Mergers, Prices, and Innovation: Lessons from the Pharmaceutical Industry*

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Abstract

The significant surge in pharmaceutical mergers and acquisitions (M&A), averaging a 50% year-to-year increase over the last decade, has drawn concerns regarding its potential impact on consumers.[1] Claims made by pharmaceutical companies suggest M&A, by increasing synergies, will cause innovation to increase and the firm to become more efficient, passing on lower prices to consumers. However, regulators worry firms, in gaining market power through M&A, will raise drug prices and have less incentive to innovate. The prior literature has not yet come to a consensus on how mergers and acquisitions will impact these outcomes. This paper empirically assesses M&A's effects, employing an event study design and difference-in-differences analysis along with new, more comprehensive data on innovation and net prices. I show that, upon an M&A event, firms increase research and development (R&D) spending, decrease filed patents, and do not experience significant changes in the the number of drugs passing through clinical trials compared to pre-M&A levels. Further, I show decreases in patents come from primary patents on new technologies, rather than secondary patents, suggesting that firms use M&A to substitute their internal R&D by acquiring new technologies in development from smaller firms. They then increase R&D spending to support the progression of these assets through clinical trials. However, despite financial backing, I find firms are largely unsuccessful in advancing newly acquired drugs through development. I also find, after M&A activity, net drug prices increase by 19%. These increases occur both in mergers and acquisitions where targets and acquirers have overlapping and non-overlapping therapeutic area portfolios, suggesting multiple mechanisms for price increases. Ultimately, these findings emphasize that M&A leaves consumers at a net loss, with higher drug prices and a pharmaceutical industry that is less efficient at producing the innovation that defines its business model. Therefore, it is critical that regulators consider the impact consolidation has on innovation, in addition to traditional measures like prices, when evaluating whether mergers and acquisitions are ultimately beneficial for consumers.

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[1] Author's calculations using Thompson/Refinitiv SDC Mergers and Acquisitions Database

1 Introduction

The volume of mergers and acquisitions (M&A) in healthcare and high-tech industries, specifically the pharmaceutical industry, has surged over the last few decades. Between 2005 and 2018, 3,000 reported M&A events by pharmaceutical companies occurred, totaling $935 billion dollars in market value.[2] During this same period, the number of pharmaceutical company M&A events grew by 54% year to year.[3] Between 1995 and 2015, the 60 leading pharmaceutical firms had merged to just 10 companies (Feldman, 2021). This increase in M&A has led to a growing concentration of market power held by the largest players of an industry earning $1.5 trillion dollars of global revenue in 2022.[4]

Although M&A has been prevalent in the pharmaceutical industry for decades, recent waves have drawn concerns whether such activity harms the competitive marketplace. For one, M&A events might reduce competition and the incentive to innovate. In the long run, this might lead to less new and innovative drug discoveries. In addition, there is fear that M&A might strengthen the market power of the few remaining pharmaceutical manufacturers, leading to higher drug prices. The rising pressure from these concerns has prompted policymakers to warn that M&A has reached a tipping point that threatens consumers through increased prices, decreased innovation, and other structural changes in the industry (Congressional Budget Office, 2021). It has also prompted regulatory agencies from across the world - the Federal Trade Commission (FTC) and the Department of Justice (DOJ) in the U.S. and the European Commission (EC) in the European Union - to review their M&A guidelines for evaluating pharmaceutical mergers and acquisitions.[5]

On the other hand, pharmaceutical industry leaders have voiced strong support for consolidation. With 63% of all new molecular entities (NMEs) discovered in 2018 coming from smaller biopharma firms, companies argue many small bio-pharmaceutical companies would benefit from the resources of larger firms to promote development activities (Feldman, 2021). In an announcement after their acquisition by Bristol Myers Squibb, Turning Point Therapeutics CEO Athena Countouriotis stated, "With Bristol Myers Squibb's leadership in oncology, strong commercial capabilities and manufacturing footprint, we will be able to further accelerate the pace at which we can bring our novel medicines to benefit people diagnosed with cancer around the world."[6] As a result, they argue, the synergies and additional resources generated by integrating with a larger company would lead to more innovation in the future. Those efficiency gains from M&A could also lead to cost savings for consumers in the form of lower drug prices. Since the effect is theoretically ambiguous, both corporate players and policymakers would

[2] Author's calculation using Thompson/Refinitiv SDC Mergers and Acquisitions Database

[3] Author's calculation using Thompson/Refinitiv SDC Mergers and Acquisitions Database

[4] Data from IQVIA accessed via `https://www.statista.com/statistics/263102/pharmaceutical-market-worldwide-revenue-since-2001/`https://www.statista.com/statistics/263102/pharmaceutical-market-worldwide-revenue-since-2001/

[5] See `https://www.ftc.gov/news-events/press-releases/2021/05/multilateral-pharmaceutical-merger-task-force-seeks-public-input`

[6] See `https://news.bms.com/news/details/2022/Bristol-Myers-Squibb-to-Acquire-Turning-Point-Therapeutics-a-Leading-Precision-Oncology-Company/default.aspx` for the complete report

benefit from a greater understanding about how mergers and acquisitions affect the unique landscape of the pharmaceutical industry.

To contribute to this debate, this paper simultaneously assesses what happens to pharmaceutical innovation and prices after M&A events among drug companies. First, I start by developing a theoretical model of mergers including the effects of cost reducing innovation. Without considering the impact of innovation and information sharing, prior models show that mergers will always reduce the incentive for firms to innovate, making consumers worse off. However, I extend this model by considering how innovation sharing contributes to a merged firm's output. After including this effect, I find that mergers are able to expand the combined firm's total output from its individual, pre-merger level depending on the costliness of innovation and the marginal cost of a firm's production. The theoretical model highlights that the question of whether mergers are beneficial is ambiguous once taking innovation into account. Therefore, the result demonstrates the importance of including innovation as a metric when evaluating mergers in addition to traditional outcomes, such as price.[7]

Using the model as a guide, I empirically examine how firms make subsequent innovation and pricing decisions after M&A events. I use an event study design, along with an aggregate difference-in-differences model, to measure the innovation and pricing changes after M&A events between 2007 and 2016. Starting from 2007, I identify a treatment event as the first instance of a merger or acquisition by an acquiring firm. As control firms may fundamentally differ from acquirers in the treated group, I employ a nearest neighbor propensity score match to pair treated firms with similar control firms. To study innovation, I draw on clinical trials and patent data from Clarivate Cortellis Competitive Intelligence and R&D spending data from Compustat Fundamentals to assess how consolidation affects both inputs and outputs of innovation. This includes novel measures tracking a molecule's movement through clinical trials, drug discontinuations, and discovery announcements. I evaluate M&A's impact on these outcomes, in addition to patents and research and development (R&D) spending, to assess if and how merged firms change their innovation strategy compared to those firms that do not. To estimate the effects on drug prices, I utilize SSR Health data on the net prices - the prices net of insurance rebates, coupons, and other discounts - of brand name, non-generic drugs. Using these data, I evaluate how the net prices of the acquirer's products change after an M&A event.

I find mergers and acquisitions in the pharmaceutical industry cause the number of filed patents to decrease and R&D spending to increase. The decline in patents mainly comes from primary patents, which signal a reduction in the creation of new products. At the same time, M&A does not lead to any significant effect on drug development, including new discovery announcements, entry into Phases I, II, and III, and discontinuations of molecules in FDA clinical trials. The impacts assessed together provide

[7] Robert Bork, whose work *The Antitrust Paradox* influenced merger policy starting in the late 1970s, believed, among other things, that mergers were not harmful unless they resulted in an increase in prices and decrease in output (Ashenfelter et al., 2014).

clues to the consequences of how M&A changes an acquiring firm's innovation strategy. Rather than developing their own, new products, larger firms supplement their portfolio with patented molecules in development from smaller, target companies. The firm then increases R&D spending post-M&A event in an effort to advance the recently obtained molecule's development. However, this new innovation strategy by the firm does not result in any statistically significant change in furthering drug development. After a merger or acquisition, even with an increase in R&D spending, there is no change in the number of new drug discovery announcements or volume of drugs making it to further phases of clinical trials. This raises questions on claims from the pharmaceutical industry, which indicate consolidation will result in greater innovation efficiency.

Examining the effects on price, I find mergers and acquisitions lead to an increase of pharmaceutical net prices of non-generic brand name drugs by around 19% per quarter. This suggests that consolidation resulting from M&A ultimately leads to higher pharmaceutical prices. The outcomes presented here also do not support the notion from drug companies that the increasing synergies from M&A result in cost savings that is passed onto the consumer. Upon further analysis, I find these effects tend to occur when both the target and the acquirer are pharmaceutical companies. I also discover that net drug price increases take place primarily in M&A events where the portfolios of targets and acquirers have overlap within a particular therapeutic class, although prices also increase in the few cases where no overlap occurs. These results suggest that pharmaceutical companies have different incentives when deciding to merge with another, going against traditional thinking regarding M&A. In the case of overlapping portfolios, the mechanism is firms seeking to increase concentration within a particular therapeutic market, consistent with traditional models of mergers and acquisitions. However, when portfolios between target and acquirer do not overlap, large acquirers might be solely seeking to increase their overall size and influence. With several key products across multiple therapeutic markets, these megacompanies post-M&A have a better position when negotiating with insurance companies for, among other things, lower rebates for all of their products. This results in higher net prices, which increase when rebates decline.

