.23	4790.09	4750.84

Note: *p<0.05, **p < 0.01, ***p<0.001. Standard errors clustered at molecule-country level (standard errors in brackets). Marginal effects (dy/dx) reported. Year, ATC1 and Country Dummies not reported.

5 ROBUSTNESS TESTS

Robustness checks were carried out by using different proxies for each control variable (regulation, market size, competition, firm and molecule characteristic). As in the base case analysis, both cloglog and logit estimates were calculated with parametric and non-parametric duration dependence. We present only parametric results with time trends included as the data suggested better overall fit with parametric specification. To avoid multicollinearity problems, competition is controlled by the concentration index in the therapeutic subgroup (*IHH*) rather the number of generic manufacturers in the destination market.

5.1 Regulation

We tested for the robustness of the generic price effect by using log lagged expected generic price and log moving average of expected generic prices over 4 quarters prior to launch[16]; log of expected generic prices (ln_ExpPg) and median generic-branded price ratio (medRatioPgPb); the interaction of generic price and time since risk onset; treatment dummies for reference pricing systems (RPS) and generic substitution (GenSubst). All regressions controlled for market size, competition, molecule and firm effects, launch lag of the originator molecule, country, therapeutic group (ATC1) and calendar year effects.

Estimates are presented in Table A.8 in the Appendix. Higher expected generic prices significantly increase the hazard of generic adoption, regardless of whether lagged prices or the moving average of expected generic price is used. The effect is robust across *cloglog* and *logit* regressions. In addition, markets with higher branded prices are associated with significantly faster generic adoption; this effect is robust across all specifications. This implies a trade-off in depressing branded prices which improves static efficiency during the exclusivity period but delays generic market entry and may jeopardize further static efficiency gains post-patent expiry.

The impact of reference pricing schemes (RPS) and generic substitution is tested by treatment dummies, on top of the effect of expected generic prices. Evidence suggests that both RPS and generic substitution increase the hazard of generic adoption; however, only the coefficient for generic substitution under non-parametric specification is significant. As stated before, treatment dummies for these policies should be interpreted with caution as there exists

[16] Moving averages are defined with the weights of 0.4, 0.3, 0.2 and 0.1 for the last four quarters

substantial heterogeneity across countries in the implementation of reference pricing and generic substitution schemes.

5.2 Market Size

We tested for the robustness of market size effects using the following proxies: expected generic market size (in USD$ and SU); log moving average of molecule sales (in USD$ and SU) and log lagged molecule sales (in USD$ and SU). Expected generic market size was defined as the product of molecule sales and the average generic share over molecules in the country. Moving averages were defined over four lagged quarters to smooth out the variability in molecule sales (weights used for the first to fourth lags are 0.4, 0.3, 0.2 and 0.1).

Expected generic market size in USD$ is significant across all specifications (Table A.9). Expected generic market size in SUs has a positive coefficient in all specifications but is significant only when calendar year dummies are excluded. The significance of the market size in the hazard of generic adoption highlights the importance of integrating demand-side policies (such as physician budgets with rewards for surpluses and sanctions for deficits and generic substitution schemes that financially reward the pharmacist) with supply-side policies (price controls) to promote generic adoption and the sustainability of the generic sector.

5.3 Market Structure and Competition

Market structure is captured by the number of generic firms in the country (NumGenFirmMed) and squared number of generic firms (firmSqMed) in the country, both divided by the median values to obtain meaningful standard errors. Competition at the therapeutic category level is controlled for by normalized Herfindahl-Hirschman index for generic firms and the number of substitute molecules in the ATC4 category (NumbMolCtryAtc4_) and the by ATC4-country and quarter.

Concentration index in the ATC4 has a significant effect (at the 0.001 level) both in *cloglog* or *logit* regression (Table A.10). The higher the concentration of generic firms in the therapeutic category, the higher the hazard of generic launch. This suggests that strong generic competition at the therapeutic level constitutes a barrier to generic entry.

We test the impact of the number of molecules in each subgroup (defined quarterly) to account for the closest possible therapeutic substitution effects. A limitation of this variable is that it does not incorporate possible substitution from molecules in the same pharmacologic group (ATC3). Results indicate that inter-molecular competition (number of active ingredients) within a therapeutic subgroup is not a significant determinant of generic entry decisions.

The coefficient of the squared number of firms is negative in all specifications, which suggests a concave relationship between the hazard of first generic launch and the number of potential competitors. However, the effect is not statistically significant.

5.4 Molecule Heterogeneity

Proxies used to capture molecule heterogeneity include: global reach of the molecule (the number of countries in which the molecule has launched); annual sales (USD$) of the molecule in each country; median sales (USD$) of the molecule in each country during 1999 Q1 – 2008 Q3; percentage molecule sales in the retail sector and launch delay of the originator (in log yrs) following the global launch of the new molecule.

Estimates for the global reach and annual or median sales of the molecule are negative but not significant .The effect of global molecule sales is not significant in either of the specifications. In all specifications local sales (expected market size) remain as a significant determinant of generic adoption probability. Contrary to our initial hypothesis, these estimates suggest that molecule characteristics are of secondary importance in generic launch strategies once we account for expected price and market size. Also, these estimates are indicative of generic launch being more locally oriented as opposed to patent-protected molecules that rely on global adoption to recoup R&D investments. Results suggest that the exclusivity period of the originator affects generic entry decisions. The sign for the originator delay is robustly positive across all specifications, which is consistent with the hypothesis that a shorter exclusivity period results in faster generic entry.

The percentage of sales in the retail channel for each molecule is used as a proxy to control for the purchasing power of the demand side. Hospital purchases are usually determined by tendering with a high concentration among purchase groups. For example, hospitals and trusts in the UK group together to negotiate price reductions with suppliers[17]. In addition, hospital prescriptions may be governed by formularies that restrict presentations of drugs to be selected within a therapeutic category in order to achieve bulk discounts.

