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REGULATION AND WELFARE: EVIDENCE FROM PARAGRAPH IV GENERIC ENTRY IN THE PHARMACEUTICAL INDUSTRY

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ABSTRACT

With increasing frequency, generic drug manufacturers in the United States are able to challenge the monopoly status of patent-protected drugs even before their patents expire. The legal foundation for these challenges is found in Paragraph IV of the Hatch-Waxman Act. If successful, these Paragraph IV challenges generally lead to large market share losses for incumbents and sharp declines in average market prices. This paper estimates, for the first time, the welfare effects of accelerated generic entry via these challenges. Using aggregate brand level sales data between 1997 and 2008 for hypertension drugs in the U.S. we estimate demand using a nested logit model in order to back out cumulated consumer surplus, which we find to be approximately $270 billion. We then undertake a counterfactual analysis, removing the stream of Paragraph IV facilitated generic products, finding a corresponding cumulated consumer surplus of $177 billion. This implies that gains flowing to consumers as a result of this regulatory mechanism amount to around $92 billion or about $133 per consumer in this market. These gains come at the expense to producers who lose, approximately, $14 billion. This suggests that net short-term social gains stands at around $78 billion. We also demonstrate significant cross-molecular substitution within the market and discuss the possible appropriation of consumer rents by the insurance industry. Policy and innovation implications are also discussed.

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1 Introduction

The Drug Price Competition and Patent Term Restoration Act, informally known as the "Hatch Waxman Act" was designed to balance access to pharmaceutical products while at the same time incentivizing pharmaceutical innovation in the United States. An important provision in Hatch-Waxman allows generic manufacturers to attempt to enter the market *before* patents protecting original branded products have expired. Using this mechanism, known as a Paragraph IV (Para-IV) certification or challenge, generic manufacturers attempt to enter patent protected markets either by claiming non-infringement or invalidity of the branded product's patent. Even though the Para-IV certification has been available to generic manufacturers since the passage of Hatch-Waxman in 1984, for reasons we will discuss, the number of challenges did not grow significantly until the late 1990s. Using unique and novel data we quantify, for the first time, the welfare effects of this accelerated generic entry as a result of Para-IV certifications.

For our analysis we focus on the hypertension (HTN) market in the U.S. over the time period 1997 to 2008. The hypertension market is significant in terms of pharmaceutical revenues and in terms of disease prevalence. Our findings on welfare gains build on and extend a rich literature on discrete choice estimation of demand (*e.g.*, Trajtenberg 1989; Berry, 1994; Stern, 1996; Petrin 2002; Cleanthous, 2002; Dutta, 2011). The empirical framework starts by modeling the utility of a consumer as a function of observed and unobserved product characteristics. The final outcome is a nested logit demand model that reduces to a standard shares specification (Berry, 1994) where shares are a function of drug prices and product characteristics. Coefficient estimates from the demand regressions are then used to estimate consumer welfare. The implementation of a counterfactual analysis allows estimation of the gains flowing to the consumer from Para-IV entry. By the end of 2008, cumulated consumer surplus amounted to approximately $270 billion in the HTN market. In a counterfactual world, over the same period without the stream of Para-IV generic products, cumulated consumer surplus was $177 billion. This implies that the gains flowing to the consumer because of Para-IV entry amounted to $92 billion, which translates into approximately $133 per representative customer in this market. Placed in context of the annual cost of treating hypertension, which the American Heart Association estimated to be $60 billion in 2007, these are significant gains from early generic entry.[1] Furthermore, over the same period we document the loss to producers to be approximately $14 billion. This leaves us with substantial net social gains arising from accelerated entry, at least in the short run.[2]

We also document significant cross-molecular substitution in this market. Cross-molecular substitution occurs when patients move from one branded product to the generic of another branded product. While this movement is facilitated by physicians, we also present some anecdotal evidence suggesting that insurance

[1] See http://www.nmanet.org/images/uploads/Publications/OC34.pdf

[2] The presence of an insurance industry that mediates transactions between drug sellers and drug consumers poses some complications for us in terms of our ability to interpret our estimates as "social gains." While a full consideration of these issues is beyond the scope of the current paper, we discuss some of their implications in Section 5.

companies encourage this shift among their customers. The implications of cross-molecular substitution are profound; a branded product's intellectual property (IP) protection, within a market, is only as strong as their weakest branded competitor's IP. For this reason, cross-molecular substitution may have important implications in terms of how incumbent pharmaceutical firms allocate their R&D resources across therapeutic disease programs, especially for rare or pediatric diseases.

Hatch-Waxman was designed to balance access with innovation. We demonstrate that the Para-IV regulatory challenge has been an effective mechanism at providing early access to consumers, but at what cost? A full welfare analysis of the balance struck by Hatch-Waxman will remain incomplete until we have analyzed its impact on innovation; ongoing research seeks to undertake this kind of analysis, but until then we make an important contribution by estimating the first-order welfare effect in the short run from accelerated generic entry due to Para-IV.

The paper proceeds as follows. Section 2 offers a brief discussion of the regulatory environment in which pharmaceutical firms operate. Section 3 discusses related literature. Our data and methodology are presented in Section 4. Section 5 presents results and we discuss the implications of our work and conclude in Section 6.

2 Regulatory environment and early generic entry

2.1 Hatch-Waxman and Paragraph IV challenges

The current regulatory environment faced by pharmaceutical companies in the United States can be traced to the passage of Hatch-Waxman in 1984. One of the hallmarks of the legislation is its purported trade-off: it allows expedited Food and Drug Administration (FDA) approval for generic entry while extending the life of pharmaceutical patents in order to compensate innovators who lost time on their "patent clocks" waiting for FDA approval (Grabowski, 2007). This balance was deemed necessary to equalize two conflicting policy objectives: giving pharmaceutical firms incentives to conduct drug research while simultaneously improving consumer welfare by enabling generic firms to quickly bring copies to market (Federal Trade Commission (FTC), 2002).

When a pharmaceutical company submits a New Drug Application (NDA) to the FDA for approval they are required, by law, to identify all relevant patented technologies necessary to create the drug; these patents are subsequently listed in the FDA Orange Book. Upon approval of a drug, the FDA will restore patent term to the pharmaceutical firm for time used by the FDA in the approval process (Grabowski, 2007).[3] In addition, the FDA will also grant each new approved product regulatory protection lasting for five years ("data exclusivity")

[3] There are limits to this. Pharmaceutical firms cannot receive a patent extension of more than five years, nor are they entitled to patent extensions that give them effective patent life (post approval) of greater than 14 years.

which runs concurrently with patent protection.[4] During this data exclusivity period, regardless of the status of the underlying patent(s), no generic entry may occur. At the conclusion of data exclusivity branded products are protected only by their patents; this period running from the cessation of data exclusivity to the expiration of the patent(s) is commonly referred to as "market exclusivity" (see Figure 1).

Prior to the passage of Hatch-Waxman, generic manufacturers seeking to sell their products in the U.S. market had to demonstrate the safety and efficacy of their products by putting them through clinical trials. While the outcome of these trials lacked the uncertainty involved in the trials of an innovative new drug, the time and expense involved were a significant disincentive for generics manufacturers to put products on the market, since they could not charge a premium price to offset the costs of clinical trials. Prior to Hatch-Waxman, it is estimated that more than 150 products existed without any patent protection and without any generic entry (Mossinghoff, 1999). While Hatch-Waxman did not lessen the burden of the clinical trials process for branded pharmaceutical companies seeking approval for new drugs, it essentially eliminated the requirement for separate clinical trials for generic manufacturers. This was made possible since generic manufacturers could simply demonstrate "bioequivalence" with branded products by showing that the active ingredient in their product diffused into the human bloodstream in a manner similar to the original product.[5]

Hatch-Waxman provides four pathways (or "Paragraphs") a generic firm may follow in order to gain entry into a market. The process starts with the filing of an Abbreviated New Drug Application (ANDA) by a generic manufacturer with one of the four Paragraph certifications. A Paragraph I certification is one for which the originator firm has not filed patent information for its branded product. Paragraph II certification relates to when the branded product's patent has already expired (*i.e.*, the end of market exclusivity), and Paragraph III certification relates to cases when the generic manufacturer notes that the patent on the branded product *will* expire on a certain date and that it seeks to enter only after patent expiry or end of market exclusivity. The fourth certification, Paragraph IV, argues that the generic manufacturer does not infringe on a branded product's patents or that those patents are invalid. More importantly, however, a Paragraph IV certification can be acted on by the FDA after the conclusion of *data exclusivity* anytime during the market exclusivity window (see

[4] Orphan drugs receive 7 years of data exclusivity; reformulations receive 3 years of data exclusivity and pediatric indications receive an additional 6 months of data exclusivity.

[5] In theory, generics should be perfect substitutes for branded drugs since they are bioequivalent. Cleanthous (2002) shows that the data do not support this relationship and suggests this is the result of 'spurious product differentiation', which he defines as arising "…when consumers perceive physically identical products to differ in quality." Recent evidence, however, may suggest that consumer perceptions have merit and while drugs may be bioequivalent, they may indeed differ in quality. Several articles appeared in the April 17, 2007 edition of the prestigious journal *Neurology* discussing the high incidence of break-through seizures with generic anti-epileptics. Insurance companies such as Blue Cross Blue Shield of Georgia allow pediatric customers to stay on branded anti-epileptic medications even though generics are available. Differences across generics for the same brand have also been reported. We are not suggesting all generics have problems but it appears in some instances where the therapeutic window is very narrow these perceptions may have some merit.

Figure 2).[6] This suggests that, if successful, these challenges can significantly decrease the effective patent life of branded products bringing generics to the market earlier than otherwise would be the case (Higgins and Graham, 2009; Grabowski and Kyle, 2007).

When a generic manufacturer files an ANDA with a Para-IV certification, the generic manufacturer is obligated to notify the incumbent. Upon receipt the pharmaceutical firm has two options: (1) do nothing or (2) sue the generic manufacturer (for patent infringement) within 45 days. If the pharmaceutical firm chooses not to file suit and does nothing then the FDA is entitled to approve the generic version of the branded product. If, however, the pharmaceutical firm chooses to file suit then that action automatically triggers a 30-month stay on FDA action. During this stay the FDA is unable to take any action on the ANDA unless there is a first court ruling. If the court rules in favor of the pharmaceutical firm, the Para-IV certification fails and the FDA is unable to authorize generic entry until the branded product's patents expire (*i.e.*, end of market exclusivity). On the other hand, upon a first court ruling in favor of the generic manufacturer the FDA may approve the ANDA. The first generic challenger is awarded 180-days of exclusivity.[7] During this 180-day exclusivity period the first challenger is the sole generic provider and occupies a position of duopoly with the original branded provider. This period of exclusivity for a challenger was deliberately placed in Hatch-Waxman as an incentive for generics manufacturers to challenge "weak" patents. As competition in the generics market has intensified, generics manufacturers have increasingly sought these periods of 180 day exclusivity and the high profits they bring. After 180 days, other generic entrants are allowed to freely enter the market.