Overall, this paper seeks to bridge two threads of the M&A literature: the effects of M&A on innovation and the effects on prices. Currently, the literature offers mixed results on how M&A influences these outcomes. I contribute to this literature as the first paper to comprehensively review M&A's impact on innovation outputs and prices together in the same work, using the same time period and sample of mergers and acquisitions. There is a growing body of literature, both theoretical and empirical, documenting the effects of consolidation on innovation, generally and in the pharmaceutical industry. Several studies find pharmaceutical innovation, namely patents, patent citations, and R&D spending, increases after an M&A event (Guadalupe et al., 2012; Phillips and Zhdanov, 2013; Grabowski and Kyle, 2008; Basant and Jaiswal, 2022; Bena and Li, 2014; Frey and Hussinger, 2011; Lee et al., 2018).

Alternatively, other empirical studies conclude mergers and acquisitions lead to a decline in innovation, in the form of fewer patents and less R&D spending (Munos, 2009; Comanor and Scherer, 2013; Danzon et al., 2007; Ornaghi, 2009; Meder, 2019; Haucap et al., 2019). Incumbent firms may also use acquisitions as a means to discontinue innovation from a rival and usurp future competition (Cunningham et al., 2021). While measurements from prior literature - R&D spending and patents - are useful to analyze the impact of M&A on pharmaceutical innovation, they do not necessarily represent the development of more innovative products. This study accounts for this in two ways. It uses new outcomes - new drug discoveries, movement through the phases of the FDA pipeline, and product discontinuations - to track changes to pharmaceutical innovation in development. Furthermore, while the innovation literature commonly looks at patents to measure innovation outcomes, it often does not distinguish between patents signaling new innovation, known as primary patents, and those commonly used to protect existing drugs from market competition, known as secondary patents (Feldman, 2018). This paper categorizes patents as primary and secondary and assess M&A's impact on them separately.

Similarly, the results from the few studies analyzing the effects of M&A on drug prices are inconclusive. While some papers (Hammoudeh et al., 2022) find no change in pharmaceutical prices after a merger, others (Gupta et al., 2019; Bonamié and Wang, 2024) show an increase in drug prices post-M&A.[8] However, the prior literature uses price data that may not reflect what is ultimately paid by consumers, as it does not account for rebates and discounts. In contrast, this paper uses data on net drug prices, which reflects those prices received by the manufacturer after accounting for insurance rebates, coupons, and other purchase discounts. Therefore, this paper evaluates how mergers and acquisitions affect the prices consumers will ultimately face. Only one other recent working paper, Feng et al. (2023), uses net price data to evaluate the impact of M&A. The authors also find an increase in net prices. However, that study does not examine how prices change when firms acquire targets with overlapping product portfolios. I am able to study this question and determine whether acquiring firms consolidate to gain market share in a therapeutic class or expand their portfolio overall to gain influence in negotiating rebates. These results provides clues to the broader role M&A plays in a firm's corporate strategy. Finally, for both innovation and prices, this study utilizes an event study design, a method not used in prior work, to assess the effects of M&A.

Overall, this paper, in concurrently analyzing mergers and acquisitions' impact on innovation and prices, provides a more complete story on M&A's impact within the pharmaceutical industry. The results demonstrate that M&A causes net drug prices to increase with no substantial improvements to some innovation metrics and declines to others. Ultimately, these outcomes indicate that, contrary to claims by the drug companies, consumers lose out with increasing pharmaceutical market consolidation. This

[8]It is important to note that these studies each use different measures of drug prices in their estimation. Gupta et al. (2019) uses the wholesale acquisition price, Hammoudeh et al. (2022) uses estimate prices from Medicaid state reimbursements, and Bonamié and Wang (2024) use the National Average Drug Acquisition Cost survey for the Centers for Medicare and Medicaid (CMS).These different data sources might explain the varying findings

raises general questions on the suggestions put forward by pharmaceutical companies in support of M&A. The findings also suggest the importance for regulators and policymakers to consider innovation effects when evaluating M&A, both in the pharmaceutical industry and across other high tech industries.

The remainder of the paper will continue as follows. Section 2 provides background information on the U.S. government's role in merger and acquisition regulation, landscape of pharmaceutical development and innovation, and a review of the current literature on M&A, innovation, and prices. Section 3 outlines a theoretical model that extends a basic framework of M&A activity and innovation for the pharmaceutical industry. I describe the data and the procedure to compile and clean the study sample in Section 4. Section 5 details the empirical model used in the analysis. I present the empirical results, extensions, and robustness checks of M&A and its impact on innovation and prices in Section 6. Finally, in Section 7, I discuss policy implications and next steps for future research.

2 Background

2.1 Merger and Acquisition Regulation

Mergers have been the subject of regulatory scrutiny in the United States and the European Union for decades, beginning with the the Federal Trade Commission Act of 1914 and the EU Competition Law in 1990. Historically, regulatory bodies such as the FTC and the DOJ have aimed to assess the implications of M&A on consumer welfare, as dictated by law. However, the metrics behind this assessment has varied over time, contingent on wide-ranging meanings of "consumer welfare" among agency and departmental leaders across administrations. The vast majority of these interpretations have stemmed from differing methods of calculating and interpreting changes in firm output, prices, and efficiencies post-M&A (Ashenfelter et al., 2014). In the U.S. and the EU, effects of M&A on business activities aside from changes in prices and output, like innovation, were not initially considered.

Only in 1995 did the FTC and DOJ agree to integrate the effect of consolidation on innovation and intellectual property in their M&A evaluations. That year, both agencies collaboratively issued the Antitrust Guidelines for the Licensing of Intellectual Property to address concerns on how mergers and acquisitions could impact innovation.[9] The guidelines specified that intellectual property should be assessed in the same manner as any other form of property when evaluating the effects of consolidation and highlighted the importance of considering innovation in evaluating effects to consumer welfare[10]. The FTC and the DOJ further strengthened their position on evaluating innovation in their revision of the Horizontal Merger Guidelines in 2010.[11] Section 6.4 of these guidelines, which was newly added

[9] See `https://www.justice.gov/atr/archived-1995-antitrust-guidelines-licensing-intellectual-property` for the complete text of these 1995 guidelines.

[10] These guidelines were further expanded in 2017 and continued to highlight the importance of considering innovation in antitrust review. See `https://www.justice.gov/atr/IPguidelines/dl`

[11] The 2010 guidelines were the latest version of the Horizontal Merger Guidelines until the current version was issued in July 2023. The July 2023 guidelines continue to support using innovation in both the FTC and the DOJ's evaluation of

in the 2010 version, stated "competition often spurs firms to innovate" and added regulators "may consider whether a merger is likely to diminish innovation competition by encouraging the merged firm to curtail its innovative efforts below the level that would prevail in the absence of the merger." The revised guidelines also addressed the potential "efficiencies" and expanded product variety that might be generated from such innovation (Shapiro, 2010). This change encouraged authorities to broaden their criteria for the M&A review process and include the impacts on innovation.

Although these guidelines enable regulators to account for effects on innovation, the methods for assessing such impacts remain relatively nascent and under-defined. In merger and acquisition cases, the burden of proof falls upon the regulatory bodies, namely the FTC, DOJ, and the European Commission (EC). To stop a merger or acquisition from occurring, these agencies must demonstrate the proposed M&A event would harm consumers. The regulatory bodies consider a range of factors when making this determination, including stifling innovation and increasing prices. Conversely, if a firm can present evidence to antitrust authorities or a judge indicating that consolidation would generate innovation efficiencies that benefit consumers on net, the merger is likely to be approved. This is also known as the efficiency defense. Said evidence typically includes demonstrations of increased synergies and shared resources in R&D activities (OECD, 2012). While authorities occasionally examine how mergers, especially in high-tech industries, directly affect the innovation incentives of the merged entity, there are notable gaps in their analyses (Rosch, 2009). Innovation among rival firms is often overlooked, and the metrics used to evaluate innovation may not necessarily capture genuine contributions to new product development (Haucap et al., 2019; Danzon et al., 2007). Models used to estimate the economic effects of mergers and acquisitions fail to account for how innovation competition among firms is affected (Spulber, 2022). These shortcomings raise significant questions on the overall impact that consolidation may have on innovation across firms.

2.2 Innovation and Drug Development

While the assessment of innovation is pivotal in pre-M&A analyses across various industries, it assumes particular importance in the pharmaceutical sector. This industry relies heavily on R&D as an integral component of its business model. The journey of bringing a new drug to Food and Drug Administration (FDA) approval is a costly endeavor, with the expected out-of-pocket expense ranging from approximately $161 million to $4.54 billion dollars in 2019 (Schlander et al., 2021). In 2019, pharmaceutical companies allocated, on average, one-quarter of their revenues to R&D expenditures— a figure exceeding the proportion spent in other technologically advanced industries such as semiconductors and software. Moreover, the share of revenue dedicated to R&D, which amounted to around $83 billion in 2019, has been on an upward trajectory, doubling the share spent in 2000 (Congressional Budget Office, 2021).

mergers and acquisitions.