In general, prices in the hospital sector are lower compared to the retail sector because brand recognition is usually weak; single-providers are preferred for multi-source products, and cost is the main driver in contract tenders / bidding process[18]. By restricting presentations of drugs to

[17] The NHS Purchasing and Supply Agency (PASA) coordinates the tendering process. The supplier with a competitive tender (i.e. competitive prices) is selected to supply a given product at the specified price whenever it receives an order from one of the hospital trusts taking part in the tendering process

[18] http://www.publications.doh.gov.uk/generics/oxera_report_a6.htm

be selected within a therapeutic category hospitals may negotiate substantial price reductions off the list price of medicines. With this control variable, a significant number of observations are lost because some countries have only retail channel data[19]. There is no robust evidence regarding the share of retail sales. Only in non-parametric specifications there is significant evidence that a higher share of retail sales increases the hazard of first generic launch, which is in line with the findings of Magazzini et al. (2004) who observe that the size of the hospital sector has a negative impact on generic market share in USA, UK, Germany, and France. This finding provides some insight into the repercussions of extending the use of tender-type systems in the retail sector. Wider use of tender-based purchasing in the retail sector would reduce incentives for generic entry or promote mergers and acquisitions further limiting generic competition.

5.5 Firm Characteristics

The robustness of the impact of firm heterogeneity was tested using the following proxies: log local and global sales of the firm, global reach of the corporation (the number of geographical markets in which the firm has sales) and firm's molecule diversity (number of molecules the firm has on sale in the global market) as a proxy for scope effects.

Paradoxically, firm characteristics do not have a robust or significant effect on the hazard of generic adoption. Both for parametric and non-parametric specifications, local and global firm sales have a positive effect on the hazard of launch if calendar year dummies are excluded. When calendar year dummies are included firm sales have a negative coefficient. However, firm sales coefficients are not significant. Only the parametric specification with no calendar year dummies yields positive coefficient estimates for local firm sales. The coefficient of firm's number of molecules is small but is robustly positive across different specifications, and significant for parametric specification with no calendar year dummies. Global reach of the corporation, i.e. the number of geographical markets in which the firm has sales, has positive coefficient estimate in 6 out of 8 different specifications; however, the effect is not significant.

Local firm sales seem to be better proxies compared to global firm sales in predicting the hazard of generic launch, which suggests generic launch strategies are more locally oriented compared to research oriented branded manufactures that aim for global optimization in international launch strategies to recoup costly R&D outlays. The significant importance of

[19] Countries with only retail-level data are Belgium, Greece, Spain, Sweden, South Africa and Turkey. Swedish data is combined sales for retail and hospital sectors. For the US, retail sales are assumed to be composed of food stores, drugstores and mail sales.

local firm sales may indicate advantages in the tendering or price negotiation procedures with bulk purchasers such as hospitals. This also indirectly suggests that economies of scale/scope in the generic sector has a less significant role compared to the research intensive sector where the scale of R&D and marketing outlays makes firm size a competitive advantage.

A summary table for the hypotheses tested, and a comparison of the expected and estimated coefficient signs is presented in Table A.4 in the Appendix.

6 CONLUDING REMARKS

This paper has attempted to investigate how regulation affects the relative adoption speed of first generic products across the OECD. We use product-level price and volume information to analyse generic adoption speed across the OECD in the past two decades (1999-2008), controlling for other influential factors such as market competition and firm heterogeneity. The panel data structure exploits variation both over time and over country-molecule pairs in discrete-time duration regressions with cloglog and logit. The evidence from our empirical analysis provides robust evidence suggestive of the effect higher expected generic prices exert on the hazard of first generic launch across the OECD. That is, adoption is found to be faster in higher priced markets. This is consistent with the trade-off between innovation and cost cutting competition, or static-dynamic efficiency trade-off in the pharmaceutical industry. A second findings indicates that expected generic market size (in USD$) is a significant determinant of generic launch, controlling for price, competition, firm and molecule characteristics.

Ex-ante expectations about competition also have a significant effect on generic launch strategies; with a highly fragmented therapeutic market is indicative of reduced incentives to generic entry. This is in contrast to the effect of competition in the patent-protected sector where competition has been associated with higher rates of entry (Kyle 2007). Our interpretation is that generics are commodity products with little room for differentiation that compete solely on price, whilst patent-protected products compete in quality and other important characteristics that allow for product-differentiation. New molecules are usually improved versions of older molecules and can capture market share from already existing molecules. In the case of generics, however, as competition makes the market more fragmented, prices and market share potential adjust accordingly.

Unexpectedly, molecule or firm characteristics do not have a robust effect across different specifications although base case results indicate that firm scale positively affects speed of

generic adoption. Local firm sales are found to be better predictors of the hazard of generic adoption compared to global firm sales. This is consistent with the idea that generic competition is based on either a low-cost base or differentiation in forms that are difficult to manufacture or market (Gorka 2009), whilst global branded competition exhibits a higher strategic advantage in overcoming the barriers to entry. The increasing significance of firm size is evidenced by the recent growth in mergers and acquisitions across generic manufacturers.

Adoption lag for the originator product relative to the first global launch is significantly and robustly associated with later generic entry. This is consistent with the observation that markets with higher prices adopt generics faster on average, and more specifically that free pricing tends to conflate lower administrative delays, and products tend to be adopted earlier in those countries. Given the potential savings offered by generics to health systems, improving access to generics and reducing adoption delays both for innovative molecules and generics should be a key goal in markets that are late adopters.

. A natural extension of this analysis is to empirically analyse determinants of generic diffusion in individual markets. Major price-controlled pharmaceutical markets such as France, Spain, Italy and Japan not only suffer from launch lags but also have very low penetration rates in the off-patent sector, less than 20% vs. over 70% in the US (European Generic Medicines Association 2007; Gorka 2009). Integration of demand-side measures such as generic substitution with supply-side measures is essential to promote a sustainable generic sector in these markets. The analysis could be further extended to assess the impact of other demand-side measures, such as risk sharing through co-payments, on generic entry and timing of generic availability.