Even though Para-IV certifications have been available to generic manufactures since the passage of Hatch-Waxman, the number of challenges remained low until the late 1990s. The acceleration of challenges since then can be tied to a series of court decisions, changes in FDA policy, and passage of the Medicare Act of 2003 (see Figure 3).[8] Over time, the ability of pharmaceutical firms to delay generic entry has been limited in important ways, dramatically intensifying competition and accelerating generic entry. In the early years, after passage of Hatch-Waxman, pharmaceutical firms were allowed to appeal initial judgments against the validity of their patents (or findings of noninfringement), and the FDA could not approve generic entry until all appeals had been exhausted -- a time consuming process that often held generic manufacturers at bay until patents expired or were about to expire. In more recent years, the FDA has approved entry as soon as courts issue a first ruling. Throughout the 1990s, incumbents often followed a practice of taking out additional patents after an

[6] Generic manufacturers may file a Para-IV certification up to one year prior to the end of data exclusivity but the FDA may not act on it until the conclusion of data exclusivity.

[7] While the FDA may approve an ANDA upon a first court ruling in favor of the generic manufacturer if that ruling is overturned on appeal the generic manufacturer exposes itself to damages for lost branded revenue. This is a gamble many generics manufacturers are willing to take, in part because the number of cases in which the first ruling is reversed on appeal is limited.

[8] In 1998, *Mova v. Shalala*, changed the interpretation of 180-day exclusivity. In 2000, the FDA started allowing generic entry following a first favorable court decision irrespective of a final court ruling. In 2003, the FDA started giving 180-day exclusivity to multiple applicants filing on the same first day. In 2006, *KSR v. Teleflex* lead to a new standard of obviousness for patents and in 2007, *Medimmune v. Sun Pharma* established new standard for non-infringement.

initial Para-IV filing and invoking non-concurrent 30-month stays for each patent allegedly infringed.[9] In more recent years, due to changes in the Medicare Act of 2003, pharmaceutical firms have been limited to one 30-month stay per product. Generic manufacturers have also been given greater leeway in their use of the 180-day exclusivity period granted to first-filers under the law. Finally, recent court rulings have made it easier to demonstrate patent invalidity and harder to demonstrate infringement.

In the early 1990s ANDA applications with Para-IV certifications accounted for about 10-20% of all generic entry, however, by the end of the 2000s they accounted for more than 40% (Higgins and Graham, 2009; Berndt *et al*., 2007). Teva Pharmaceuticals is the most prolific filer of Para-IV challenges although there has been increased activity in recent years by Indian generic manufacturers. In 2007, Teva's Annual Report claimed that 92 of their 160 ANDA filings were Para-IV challenges putting at risk over $100 billion in branded sales.[10] Because the costs of challenging a patent are a relatively small -- $5 million (American Intellectual Property Law Association, 2007) -- compared with the large, average, potential payoff of $60 million for the 180-day generic exclusivity period (Federal Trade Commission (FTC), 2009), generic manufacturers have begun to engage in "prospecting" by filing numerous ANDAs with Para-IV certifications. Evidence suggests that these challenges are occurring earlier in a branded products lifecycle (Panattoni, 2011; Saha *et al*., 2006; Grabowski, 2004; Scherer, 2001) and now affect smaller market drugs with yearly sales under $100 million; "blockbusters" are not the only target (Grabowski and Kyle, 2007). Moreover, in a recent event study, Panattoni (2011), reports cumulative abnormal market losses of slightly over $1 billion when a pharmaceutical firm losses a Para-IV case in court.

Studying the outcomes of the 104 ANDA applications with Para-IV certifications, the FTC found that 75 of these applications had resulted in litigation (FTC, 2002). Of the 53 cases that had been resolved, 22 (42%) were resolved in the generic manufacturer's favor thus allowing a generic product introduction prior to the expiration of the branded product's patents. As we have already noted, regulatory and legal changes have increased the ability of generic manufacturers to mount successful challenges. In an effort to counteract the increase in Para-IV certifications (more than 230 were filed in 2010) pharmaceutical firms have turned to authorized generic agreements (FTC, 2009).[11] That is, pharmaceutical firms exercise their right as patent owners to license their technology to a generic manufacturer, and that generic producer then enters the market at a low price. This means that a successful Para-IV challenger will confront a triopoly, not a duopoly, and will earn lower profits. Pharmaceutical firms may have hoped that the use (or threat of use) of authorized generics producers might have reduced the incentives for Para-IV challenges and, therefore, their incidence. However, the evidence suggests otherwise (Berndt *et al.*, 2007a; Berndt *et al*., 2007b). Evidence also exists that pharmaceutical firms have engaged in out-of-court settlements to delay entry (FTC, 2002; Bulow, 2004) and

[9] The interested reader can see Bulow (2004) for a more complete discussion.
[10] U.S. SEC, Form 20-F, (December 31, 2007); http://www.tevapharm.com/pdf/teva20f2007.pdf.
[11] http://money.cnn.com/2011/03/11/news/companies/big_pharma_lawsuits.fortune/index.htm

maintain patent monopolies. This practice has attracted the attention of antitrust authorities, however, the Supreme Court recently refused to overturn the practice.[12] Regardless of any efforts by pharmaceutical firms, the intensity of Para-IV certifications has remained high.

To summarize, over the years of our sample period (the late 1990s-2008), a series of legal and procedural changes turned Para-IV certifications from a rare occurrence to a first-order challenge to the profitability of the branded pharmaceutical industry. We will think of these changes as a kind of gradually unfolding natural experiment. Collectively, these changes substantially reduced the cost of a Para-IV certification and dramatically increased their likelihood of success. Thus, the measured increase in Para-IV certifications will be viewed largely as a response to the exogenous (at least from the point of view of any one generic challenger) policy shift. In addition to presuming that the overall increase in incidence of Para-IV challenges was largely exogenous, we also posit that there was a strong element of exogeneity in determining which branded products were ultimately challenged.[13] The patents protecting most products hit with a Para-IV certification were written before such challenges became prevalent (Knowles, 2010). The weakness of some of these patents in court proceedings was evident, in many cases, only in hindsight.

2.2 Cross-molecular substitution

Most prescription health plans in the U.S. allow for the use of branded products until generics become available. In most cases patients will be given the generic by retail pharmacies unless the prescription is written "Dispense as Written" or if the patient explicitly asks for a branded drug (in which case there is usually a much higher co-payment). More recently, however, insurance firms have begun to engage in "cross-molecular" substitution. For example, let's assume there are 3 branded products in a particular market, *Drug A*, *Drug B* and *Drug C*, sold by three different pharmaceutical firms and that *Drug B* just lost a Para-IV challenge in court and a generic, *Generic B*, has entered the market. Cross-molecular substitution exists when insurance companies attempt to encourage patients taking *Drug A* or *Drug C* to switch to *Generic B*. While insurance firms cannot force patients to move they can entice them with lower (or no) copayments for *Generic B*. Table 1 provides an example extracted from a letter Blue Cross Blue Shield of Georgia (BCBSGA) sent to patients suggesting generic alternatives to different branded products across several therapeutic categories. In the letter BCBSGA offered to pay for the generic co-pay for a period of three months.

The implications of cross-molecular substitution are significant. For pharmaceutical firms with branded products, cross-molecular substitution implies that their drug's market protection is only as strong as the

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[12] On March 7, 2011, the Supreme Court rejected a challenge to a 1997 settlement in which Bayer AG paid Barr Pharmaceuticals to drop an early bid to market an antibiotic.
http://online.wsj.com/article/SB10001424052748703386704576186713514684524.html

[13] Evidence exists that both large market (Panattoni, 2011) and small market (Grabowski and Kyle, 2007) have been targeted. Recent work by Hemphill and Sampat (2010) make a first attempt to explore characteristics of patents in order to understand the likelihood of generic challenge.

weakest protected drug in a particular market. In the above example, the transition from *Drug A* and *Drug C* to *Generic B* is occurring irrespective of the underlying IP protection or exclusivity periods for those drugs. This activity has obvious welfare implications; the gains to consumers are potential larger since patients from *Drug A* and *Drug C* can potentially benefit but the producer loss will also be larger because the incumbents that market *Drug A* and *Drug C* will lose revenues. The extent of these impacts will vary across therapeutic categories as some drugs are more easily substitutable. For example, we would expect higher substitutability in markets such as hypertension and allergy and lower substitutability in markets such as depression and epilepsy.

3 Related literature

This paper draws upon the literature of welfare estimation and demand modeling dating back to Trajtenberg's (1989) pioneering work on the CT scanner industry. Trajtenberg, in turn, built upon an even older literature relating discrete consumer choices to product characteristics (Lancaster, 1966; McFadden, 1973; Lancaster, 1977). This approach has proven extremely useful in studying product choice in the presence of significant product differentiation (Anderson *et al*., 1992), and it has been applied to a range of industries, including , automobiles (Petrin, 2002 and Goldberg 1995), digital goods (Brynjolfsson and Smith, 2003), personal computers (Bresnahan *et al.*, 1997), Medicare HMOs (Town and Liu, 2003) and banking (Dick, 2008). Methodological improvements have also permitted researchers to utilize these models using aggregate data in the absence of consumer level data (Berry, 1994; Berry *et al.*, 1995 and 1999). Given their theoretical underpinnings it is also worthwhile to note that discrete choice models have been applied to understand a variety of economic situations beyond studying the social value of new goods. For example, Nevo (2000, 2001) examines price competition and mergers in the ready-to-eat cereal industry and Davis (2000) studies spatial competition in movie theaters, while some other papers have used this framework to understand gains from trade and globalization (Broda and Weinstein 2006; Clerides 2008).

These approaches have also been applied to the pharmaceutical industry, although researchers have had to confront some additional challenges unique to this sector. Products are highly differentiated and the choice of a particular product is often made by agents of the consumer (*i.e.*, doctors) versus the consumers themselves. Consumer choice can also be influenced by the presence (or not) of insurance coverage. Notwithstanding these difficulties, Ellickson *et al.* (2001) explore patient welfare from new drugs and find that gains are contingent upon compliance and the role of the physician. Stern (1996) employs a discrete-choice framework to estimate demand to evaluate patterns of substitutability between branded and generic drugs. Ellison, *et al.* (1997) models demand in order to compute substitution elasticities between branded and generic antibacterial drugs. More recently, studying the U.S. anti-depressant market Cleanthous (2002) finds large welfare gains from drug innovation; Bokhari and Fournier (2009) report welfare gains due to first time generic entry; and, Dutta (2011) analyzes the welfare impacts of stronger intellectual property (IP) in India. Other complementary work has

focused on the enhancements to social welfare through reductions in mortality, morbidity and total medical expenditures Lichtenberg (1996a, 1996b, 1998, 2001, and 2005).