In addition to relying heavily on R&D, the pharmaceutical industry provides an environment conducive to examining the impact of consolidation on innovation for several reasons. First, data to track innovation progress are readily available in this sector. The FDA mandates a sequence of regulatory phases for new drug applications (NDAs), aiming to ascertain both safety and efficacy through what is commonly known as the FDA approval pipeline.[12] In total, the approval pipeline from discovery to final approval can last an average of 12 years (Van Norman, 2016). When a firm discovers new potential drug molecules, they first run screenings to determine toxicity and its potential effectiveness in animals. After these preclinical sessions, drugs go through three phases of clinical trials - Phase I, II, and III - to prove their safety and efficacy in human subjects. The FDA tracks this progress of a drug through these three phases of development before the product is finally approved for launch.[13] The progression of a new drug through each phase can be clearly seen in available data, which is uncommon in other industries. This makes it easier to track innovative advancement within the industry. Conversely, data are also available to see pharmaceutical innovations failures, whether a company announces a drug prospect has ended development or development has failed to progress in an expanded manner. Additionally, comprehensive and publicly accessible data on drug patents further facilitate monitoring innovation.

Second, the pharmaceutical industry contains predetermined and standardized product markets. These product markets traditionally exist by way of therapeutic classes and indications for the disease groups they treat. Before a product launches, the FDA defines which indications and broader therapeutic classes drugs are granted approval for.[14] These market definitions allow analyses of shifts in market competition and determination of an acquiring firm's product market overlap with prospective targets. Third, the FDA classification and approval process means that drugs, after launch, must maintain the same quality and product dose amount after approval (Bonamié and Wang, 2024). Unlike the pharmaceutical industry, quality in other product markets changes around an M&A event (Sheen, 2014). However, in the drug industry, the FDA legally requires that companies hold product formulations to the specific doses of ingredients in their applications once a product has been approved. This consistency allows for an evaluation of prices changes while still holding quality constant.

2.3 Literature Review and Contributions

This paper aims to combine two distinct strands of the M&A literature: the effects on innovation and the impact on drug pricing. To this day, there is a growing body of literature, both theoretical and empirical, documenting the effects of consolidation on innovation, generally and in the pharmaceutical

[12] The FDA's website provides guidance for the steps a drug takes to go from its discovery to new product approval. See `https://www.fda.gov/drugs/cder-small-business-industry-assistance-sbia/new-drug-development-and-review-process`

[13] After approval, the FDA might require a fourth phase of trials, known as Phase IV. This monitors the drug's performance to study long terms risks and benefits once the drug is available to the public.

[14] Off-label prescribing, or prescribing a drug for an indication that has not received FDA approval, by medical providers also legally occurs. However, data on what indications drugs are prescribed off-label for are not readily available.

industry. The literature demonstrates consolidation has the potential to produce two opposing results on both outcomes.

Scholarly investigations into mergers and acquisitions' effects on innovation have a long history (Schumpeter, 1912). According to one perspective, M&A across industries allows for information sharing and resource assistance between smaller, innovative target firms and larger acquiring entities. Mergers bringing together targets and acquirers are found to engender efficiency and foster innovation (Sheen, 2014; Hoberg and Phillips, 2010). This pattern is evident in the pharmaceutical industry. Multiple studies indicate that, post-M&A event, smaller firms experience an increase in patenting and R&D expenditures (Guadalupe et al., 2012; Phillips and Zhdanov, 2013; Grabowski and Kyle, 2008; Basant and Jaiswal, 2022). These increases mostly come from mergers with smaller firms, which are less likely to advance projects given budget constraints. Acquirers with prior technological linkage to targets also tend to yield more innovation outcomes (Bena and Li, 2014; Frey and Hussinger, 2011; Lee et al., 2018).

Conversely, several empirical studies suggest that market consolidation may dampen innovation. Across industries, target firms substantially decrease their innovation efforts after a merger or acquisition, while the R&D intensity of acquirers declines due to increasing sales (Szücs, 2014). M&A is also found to foreclose disruptive rivals and reduce the pressure on the incumbent to innovative (Federico et al., 2020). Similarly with pharmaceutical companies, M&A is also found to negatively impact innovation, reducing the number of independent pathways to new drug discoveries (Comanor and Scherer, 2013) while failing to stimulate new product introductions (Munos, 2009). Several papers (Danzon et al., 2007; Ornaghi, 2009; Meder, 2019; Haucap et al., 2019) find that M&A leads to worse innovation outcomes, both from the acquiring firm and from spillover effects by firms with products across similar therapeutic markets. Incumbent firms may also use acquisitions as a means to discontinue innovation from a rival and preventing future competition from reaching full development (Cunningham et al., 2021).

Similarly, this paper also expands upon existing research examining the impact of M&A on drug prices. Numerous economic studies explore the implications of M&A on prices across sectors of the healthcare industry (Dafny, 2009; Hosken et al., 2011; Roberts et al., 2017). . However, few studies have examined how mergers and acquisitions among pharmaceutical companies affect drug prices. Those few studies produce mixed results. Hammoudeh et al. (2022) documents a negligible effect of pharmaceutical mergers on drug prices. However, other studies (Gupta et al., 2019; Bonamié and Wang, 2024) show that the price of drugs increases after a merger. In these studies, it is important to note that each use different measures of drug prices in their estimation, which could explain the discrepancy.[15] Across all of these studies, the authors use a measurement of price that does not represent drug prices net of insurance rebates, coupons, and other purchase discounts. This means these studies do not capture the effects on

[15]Gupta et al. (2019) use the wholesale acquisition price, Hammoudeh et al. (2022) use estimate prices from Medicaid state reimbursements, and Bonamié and Wang (2024) use the National Average Drug Acquisition Cost survey for the Centers for Medicare and Medicaid (CMS).

prices that consumers are commonly exposed to. Only one paper, written in parallel to this study, Feng et al. (2023) also assesses the effects of mergers and acquisitions on net drug prices, finding a similar increase.

Overall, this paper makes several contributions to the current literature. It concurrently analyzes M&A's impact on output innovation and prices together in the same work using the same sample of mergers and acquisitions. Regarding innovation, while measures from prior literature - R&D spending and patents - are useful to analyze, they do not necessarily represent the development of more innovative products. In other words, companies can spend money and file patents without it resulting in any new drugs. This study accounts for this in two ways. It uses new measures of innovation output- drug discoveries, movement through the phases of the FDA pipeline, and product discontinuations - to directly track changes to pharmaceutical innovation in development. Second, while the innovation literature commonly uses patents to measure cutting edge products, it often does not distinguish between patents signaling new innovation, known as primary patents, and those used to protect existing drugs from market competition, known as secondary patents (Feldman, 2018). This paper identifies both primary and secondary patents and assesses M&A's impact on them separately.

In evaluating drug prices, this paper uses data on net drug prices, which reflects those prices received by the manufacturer after accounting for insurance rebates, coupons, and other purchase discounts. In doing so, this study evaluates how mergers and acquisitions affect the best representation of what consumers pay for medication. It is also the first to examine how drug prices change when firms acquire targets with overlapping product portfolios. The results of this analysis help explain why acquiring firms merge with other companies, whether to consolidate to gain market share in a therapeutic class or expand their portfolio overall to gain influence in negotiating rebates. Finally, for both innovation and prices, this paper contributes by utilizing an event study design, a method not used in prior work, to assess the effects of M&A. In general, by studying both innovation and prices concurrently, this paper allows for the evaluation of two commonly studied outcomes of consolidation by regulators at the same time, providing a more complete story on M&A's impact. More broadly, by assessing results on both innovation and prices, this paper contributes in providing clues to the role mergers and acquisitions play in a firm's corporate strategy and whether M&A makes firms more efficient.

3 Conceptual Framework and Theoretical Model

For more than a century, the relationship between competition and innovation has been the subject of extensive economic theorization (Schumpeter, 1912). Arrow (1962)'s formal proposal demonstrated that competition increased innovation incentives due to increased prices. This theory has been iteratively refined, both horizontally (Gilbert, 2006) and vertically (Greenstein and Ramey, 1998; Gilbert and

Newbery, 1982). Nevertheless, the relationship Arrow describes does not universally hold across all contexts (Boone, 2001). Gilbert (2006)'s comprehensive review of the literature concludes that the effects of competition on innovation could be either positive or negative, depending on specific circumstances, stating, "we remain far from a general theory of innovation and competition."