APPENDIX

Table A.1 Findings from the Literature on generic drug entry

Risk Factor	Observed Effect	Evidence from	Author(s)
Pre-entry market size and expected profits	Increases speed and extent of generic entry	US, UK, Germany, Spain, Sweden, Japan	Grabowski, Vernon 92; Scott Morton 99, 00; Reiffen and Ward 05; Saha 06; Moreno-Torres 09; Appelt 09; Iizuka 09
Firm Characteristics	Economies of scope (entry in several markets; number of form strengths for a given molecule)	US, Japan	Bae 97; Scott Morton 99; Iizuka 09
Drug characteristics	• Drugs for chronic conditions exhibit a higher entry rate • Entry dynamics depend on therapeutic class	US, Japan	Bae 97; Scott Morton 00; Saha, Grabowski 06; Iizuka 09
Price regulation/ Reimbursement	• Reference pricing restrains generic entry by reducing generic profits (the empirical evidence is weak) • Higher price premium for branded drugs over generics increases generic share	Spain, Sweden US	Moreno-Torres 09; Ekelund 01; Konigbauer 06; Rudholm 01; Danzon & Chao 00 Hurwitz, Caves 88
Competition/ Market structure	Slower if market is highly competitive (importance of generic vs. branded competition is market-dependent) • Number of generic incumbents negatively affects extent of entry in Spain • Impact of branded competition is not clear [US and Japanese evidence suggests slower entry with increasing number of competitor molecules; Magazzini (2004) finds counter evidence]	Spain, Japan; France, Germany, UK, US	Iizuka 09; Moreno-Torres 09; Saha 06; Bae 97; Scott Morton 00; Magazzini 04
Proportion of hospital sales	Market Dependent. Increases generic entry in the US but not in Japan; a study on France, Germany, UK,US indicates size of hospital sales has negative impact on generic shares	US, Japan; France, Germany, UK	Iizuka 09; Scott Morton 00; Magazzini 04
Branded firm strategies	Partnerships and agreements deter entry	US, Canada	Hollis 03; Reiffen 05; Berndt et al. 07; Reiffen 07
Goodwill Stock of the Branded Product	• More entrants if patent protection period is shorter *Mixed Evidence regarding Pre-Patent Expiry Brand Advertising* • Higher promotion during patent exclusivity preserves brand shares (brand loyalty) • Pre-patent advertising declines with patent expiry; no significant effect on generic entry *Advertising in Generic Industry* • Not effective since little potential for differentiation	Sweden US US US	Rudholm 01 Hurwitz, Caves 88 Caves, Whinston 91; Grabwoski, Vernon 92; Ellison, Ellison 07 Scherer 00; Scott-Morton 00

Discrete Time Survival Analysis

In practice, it has been shown that if the hazard rate is relatively small and cloglog and logistic hazard models share the same duration dependence and covariate vector, then the estimates they yield are similar. This can be illustrated by writing the hazard rates in each model as a power series and using $G = \exp\left(\gamma_t + \mathbf{z}_j\boldsymbol{\beta}\right)$ (see Table A.2). When the probability of failure in each interval is small (i.e. $h \leq 0.10$ or less), then

$\gamma_t + \mathbf{z}_j\boldsymbol{\beta} = \log\left[-\log\left(1-h\right)\right] \leq -2.25$ in the cloglog model, and $\gamma_t + \mathbf{z}_j\boldsymbol{\beta} = \log\left[\frac{h}{1-h}\right] \leq -2.20$ in the logistic model. In this case, $G = \exp\left(\gamma_t + \mathbf{z}_j\boldsymbol{\beta}\right) = \approx \exp\left(-2.2\right) \approx 0.10$ and terms of the order G^2 and higher are close to zero and $\left(1-h\right)$ can be approximated by $\left(1-G\right)$ both for the cloglog and logit model. In the instances where the hazard is small, therefore, the parameters of the logistic model and the proportional hazard model will be nearly equal (Abbott 1985; Jenkins 2005).

Table A.2 Comparison of Cologlog and Logit Models

	Cloglog model	*Logit model*
$\gamma_t + \mathbf{z}_j\boldsymbol{\beta} =$	$\log\left[-\log\left(1-h\right)\right]$	$\log\left[\frac{h}{1-h}\right]$
$1-h =$	$1-G+\frac{G^2}{2!}-\frac{G^3}{3!}\ldots+\frac{(-1)^n G^n}{n!}\ldots$	$1-G+G^2-G^3\ldots+(-1)^n G^n\ldots$
$h\left(t,\mathbf{z}_j\right) =$	$1-\exp\left(-\exp\left(\gamma_t + \mathbf{z}_j\boldsymbol{\beta}\right)\right)$	$\frac{1}{1+\exp(-\gamma_t - \mathbf{z}_j\boldsymbol{\beta})}$
$\partial h / \partial z_i =$	$\exp\left\{-\exp\left(\mathbf{z}_j\boldsymbol{\beta}+\gamma_t\right)\right\}\exp\left(\mathbf{z}_j\boldsymbol{\beta}+\gamma_t\right)\beta_i$	$=\frac{\beta_i \exp(\mathbf{z}_j\boldsymbol{\beta}+\gamma_t)}{\left[1+\exp(\mathbf{z}_j\boldsymbol{\beta}+\gamma_t)\right]^2}$