In addition to work that quantifies welfare effects from product innovation using discrete choice models, this paper also relates to other work focusing on various dimensions and implications of generic entry (Caves *et al*., 1991). Saha *et al.* (2006) report the dramatic rise in generic introductions since the passage of Hatch-Waxman while Reiffen and Ward (2005) show that the cost to obtain generic drug approval has decreased. Time to market for generics after branded product patent expiration has also declined substantially, from approximately three years prior to Hatch-Waxman to only one to three weeks (Congressional Budget Office, 1998).[14] Other research has focused on entry decisions by generic manufacturers (Morton, 1999, 2000; Grabowski and Vernon, 1992, 1996; Berndt *et al.*, 2003, 2007; Frank and Salkever, 1997; Hurwitz and Caves, 1988; Hudson, 2000; Appelt, 2010), prices (Danzon and Chao, 2000a, 2000b), price controls (Kyle, 2007; Danzon *et al*., 2005; Lanjouw, 2005) and entry costs (Djankov *et al.*, 2002).

Researchers have also recognized the potential that accelerated generic entry can have on the incentives to develop new drugs. Terming the phenomenon 'Napsterization of Pharmaceuticals', Hughes *et al.* (2002) show in theoretical work that providing greater access to a current stock of prescription drugs yields large benefits to existing consumers. However, this access comes at a cost in terms of lost consumer benefits from reductions in the *flow* of future new drugs. This trend could be problematic since newer drugs have been shown to be positively related to life expectancy (Lichtenberg, 2005) and in lowering non-drug medical spending of all types (Lichtenberg, 2001). This potential problem has been discussed by recent researchers (Grabowski and Kyle, 2007; Higgins and Graham, 2009; Graham and Higgins, 2010; Knowles, 2010; Panattoni, 2011) and the extant literature provides ample evidence *suggesting* that acceleration of generic entry has undermined incentives for R&D. What is still lacking in the literature, however, is firm econometric evidence demonstrating that generic entry has actually led to a decline (or changes) in R&D investment that can be plausibly ascribed to the generic entry itself. Any complete welfare analysis of Hatch Waxman must account for both the short-run gains to consumer welfare that stem from more rapid generic entry and the possible longer-run losses that result from reduced investment in pharmaceutical R&D. Our current paper focuses on the short-run gains to consumer welfare; ongoing research by the authors is examining the longer-run issues.

4 Data and methodology

Previous research in this area has struggled with data limitations. We are fortunate to have access to a range of unique and comprehensive data sets that provide us with powerful leverage over some of the econometric challenges we confront. First, data from Parry Ashford Publications (www.paragraphfour.com)

[14] Berndt and Aitken (2010) provide an excellent summary of the increase of generic competition in the U.S. over the last decade.

allows us to identify each Para-IV certification dating back to 2003.[15] This data provides full drug level information about the challenge and outcome which we can link to our other data resources. For data prior to 2003 we filed a Freedom of Information Act (FOIA) request with the FDA. Next, we gathered demand side information for the drugs (and markets) where challenges occurred. For this we turned to the IMS MIDAS™ database which provides sales (quantity) and revenue information for every product sold by every firm, across all therapeutic disease categories, branded and generic, in the U.S. This database also provides information on dosages and expected market exclusivity expiry dates. All branded products are also listed in the FDA Orange Book, and this database provides an alternative source for approval, data exclusivity and patent expiry dates. Our final sample covers 1997 to 2008 and unlike the prior literature (Dutta, 2011; Cleanthous, 2002) that use annual data, we instead utilize quarterly data. This choice is necessary so we can more accurately track entry (and subsequent entry after 180-day exclusivity periods granted to first-filers) by generics. The start date for the sample is due to data constraints with IMS MIDAS™. We do not believe this causes any bias in our results since, as we demonstrate below, few Para-IV challenges occurred prior to 1997.

A key aspect of our methodological framework is the definition of our market and how it relates to the measurement of the outside good. We choose to focus on the U.S. hypertension market as our initial research setting. The market is large; for example, in 2007 the American Heart Association estimated the burden of hypertension on the healthcare budget to be close to $60 billion (see Figure 4). This category of disease is medically significant too, with prevalence around 26%-29% of the population in 2008.[16] We consulted experts at the Center for Disease Control (CDC) to help retrieve disease prevalence statistics for hypertension from the National Health Interview Survey (NHIS), which we discuss more fully below in Section 4.1.2. Para-IV certifications have also been active in this market. Finally, discussions with physicians suggest a relatively high degree of substitution across different drugs, allowing for cross-molecular substitution. Inspection of product level data confirms the reality of extensive cross-molecular substitution in this market.

4.1 Demand estimation – nested logit model

Our potential market is all prospective U.S. hypertension patients who might consume one of a number of drugs spread across six specific drug categories used broadly to treat hypertension (see Table 2).[17] Our product level data are organized in a taxonomy known as the anatomical therapeutic chemical (ATC) classification system, and we will refer henceforth to ATC codes and categories. As identified in the table, we

[15] Para-IV certification data only became publicly available in 2003. In order to supplement the data prior to 2003 we filed a FOIA request with the FDA. Other researchers (Berndt *et al*., 2007) have used survey data in order to capture pre-2003 activity. In a recent study, Panattoni (2011) collected data from District Court decisions.

[16] See http://www.cdc.gov/nchs/data/databriefs/db03.pdf.

[17] The ATCs used to define the market are: (1) C7A0 BETA-BLOCKING AGENTS, PLAIN; (2) C7B1 BETA-BLOCKERS IN COMBINATION WITH HYPOT/DIURETICS; (3) C8A0 CALCIUM ANTAGONIST, PLAIN; (4) C9A0 ACE INHIBITORS, PLAIN; (5) C9B1 ACE INHIBITORS USED IN COMBINATION+A-HYP/DIURETICS; and, (6) C9B3 ACE INH COMB+CALC ANTAG. Angiotensins and their combinations with calcium antagonists or diuretics (C9C0+C9D1+C9D3) have not faced patent expiration or Para-IV challenges and were thus excluded from the sample.

assign chemically distinct products to different categories. A drug containing a single active ingredient is treated differently from a drug that combines multiple active ingredients; each chemically distinct category will be classified as a "molecule" (even though some substances may combine multiple active ingredients). We follow Berry (1994), Stern (1996) and Dutta (2011) and model demand with a nested logit model. Formally, let *M* be the number of molecules (including combinations) being sold in the hypertension market, M_1, M_2,…..M_N. Let S_k be the set of all products that contain molecule M_k. Consumer *i*'s utility from consuming firm *j*'s product in molecule *m* is given by (excluding a time subscript):

$$u_{ijm} = \delta_{jm} + \vartheta_{im} + (1-\sigma)\varepsilon_{ijm} \quad (1)$$

All products in a molecule (that is, all products that possess the same active ingredient or same combination of active ingredients) are presumed to be closer substitutes than chemically different products associated with other molecules. In the language of discrete choice models, we think of them as belonging to the same "nest." Our approach also allows for the possibility of substitution across molecules. This was based on direct conversations with physicians, who maintain that it is consistent with their prescribing behavior and consistent with published prescription guidelines.[18] As an example, in Table 1, BCBSGA is attempting to induce patients to switch from branded drugs made with the molecule nifedipine to generic drugs made with the molecule amlodipine.

In Equation 1, σ captures the correlation of consumer choices between molecules (or the degree of substitution across molecules) and the ε_{ijm} are i.i.d. extreme value. ϑ_{im} is common to all drugs that belong to the molecule *m* and Cardell (1997) proves that since the ε_{ijm} are i.i.d. extreme value so is $[\vartheta_{im} + (1-\sigma)\varepsilon_{ijm}]$. As σ approaches 1, the within molecule correlation of utility levels converges to 1 and indicates perfect substitutability of the molecules. In other words, if σ approaches 1, products within a molecule are no more close substitutes for one another than products in a different molecule. If, on the other hand, σ approaches 0, then there is no substitution across molecules. An important test of the validity of our estimation procedure will be an estimated value for σ that lies between 0 and 1. δ_{jm} is the mean utility of the product, is invariant across consumers (*i.e.*, patients) and is a function of observed product characteristics (x_{jm}), price (p_{jm}) and unobserved product characteristics (θ_{jm}) that could affect utility. Formally, the mean utility can be specified as follows:

$$\delta_{jm} = \beta x_{jm} - \alpha p_{jm} + \theta_{jm} \quad (2)$$

Following Berry (1994), market shares in this framework are given by:

[18] See http://www.nhlbi.nih.gov/guidelines/hypertension/phycard.pdf

$$s_{j|m} = \frac{e^{\delta_{jm}/(1-\sigma)}}{D_m} \tag{3}$$

where $s_{j|m}$ is the probability of choosing a product *j*, given a choice of a molecule *m* and D_m is:

$$D_m = [\sum_{h \in S_m} e^{\delta_{hm}/(1-\sigma)}] \tag{4}$$

The probability of choosing molecule *m* is given by:

$$s_m = \frac{D_m^{1-\sigma}}{[1+\sum_k D_k^{1-\sigma}]} \tag{5}$$

Thus, the market share of product *j* in molecule *m* is given by:

$$s_{jm} = s_m s_{j|m} \tag{6}$$

Finally, the share of the outside good in this model is given by:

$$s_0 = \frac{1}{[1+\sum_k D_k^{1-\sigma}]} \tag{7}$$

Berry (1994) then demonstrates that this can be substituted and worked out into a linear estimable specification:

$$\ln(s_{jm}) - \ln(s_0) = \beta x_{jm} - \alpha p_{jm} + \sigma \ln(s_{j|m}) + \theta_{jm} \tag{8}$$

The expression in Equation (8) gives us the mean utility from Equation (2) along with a conditional share term, $\sigma \ln(s_{j|m})$, which captures within group correlation. Depending on the nature of the product characteristics vector, the expected sign of the elements in the coefficient vector β can either be positive or negative. For example, if the focal product characteristic is the number of contraindications for a drug then one might reasonably expect a negative coefficient; its usage may be more limited because of the larger number of contraindications. On the other hand, if the focal product characteristic is advertising then we might reasonably expect a positive coefficient. The sign of the price coefficient, α, is expected to be negative and σ should be between 0 and 1 assuming a large enough market such that the conditional shares on the right-hand side (RHS) are different from the unconditional shares on the left-hand side (LHS). Without the conditional within-group

term, $\ln(s_{j|m})$, on the RHS, Equation (8) would reduce to a simple multinomial logit specification, which we include as a robustness check.

Our approach carries with it the important benefits of simplicity and ease of estimation, and recent related work using discrete choice models to measure the welfare impact of changes in the monopoly power of pharmaceutical producers (*e.g.*, Dutta, 2011) has demonstrated its usefulness in that context. Of course, these benefits come at a cost. Unlike the more complicated approach of Berry, Levinsohn, and Pakes (1995) -- which we will denote hereafter as BLP -- we do not simultaneously estimate the core parameters of a discrete choice demand model with those of a fully specified supply side model, nor do we allow for an interaction between consumer and product characteristics, either at the individual level or at the market level. Our particular distributional assumptions and the "nests" we impose on the data necessarily restrict the substitution possibilities across products in ways that BLP are able to avoid. While we explore the empirical implications of alternative nesting structures for our core conclusions, we are unable to estimate the differential reactions of different kinds of consumers to product characteristics with our current approach. These are important considerations, and the eventual combination of our rich data on product level sales and characteristics with extensive data on the demographic characteristics of consumers using these drugs is the focus of ongoing research.[19] However, the effective combination of these data presents its own challenges, and, given the current absence of any credible estimate of the welfare impact of Para-IV entry on U.S. drug consumers, our current approach would seem to offer an expedient path to an informative, if incomplete, estimate of the welfare impact that could be compared with the revenue losses of incumbent producers.