However, only recently has the literature tackled the question of how singular merger events impact innovation outcomes. A distinct body of work argues that mergers invariably lead to reduced R&D investments and diminished consumer surplus (Cabral, 2018; Federico et al., 2017,0; Fumagalli et al., 2020; Bryan and Hovenkamp, 2020; Motta and Tarantino, 2021) (Cabral, 2017; Federico, Langus, and Valleti, 2017; 2018; Motta and Tarantino, 2018; Fumagalli, et al., 2020; Bryan and Hovencamp, 2020). These latter studies operate within what has been deemed as the "innovation theory of harm" framework (Denicolo and Polo, 2021), which assumes that all horizontal mergers, in increasing market power, will stifle innovation and be considered anti-competitive. However, recent literature has argued the assumptions behind the innovation theory of harm are too fragile and simplistic (Denicolo and Polo, 2018; Vives, 2007). The innovation theory of harm restricts firms to not engage in innovation that may reduce inefficiencies, such as information and resource sharing. In the pharmaceutical space, several key industry white papers from leading consulting companies find this increase in synergies resulting from mergers and acquisitions demonstrate consolidation can be beneficial in the long run.[16] With these industry examinations in mind, I challenge the notion that merging firms do not engage in information and innovation sharing made from prior theoretical literature. The model, as outlined in the Appendix, incorporates considerations detailed in Denicolo and Polo (2021) and permits firms to share technologies and information following the merger, contingent on the level of technological overlap between the entities.[17]

The derivation of the proof of this proposition can be found in Section 1 of the appendix. In summary, the model finds that, in some specific regions, taking innovation related metrics into account, mergers can be beneficial. The results of this theoretical model demonstrate the nuance of the discussion regarding the relationship of consolidation and innovation. According to prior theory, without taking the synergistic aspect of innovation into account, mergers are assumed to always reduce productivity across firms. This ultimately hurts consumers. However, after introducing cost-reducing innovation, mergers can potentially result in greater efficiencies for firms, benefiting individuals. These findings highlight the importance of considering effects to innovation, in addition to price, when thinking about the welfare of mergers, particularly in high tech industries. As discussed in Section 2.1, regulators have only recently gauged the value of innovation and are continuing to refine its measurement along various

[16] See the industry white papers from McKinsey and Company (`https://www.mckinsey.com/capabilities/strategy-and-corporate-finance/our-insights/whats-behind-the-pharmaceutical-sectors-m-and-a-push`) and Bain and Company (`https://www.bain.com/insights/healthcare-m-and-a-report-2022/`)

[17] If merging firms have overlapping technologies, such as similar drug indications, they might choose to streamline their efforts and be more efficient with their effort to produce the same outcome.

metrics. Without taking innovation into account, consumers could miss out on beneficial consolidation. Therefore, as shown in subsequent sections, this model demonstrates the importance of empirically evaluating the effects of mergers on innovation to estimate a better overall impact to consumers. I evaluate these effects of mergers on innovation, along with prices, empirically in the sections below.

4 Data

I employ the pharmaceutical industry to empirically investigate the impact of mergers and acquisitions on innovation and prices. As outlined in Section 2.2, consolidation among drug companies serves as an ideal setting for examining these effects. The subsequent sections detail the data sources and construction procedures utilized in crafting the final sample.

4.1 Mergers and Acquisitions

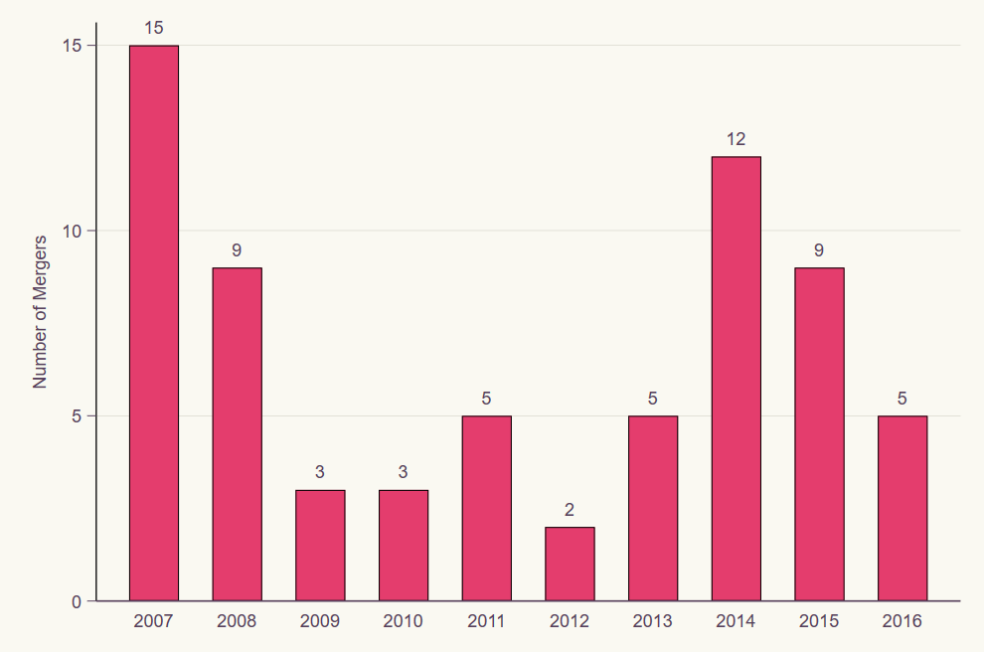
Data measuring merger and acquisition events come from Thompson/Refinitiv SDC Mergers and Acquisitions database. These data record M&A activity across all firms, capturing details such as the announcement date and net worth of the transaction, as well as identifying information on targets and acquirers. To create a refined final sample, I conduct a multi-step cleaning process. First, I restrict the sample to acquirers classified as pharmaceutical companies and targets classified as either pharmaceutical or biotechnology companies. Using a framework of prior literature (Bena and Li, 2014), I select M&A events categorized by Thompson/Refinitiv as a merger, an acquisition of assets, or an acquisition of majority interest. To account for majority ownership, I also only include acquisitions where the acquirer owns less than 50% of the target before the transaction and at least 90% afterwards. If firms undergo more than one M&A event within the sample time period, I select the first instance that occurs. It is worth noting that acquiring firms must be public at the time of the M&A event for it to be included in the Thompson/Refinitiv data. Lastly, I standardize firm names, both for targets and acquirers. These standardized firm names will be used as the reference to add in additional data, as detailed in the sections below. After this cleaning process, the final sample consists of 68 total mergers and acquisition events involving pharmaceutical companies from 2007 to 2016, worth about $700 billion dollars. Figure 2 illustrates the temporal distribution of these merger and acquisition events, depicting an even distribution of M&A events across years.

4.2 Pharmaceutical Innovation

4.2.1 Clinical Trials and Patents

Data describing patents and clinical trials information originates from Clarivate Cortellis Competitive Intelligence. This database is considered one of the most comprehensive databases of pharmaceutical

Figure 1: Mergers and Acquisitions by Pharmaceutical Companies - 2007-2016



Note: Figure 2 depicts the distribution of pharmaceutical mergers and acquisitions by year between 2007 and 2016. To qualify as a merger or acquisition in this sample, acquirers must be pharmaceutical companies and targets must be either pharmaceutical or biotechnology firms. The sample is defined by the first instance of an M&A event for a particular acquirer in the time period.

innovation and is used by several recent papers to track drug development (Hermosilla, 2021; Agha et al., 2022; Garthwaite et al., 2021). The data come from a comprehensive analysis of company records, conferences, and other public sources, analyzed by over 500 investigators. As of 2016, Cortellis cataloged more than 65,000 drug development histories, each extending back several decades.

Clarivate Competitive Intelligence provides detailed timelines on a drug's progress through FDA clinical trials, including its discovery announcement and passage through clinical trial Phases (I, II, and III). It also documents instances when development is halted or suspended by the pharmaceutical company or when the product is ultimately launched.[18] Additionally, Clarivate includes details about a drug's indication, or disease a drug is prescribed to treat, and the firm a given drug belongs to, along with other identifying information.

Cortellis Competitive Intelligence also includes data on drug patents, specifying the dates when new patents are filed by pharmaceutical firms. The patent data also identify what type of technology the patent is filed for. In the context of pharmaceutical markets, several categories of patents can be filed for the same molecule to protect different elements of the drug's technology. These categories include, but are not limited to, macromolecule, product, formulation, and new use. Ultimately, these data allow

[18]For a drug to be eligible to launch in the U.S. pharmaceutical market, it must pass through the extensive phases of the FDA approval process. This includes three rounds (Phase I, Phase II, and Phase III) of clinical trials, in which a panel of doctors and scientists must evaluate a molecule's safety and efficacy. Drugs are only approved to treat the indications for which the company files. Figures tracking the volume of drugs moving through various phases of the FDA approval pipeline during the time frame of the analysis can be found in Appendix Figures B.1. and B.2.

me to see how and when different phases of drug development occurs. For the scope of my research, I use the number of drugs an acquiring firm has in various stages of development, including discovery, Phase I, II, and III, and discontinuations, and the number of patents filed, as part of the main innovation outcomes of the empirical specification described in Section 5. The focus of these data are drugs in active development, starting at the discovery announcement. Due to this, I am unable to assess molecules in preclinical development before a firm's announcement.[19]

4.2.2 Research and Development Spending

Quarterly and yearly data on research and development (R&D) expenditures come from the Compustat North America and Global Market Intelligence Fundamentals Spending database, published by Standard and Poor's (S&P). Compustat aggregates financial information from company SEC filings, specifically 10-K forms for annual data and 10-Q forms for quarterly. The database encompasses financial records from approximately 80,000 firms worldwide. As the data draw on company SEC filings, firms must be publicly listed for their information to be available in Compustat. For my analysis, I extract quarterly R&D expenditures alongside data on firm's yearly sales, revenues, assets, and employee counts spanning from 2005 to 2018. All monetary values are adjusted for inflation using the US Consumer Price Index, with the base year of 2017 for calibration. To ensure consistency, names of firms from Compustat and Clarivate Cortellis are standardized to match those from Thompson/Refinitiv. Names are then matched using a fuzzy matching algorithm to combine all innovation data and are manually crosschecked to ensure a successful match. After this process, I observe approximately 9 percent of firms, about 68 out of 740, in the full sample experience either a merger or acquisition event between 2007 and 2016.