Note: $G = \exp\left(\gamma_t + \mathbf{z}_j\boldsymbol{\beta}\right)$

Table A.3 Variable Definitions and Descriptive Statistics

Expected Price	**Description**	**Level**	**N**	**mean**	**Std.dev**	**min**	**max**
ln_Pb	Log of NonGeneric Retail Price of the Molecule	Ctry-Mol-Qrt	521376	0.147	2.104	-7.055	7.739
LMAvg_Pb	Log of Moving Average of NonGeneric Retail Price of the Molecule	Ctry-Mol-Qrt	462450	0.138	2.103	-5.622	7.714
medRatioPgPb	Expected Price Ratio Pgen/Pnongen	Ctry-Qrt	614538	0.765	0.150	0.220	1.035
LMAvgExpPg	Log Moving Average of Expected Generic Price [Log Pb * medRatioPgPb]	Ctry-Mol-Qrt	462450	-0.158	2.086	-5.796	7.458
ln_ExpPg	Log Expected Generic Price [Log Pb*medRatioPgPb]	Ctry-Mol-Qrt	521376	-0.148	2.087	-7.273	7.550
RPS	Treatment Dummy for Reference Pricing System	Ctry-Qrt	816660	0.551	0.497	0	1
GenSubst	Tratement Dummy for Generic Substitution	Ctry-Qrt	775827	0.677	0.467	0	1
Market Size	**Description**	**Level**	**N**	**mean**	**Std.dev**	**min**	**max**
LMAvg_USD_molCtr_	Log Moving Average of Molecule Sales in the Country ($)	Ctry-Mol-Qrt	525018	6.152	2.738	-7.012	14.407
LMAvg_SU_molCtr_	Log Moving Average of Molecule Sales in the Country (SU)	Ctry-Mol-Qrt	525057	6.068	3.311	-6.908	13.789
ln_USD_moleculeCtry_i	Log Molecule Sales in the Country ($)	Ctry-Mol-Qrt	590559	6.076	2.824	-7.650	14.412
ln_SU_moleculeCtry_i	Log Molecule Sales in the Country (SU)	Ctry-Mol-Qrt	590622	5.981	3.385	-6.908	13.886
avgGenShare_USD_	Average Generic ($) Share	Ctry-Qrt	816660	38.526	12.104	6.614	64.023
ExpMarketSizeSU	Expected Market Size (SU)	Ctry-Mol-Qrt	525057	9.795	3.342	-3.715	18.028
ExpMarketSizeUSD	Expected Market Size ($) [Log MAvg_USD_molCtr * avgGenShare_USD]	Ctry-Mol-Qrt	525018	9.764	2.758	-3.911	18.507
Competition	**Description**	**Level**	**N**	**mean**	**Std.dev**	**min**	**max**
NumbMolCtryAtc4_	Number of Molecules in the ATC4 category (number of substitute molecules)	Ctry-Qrt-Atc4	296010	10.040	10.600	0	191
NumGenFirm	Number of Generic Firms in the Country	Ctry-Qrt	816660	143.778	77.369	47	380
NumGenFirmMed	Number of Generic Firms in the Country/Median	Ctry-Qrt	816660	1.188	0.639	0.388	3.140

firmSqMed	Squared number of generic firms in the Ctr/Median of Firms squared	Ctry-Qrt	816660	1.821	2.195	0.151	9.863
IHHatc4_gen	Herfindahl Index for Generic Sector	Ctry-Mol-Qrt	296010	4151.811	4056.628	0	10000
norm_IHHatc4_gen	normalized Herfindahl index for generic sector: (IHH_gen-mean)/std dev	Ctry-Mol-Qrt	296010	0	1	-1.023	1.442
Molecule	**Description**	**Level**	**N**	**mean**	**sd**	**min**	**max**
MolGlobalReach	Number of Markets the molecule has launched in	Mol	816660	16.779	4.242	2	20
ln_MolGlobalUSDAnnual_	Log Annual Molecule Sales ($)	Mol-Year	811260	11.535	2.277	-4.881	16.279
ln_MolGlobalUSDMedian_	Log Molecule Sales ($) [median of annual sales over 1999-2008]	Mol	816660	11.606	2.222	2.908	16.023
ln_lag_yrs	Lag Years of the Branded Version (Local Launch - Global Launch Date)	Mol-Ctry	602316	1.279	1.256	-2.554	4.681
PercRetailUSD_	Percentage retail sales of molecules in each market($)	Ctry-Mol-Qrt	388461	71.843	37.543	0	100
Firm	**Description**	**Level**	**N**	**mean**	**Std.dev**	**min**	**max**
lnLocalCorpSales	Log Local Sales of the Firm	Firm-Cty-Qrt	287133	9.690	2.474	-7.078	15.762
ln_globalFirmSales	Log Global Sales of the Firm	Firm-Qrt	289110	12.186	3.041	-7.078	16.225
CorpGlobalReach	Number of Markets in which the firm has sales	Firm-Qrt	293319	11.837	7.578	0	20
FirmMolDivAtT_	Firm's number of molecules on sale at time t	Firm-Qrt	291291	375.761	310.072	1	1112

Note: Ctry: Country; Mol: Molecule; Qrt: Quarter

Table A.4 Hypotheses tested in the empirical analysis

Factor	*Testable Hypotheses*	*Evidence from the Literature*	*Expected Sign of the Coefficient*	*Estimated Sign*
Regulation	H1 a: High expected generic prices increase the hazard rate (decrease launch lag) for generic products	No direct empirical evidence	+ Price Coefficient (Higher generic prices, controlling for other factors, increase expected revenue and profitability for generic manufacturers)	+
	H1 b.1: Higher branded prices increase the hazard of launch of generic products	Evidence exists	+ Pb Coefficient (Generic prices may be directly linked to branded prices; markets with higher prices tend to have higher generic prices)	+
	H1 b.2: Generic-branded price ratio Pg/Pb negatively affects hazard of launch.	No evidence on timing of generic entry	- Pg/Pb Coefficient (Keeping branded price fixed, lower generic prices allow generics to capture a higher volume share)	-
Market Size	H1 c.1: The higher the branded molecule sales prior to generic launch (in $ or SU), the higher the hazard of launch	Empirical evidence exists for $ sales of branded products	+ Market Size Coefficient (Both the sign of SU and USD sales are expected to be positive)	+
	H1 c.2: The higher the expected generic market size (= branded molecule sales * the average generic share in the local market), the higher the hazard of launch	No direct empirical evidence	+ Expected Market Size Coefficient (Market size increases incentives for entry as the net present value of entry is increased)	+
Competition & Market Structure	H1 c.1: A higher number of expected generic competitors decreases the hazard of entry	No evidence	- Coefficient for number of competitor firms (The number of generic entrants has a negative impact on expected profits)	- (concave relationship); effect not robustly significant
	H1 c.2: The higher the number of substitute molecules in the therapeutic class, the lower is the hazard rate	No evidence	- Coefficient for Substitute Molecules (Either reference pricing or competition will drive prices and potential profits down)	+ ; effect not significant
	H1 c.3: The higher the Herfindahl concentration index of generic manufacturers at the therapeutic class level, the lower the hazard rate	No evidence	+ Concentration Coefficient (Less fierce price competition in)	+