Finally, Equation (8) includes variables on the right hand side that could be endogenous and/or correlated with omitted variables in the error term. These concerns extend to the conditional share term capturing substitutability, $\ln(s_{j|m})$, and price, p_{jm}. We include data on advertising expenditures for particular products, and this variable could also be endogenous. Therefore, we consider the use of instrumental variables, which we discuss below.

4.1.1 Quantities and prices

As we indicated above, our unit of observation is molecule-firm-brand-quarter, which means that if two branded firms and a generic firm are each selling chemically identical products, we still treat each of the three products as distinct, and we track sales on a quarterly basis. IMS MIDAS™ provides sales data in Standard Units (SU). The SU measurement is designed to equate different dosage forms (*e.g.*, tablets, capsules, liquid) into comparable patient dosages. Products that have multiple presentations of a molecule sold by a

[19] The National Health Interview Survey (NHIS) is an annual, large-sample, comprehensive survey of Americans' health status, and the data collected include information on the incidence of diseases like hypertension and the consumption of particular categories of drugs, as well as important demographic information on the survey respondents. In principle, these data on the distribution of consumer characteristics within the drug consuming population could be integrated into our analysis, as in Cleanthous (2002).

single firm are aggregated together. Revenues are reported over the same period and are converted into real dollars using a base year 2000 GDP deflator. For each quarter observation, wholesale price is defined as revenues divided by SU sales.

4.1.2 Hypertension market and unconditional shares

We consulted experts at the CDC to help retrieve and construct disease prevalence statistics for hypertension from the National Health Information Survey (NHIS). Specifically, for children and adults, we retrieve counts of the number of U.S. residents taking the NHIS who answered that they ever had hypertension or the related conditions of high blood pressure, a heart condition, or coronary heart disease. CDC recommended weightings were then applied in order to back out national estimates of hypertension prevalence.[20]

To create a correspondence between sales data (pill-level) and prescription-level data or the number of patients consuming hypertension drugs, we impose an assumption on the length of treatment. For this we assume chronic intake of hypertension drugs (*i.e.*, patients stay on the drug throughout a year) and combine this with prescription-level data on average treatment days from the IMS National Prescription Audit™ (NPA) and the IMS National Disease and Therapeutic Index™ (NDTI), supplemented with information from medical references. We take our estimates of the number of patients with hypertension and multiply this by 90 (days in a quarter) and then by 4 (four quarters in a year). This multiplication yields the potential market size for hypertension drugs. We therefore define the unconditional share for a particular quarter, s_{jm}, as brand level sales divided by our estimate of the potential market size, in SU.

4.1.3 Outside good share

The approach in Section 4.1.2 also allows us to create the outside good measure, s_0 or the number of potential patients with hypertension that are *not* actively receiving drug treatment. In any given quarter, we can sum hypertension drug sales across all relevant ATC categories and compare that with the overall *potential* market derived from the CDC NHIS data above, the difference is our measure of the outside good.[21]

4.1.4 Conditional share

Equation (8) includes the term $\ln(s_{j|m})$ which captures within group correlation, σ, or, as we argue, provides an average measure of cross-molecular substitution. Construction of the numerator is defined as branded product-level sales for each quarter. The denominator is the summation of all sales for a specific

[20] For more information on the CDC weighting recommendation and methodology please see:ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2009/srvydesc.pdf

[21] We experiment with the outside good measure in various ways, since its reasonable computation might have a bearing on the results. This involved imposing different assumptions on the length of treatment and reconciling all the measures of outside good shares with epidemiological estimates of U.S. patients who are aware of they being hypertensive but are not getting treated (for a variety of reasons). Our findings remain robust to these various measures and are available from the authors upon request.

molecule (branded and generic) in each quarter. Using the calcium channel blocker Norvasc® and Q1:2000 as an example, the numerator would be Norvasc® sales in Q1:2000 divided by all the sum of products (branded and generic) that contain the molecule amlodipine.

4.1.5 Product Characteristics

Formal modeling of demand in this setting occurs in a manner such that the utility of a consumer from consuming a drug product, in a certain time period, is a function of product characteristics, observed and unobserved. Following the extant literature (*e.g.*, Stern, 1996; Cleanthous, 2002; Dutta, 2011), we include information on drug side effects. More specifically, we use drug-label information, cross-checked with medical references, to gather the number of contraindications (*i.e.*, circumstances under which the drug cannot be safely taken) for each drug. Advertising expenditures on a product are also a significant determinant of sales and the literature points to biases in demand estimates without advertising (Moul, 2006). As a result, we incorporate product-specific detailing information from IMS MIDAS™. Detailing data is comprised of three components: (1) direct journal advertising, (2) direct mail advertising and (3) direct interactions between drug representatives and physicians. We aggregate three forms of detailing together at the product level, converting all financial variables to real dollars. We do not possess quarterly data on direct-to-consumer advertising (DTC) but since physicians are acting as agents on behalf of patients (consumers), it can be argued that detailing is a critical component of a pharmaceutical firm's advertising strategy. Rosenthal *et al.* (2003) supports this notion and demonstrates that total promotion expenditures were approximately 14% of sales. Of this 14%, DTC comprised 2.2% while total physician promotion accounted for 11.8%. Finally, because there are important product attributes that are difficult to measure consistently across products we include product-specific fixed effects. These fixed effects will vary across products but not over time.

4.2 Instruments

A clear econometric challenge arises with respect to price, the level of advertising, and the conditional share term. All of these variables are potentially correlated with the unobserved product characteristics, θ_{jm}, in Equation (2), a problem that is well recognized in the demand estimation literature (*e.g.,* Berry, 1994; Berry *et al.*, 1995, 1999; Nevo, 2000). Consistent with other studies (*e.g.,* Stern, 1995; Cleanthous, 2003; Dick, 2008; Dutta, 2011) we use two competition related instrumental variables and one related to product design that are less likely to be correlated with the error term.

Our first instrument is the count of dosage levels in which a product is available, *Form Numbers*. FDA data allows us to track changes in these numbers over different molecules. As Stern (1996: p.18) points out "Unless consumers value products sold by a particular firm because it is a multiproduct firm, measures of multiproduct ownership will be correlated with price and advertising, but be uncorrelated with unobserved quality." The second instrument we employ is the *Time Since Generic Entry* and is coded as 0 for all

observations before entry into a molecule market. After entry a counter starts and increases by one unit for each quarter that elapses. Our final instrument is the *Number of Firms* (branded and generics) selling products across the market. The second and third instruments relate to the level of competition in the market, and under the assumption that entry is exogenous, should be uncorrelated with unobserved product characteristics. For all instruments we also used lagged values. The results of the standard over-identification tests are reported below.

4.3 Consumer surplus (CS) and counterfactual analysis

4.3.1 Real world

Given the coefficient estimates on price and product characteristics, quarterly consumer surplus in the nested logit model outlined above follows Small and Rosen (1981) and Train (2003) and is given by:

$$CS_{real} = \frac{1}{\alpha} * P * \ln\left[1 + \sum_{m \in M_n} \sum_{j \in J} exp^{\frac{\delta_{jm}}{(1-\sigma)}}\right] \quad (9)$$

Where *P* captures prevalence information and is converted into daily-doses using our previously discussed length of treatment assumption (see Section 4.1.2). Within the bracketed term, 1 represents the utility derived by the average consumer from consuming the outside good; the remaining expression comes from the indirect utility derived by the average consumer, through coefficient estimates applied on realizations of price and product characteristics (Train, 2003).[22] The double summation term implies that the indirect utility in each quarter is first summed across all products (brands, generics and Para-IV generics) within a molecule and then across all molecules. The entire expression is then logged, multiplied by *P* and $\frac{1}{\alpha}$ (where α is the coefficient on price and is defined as the marginal utility of income) in order to express consumer surplus in dollar terms.

4.3.2 Counterfactual world

In order to understand the impact of Para-IV early generic entry we need to establish the counterfactual which will allow us to determine the consumer surplus generated had there not been entry before patent(s) expiry (*i.e.*, end of market exclusivity) by the generic entrants. In constructing the counterfactual consumer surplus series we first drop the Para-IV generic entrants (and the subsequent follow-on generic entrants that entered as a result of the Para-IV action after the 180-day exclusivity period) but retain the branded pharmaceuticals along with the generics that entered *after* patent expiry or the end of market exclusivity.

We need to make several assumptions relating to pharmaceutical firm action in this counterfactual world. First, we assume a pharmaceutical firm would not launch a product reformulation or me-too drug since they would end up cannibalizing sales of their existing product. Second, we assume that the pharmaceutical

[22] It is important to note that δ_{jm} in our specification not only includes the product characteristic variables, number of contraindications, detailing, but also price, and further, the constant term and the coefficient on product fixed effects that are generated in the regressions.

firm follows pre-entry trends in terms of price and advertising until the end of market exclusivity, after which they follow normal post-entry trends in the face of normal (non Para-IV) generic entry. As a consequence of these assumptions we are able to impute price and advertising from the quarter of Para-IV generic entry until patent expiry of the incumbent's product. We have tested the accuracy of our counterfactual predictions by using early sample data to estimate late sample prices, quantities, and advertising in markets where generic entry never occurred. We find that our predictions track actual values fairly closely.[23] We repeat the calculation outlined in Equation (9) to create a $CS_{counterfactual}$ series by quarter with the difference between the two consumer surplus series giving us welfare going to consumers as follows:

$$W = CS_{real} - CS_{counterfactual} \quad (10)$$

In order to get a sense of the plausibility of these CS estimates we need to reconcile them with the average patient's annual drug expenses, estimates of surplus in hypertension in other economies, and producer surplus figures. We discuss all these issues below.

4.4. Robustness - alternative nesting strategy

While our exposition, and our results, suggest a high degree of cross-molecular substitution in the hypertension market, it is useful to consider the robustness of our results to alternative characterizations of the market. One logical way to do this is to segregate hypertension drugs into broad categories based on the biochemical pathway through which the drug treats the underlying disease. Broadly speaking, three major categories of hypertension drugs coexist during our sample period: ACE inhibitors, beta blockers, and calcium channel blockers. We will not go into the biochemical details of the different ways in which these drugs treat hypertension, but the differences are substantial enough that each of these categories is independently recognized in the ATC classification system.

We consider two substantially different ways to nest hypertension drugs in the product space. We could imagine that consumers choose molecules but not treatment categories, and model consumer choice as being one in which consumers are just as likely to substitute a beta blocker for an ACE inhibitor as they are to substitute between ACE inhibitors. This is the approach described above. An alternative is to model consumers as first choosing a treatment category – ACE inhibitors, beta blockers, or calcium channel blockers – then choosing molecules within (but not outside) these categories. This second approach allows for significant cross molecular substitution within categories, but zero substitution across them. The reality of prescription and consumption behavior probably lies somewhere between these sharply different modeling approaches. If, however, we can demonstrate that estimated consumer gains are broadly similar, regardless of which approach we take, then that would engender greater confidence in our results and suggest that they are not simply an

[23] We thank Brian Kovak for this suggestion. Results of this test are available from the authors upon request.

artifact of a particular approach to demand modeling. As it turns out, our estimates, which we discuss below, do appear to be robust to this alternative nesting strategy.