[19]The preclinical phase of drug development occurs before the molecule's discovery is announced. The preclinical phase takes an average of 31 months to complete and consists of feasibility and safety testing, typically conducted in laboratory animals. In total, preclinical development makes up an average of 31% of a company's total expenditures for a drug's research and development costs, or around $474 million dollars per drug. See DiMasi et al. (2016) and Congressional Budget Office (2021) for more information.

Table 1: Summary Statistics - Drug Innovation

	Non-M&A	Acquirer	Target	All	# Firms
Panel A: Full Sample					
Patents Filed	4.34	27.34	.113	6.45	
	(11.20)	(69.95)	(.846)	(24.64)	
R&D Spending (Millions of $)	328.99	1415.23	274.25	424.67	
	(1952.84)	(6768.60)	(441.80)	(2790.32)	
N	672	68	68	740	
Panel B: Development Subsamples					
Drug Discovery Announcements	2.72	5.31	.047	2.98	459
	(31.82)	(33.68)	(.320)	(32.06)	
Drug Discontinuation Announcements	1.51	2.58	.066	1.66	278
	(10.58)	(38.82)	(.538)	(18.23)	
Drugs Entering Phase I	1.36	1.93	.030	1.44	253
	(2.17)	(3.47)	(.223)	(2.40)	
Drugs Entering Phase II	1.23	1.87	.006	1.34	230
	(2.05)	(3.18)	(.089)	(2.29)	
Drugs Entering Phase III	.525	1.36	.000	.734	104
	(.880)	(2.79)	(.080)	(1.63)	

Note: Table 1 lists the summary statistics of the various drug innovation outcomes, taken as the average from the two years of the pre-M&A period (2005 to 2006) of the sample. The top number listed in the chart is the mean of the innovation measure across two years of the pre-period, while the standard deviation is found in the parentheses. Patent and drug development pipeline data come from Clairvate Cortellis Competitive Intelligence. Research and development spending data come from Compustat. Merger and acquisition data, which determines whether firms are or are not acquirers, comes from Thompson/Refinitiv. Number of firms, denoted "# Firms", indicates the number of firms that have molecules able to reach that stage of approval in the sample. As specified in Section 5 and 6.1, when evaluating M&A's effect on the progression of molecules through FDA clinical trials (Phases I-III) I condition inclusion of treated firms in the model only if they are able to reach Phase I, as firms able to succeed progressing molecules through clinical trial phases may be fundamentally different than those that are unsuccessful.

Table 1 shows descriptive statistics for values of clinical trial outcomes, patents, and R&D spending separately for acquiring and non-acquiring firms, alongside the full sample, taken as the average during the pre-M&A analysis period of 2005 to 2006. The table shows considerable differences between acquiring and non-acquiring firms regarding innovation during the specified time frame. Acquiring firms demonstrate higher levels of innovation across all measures compared with those who are not involved in M&A activity. These summary statistics on quarterly innovation, specifically those values of patents and R&D expenditures, align with findings from prior literature (Ornaghi, 2009; Meder, 2019; Haucap et al., 2019).

As delineated in Table 1, while all sample firms engage in patent filing and R&D spending, not all successfully advance molecules through the FDA pipeline to market launch.[20] Fewer firms manage to progress molecules to more advanced clinical trial stages (i.e., Phase III) compared to less advanced stages (i.e., Phase I). This observation is intuitive, as each progression to a subsequent phase requires an increasing level of evidence. This means firms face a growing financial and risk burden to pass a molecule to the next consecutive stage of development.[21].

[20]The fifth column of Table 1, labeled # firms, denotes how many firms in the sample reach that given phase in the sample period.

[21]Drug development is a risky endeavor, with only 12% of drugs making it from their initial discovery announcement

4.3 Drug Prices

Most publicly available data on drug prices report list prices, or, in other words, the sticker price a pharmaceutical company gives to their product. However, due to various discounts such as insurance rebates, coupons, and other financial incentives, consumers rarely pay this full list price. In many cases, the spread between the list price and the net price - the price of a drug net these rebates and discounts - deviates widely. This gap between net and list price has only grown in recent years (Congressional Budget Office, 2022).[22]

To accurately capture the impact of market consolidation on the net price of prescription drugs, I use data from SSR Health. SSR Health, LLC, a private data aggregation firm, derives net prices using pharmaceutical company revenues across approximately 1,200 branded products, covering around 3,300 product-formulations. The company calculates quarterly net price by dividing net revenues for a specific drug, dose form, and strength combination by the volume of the drug sold. These net prices incorporate all forms of manufacturer discounts, including rebates, coupons, 340B discounts, and any other concession accounted for in the reporting of sales, thus providing a more accurate reflection of what consumers pay (Ippolito and Levy, 2022). Recent studies have validated the use of SSR Health's net prices for evaluating patients' prescription drug costs (Kakani et al., 2020; Hernandez et al., 2020).

I conduct a cleaning procedure to extract the final sample of net prices. Due to the differing pricing and marketing mechanisms between brand names drugs in periods of FDA exclusivity and those with generic competitors, I exclude brand name drugs where generic entry is present.[23] I also omit drugs where SSR Health records the price as a "volume estimate." This is done for two reasons. First, SSR Health identifies a volume price if a drug only has a small number of units sold, but at a high enough price that the net price is captured. Thus, the small sample size of these drugs is more likely to deliver inaccurate estimates of net price. Second, volume prices are typically present for specialty drugs distributed through non-traditional channels, such as hospital specialty pharmacies. This often results in an underestimation of sales and an overestimation of price (Ippolito and Levy, 2022).

After these exclusions, I amass a sample of prices from around 1255 unique product-formulation combinations from 2008 to 2018. Individual drugs are identified by the unique brand name, dose form,

to final approval. The FDA requires evidence from more participants as a drug progresses to Phases I, II, and III. In Phase I, the FDA requires 20-100 participants, in Phase II, they require several hundred, and, in Phase III, they require between 300-3,000 people with the disease. Due to this, each phase becomes significantly more risky, with only 70% of drugs passing Phase I, 33% of drugs passing Phase II, and 25-30% of drugs passing Phase III. Each subsequent phase of development also becomes incredibly more expensive, with a mean cost of $25.3 million dollars for Phase I, $58.6 million dollars for Phase II, and $225.4 million dollars for Phase III (DiMasi et al., 2016; Wong et al., 2018) See also `https://www.fda.gov/patients/drug-development-process/step-3-clinical-research` for more detail regarding FDA clinical trials

[22] For Medicare Part D, between 2009 and 2018, the average net price of a brand name drug has more than doubled, from $149 to $353 dollars. In the same time period, the average list price of a brand name drug as more than tripled, from $175 to $547. See Congressional Budget Office (2022).

[23] New drug applications (NDAs) for small molecules approved by the FDA receive a period of market exclusivity for five years. For orphan drugs, this period of exclusivity lasts for seven years and, for biologics, twelve. During this time, generic manufacturers cannot enter the market as competitors, protecting the new molecule from competition. The intent of this exclusivity period, along with patents, is to incentivize pharmaceutical manufacturers to develop new products. Once this exclusivity period is over, assuming the patents for that drug expire, generic firms may enter the market.

and strength combinations present in the data. To identify a drug's therapeutic class, I use a fuzzy match procedure to bring together the brand name of the drug listed in SSR Health with the corresponding chemical name listed in the corporate extracts from the Clavirate Competitive Intelligence data.[24] The Clarivate data contain the text of the corporate report announcing the drug's progression through each clinical trial stage. These reports contain the drug's brand name, among other information. To match the net price data with the clinical trials data, I scrape the brand name from the corporate report and match it to the brand name listed in SSR Health's net price data.

As specified in Dranove et al. (2020), Clarivate Competitive Intelligence categorizes molecules based on the targeted disease, identified as its "indication." However, these indications are too detailed to create markets of drugs, as only a few might fall into each classification. To resolve this, I use a crosswalk that links the indications of each drug to the broad International Classification of Diseases (ICD)-9 three digit disease category classification codes. Using the ICD code, I then assign each drug to a broader therapeutic market.[25] If a drug is identified to be in multiple ICD-9 disease category classifications, I categorize the drug into the category the FDA first granted approval for.[26]

[24] As Clarivate only identifies molecules by their chemical name (i.e. Ibuprofen) rather than SSR Health, which only identifies molecules by their brand name (i.e. Advil), I am unable to directly match Clarivate and SSR Health.

[25] The indication to ICD-9 crosswalk I use in my analysis is the crosswalk created and used by Dranove, Garthwaite, and Hermosilla (2020). ICD is the standard disease categorization used in medical billing. As specified in their paper, two expert medical coders independently assigned 3-digit ICD-9 codes to the targeted condition listed in Clarivate Cortellis Competitive Intelligence and then were reviewed with their authors in consultation with the coders. I graciously thank Manuel Hermosilla for providing me this crosswalk to complete this project.

[26] SSR Health also categorizes drugs into therapeutic classes. However, similar to Clarivate Competitive Intelligence, SSR Health's therapeutic categories are specific, making it difficult to create markets for which drugs compete with one another. Some ICD-9 disease category codes - such as ocular and transplantation - had no drugs affected by a merger or acquisition in the time period of the sample. Therefore, drugs in those categories were excluded from the analysis.