Molecule	H1d.1: Generic entry for therapeutically/commercially important molecules is faster (higher branded prices and higher profit potentials)	No evidence	+ Coefficient for Molecule's Global Reach (Molecules with wider global diffusions have higher therapeutic importance)	- but not significant
			+ Coefficient for Molecule's Global Sales (Hazard of adoption should be higher for molecules that have higher sales [therapeutic importance and sales are positively correlated]).	No robust evidence
	H1d.2: The longer the lag for the entry of the originator molecule, the faster the generic entry	No evidence	+ Coefficient for the Lag of the Originator (Longer lags imply shorter exclusivity and lower brand loyalty)	+ across models; not significant
	H1d.2: Percentage of molecule sales in the retail sector increases hazard of launch	Contradictory	+ Coefficient for % Sales in Retail Sector (Prices in the hospital sector tend to lower than in the retail sector but volume effect could dominate)	+; significant for non-parametric models
Firm	H1 e.1: Firm economies of scope (number of molecules in the portfolio) increase the hazard of launch	Evidence exists	+ Economies of Scope Coefficient (Economies of scope allow lower-cost entry as the firm can switch quickly and less costly from one product line to another. Knowledge spillovers across different product lines may further reduce development and entry costs)	+ and significant
	H1 e.2: Firms' scale has positive effect on the hazard of launch.	Evidence from the branded sector; No firm empirical evidence exists for the generic sector	+ Coefficient for Firm's Global/Local Sales (Scale economies allow vertical integration in the supply chain and mergers with other firms to decrease costs)	+ for local; no robust evidence for global sales
			+ Coefficient for Firm's Global Reach (A wider global presence indicates potentially bigger firm size and higher familiarity with diverse regulatory environments)	+ but not significant

Table A.5 Non-parametric Duration Dependence: Coefficients for Base Case Cloglog and Logit Estimates for First Generic Launch

Coefficient Estimates	*With Calendar Year Dummies*						*No Calendar Year Dummies*					
	CLOGLOG			LOGIT			CLOGLOG			LOGIT		
	1	2	3	1	2	3	1	2	3	1	2	3
Expected Generic Price												
LMAvgExpPg	0.052	0.063		0.055*	0.067		0.074**	0.141**		0.076**	0.146**	
	[0.0267]	[0.0413]		[0.0282]	[0.0435]		[0.0256]	[0.0438]		[0.0265]	[0.0452]	
LMAvg_Pb			0.051			0.054			0.073**			0.074**
			[0.0266]			[0.0281]			[0.0248]			[0.0257]
medRatioPgPb			0.199			0.318			-1.743*			-1.835*
			[0.6895]			[0.7224]			[0.7777]			[0.8011]
Expected Market Size												
ExpMarketSizeUSD	0.091**			0.097**			0.187***			0.194***		
	[0.0341]			[0.0365]			[0.0369]			[0.0378]		
ExpMarketSizeSU		0.022			0.022			0.082*			0.086*	
		[0.0305]			[0.0331]			[0.0323]			[0.0334]	
LMAvg_USD_molCtr_			0.087*			0.093*			0.136***			0.142***
			[0.0341]			[0.0366]			[0.0351]			[0.0360]
avgGenShare_USD_			0.001			-0.002			0.095***			0.097***
			[0.0123]			[0.0127]			[0.0110]			[0.0113]
Competition												
NumGenFirmMed	-1.779*	-1.818*	-1.791*	-1.597*	-1.627*	-1.638*	5.761***	5.904***	4.683***	5.905***	6.065***	4.855***
	[0.7671]	[0.7688]	[0.7651]	[0.7990]	[0.8017]	[0.7978]	[0.7922]	[0.7943]	[0.7097]	[0.8117]	[0.8145]	[0.7295]
Molecule Characteristics												
ln_lag_yrs	0.071	0.065	0.071	0.074	0.067	0.073	0.015	0.004	0.023	0.017	0.005	0.025
	[0.0372]	[0.0371]	[0.0372]	[0.0390]	[0.0388]	[0.0390]	[0.0353]	[0.0348]	[0.0349]	[0.0363]	[0.0357]	[0.0361]
ln_MolGlobalUSDAnnual_	0.029	0.082*	0.033	0.036	0.093*	0.04	0.002	0.082*	0.022	0.005	0.087*	0.026
	[0.0385]	[0.0368]	[0.0385]	[0.0404]	[0.0386]	[0.0404]	[0.0395]	[0.0375]	[0.0380]	[0.0400]	[0.0379]	[0.0385]
Firm Characteristics												
ln_globalFirmSales	0.005	0.004	0.005	0.006	0.005	0.006	0.015	0.013	0.011	0.016	0.014	0.012
	[0.0145]	[0.0145]	[0.0145]	[0.0150]	[0.0150]	[0.0150]	[0.0136]	[0.0135]	[0.0131]	[0.0139]	[0.0138]	[0.0134]
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
ATC1 Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Monthly Period Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Model Stats												
Number of observations	41104	41104	41104	41104	41104	41104	41104	41104	41104	41104	41104	41104
Log Likelihood	-3302.54	-3306.22	-3302.93	-3294.88	-3298.66	-3295.2	-3505.01	-3516.33	-3465.35	-3503.12	-3514.59	-3463.26
chi2	14057.04	14280.89	14313.13	12763.67	12976.81	12988.19	17497.36	18261.92	18189.47	16603.75	17342.02	17238.23
p value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Akaike Info Criteria	6927.08	6934.44	6931.86	6911.76	6919.31	6916.4	7316.02	7338.65	7240.7	7312.23	7335.19	7236.52
Bayesian Info Criteria	8315.52	8322.88	8337.55	8300.2	8307.75	8322.09	8635.47	8658.1	8577.4	8631.68	8654.64	8573.22

Note: *p<0.05, **p < 0.01, ***p<0.001. Standard errors clustered at molecule-country level (standard errors in brackets).
Year, ATC1 and Country Dummies not reported
LMAvg: Log Moving Average

Table A.6 Variance Inflation Factors with number of generic firms in the market

Variable	*VIF*	*1/VIF*
NumGenFirmMed	244.7	0.0041
country == US	187.5	0.0053
country == GERMANY	102.13	0.0098
country == ITALY	34.07	0.0293
country == UK	14.49	0.0690
country == POLAND	13.04	0.0767
country == SPAIN	11.31	0.0884
country == GREECE	11.19	0.0893
country == JAPAN	10.65	0.0939
country == FRANCE	10.09	0.0991
year == 2003	8.05	0.1242
year == 2002	7.58	0.1319
year == 2004	7.52	0.1330
year == 2001	6.67	0.1500
year == 2005	6.61	0.1514
year == 2006	5.65	0.1770