5 Empirical results

5.1 Descriptive statistics

Table 3 summarizes descriptive statistics for the hypertension market and the products we focus on in this study. Panel A presents the variables directly related to our demand estimation: market size, price, quantity sold, number of contraindications, product level detailing (advertising), share of the outside good and unconditional share. The hypertension market is both medically important and economically meaningful with quarterly sales averaging $3.9 billion and ranging between $2.5 billion and $5.0 billion. Average real price per SU was approximately $0.90 and average sales were approximately 16 million SUs each quarter. We note that maximum price is in excess of $100 which is due to the presence of injectable brands in our sample; we have four such branded products. While product-level variation exists, there are, on average, three contraindications per product. Aggregate quarterly detailing, on average, was $1.67 million for branded products and zero for generic products. The share of the outside good averaged 43% while the unconditional share averaged 0.90% per quarter. Finally, we observe that the number of firms, including both branded and generic, per quarter ranged from 54 to 73 during our sample period.[24]

Panel B summarizes the impact of Para-IV entry on our branded hypertension products. Prices, on average, decreased by 20% for all products after entry in challenged markets. For each molecule where there was entry the pharmaceutical firm increased branded price by 23%. This is not unexpected since the remaining brand consumers will have a more inelastic demand (Bhattacharya and Vogt, 2003). In the quarter of entry we find that the discount factor offered by the generic entrant is approximately 38% in comparison to branded product prices, however it varies widely depending on the type of drug. For example, in one case the discount factor offered in the quarter of entry was just over 97%. Figure 5 illustrates the variability in these discount rates. For illustrative purposes we include drugs from other markets in addition to hypertension to show the variability in these discount rates.

Another key feature in the data is the intensity of entry that follows a Para-IV challenge (*i.e.*, other follow-on generic firms that enter once the generic entrant's 180-day exclusivity period ends). Across therapeutic markets there are, on average, 17 subsequent generic entrants. This subsequent follow-on entry, more so than the first (Para-IV) generic entrant, drives prices down and compresses pharmaceutical firm revenue. For example, during the first year after Para-IV entry, average branded pharmaceutical product revenues eroded by an average of 52% collapsing to almost 90% after this first year.

[24] These numbers are for disaggregate data. For our analysis in order to avoid issues with trivial market shares we aggregate all generics generating prices for them weighed by sales. Incumbent brands are retained with no modifications.

5.2 Results

5.2.1 Coefficient estimates

The nested logit demand regression results are reported in Table 4 and for robustness purposes multinomial regression results are reported in Table 5.[25] Recall that the dependent variable, defined in Equation 8, is the difference between the logs of the conditional share and share of the outside good. Focusing on the nested logit results, Model 1 (Table 4) presents results utilizing instrumental variables. Several items are worth noting. First, the sign on the coefficient *Price* is negative (-0.303) and statistically significant. When we compare this coefficient estimate for hypertension with those obtained from recent work on other therapeutic markets, our results lie within the range of results obtained by those authors. For example, Stern (1996) uses aggregate U.S. data across four therapeutic categories from 1978 to 1991 and finds a price coefficient ranging between -0.91 and -10.95. Cleanthous (2002) uses aggregate data on depression from 1980 to 2001 and finds a price coefficient of -1.93. A more recent comparison is with Dutta (2011) who uses a panel of drugs across various therapeutic markets to estimate pharmaceutical demand in India. For anti-hypertensive drugs she reports a price coefficient of -0.07, perhaps indicative of how elasticity of demand varies across different countries.

The results also point to strong evidence of cross-molecular substitution; the coefficient on the within-group term $ln(s_{j|m})$ is positive (0.497) and significant. This indicates a fair amount of substitutability across molecules within hypertension markets. Discussions with physicians and drug substitution guidelines issued by a major insurer also attest to a high degree of substitution across molecules. The overall impact of Para-IV entry on consumers and producers is likely to be much greater in treatment areas with high levels of cross-molecular substitution. In terms of the signs on the other variables, our results seem to follow economic intuition. Shares are decreasing in number of contraindications for drugs, which is to be expected. Finally, the coefficient on the log of advertising, *ln(adver)*, is positive and significant providing evidence of its critical role in influencing drug demand.

5.2.2 Welfare implications and counterfactual analysis

Welfare calculations are derived using Equation (10). Cumulative consumer surplus generated from 1997 to 2008 was approximately $270 billion. This includes *all generic entry* with all choice sets available to the consumer. Average quarterly consumer surplus generated from this calculation is approximately $5.7 billion

[25] When σ approaches 1 (perfect substitutability) $\ln(s_{j|m})$ becomes 0 and the nested logit simplifies to a multinomial logit. Demand is now solely a function of mean utility, δ_{jm} and products with the same market shares will have the same cross-price elasticities. The implication of this restriction implies that if Sular and generic amlodipine are found to have the same market shares and there is a decrease in the price of Norvasc (all three are calcium channel blockers), then the logit model suggests that its effect on Sular's demand would be the same as the effect on the demand for generic amlodipine.

or about $23 billion per year. When we remove the Para-IV facilitated generic entry from the sample and generate consumer surplus in a counterfactual world the figure drops to approximately $177 billion. This implies that early Para-IV generic challenges created a cumulative consumer surplus of $92 billion over our time period in the U.S. hypertension market (see Figure 6). Hatch-Waxman set out to strike a balance between access and innovation; for the first time we have been able to quantify the benefits to consumers as a result of the early entry via Para-IV challenges.

The average quarterly consumer surplus in the counterfactual world is about $3.8 billion ($5.7 billion in the real world), suggesting that in each quarter of our analysis, Para-IV entry delivered gains to the consumer of just over $2 billion or $8 billion annually. These are large flows that can be explained by lower prices and the expansion in the consumer choice set. To illustrate the size of these gains for expositional purposes, we can re-express them in terms of cost savings per-dose of medication.[26] If we assume that, on average, 60 million consumers in the U.S. are annually suffering from hypertension and that all of them took medication for this condition (a counterfactual, but illustrative assumption), this translates to annual consumption of 21.6 billion pills (60 million * 360), assuming chronic intake. Given annual consumer surplus gains of $8 billion, this amounts to per pill consumer gain of approximately $0.37 which translates to a yearly savings of $133 per consumer. Given the high incidence of prescription drug insurance coverage in the U.S., a question remains however as to whether the full welfare gains flow through to consumers or whether some of that value is appropriated by the insurance industry, an issue we raise below.

5.2.3 Robustness - alternative nesting strategies

In Section 4.4 we discussed alternative ways of partitioning the product space and modeling consumer choice across potential substitutes in the hypertension market. In the main results stressed in this paper, we "nest" or cluster products into groups with the same active ingredient(s), but we do not impose any additional structure on consumer choices, and we allow for relatively unconstrained substitution across the major subcategories of hypertension drugs, such as ACE inhibitors, calcium channel blockers, beta blockers, and their combinations.

An alternative approach is to allow for substitution across molecules within a subcategory (*i.e.*, ACE inhibitors and drugs containing ACE inhibitor compounds), but not across subcategories. We treat the subcategories as distinct markets. Discussions with prescribing physicians suggest that the reality is somewhere between the assumptions we made in the previous section and the assumption we make here. Fortunately, we can demonstrate that we get broadly similar estimates of consumer surplus gains, regardless of which set of assumptions we make. Table 6 reports the coefficients we obtain for the parameters of our indirect utility function when we estimate demand by subcategories. Table 8 reports the difference between real and

[26] This back-of-the-envelope calculation is offered purely for expositional purposes, to help readers comprehend the magnitude of estimated gains.

counterfactual consumer and producer surplus when we calculate both measures by subcategories. The results are not that different from those described above.

5.2.4 Welfare for whom? And at what cost?

A number of issues arise when considering these estimates of consumer surplus. First, how do these gains compare with producer surplus losses, and are their net social gains? Such a comparison requires an estimate of what producer prices and quantities would have been in a counterfactual world without Para-IV generic challenges. We find that we are able to predict incumbent sales and price outcomes with surprising accuracy, simply by extrapolating the trends found in early sample data for particular products to their later periods.[27] In many cases, patent expiry lies beyond our sample period, so we can simply predict counterfactual producer behavior as a continuation of pre-Para-IV entry trends that extends to the end of our sample. In other cases, patent expiry occurs before the end of the sample. In that case, we take the price and quantity declines observed after the initial 180-day exclusivity period, but re-date these to the expiration of the patent rather than the successful Para-IV challenge.

Of course, calculating producer surplus requires that we subtract costs from revenue. Rather than use a formal model to derive an estimate of marginal cost, we take the late sample generic price as a measure of marginal cost.[28] Reiffen and Ward (2005) demonstrate that after ten generic manufacturers enter the market prices begin to approach long-run marginal cost. Moreover, conversations with industry insiders confirmed that significant generic entry tends to drive prices close to marginal cost, limiting the profits even for generic producers. We also subtract product-specific advertising expenditures from producer surplus. In calculating the counterfactual, we presume that advertising expenditures follow early sample trends. In the real world, producers tend to cut off advertising almost entirely after generic entry, and we use real world expenditure levels in computing producer surplus for the actual market history we observe. While we have total R&D spending for publicly listed pharmaceutical firms, we do not possess data on R&D spending for creation or improvement of particular products. As such, we assume that branded pharmaceutical firms spend as much on R&D as on advertising, and we deduct this from revenues to create a final measure of "producer surplus."

Generics producers earn profits in the real world that they would not have earned in the counterfactual world, but the intensity of generic competition compresses these profit flows very rapidly after the 180-day exclusivity period ends. Cumulatively, by the end of our sample in 2008, total losses to all producers because of Para-IV entry amount to approximately $14 billion or approximately about 15% of the gains that flow to the consumer (see Figure 6). This suggests that the social gains are quite large – cumulating to nearly $78 billion

[27] We actually applied this procedure to markets that either never saw generic entry or saw it very late in the sample, and found that our "out of sample" predictions were accurate for price and quantity.

[28] To be precise, for each molecule we looked for the lowest late sample generic price and took that as our estimate of marginal cost for all producers in the molecule. In two cases of combination molecules, there was no generic entry, so we took the average of the lowest generic price for the element molecules in that combination, and used that average as our estimate for marginal cost.

over our sample period. While more in-depth work needs to be completed on the supply-side, these figures represent the first attempt that we are aware of to quantify the loss to producers and net social gains resulting from Para-IV entry under Hatch-Waxman.