Table 2: Summary Statistics - Drug Prices

	Drug Price	SD	Number of Drugs
All Drugs	238.12	742.13	1280
By M&A Status:			
Not affected by M&A	253.74	752.17	1115
Affected by M&A	170.13	692.74	165
By Overlap in Portfolio:			
Overlap	104.75	510.69	145
No overlap	632.32	1336.91	20
By Therapeutic Class:			
Allergic	59.18	170.77	25
Autoimmune/Inflammatory	1384.06	1827.60	68
Cancer	366.59	718.71	128
Cardiovascular	49.80	100.08	142
Central Nervous System	27.05	91.88	124
Dermatologic	42.75	384.67	43
Endocrine	141.22	427.31	264
Gastrointestinal	596.02	1522.48	65
Gynecologic/Urinaary	247.14	569.79	74
Hematologic	594.39	1007.49	66
Infectious	247.84	771.46	133
Other/Unknown	143.23	464.91	115
Psychiatric	42.23	128.61	172
Respiratory	50.96	203.40	69

Note: Table 2 contains the summary statistics of brand name net drug prices in the final sample from the pre-period of 2008 to 2009. Drug prices are categorized and calculated based on broad ICD-9 classification, if they are a part of an acquirer's portfolio during an M&A event, and whether the drug is a part of a merger or acquisition where there is overlap in the therapeutic class of the portfolio between the target and the acquirer. Data on net drug prices comes from SSR Health, LLC. The net prices have been adjusted to 2017 dollars.

Table 2 presents summary statistics on net prices, focusing on the branded drugs from SSR Health included in my sample, taken as an average during the pre-M&A analysis period of 2008 to 2009. Prices are categorized by ICD-9 broad classifications, merger involvement, and therapeutic overlap. I adopt the framework of Cunningham et al. (2021) to determine portfolio overlap in a given M&A event. If an acquiring firm has either a launched drug or a drug in at least Phase I of FDA development in the same broad ICD-9 classification as the target firm, then that merger or acquisition is considered to be overlapping. As discussed in Cunningham et al. (2021), stratifying the data based on the existence of an overlapping portfolio gives more insight on the purpose of such mergers for the acquiring firm. More specifically, it illuminates whether M&A is intended to generate synergy or increase market power. From Table 2, drugs affected by M&A are less costly than those not affected. This effect is more pronounced when there is portfolio overlap between the target and acquiring companies versus when there isn't. Table 2 also shows a broad range of prices when drugs are stratified by therapeutic class.

5 Empirical Design

In this study, I examine the effects of pharmaceutical merger and acquisition activity on drug innovation and prices. To assess both outcomes, my main empirical specification consists of an event study analysis. I use this to visualize and evaluate the effects on the outcome after the M&A event and to check for pre-trends before the M&A event occurs. I also implore an aggregate difference-in-differences strategy to measure the degree of the consolidation response. In both empirical specifications, I also utilize a propensity score match to gather a set of control firms that best compliment the treated ones.

First, I estimate the effects of mergers and acquisitions on innovation using the following event study design:

$$Y_{st} = \sum_{j=\underline{j}}^{\overline{j}} \beta_j b_{st}^j + \mu_s + \lambda_t + \epsilon_{st} \tag{5a}$$

where

$$b_{st}^j = \begin{cases} \mathbb{1}\left[t \leq Merger_s + j\right] & \text{if: } j = \underline{j} \\ \mathbb{1}\left[t = Merger_s + j\right] & \text{if: } \underline{j} < j < \overline{j} \\ \mathbb{1}\left[t \geq Merger_s + j\right] & \text{if: } j = \overline{j} \end{cases} \tag{5b}$$

In this event study model, Y_{st} is the outcome variable measuring innovation of firm s in quarter-year t. In this analysis, I assess R&D spending, the volume of patents filed, the number of new drug discoveries, the volume of product discontinuations from development, and progression through each phase of clinical trials pipeline as potential outcomes of the M&A event, $Merger_s$. For the treated group, Y_{st} denotes the combined values of innovation for the target and acquirer in the pre- and post-M&A period.[27][28] For the control group, Y_{st} is the level of innovation for a firm not involved in an M&A event, either as an acquirer or a target. μ_s represents firm fixed effects, λ_t represents quarter-year fixed effects, and ϵ_{it} represents clustered standard errors at the firm level.

In the analysis, each firm s receives at most one treatment, indicated at the time of M&A event, $Merger_s$. Since firms might undergo multiple M&A events during the ten year potential treatment window, I measure outcomes from the first instance of M&A activity a firm engages in.[29] I then estimate the effect on Y_{st}, the outcome variable of firm s at different quarter-year time periods $t = \underline{t}...\overline{t}$. Here, $\left[t, ..., \overline{t}\right]$ is the observation window for Y_{st} As the treatment window is set to vary over time, I study the dynamics over a range from $\underline{j} < 0$ periods prior to the event through $\overline{j} > 0$ after the event. In the

[27] In the M&A literature, it is common to treat the merging firm as a combined entity both before and after an M&A event. See Haucap et al. (2019) and Gugler and Siebert (2007).

[28] A unique challenge when evaluating mergers and acquisitions in the pharmaceutical industry is the heterogeneity in how firms report ownership of molecules once the merger or acquisition is complete. In some cases, the target (and all of the products that fall under it) take on the acquirer's name once combined. In other cases, products once owned by the targets keep their "legacy" names in the data. Thus, adding the innovation of the target and the acquirer keeps the innovation level consistent despite the heterogeneity of firm reporting.

[29] The entire time period of the sample of innovation measures extends from 2005 to 2018. In my analysis, when selecting mergers and acquisitions, I provide two years

main specification of these events studies, I set the treatment window 12 quarters, or 3 years, before and after the merger event (i.e. $\underline{j} = -12$ and $\overline{j} = 12$). b_{it}^{j} is a treatment indicator for an event happening in $j \in [j, \overline{j}]$ periods away from t, as defined above in Equation 5b. The base quarter is set one period before the M&A event occurs. Ultimately, I am interested in whether the coefficients in the quarters following the base quarter are significantly different than zero.

I also estimate the equivalent aggregated difference-in-differences model

$$Y_{st} = \alpha + \beta Merger_{st} + \mu_s + \lambda_t + \epsilon_{st} \tag{6}$$

The main explanatory variable, $Merger_{st}$, takes a value of 1 after the first instance of an M&A event in quarter-year t and 0 otherwise. Similar to the event studies above, I compare the innovation measures of treated firms involved in an M&A event to the control group of drug companies not experiencing any M&A activity during the treatment period. Here, I use a 12 quarter, or 3 year, time frame, as it helps to alleviate potential concerns related to auto correlation stemming from a long treatment window Bertrand et al. (2004).[30]

As above, Y_{st} measures the innovation outcomes, R&D spending, the volume of patents filed, the number of new drug discoveries, the number of product discontinuations, and progression through each phase of FDA clinical trials, of either a singular control firm or the sum of the outcomes between the target and acquiring treated firms. μ_s represents firm fixed effects, λ_t represents quarter-year fixed effects, and ϵ_{it} represents clustered standard errors at the firm level. As stated above, treated firms, i.e. those undergoing an M&A event, are represented by both the target and acquirer in the pre- and post-period, holding the combined firm's fixed effects constant over the time period.[31] For the outcomes measuring the advancement of molecules through FDA clinical trials (Phases I-III), I also condition inclusion of treated firms only if they have molecules that are able to reach Phase I. This is because firms that are able to succeed in advancing molecules through clinical trials may be fundamentally different than those that are never successful.

To evaluate the effects of mergers and acquisitions on drug prices, I estimate the following event study model:

$$Y_{ist} = \sum_{j=\underline{j}}^{\overline{j}} \beta_i b_{st}^{j} + \phi_i + \lambda_t + \epsilon_{ist} \tag{7a}$$

[30] As I show in results Section 6.1, the results are robust when extending the treatment window to five years.

[31] As stated above, it is common in M&A literature to treat the merging firm as a combined entity before and after the M&A event. Note that, in the case of R&D spending, the target firm is typically not considered a public firm. As the source of my R&D spending data relies on public financial filings, the results for R&D spending are represented primarily by spending of the acquiring firm. See Section 6.1 and Appendix Section D.2 for additional information.

where

$$b_{st}^{j} = \begin{cases} \mathbb{1}\left[t \leq Merger_s + j\right] & \text{if: } j = \underline{j} \\ \mathbb{1}\left[t = Merger_s + j\right] & \text{if: } \underline{j} < j < \overline{j} \\ \mathbb{1}\left[t \geq Merger_s + j\right] & \text{if: } j = \overline{j} \end{cases} \tag{7b}$$

Similarly to equations 5a and 5b, I use an event study design to estimate the effects of $Merger_s$ on the price of drug i from firm s at time t, written as outcome Y_{ist}. As above, I measure outcomes from the first instance of M&A activity a firm engages in and set the treatment window 12 quarters pre- and post-M&A event. I include drug level fixed effects, ϕ_i, to control for unobserved, fixed characteristics of drugs that might influence their price, quarter-year fixed effects λ_t, to control for national trends in pricing over time, and ϵ_{ist} to account for idiosyncratic factors across drugs and time. For this analysis, I cluster standard errors at the firm level.