Variable	*VIF*	*1/VIF*
sequence	5.34	0.1872
country == BELGIUM	5.09	0.1964
year == 2000	4.93	0.2029
ln_sequenceSq	4.22	0.2370
country == CANADA	4.09	0.2443
year == 2007	3.94	0.2535
ExpMarketSizeUSD	3.84	0.2604
country == SWITZERLAND	3.59	0.2788
country == PORTUGAL	3.2	0.3120
country == TURKEY	3.17	0.3154
ATC1 == N	2.88	0.3477
LMAvgExpPg	2.82	0.3552
country == S. AFRICA	2.63	0.3800
ATC1 == L	2.53	0.3946
ln_MolGlobalUSDAnnual_	2.38	0.4204
country == FINLAND	2.36	0.4229

Variable	*VIF*	*1/VIF*
country == SWEDEN	2.22	0.4514
ATC1 == C	2.21	0.4527
ATC1 == M	2.13	0.4690
country == NETHERLANDS	2.01	0.4979
ATC1 == R	1.89	0.5297
ATC1 == J	1.86	0.5370
country == BELGIUM	1.85	0.5394
ATC1 == D	1.6	0.6257
ATC1 == H	1.59	0.6285
ln_globalFirmSales	1.55	0.6435
ATC1 == G	1.55	0.6459
ln_lag_yrs	1.52	0.6584
ATC1 == S	1.2	0.8312
ATC1 == B	1.12	0.8897
Mean VIF	**16.58**	

Command:

```
xi: regress _d LMAvgExpPg ExpMarketSizeUSD  NumGenFirmMed   ln_MolGlobalUSDAnnual_  ln_lag_yrs  ln_globalFirmSales  sequence
ln_sequenceSq   i.year i.countrynosector i.atc1
estat vif
```

Table A.7 Variance Inflation Factors with Herfindahl Index in ATC4

Variable	*VIF*	*1/VIF*
year == 2003	7.71	0.1297
year == 2004	7.26	0.1377
year == 2002	7.21	0.1386
year == 2005	6.47	0.1545
year == 2001	6.11	0.1636
year == 2006	5.62	0.1781
sequence	5.34	0.1874
year == 2000	4.34	0.2305
ln_sequenceSq	4.21	0.2374
year == 2007	3.94	0.2539
ExpMarketSizeUSD	3.83	0.2608
country == US	3.46	0.2893
ATC1 == N	2.97	0.3362
LMAvgExpPg	2.81	0.3553
country == S. Africa	2.63	0.3803

Variable	*VIF*	*1/VIF*
ATC1 == L	2.61	0.3835
country == CANADA	2.49	0.4013
country == GERMANY	2.4	0.4160
ln_MolGlobalUSDAnnual_	2.38	0.4205
country == SPAIN	2.36	0.4245
country == FINLAND	2.31	0.4332
ATC1 == C	2.22	0.4506
country == PORTUGAL	2.19	0.4571
country == GREECE	2.17	0.4606
country == UK	2.15	0.4645
ATC1 == M	2.14	0.4675
country == AUSTRIA	2.07	0.4823
country == TURKEY	2.06	0.4865
country == FRANCE	2.05	0.4879
country == SWEDEN	2	0.4994

Variable	*VIF*	*1/VIF*
country == JAPAN	1.99	0.5016
country == NETHERLANDS	1.95	0.5117
country == POLAND	1.95	0.5128
ATC1 == J	1.9	0.5271
ATC1 == R	1.89	0.5286
country == ITALY	1.85	0.5402
country == BELGIUM	1.84	0.5448
country == SWITZERLAND	1.79	0.5594
ATC1 == D	1.62	0.6154
ATC1 == H	1.59	0.6271
ln_globalFirmSales	1.56	0.6415
ATC1 == G	1.55	0.6457
ln_lag_yrs	1.52	0.6593
ATC1 == S	1.2	0.8302
norm_IHHatc4_gen	1.2	0.8343
ATC1 == B	1.12	0.8916
Mean VIF	**2.91**	

Command:

xi: regress _d LMAvgExpPg ExpMarketSizeUSD norm_IHHatc4_gen ln_MolGlobalUSDAnnual_ ln_lag_yrs ln_globalFirmSales sequence ln_sequenceSq i.year i.countrynosector i.atc1

estat vif

Table A.8 Robustness Check (Regulation): Parametric Duration Dependence, Coefficient Estimates

Variables	1 cloglog	1 logit	2 cloglog	2 logit	3 cloglog	3 logit	4 cloglog	4 logit	5 cloglog	5 logit	6 cloglog	6 logit	7 cloglog	7 logit
Regulation														
LMAvgExpPg	0.150***	0.146***					0.150***	0.146***	0.129**	0.124**	0.146***	0.141**		
	[0.0410]	[0.0429]					[0.0410]	[0.0430]	[0.0430]	[0.0451]	[0.0425]	[0.0447]		
L3ln_ExpPg			0.139***	0.135**										
			[0.0419]	[0.0439]										
ln_ExpPg					0.146***	0.141***								
					[0.0407]	[0.0426]								
L3ln_Pb													0.141***	0.136**
													[0.0418]	[0.0437]
medRatioPgPb					-0.291	0.016							-0.067	0.233
					[0.9626]	[1.0066]							[0.9588]	[1.0032]
RPS							0.161	0.198						
							[0.2421]	[0.2496]						
GenSubst									0.43	0.409				
									[0.3548]	[0.3695]				
LMAvgExpPgxlnT											0.012	0.013		
											[0.0177]	[0.0196]		
Controls														
Market Size														
ExpMarketSizeUSD	0.132*	0.147**	0.127*	0.143*	0.130*	0.145**	0.131*	0.146**	0.122*	0.137*	0.129*	0.145**	0.129*	0.143*
	[0.0534]	[0.0561]	[0.0529]	[0.0556]	[0.0532]	[0.0558]	[0.0533]	[0.0560]	[0.0543]	[0.0569]	[0.0534]	[0.0560]	[0.0527]	[0.0555]
Competition														
norm_IHHatc4_gen	0.647***	0.682***	0.644***	0.679***	0.646***	0.681***	0.647***	0.683***	0.650***	0.683***	0.646***	0.682***	0.645***	0.679***
	[0.0491]	[0.0535]	[0.0491]	[0.0534]	[0.0493]	[0.0535]	[0.0491]	[0.0534]	[0.0504]	[0.0544]	[0.0491]	[0.0534]	[0.0492]	[0.0534]
Molecule Charateristics														
ln_MolGlobalUSDAnnual_	-0.064	-0.069	-0.064	-0.07	-0.054	-0.059	-0.062	-0.067	-0.06	-0.065	-0.062	-0.068	-0.064	-0.069
	[0.0634]	[0.0669]	[0.0630]	[0.0664]	[0.0625]	[0.0664]	[0.0632]	[0.0667]	[0.0659]	[0.0693]	[0.0632]	[0.0667]	[0.0631]	[0.0665]
ln_lag_yrs	0.054	0.077	0.05	0.073	0.047	0.068	0.053	0.076	0.037	0.058	0.056	0.079	0.05	0.072
	[0.0711]	[0.0758]	[0.0709]	[0.0756]	[0.0709]	[0.0755]	[0.0709]	[0.0756]	[0.0719]	[0.0765]	[0.0710]	[0.0757]	[0.0710]	[0.0758]
Firm Charateristics														
ln_globalFirmSales	-0.003	-0.002	-0.002	-0.002	-0.006	-0.006	-0.002	-0.001	0	0	-0.002	-0.002	-0.002	-0.002