But the extent to which these social gains are being realized by the consumer is open to question. Most American consumers do not purchase prescription drugs directly; the drugs they consume are prescribed by physicians and they pay a fraction of the retail price (the co-pay) at the point of purchase, with the rest being covered by prescription drug insurance. In this paper, we abstract from the reality that there are institutions mediating between the ultimate drug consumers and the sellers, and we assume that the measured price declines and generic entry really do translate into "consumer surplus." In a world in which doctors and insurance firms really do act in the best interests of their patients and policyholders, it would not matter whether consumers participate directly or indirectly in this market. Drug price declines would, in such a world, be passed through to consumers, either in the form of lower co-pays, lower premiums or both. For our purposes, we will maintain the assumption that insurance firms work this way.

In future work, though, a much more complete and thorough consideration of the degree to which insurance firms appropriate the gains generated by pharmaceutical price declines is certainly warranted. Inspection of actual co-pay data from IMS NPA™ revealed the existence of a number of products in which the insurance company realized very significant declines in real drug cost, but did not adjust patient co-pays by the same amount, in percentage change terms. Furthermore, while originator products' prices typically rise modestly after generic entry, the co-pays required of consumers who choose these products often go up by much more than the price, in percentage change terms. As an illustrative example, we observed the case of a branded drug, Altace®, which encountered very strong generic competition toward the end of the sample.[29] Using co-pay data, we constructed a "pass-through" coefficient that measured the percent change in the branded drug's price after generic entry divided by the percent change in co-pay for patients who elected to continue to purchase the branded drug. This coefficient was about 0.55, well below one, demonstrating that the percent change in price was much smaller than the percent change in patient co-pay. On the other hand, the price of generic versions of the drug plummeted. However, patient co-pays fell only modestly. The ratio of the percent change in price over the pre- and post-entry periods to the percent change in co-pays was well above one, implying that co-pays fell by far less than the wholesale price for patients switching to generic versions.

Finally, even if the measured price declines generate increased welfare for consumers in the short run, the prospect of limited profitability from future drug development could lead to either a significant decline in pharmaceutical R&D or a change in the type of drugs being developed.[30] If this, in turn, leads to a significant slowdown in the rate at which new effective drugs are introduced, then consumer welfare could decline in the long run, even if the short-run gains from increased access are large. For example, work by Lichtenberg (2005)

[29] We find that the data behaves in a strikingly similar manner in other brands like Coreg® and Norvasc®.
[30] Especially in orphan drugs or drugs for rare pediatric diseases with low patient population base.

has demonstrated that newer drugs were positively related to life expectancy. In this paper, we do nothing to estimate the losses associated with foregone future innovation. However, a full welfare analysis of the balance struck by Hatch-Waxman will remain incomplete until our estimates of short-run gains can be compared to appropriately discounted (potential) losses induced by an R&D slowdown. Conducting such an analysis is the focus of ongoing research efforts by the authors.

6 Conclusion

This paper estimates the impact of early generic entry facilitated via Para-IV certifications in the U.S. hypertension market between 1997 and 2008. While Para-IV certifications have been legally possible since the passage of the Hatch-Waxman Act in 1984, a series of legal and institutional barriers kept the number of challenges quite low until the late 1990s. Since then, a series of court cases and procedural changes have significantly lowered the costs and raised the success probabilities of these challenges. We view these changes as constituting a slowly unfolding natural experiment. Using unusually rich data, we estimate a discrete choice demand model, and use this model to back out the first known estimates of impact of these challenges on social welfare. We calculate welfare gains to the consumer of approximately $92 billion over our time period. Our regression results also point to substantial cross-molecular substitution within the hypertension market, a feature which amplifies the impact of early generic entry on consumers and producers. The gains to the consumer are an order of magnitude larger than estimated losses incurred by producers ($14 billion). Placed in context with the cost of treating hypertension in the United States, the gains appear to be quite large. Given the scope of Para-IV certifications in other large drug markets, our results suggest that Hatch-Waxman has generated substantial (short-term) net benefits.

However, our estimates come with important caveats. In the long run, diminished profits for pharmaceutical innovators could lead to lower consumer welfare as the level of R&D and the pace of product development decline in the future. It may be the case that we are trading gains today at the cost of future drug development; an issue we are currently exploring in follow-up work. Industry representatives' point to the relatively short period of data exclusivity provided for under Hatch-Waxman, and note that other major pharmaceutical markets like European Union, Japan or Canada provide significantly longer data exclusivity periods (Higgins and Graham, 2009). There is also no comparable Para-IV mechanism in these other markets. Recently, Congress passed legislation mandating a 12 year data exclusivity period for large molecule (biotechnology) drugs. Our results point to significant loss to producers as a result of Para-IV entry in the small molecule hypertension market. If incentives, on the margin, push producers to shift R&D away from small molecule drugs then policy makers may need to consider altering current data exclusivity periods for these drugs.

While we presume that the "consumer surplus" generated by increased generic availability and price declines actually goes to consumers, it is at least possible that some of this downstream surplus is appropriated

by insurance firms or retail pharmacies. Using proprietary data from IMS Health we intend to bring this possibility into our analysis in future work. If it is the case that these actors are appropriating a significant portion of the consumer surplus generated from these regulatory actions, then our work calls for a much deeper understanding of the distortion that they are causing in the pharmaceutical market.

Finally, the hypertension market is just one of many important therapeutic categories in the U.S. pharmaceutical industry. Future research should supplement the results described herein with results from other markets, many of which are plausibly characterized by significantly different levels of cross-molecular substitution (*e.g.*, depression, epilepsy and GERD). Such analyses will allow for a more complete understanding of the role cross-molecular substitution is playing in the market and also allow for a more complement judgment on the efficacy of Hatch-Waxman. As is usually the case in economic research, much more remains to be done.

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Figure 1. Exclusivities and innovation in pharmaceuticals. This figure demonstrates the two types of protection conferred on new drugs. When a new drug is approved by the FDA the first five year period (seven years for orphan drugs and 5 ½ years for pediatric drugs) carries with it a regulatory protection called 'data exclusivity' that runs concurrent with underlying patent protection. Data exclusivity protects the underlying clinical data. At the conclusion of data exclusivity a drug is protected only by its patents until they expire, a period termed 'market exclusivity'. Para-IV challenges occur only during the market exclusivity period. Note that patents are generally applied for and granted well before a drug is approved by the FDA.

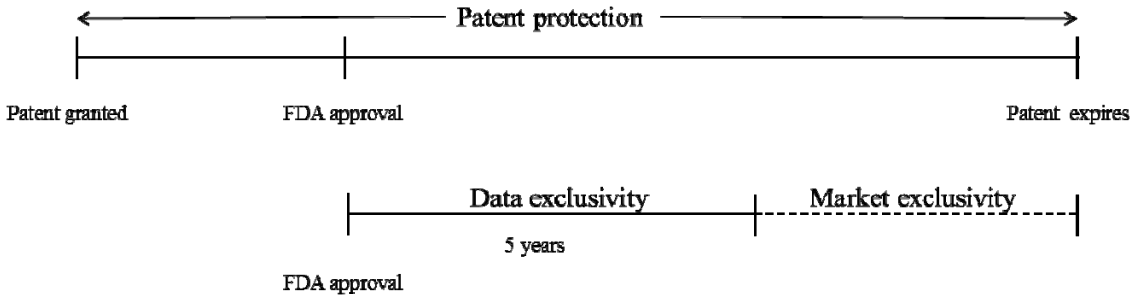

Figure 2. ANDA patent certification options for generic manufacturers. The regulatory pathway for generic entry in the U.S. can occur in one of four ways. Paragraph I, Paragraph II, and Paragraph III are used by generic manufacturers for drugs whose patents are either not listed in the FDA Orange Book or for those patents that have expired (or will expire). Paragraph IV is the only pathway that facilitates generic entry before expiry of patents or the conclusion of market exclusivity. Source: FTC (2002).

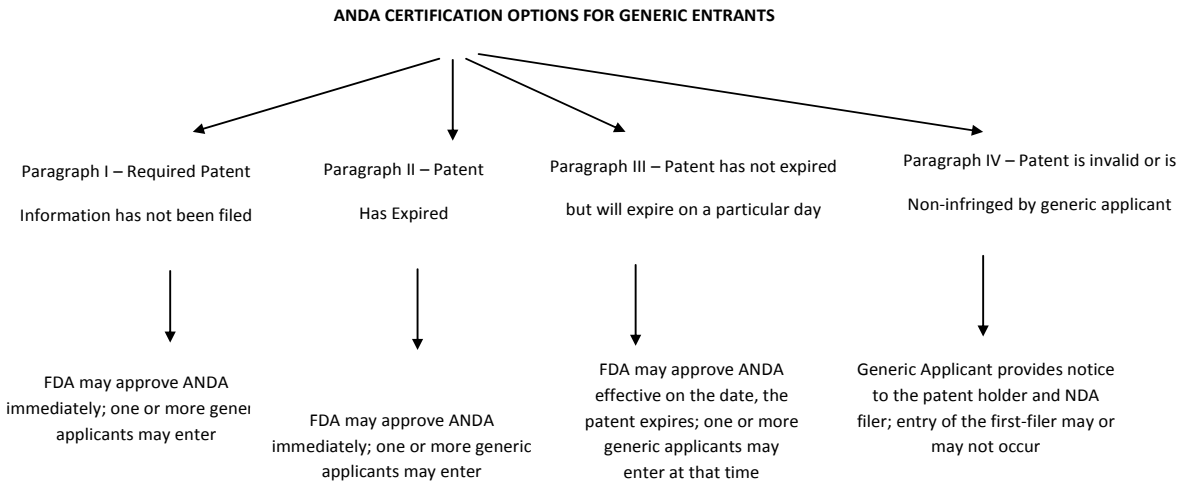

Figure 3. Para-IV challenges are increasing in the U.S. The number of Para-IV challenges has steadily increased as a result of a series of Supreme Court cases and the passage of the Medicare Act of 2003. Source: Higgins and Graham (2009), Berndt *et.al* (2007) and FDA.

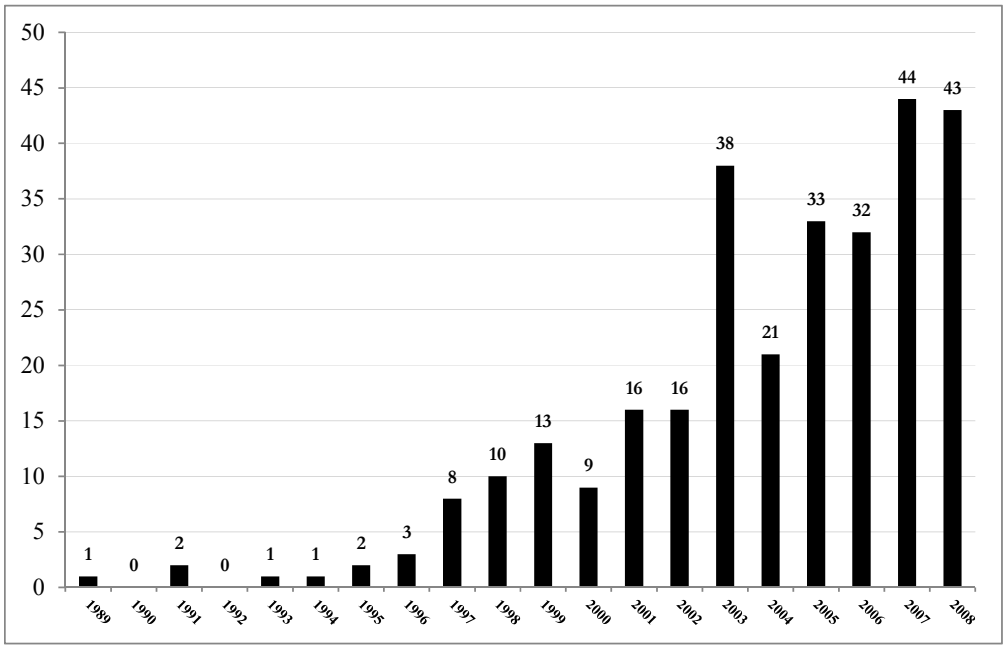

Figure 4. U.S. sales of hypertension drugs, 1997-2008. This figure plots real sales (in thousands) for hypertension drugs in the U.S. Aggregate sales are presented along with four individual sub-markets. Sales increased over time peaking at $5 billion in Q2:2007 before declining. This decline in sales can be attributable to lower prices as a result of generic entry in this market. As we discuss in the text, the market expanded in terms of quantity (more than doubled) during this same period. The x-axis covers 47 quarters from Q2:1997 to Q4:2008. Source: IMS MIDAS™.