Similarly to equation 6, I also estimate an aggregated difference-in-differences model

$$Y_{ist} = \alpha + \beta Merger_{st} + \phi_i + \lambda_t + \epsilon_{ist} \tag{8}$$

Here, I estimate outcome variable Y_{ist}, which measures the change in drug i's price from firm s at time t. I represent each drug by the unique brand name, dose form, and strength combination. As above, ϕ_i accounts for drug-level fixed effects, λ_t accounts for quarter-year fixed effects, and standard errors are clustered at the firm level. For both the event study and the aggregated analysis of drug prices, I winzorize net drug prices at the 99% level. This is due to the right tail skew of the net price data, resulting from a few, very expensive drugs.

To address the potential endogeneity of merger decisions, I employ a propensity score match in the above event study analyses and aggregated difference-in-differences regressions. This procedure matches acquiring, treated firms with non-acquiring firms based on their pre-merger attributes, creating a similar control group.[32] Propensity score matching allows me to control for heterogeneous firms in the control group that might bias the results and results in a more balanced sample of controls. To determine propensity scores, I estimate the Probit model $\hat{pr}(Merger_{it} = 1|X_{it-2})$, the predicted probability of an M&A event occurring, using each firm's annual number of employees, annual sales, annual revenue, and total assets. [33] To avoid reverse causality, I match firm characteristics taken two years before the M&A event of the treated group takes place. I then use a nearest neighbor match to pair like firms based on these characteristics. Due to the relatively large group on controls, this match procedure is conducted without replacement for each treatment year. The results of the match are summarized in Section C.1 of the Appendix, which shows the density of both the treatment acquiring firms and both the pre-matched

[32] Propensity score methods have been used widely in the literature to study the effects of mergers and acquisitions, due to the absence of random assignment. See Schmitt (2017); Haucap et al. (2019); Guadalupe et al. (2012) for other examples.

[33] All values listed here are obtained from the Compustat Market Intelligence Annual Fundamentals data.

(i.e. the full sample) and post-matched control firms. Ultimately, I find that matching helps improve the balance of the control group. I then conduct the empirical analyses above using the subset of matched firms as the control.

6 Results

The subsequent section presents the empirical findings on the impact of mergers and acquisitions (M&As) in the pharmaceutical industry. I first focus on innovation outcomes in Section 6.1, followed by the analysis on drug pricing in Section 6.2. The results conclude with robustness checks in Section 6.3 to validate the integrity of these results.

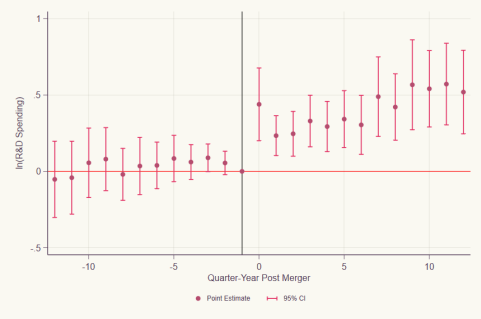
6.1 Pharmaceutical Innovation

6.1.1 Primary Analysis

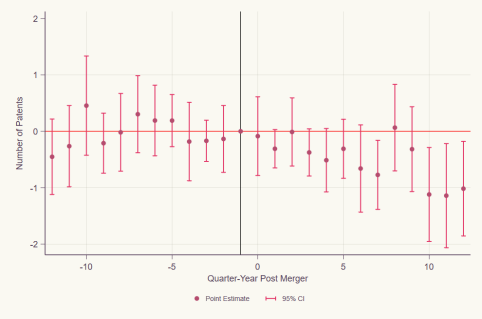
First, I examine the impact of M&A on multiple innovation metrics for firms. Specifically, I evaluate the number of patents filed, logarithm of R&D expenditures, new drug discoveries, discontinued drug announcements, and progression through Phases I-III of clinical trials. As described in Section 5, I incorporate firm-level and quarter-year fixed effects, cluster standard errors by firm and take the sum out the outcomes for both target and acquirer, as is common in the M&A literature. I also use propensity score matching to create a more balanced sample of control firms. Figure 3 contains event studies depicting these outcomes for 12 quarters (or three years) both before and after the M&A events. Table 3 contains the corresponding difference-in-differences coefficients for these event studies.[34] From the event studies in Figure 3, I find no evidence of a difference in the pretrends between the treated and control firms for any of the seven measures of innovation. Following an M&A event, there is a notable decline in the number of patents filed by the new entity —approximately three fewer per year compared to the pre-period. However, R&D expenditures rise by around $380 million annually post-merger. Notably, the results reveal no statistically significant change in the number of new drug discoveries, nor in the number of drugs reaching any phase of the FDA pipeline. Likewise, there is no significant alteration in the number of drugs withdrawn from clinical trials during development.

[34]For the regression results including the full control group before the propensity score match, see Section D.1 of the Appendix.

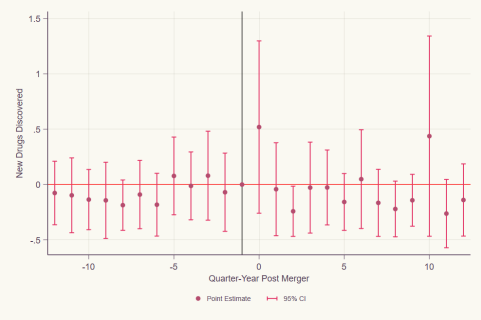
Figure 2: Event Studies of the Effects of M&A - Measures of Innovation



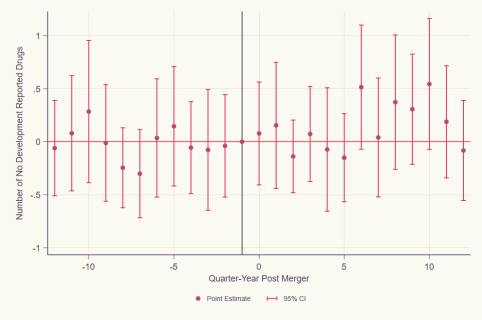
(a) R&D Spending



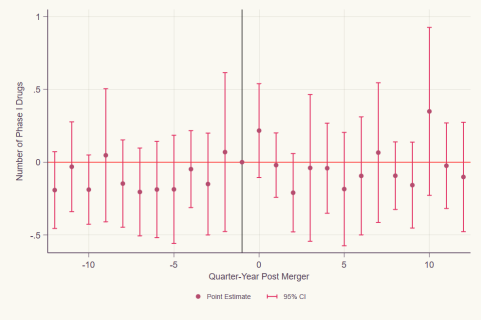
(b) Number of Patents



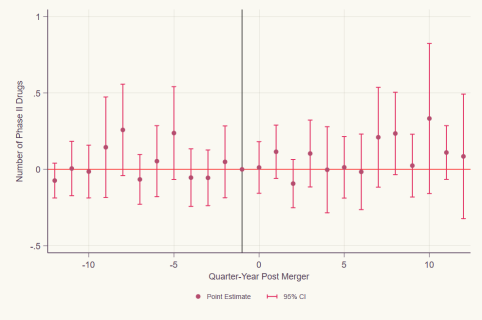
(c) New Drug Discoveries



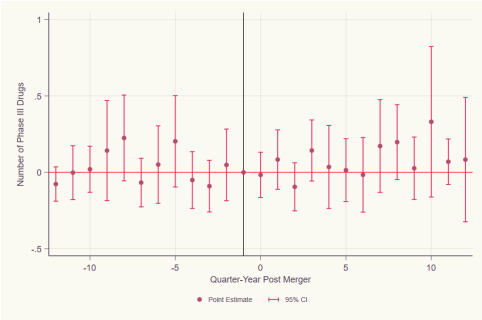
(d) Discontinued Drugs



(e) Drugs in Phase I



(f) Drugs in Phase II



(g) Drugs in Phase III

Note: Figure 3 shows event studies plotting logarithmic research and development spending, the number of patents, new drug discoveries, drug discontinuations from development, and movement through different drug development clinical trial phases (I, II, and III) 12 quarters, or three years, post-M&A event. Prior to this analysis, propensity score matching ensures the control group was more balanced to the treated group. Clinical trials and patent data come from Clarivate Cortellis Competitive Intelligence. Research and development data come from Compustat. Data on mergers and acquisitions come from Thompson/Refinitiv SDC Mergers and Acquisitions database.

Table 3: Regression Results: Effects on Innovation

	(1) ln(R&D Spending)	(2) Patents	(3) Discoveries	(4) End Development	(5) Phase I	(6) Phase II	(7) Phase III
Merger == 1	0.411***	-0.743*	0.247	0.186	0.029	0.023	0.025
	(.121)	(0.313)	(0.145)	(0.152)	(0.021)	(0.045)	(0.044)
Firm FE	X	X	X	X	X	X	X
Quarter-Year FE	X	X	X	X	X	X	X
Mean of Outcome	232.1	1.48	0.555	1.386	.118	.109	.058
Number of Firms	108	108	73	73	43	43	43

Standard Error in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Table 3 shows the results of the corresponding difference-in-differences regression of the effect of an M&A event on different forms of innovation. Prior to this analysis, propensity score matching was conducted to ensure balance of the control group compared to the treated group. Clinical trials and patent data come from Clarivate Cortellis Competitive Intelligence. Research and development data come from Compustat. Data on mergers and acquisitions come from Thompson/Refinitiv SDC Mergers and Acquisitions database. The values in the parentheses are the standard error values of the regressions.