	[0.0221]	[0.0228]	[0.0220]	[0.0228]	[0.0221]	[0.0228]	[0.0221]	[0.0228]	[0.0230]	[0.0237]	[0.0221]	[0.0229]	[0.0220]	[0.0228]
Time Since Risk Onset														
t	0.018***	0.018***	0.018***	0.018***	0.018***	0.018***	0.018***	0.019***	0.019***	0.019***	0.019***	0.019***	0.018***	0.018***
	[0.0035]	[0.0037]	[0.0035]	[0.0037]	[0.0035]	[0.0037]	[0.0035]	[0.0037]	[0.0036]	[0.0038]	[0.0035]	[0.0037]	[0.0035]	[0.0037]
ln_(t*t)	-0.348***	-0.360***	-0.345***	-0.356***	-0.344***	-0.355***	-0.348***	-0.360***	-0.357***	-0.369***	-0.353***	-0.364***	-0.345***	-0.357***
	[0.0346]	[0.0376]	[0.0346]	[0.0375]	[0.0348]	[0.0378]	[0.0345]	[0.0376]	[0.0358]	[0.0389]	[0.0354]	[0.0385]	[0.0345]	[0.0375]
Heterogeneity Controls														
ATC1 Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Calendar Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Model Stats														
Number of observations	19698	19698	19809	19809	19827	19827	19698	19698	18560	18560	19698	19698	19809	19809
Log Likelihood	-2083.37	-2082.67	-2095.24	-2094.59	-2092.62	-2091.99	-2083.12	-2082.32	-1955.74	-1955.23	-2083.01	-2082.36	-2095.04	-2094.47
chi2	798.35	668	790.37	662.33	799.72	671.3	803.27	671.83	776.35	644.57	802.81	670.53	795.13	666.84
p value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0
Akaike Info Criteria	4260.73	4259.34	4284.49	4283.18	4281.25	4279.98	4262.23	4260.64	4005.48	4004.47	4262.02	4260.73	4286.08	4284.93
Bayesian Info Criteria	4631.48	4630.09	4655.5	4654.2	4660.2	4658.93	4640.87	4639.27	4373.44	4372.42	4640.65	4639.36	4664.98	4663.84

Note: *p<0.05, **p < 0.01, ***p<0.001. Standard errors clustered at molecule-country level (standard errors in brackets).
Duration dependence is specified as $t + \ln(t * t)$, where t corresponds to months since risk onset.
L3: lagged by one one quarter; LMAvg: Log Moving Average

Table A.9 Robustness Check (Market Size): Parametric Duration Dependence, Coefficient Estimates

Variables	1 cloglog	1 logit	2 cloglog	2 logit	3 cloglog	3 logit	4 cloglog	4 logit	5 cloglog	5 logit	6 cloglog	6 logit
Market Size												
ExpMarketSizeUSD	0.127*	0.143*										
	[0.0529]	[0.0556]										
ExpMarketSizeSU			0.06	0.071								
			[0.0493]	[0.0520]								
LMAvg_USD_molCtr_					0.123*	0.140*						
					[0.0534]	[0.0562]						
LMAvg_SU_molCtr_							0.054	0.066				
							[0.0496]	[0.0524]				
L3ln_USD_moleculeCtry_i									0.103*	0.116*		
									[0.0514]	[0.0541]		
L3ln_SU_moleculeCtry_i											0.044	0.053
											[0.0473]	[0.0499]
Controls												
Expected Generic Price												
L3ln_ExpPg	0.139***	0.135**	0.188**	0.194**	0.138***	0.134**	0.181*	0.189*	0.157***	0.154***	0.190**	0.197**
	[0.0419]	[0.0439]	[0.0712]	[0.0742]	[0.0420]	[0.0440]	[0.0715]	[0.0746]	[0.0416]	[0.0436]	[0.0688]	[0.0717]
Competition												
norm_IHHatc4_gen	0.644***	0.679***	0.646***	0.679***	0.645***	0.680***	0.646***	0.679***	0.649***	0.684***	0.649***	0.683***
	[0.0491]	[0.0534]	[0.0493]	[0.0534]	[0.0491]	[0.0534]	[0.0493]	[0.0534]	[0.0484]	[0.0527]	[0.0486]	[0.0527]
Molecule Characteristics												
ln_MolGlobalUSDAnnual_	-0.064	-0.07	-0.011	-0.013	-0.061	-0.067	-0.006	-0.009	-0.036	-0.039	0.01	0.01
	[0.0630]	[0.0664]	[0.0612]	[0.0644]	[0.0632]	[0.0666]	[0.0614]	[0.0646]	[0.0614]	[0.0647]	[0.0595]	[0.0626]
ln_lag_yrs	0.05	0.073	0.038	0.058	0.049	0.072	0.036	0.057	0.036	0.057	0.025	0.044
	[0.0709]	[0.0756]	[0.0712]	[0.0757]	[0.0710]	[0.0757]	[0.0713]	[0.0758]	[0.0690]	[0.0732]	[0.0693]	[0.0734]
Firm Characteristics												
ln_globalFirmSales	-0.002	-0.002	-0.003	-0.003	-0.002	-0.002	-0.003	-0.003	-0.002	-0.002	-0.003	-0.002
	[0.0220]	[0.0228]	[0.0220]	[0.0227]	[0.0220]	[0.0228]	[0.0220]	[0.0227]	[0.0214]	[0.0222]	[0.0214]	[0.0222]
Time since risk onset												
t	0.018***	0.018***	0.017***	0.017***	0.018***	0.018***	0.017***	0.017***	0.019***	0.020***	0.019***	0.019***
	[0.0035]	[0.0037]	[0.0035]	[0.0038]	[0.0035]	[0.0037]	[0.0035]	[0.0038]	[0.0034]	[0.0037]	[0.0035]	[0.0037]