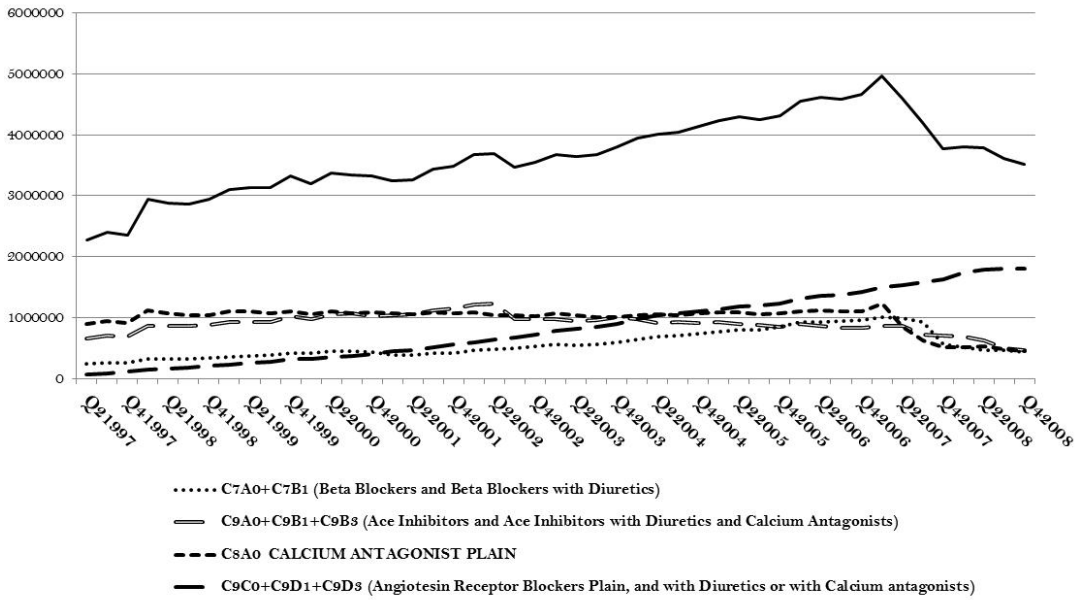

Figure 5. Discount factor by Para-IV generics in quarter of entry across therapeutic categories. Pre-entry average originator price is normalized to 100. Originator price in quarter of entry on this scale is computed and the exercise is repeated with generic price from Para-IV entrants. These prices are reported on the left-side y-axis. The resulting discount factor is reported in the figure and along the right-side y-axis. The dashed line connects the discount factors over several representative branded products across therapeutic markets. Source: IMS MIDAS™.

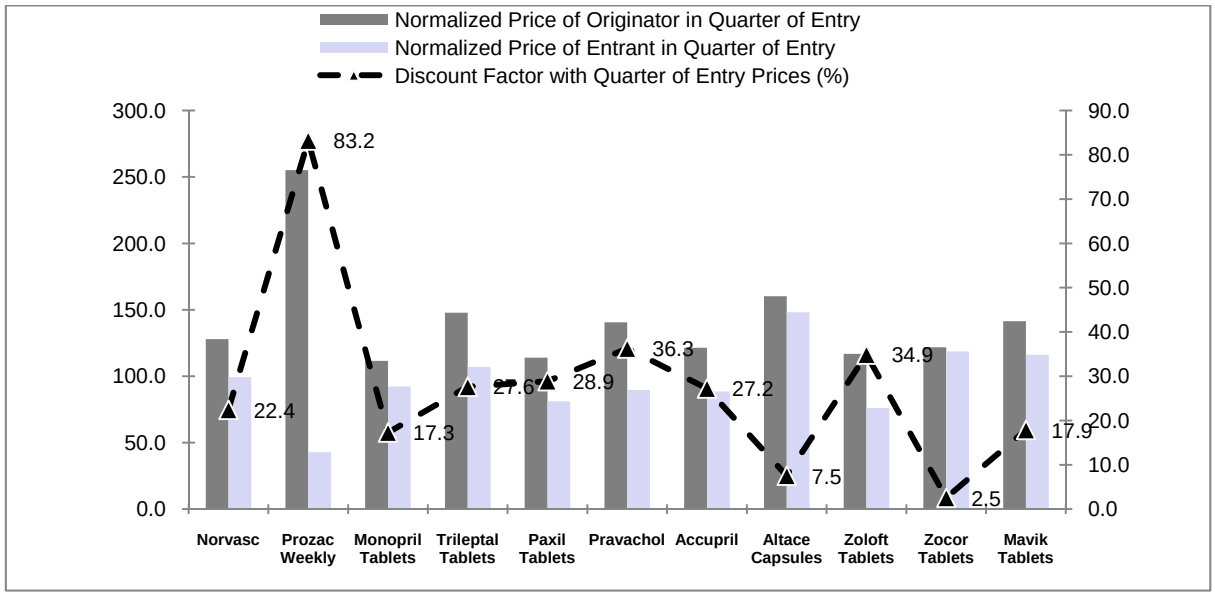

Figure 6. Consumer gains and producer loses in the U.S. hypertension market. This figure plots (in billions) the consumer surplus, producer surplus and total welfare numbers derived from Equations 9 and 10 for the U.S. hypertension market. Total consumer surplus over our time period was $92.2 billion; total producer surplus was negative $14.2 billion resulting in a net social gain of approximately $78 billion.

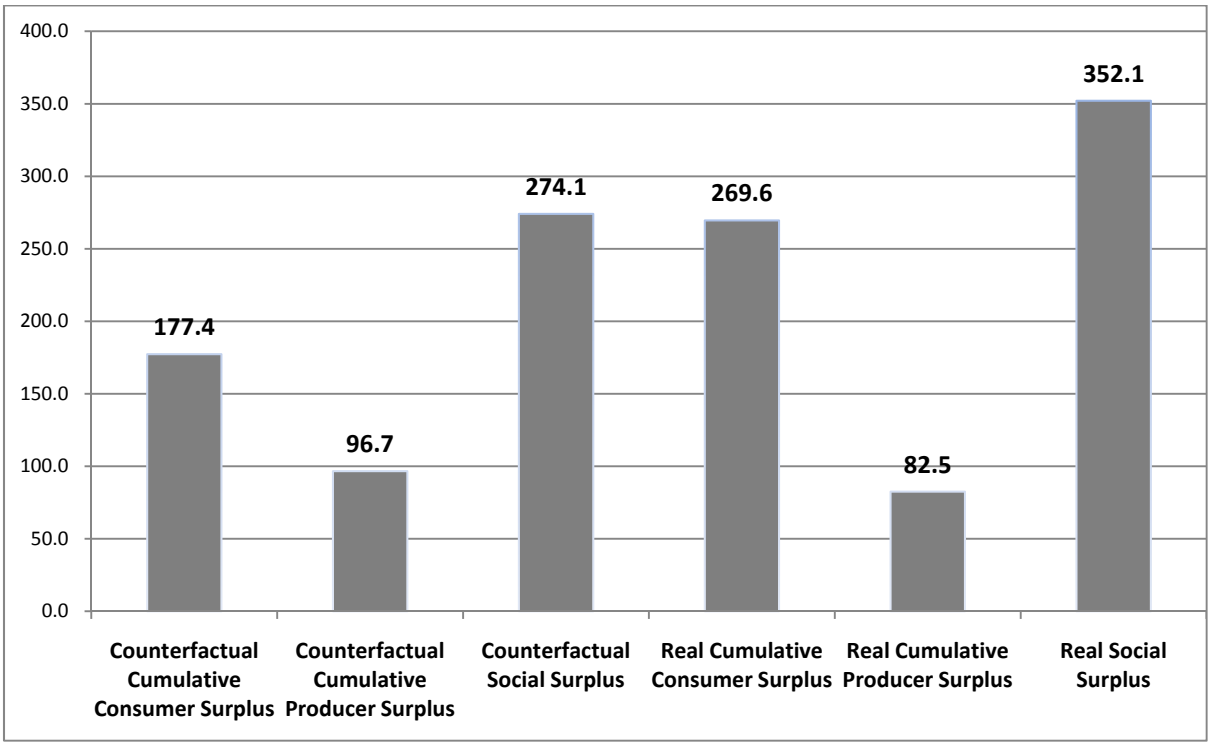

Table 1. Cross molecular substitution suggestions by Blue Cross Blue Shield of Georgia. This table presents data from a consumer communication sent by Blue Cross Blue Shield of Georgia to patients taking the brand name products listed in the second column. The letter provided a financial incentive in terms of a subsidized co-payment if they would consider asking their physician to switch them to one of the respective generics identified in the third column. This communication is the basis for cross-molecular substitution.

DRUG CLASS	BRAND NAME	GENERIC SUGGESTED THROUGH GENERICSELECT PROGRAM
Angiotensin Receptor Blocker/Angiotensin Converting Enzyme Inhibitor	Cozaar, Diovan/HCT, Hyzaar, Altace (2.5, 5, or 10 mg), Atacand/HCT, Avapro, Avalide, Benicar/HCT, Micardis/HCT, Teveten	Benazepril, Enalapril, Enalapril HCTZ, Lisinopril, Lisinopril HCTZ
Antidepressant	Cymbalta, Effexor XR, Lexapro, Prozac (2 mg/ 5 ml solution), Effexor, Luvox/CR, Paxil/CR, Pexeva, Celexa, Zoloft, Prozac (non solution formulations)	Citalopram, Sertraline, Fluoxetine
Calcium Channel Blocker	Sular, Adalat CC, Cardene/SR, Norvasc, Plendil, Procardia XL	Amlodipine
Statin	Lipitor, Crestor, Pravachol, Zocor, Lescol, Lescol XL, Vytorin, Mevacor	Simvastatin, Lovastatin
Triptan	Maxalt, Maxalt – MLT, Zomig, Zomig – ZMT, Amerge, Axert, Frova, Imitrex, Relpax	Sumatriptan Tablets (Limit to 9 tabs/rolling 30 days)

Table 2. Sample molecules with quarter of entry. This table identifies sample molecules and whether they experienced entry during our sample period. The molecules are further subdivided across six categories: Beta Blocking Agents (1); Beta Blockers + Diuretics (2); Calcium Antagonist Plain (3); ACE Inhibitors (4); ACE Inhibitors + Diuretics (5); and, ACE Inhibitors + Calcium (6). Patent expiration month and year identify the end of market exclusivity. Source: Perry Ashford Publications (www.paragraphfour.com) and IMS MIDAS™.