ln_(t*t)	-0.345*** [0.0346]	-0.356*** [0.0375]	-0.341*** [0.0346]	-0.352*** [0.0376]	-0.345*** [0.0346]	-0.356*** [0.0375]	-0.341*** [0.0346]	-0.352*** [0.0376]	-0.363*** [0.0338]	-0.377*** [0.0368]	-0.359*** [0.0338]	-0.373*** [0.0368]
Heterogeneity Controls												
ATC1 Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Calendar Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Model Stats												
Number of observations	19809	19809	19809	19809	19809	19809	19809	19809	20708	20708	20708	20708
Log Likelihood	-2095.24	-2094.59	-2098.68	-2098.37	-2095.58	-2094.86	-2098.91	-2098.59	-2149.67	-2149.19	-2152.4	-2152.2
chi2	790.37	662.33	791.14	663.76	788.55	660.11	790.85	663.23	851	715.06	851.5	715.81
p value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Akaike Info Criteria	4284.487	4283.184	4291.356	4290.748	4285.166	4283.73	4291.828	4291.181	4395.339	4394.377	4400.794	4400.41
Bayesian Info Criteria	4655.5	4654.2	4662.37	4661.76	4656.18	4654.74	4662.84	4662.19	4776.38	4775.41	4781.83	4781.45

Note: *p<0.05, **p < 0.01, ***p<0.001. Standard errors clustered at molecule-country level (standard errors in brackets).
Duration dependence is specified as $t + \ln(t * t)$, where t corresponds to months since risk onset.
L3: lagged by one one quarter; LMAvg: Log Moving Average

Table A.10 Robustness Check (Competition): Parametric Duration Dependence, Coefficient Estimates

Variables	1 cloglog	1 logit	2 cloglog	2 logit	3 cloglog	3 logit	4 cloglog	4 logit
Competition								
norm_IHHatc4_gen	0.645*** [0.0491]	0.680*** [0.0534]						
NumbMolCtryAtc4_			0.003 [0.0074]	0.004 [0.0075]				
NumGenFirmMed					-1.652 [0.9857]	-1.528 [1.0172]	-1.314 [1.9361]	-0.869 [2.0172]
firmSqMed							-0.106 [0.5114]	-0.207 [0.5349]
Controls								
Expected Generic Price								
L3ln_ExpPg	0.138*** [0.0420]	0.134** [0.0440]	0.080* [0.0382]	0.080* [0.0397]	0.080* [0.0374]	0.079* [0.0388]	0.080* [0.0374]	0.079* [0.0387]
Expected Market Size								
*LMAvg_USD_molCtr_*	0.123* [0.0534]	0.140* [0.0562]	0.112* [0.0455]	0.120* [0.0473]	0.113* [0.0449]	0.120* [0.0466]	0.113* [0.0449]	0.120* [0.0467]
Molecule Characteristics								
ln_MolGlobalUSDAnnual_	-0.061 [0.0632]	-0.067 [0.0666]	-0.036 [0.0563]	-0.036 [0.0583]	-0.038 [0.0562]	-0.037 [0.0583]	-0.038 [0.0562]	-0.038 [0.0583]
ln_lag_yrs	0.049 [0.0710]	0.072 [0.0757]	0.122* [0.0620]	0.128* [0.0640]	0.121* [0.0618]	0.127* [0.0638]	0.122* [0.0618]	0.128* [0.0637]
Firm Characteristics								
ln_globalFirmSales	-0.002 [0.0220]	-0.002 [0.0228]	0.008 [0.0190]	0.009 [0.0195]	0.007 [0.0189]	0.008 [0.0194]	0.007 [0.0189]	0.008 [0.0195]
Time Since Risk Onset								
t	0.018*** [0.0035]	0.018*** [0.0037]	0.016*** [0.0032]	0.016*** [0.0035]	0.016*** [0.0032]	0.017*** [0.0035]	0.016*** [0.0032]	0.017*** [0.0035]
ln_(t*t)	-	-	-	-	-	-	-	-

	0.345***	0.356***	0.331***	0.342***	0.335***	0.346***	0.335***	0.346***
	[0.0346]	[0.0375]	[0.0340]	[0.0364]	[0.0339]	[0.0363]	[0.0340]	[0.0363]
Heterogeneity								
ATC1 Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Calendar Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Model Stats								
Number of observations	19809	19809	19809	19809	19809	19809	19809	19809
Log Likelihood	-2095.58	-2094.86	-2231.52	-2232.97	-2230.23	-2231.99	-2230.21	-2231.93
chi2	788.55	660.11	719.56	659.22	723.32	668.24	721.62	664.89
p value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Akaike Info Criteria	4285.17	4283.73	4557.04	4559.93	4554.46	4557.98	4556.43	4559.86
Bayesian Info Criteria	4656.18	4654.74	4928.05	4930.94	4925.48	4928.99	4935.34	4938.76

Note: *p<0.05, **p < 0.01, ***p<0.001. Standard errors clustered at molecule-country level (standard errors in brackets).
Duration dependence is specified as $t + \ln(t * t)$, where t corresponds to months since risk onset.
L3: lagged by one one quarter; LMAvg: Log Moving Average

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