Molecule	Did Para-IV entry occur?	Quarter of Para-IV entry	Patent Expiration
AMLODIP BES/BENAZ (6)	Y	Q2:2007	Dec-17
AMLODIPINE (3)	Y	Q1:2007	Mar-07
ATENOLOL (1)	N		
ATENOLOL/CHLORTHAL (2)	N		
BENAZEPRIL (4)	N		
BENAZEPRIL/HCTZ (5)	N		
CAPTOPRIL (4)	N		
CAPTOPRIL/HCTZ (5)	N		
CARVEDILOL (1)	Y	Q3:2007	Jun-07
DILTIAZEM (3)	Y	Q2:1999	Jul-05
ENALAPRIL (4)	N		
ENALAPRIL MAL/HCTZ (5)	N		
ENALAPRIL/FELODIPINE (6)	N		
FELODIPINE (3)	Y	Q4:2004	Oct-07
FOSINOPRIL (4)	Y	Q4:2003	Jul-09
FOSINOPRIL/HCTZ (5)	Y	Q4:2004	Jul-09
ISRADIPINE (3)	N		
LABETALOL (1)	N		
LISINOPRIL (4)	N		
LISINOPRIL/HCTZ (5)	N		
METOPROLOL SUCCIN (1)	Y	Q4:2006	Sep-10
METOPROLOL TART (1)	N		
METOPROLOL/HCTZ (2)	Y	Q3:2004	Sep-10
MOEXIPRIL (4)	Y	Q2:2003	Feb-07
MOEXIPRIL HCL/HCTZ (5)	Y	Q1:2007	Feb-07
NADOLOL (1)	N		
NADOLOL/BENDROFLUM (2)	N		
NICARDIPINE (3)	N		
NIFEDIPINE (3)	Y	Q2:1997	
PERINDOPRIL (4)	N		
PINDOLOL (1)	N		
QUINAPRIL (4)	Y	Q4:2004	Feb-07
QUINAPRIL HCL/HCTZ (5)	Y	Q2:2004	Feb-07
RAMIPRIL (4)	Y	Q4:2007	Oct-10
TIMOLOL (1)	N		
TRANDOLAPRIL (4)	Y	Q1:2007	Oct-10
TRANDOLAPRIL/VERAPAMIL	N		
VERAPAMIL (3)	Y	Q3:2007	Jun-07

Table 3, Panel A. Descriptives related to demand regression. Panel A presents the variables directly related to our demand estimation: market size, price, quantity sold, number of contraindications, product level detailing (advertising), share of the outside good and unconditional share. Price is dollar per standardized unit (SU). SU is a unit of measurement that equates different forms, for example, pills, capsules and tablets. Revenues and advertising (detailing) are at the firm-product-quarter level.

	Average	Std. Dev	Min	Max
ATC market size ('000 USD)	3892365	570038	2546643	5016018
Price ($ per SU)	0.90	4	0.004	116.4
SUs (quantity) sold per quarter ('000)	16343.7	41617.5	1	474276
Number of contraindications	3.8	2.2	0	10
Product level advertising (detailing) per quarter ('000 USD)	1678.7	3145.9	0	19983.1
Share of outside good (s_0)	0.43	0.05	0.38	0.59
Unconditional share (s_{jm})	0.009	0.02	0	0.13
Number of firms per quarter	59.3	4.9	54	73

Table 3, Panel B. Descriptives related to hypertension products experiencing Para-IV entry. Panel B presents descriptives for those hypertension products experiencing Para-IV entry. Prices of drugs decrease, on average, while incumbents increase price, on average, after entry. Branded revenue erosion accelerates due to additional entry after the expiry of the first generic entrant's 180-day exclusivity period.

	Average	Std. Dev	Min	Max
Pecent change in price *after* entry (brand and generic)	-20.4	32.8	-3.5	-68
Percent change in branded drug price *after* entry	23.5	22.7	-15.4	86.1
Discount factor (%)	37.8	24.7	7.5	96.8
Number of entrants	17	10	6	32
Branded product revenue during year *before* first entry ($,000 USD)	156150.4	188035.4	3365.6	619710.2
Branded product revenue during year *after* first entry ($,000 USD)	70735.5	91120.2	1934.3	310499.3
Revenue erosion during first year of generic entry (%)	56	14.4	19	74.2
Revenue erosion after first year of generic entry (%)	89.2	7.9	67.5	96.6

Table 4. Demand estimation: Nested logit specification. These estimates come from operationalizing Equation 8. The dependent variable, *Diff*, is the difference between the log of unconditional shares and log of the share of outside good. The independent variables include product characteristics such as price, log of detailing and number of contraindications. Specifications include a within group share term, log of conditional shares, and product fixed effects. First-stage Fs for each of the instrumented endogenous variables are noted. Instruments used are derived from the nature of competition and market power for multi-product firms (Dutta, 2011; Cleanthous, 2002; Stern, 1996) and include: number of firms in a quarter, time since generic entry and form number.

	Nested Logit – IV	**Nested Logit - OLS**
VARIABLES	Diff	Diff
Price	-0.303***	-0.0182***
	(0.0563)	(0.0008)
$ln(s_{j\|m})$ (conditional share)	0.497***	0.981***
	(0.1350)	(0.0071)
ln(adver)	0.433***	0.0455***
	(0.1150)	(0.0064)
Number of contraindications	-0.189	0.0695***
	(0.1530)	(0.0089)
Constant	-4.652***	-2.706***
	(1.5440)	(0.0837)
Product Fixed Effects	Yes	Yes
Observations	3,745	3,813
R-squared	0.711	0.973
Hansen J Statistic	2.436	
Chi-sq(1) P-val	0.11859	
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1		
F-First Stage (Price) = 12.62; F-First Stage ($ln(s_{jm})$= 314.59; F-First Stage (ln(adver))= 201.85		
Instruments used: Form number, number of firms in quarter, time since generic entry and lags		
Dependent Variable: Diff = $ln(s_{jm})$-$ln(s_0)$		

Table 5. Demand estimation: Multinomial logit. These results are for the standard multinomial logit specification, where we adopt a specification similar to Equation 8 and Table 5 above, but without the conditional share term, $ln(s_{j|m})$, on the right hand side. When σ approaches 1 (perfect substitutability) $ln(s_{j|m})$ becomes 0 and the nested logit simplifies to a multinomial logit. Demand is now solely a function of mean utility, δ_{jm} and products with the same market shares will have the same cross-price elasticities. The implication of this restriction implies that if, for example, Sular® and generic amlodipine are found to have the same market shares and there is a decrease in the price of Norvasc® (all three are calcium channel blockers), then the logit model suggests that its effect on Sular®'s demand would be the same as the effect on the demand for generic amlodipine.

	Multinomial Logit - IV	**Multinomial Logit - OLS**
VARIABLES	Diff	Diff
Price	-0.394***	-0.00772**
	(0.0706)	(0.0030)
ln(adver)	0.828***	0.370***
	(0.0401)	(0.0143)
Number of contraindications	0.363***	-0.403***
	(0.0407)	(0.0347)
Constant	-10.21***	-6.487***
	(0.4150)	(0.3450)
Product Fixed Effects	Yes	Yes
Observations	3,745	3,813
R-squared	0.388	0.803
Hansen J Statistic	7.798	
Chi-sq(1) P-val	0.02026	
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1		
F-First Stage (Price)=12.62; F-First Stage (ln(adver))=201.85		
Instruments used: Form number, number of firms in quarter, time since generic entry and lags		
Dependent Variable: Diff = $\ln(s_{jm})-\ln(s_0)$		

Table 6. Demand estimation: Alternative nesting approach. These estimates come from operationalizing Equation 8 with an alternative nesting approach as compared to those presented in Table 4. This alternative approach allows for substitution across molecules within a subcategory (*i.e.*, ACE inhibitors and drugs containing ACE inhibitor compounds) but not across subcategories. Thus, we treat these subcategories as distinct market. The dependent variable, *Diff*, is the difference between the log of unconditional shares and log of the share of outside good. The independent variables include product characteristics such as price, log of detailing and number of contraindications. Specifications include a within group share term, log of conditional shares, and product fixed effects. First-stage Fs for each of the instrumented endogenous variables are noted. Instruments used are derived from the nature of competition and market power for multi-product firms (Dutta, 2011; Cleanthous, 2002; Stern, 1996) and include: number of firms in a quarter, time since generic entry and form number.

	Calcium Antagonist	**Beta Blockers**	**Ace Inhibitors**
VARIABLES	Diff	Diff	Diff
Price	-1.164	-0.276**	-9.075***
	(0.917)	(0.133)	(1.485)
$ln(s_{j\|m})$ (conditional share)	0.722***	0.739***	0.483***
	(0.163)	(0.0505)	(0.179)
ln(adver)	0.445***	0.348***	0.184
	(0.111)	(0.0979)	(0.154)
Number of contraindications	-0.166	-0.381*	-7.738***
	(0.199)	(0.203)	(1.632)
Constant	-2.384***	-2.702	36.98***
	(0.533)	(2.089)	(8.395)
Product Fixed Effects	Yes	Yes	Yes
Hansen J-Stats	0.077	2.456	0.654
Chi Sq P-Value	0.78206	0.11709	0.41865
First Stage Fs	45.7;72.5;54.3	114.9;1293.3;654.7	121.7;135.8;485.9
Observations	1,312	1,024	1382
R-squared	0.890	0.971	0.407
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1			
Instruments used: Form number, number of firms in quarter, time since generic entry and lags			
Dependent Variable: Diff = $\ln(s_{im}) - \ln(s_0)$			

Table 7. Comparison of welfare calculations. These figures come from calculating the quarterly consumer surplus (CS) and producer surplus (PS) in the real and counterfactual world using Equation 10 and coefficient estimates from Table 5 and Table 8. The CS, PS and social gain numbers are summed up through 2008 and reported below. The top panel reports final cumulated gains and losses to the consumer and producer using coefficient estimates from Table 5 on Equation 9. The lower next panel reports the numbers using the alternative nesting approach from Table 6. Values are in real USD billions and compare favorably with each other.

	Cumulated CS Gains	Cumulated PS Gains	Cumulated Social Gains
Aggregate Nesting	92.2	-14.2	78.0
Market by Market Gains and then Aggregation			
Calcium	67.7	-7.1	60.5
Beta	0.8	-2.1	-1.3
Ace	7.7	-4.7	3.0
Total	**76.1**	**-13.8**	**62.3**
All numbers are in USD billion			