There are multiple possible explanations for why, despite an increase in R&D spending, the number of patents declines while other innovation metrics remain stagnant post-M&A event. One likelihood is that firms may be realigning their R&D strategy to acquire products, and their patents, from target companies during a merger or acquisition. This is instead of acquirers filing their own patents on new molecules "in-house". This shift in strategy could be an effort to expedite the development of newly acquired products through clinical trials, as these molecules have already completed steps of preclinical development. As depicted in Figure 3a, firms dedicate monetary resources to advance the acquired patented technologies through FDA clinical trials, creating a surge in R&D spending. However, as firms focus on these newly acquired molecules, and their patents, they shift away from filing patents themselves. Eventually, as seen in Figure 3b, this causes the sum of total new patents to decline. Moreover, baseline results suggest that this strategic reorientation does not effectively accelerate new drugs through FDA development, at least in the short term. In addition, it is important to note that few drugs ever make it to later stages of development and final approval, with many factors promoting or inhibiting development and high risks of failure through each stage. (DiMasi, et al., 2016). [35] Therefore, the results pertinent to the outcomes associated with FDA development (as depicted in Figures 3e, 3f, and 3g) appear to exhibit a considerable degree of noise.

A limitation of this study is the relatively short three year, or 12 quarter, window post-M&A for observing effects on drug discoveries and progression in FDA clinical trials. Unlike filing patents, increasing R&D spending, or discontinuing a drug from clinical trials, discovering a new molecule and moving drugs through FDA phases is not an instantaneous action. It takes substantial time and resources

[35] The probability of success of making it to each FDA phase also varies, as the FDA requires different scopes of evidence to move from one FDA stage to the next. In general, a molecule has a 70% chance of moving from Phase I to Phase II, a 30% chance to move from Phase II to Phase III, and a 25-30% chance to move from Phase III to final approval. See https://www.fda.gov/patients/drug-development-process/step-3-clinical-research for more details regarding FDA clinical trials.

to conduct both preclinical and clinical trials. In fact, clinical trial phases last 33, 38, and 45 months in Phase I, Phase II, and Phase III , respectively (DiMasi et al., 2016). Accordingly, I conduct an extended robustness check with a five-year pre- and post-M&A window, the details of which are in Section C.3 of the Appendix. Consistent with the initial findings, no statistically significant impacts are observed on new drug discoveries or progress through FDA clinical phases.

Figure 3 and Table 3 look at the effects of mergers and acquisitions on the sum of innovation between targets and acquirers. As stated in Section 5, it is common across the M&A literature to evaluate the treated firm, target and acquirer, as a combined entity in the M&A pre-period. However, this empirical strategy has a few limitations in this particular environment. For one, comparing the sum of independent targets and acquirers with singular control firms could result in having a disparity of trends in the pre-period. In addition, the data for research and development spending, Thompson/Refinitiv, are sourced from SEC filings, which are only disclosed by public firms. However, some of the target firms in the data are not public and, therefore, their research and development spending is not captured as a summation. Due to these potential limitations, I also consider an alternative empirical specification and measure innovation solely from the acquirer as the treatment. Using this treated group allows me to compare the outcomes of the acquiring firm - a single firm in the pre-period - to that of the singular control firms. The results from this analysis are located in Section D.2 in the Appendix. From the event studies and the coefficient estimates, I see that the results are similar between both specifications.

6.1.2 Primary versus Secondary Patents

As the results above show, although R&D spending increases, the total number of patents filed decreases, while the number of drugs progressing into subsequent development stages does not change. This discrepancy may reflect a short-term strategic innovation shift within acquiring firms. Instead of filing patents themselves, acquirers procure existing patents from targets. The firms then increase R&D spending to move newly obtained molecules through the pipeline. Despite this potential account, some might view the opposing results of innovation outcomes - R&D spending increasing while patents decreasing - as perplexing.

Given the potential discrepancy of the narrative above, the utility of patents as a reliable metric for innovation warrants discussion. Although patents have been employed as a metric in numerous studies, it must be noted that not all serve as equivalent indicators of innovation. The decline in patents may reflect a strategic shift on the part of pharmaceutical companies away from patenting currently existing technologies, or secondary patenting, and toward newer, more innovative patents, or primary patenting, as part of a firm's long-term strategy post-M&A. Pharmaceutical firms have often relied on the former as part of their business model. Feldman (2018) has documented this process, finding 78% of the drugs associated with new patents are not new drugs, but ones that already exist. The trend is such that

many leading pharmaceutical industry experts have asserted that patents "fail to represent any measure of true innovation" (Reeb and Zhao, 2020). It is therefore important to discern whether the decline in patents is due to a reduction in secondary patents with little incremental benefit or due to a shift away from filing innovative, primary patents.

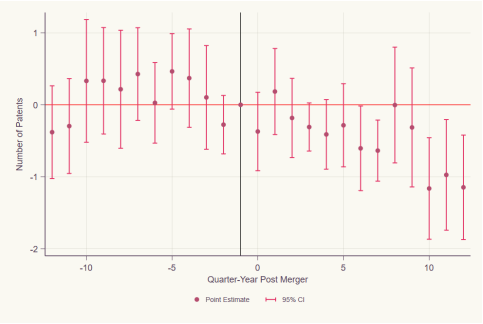
While the patents data from Clarivate Competitive Intelligence does not directly identify whether a patent is primary or secondary, prior literature provides information that allows for categorization of them indirectly (Hutchins, 2003; Sampat and Shadlen, 2017; Amin and Kesselheim, 2012). Primary patents are those that firms first file when they discover new chemical entities during the preclinical phase. These primarily include those filed on the basic molecules on the drug, also known as product patents. Secondary patents are follow-on patents usually filed after a drug has been on the market for some time and already has primary, product patents in place. Some of these secondary patents can be instances of follow-on innovation or closing in gaps in patent portfolios, such as extended release. However, secondary patents may also be used to extend expiring market exclusivity in the face of an expiring patent, a practice known as evergreening. It may also be used to substitute a drug with an expiring patent for a similar drug with a newly patented constituent other than the molecule in the market. Known in the industry as product hopping, this practice involves the manufacturer pulling the drug with the expired patent from the market, forcing consumers to take up the newly patented drug (Richards et al., 2022). Prior literature has shown that the types of patents commonly used in evergreening and product hopping are those that cite the drug for a new formulation of existing molecules or those filed for a new use that is not actually novel (Danzon et al., 2007; Seymore, 2020). [36]

In my subsequent analysis, I focus on the effects of M&A activities on active primary and secondary patents filed by acquiring firms post-merger. As stated in Section 4.2.1, Clarivate defines the type of patents filed on pharmaceutical products based on their patent reports. These categorizations include formulation, product, manufacturing, delivery, among others. In line with industry and academic perspectives, I categorize product patents on new macromolecules as primary patents, and, thus, clear indicators of innovation within the pharmaceutical industry. The event study on primary patents, found in Figure 4a, specifically examines those filed on such macromolecules that have not had patents issued in previous years. The findings reveal a decline in the number of primary patents filed post-M&A event.

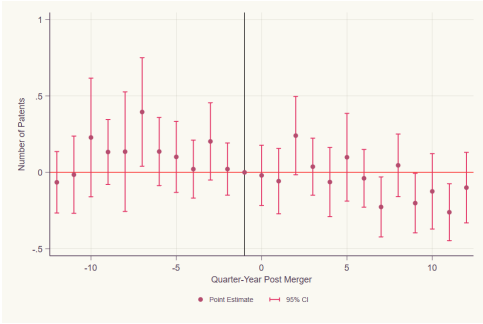
Next, I investigate the impact of M&A events on secondary patents. Such patents are often employed as defensive strategies to prolong market exclusivity, rather than serving as indicators of novel innovation. In this event study, the analysis focuses on patents categorized as "formulation" or "new use" in the Clarivate data. These are cross-referenced with molecules that are either already on the market or that have already have primary, product patents filed. The results, shown in Figure 4b, indicate a modest yet erratic decline in the number of secondary patents filed post-M&A, compared to the decrease

[36] In the Clarivate Competitive Intelligence data, new formulation patents are identified as "formulation" in the data.Patents on new uses for old products are identified as "new use".

Figure 3: Patents Filed: Primary versus Secondary Patents



(a) Primary Patents on New Macromolecule Products



(b) Secondary Patents on New Use or Formulations on Existing Molecules

Note: Figure 4 presents event studies resulting from the difference-in-differences regression of the effects of an M&A event on patents based on whether the patent was considered primary (A) or secondary (B). The effects from the baseline regressions on patents from the event study in Figure 3b are more similar to those in Figure 5a, the primary patents. While secondary patents do show a slight decline, the effects are more noisy. This suggests that the majority of the decrease in new patents post-M&A come from primary patents on new macromolecules.

in primary patents.

Additionally, I use an alternative strategy to identify innovative patents. As stated above, Clarivate's data comes from scientists, who analyze company announcements and patent records to create standardized data. Among additional information, these data indicate whether a patent provides a specific advantage to an existing technology. Therefore, I conduct the analysis on primary and secondary patents using Clarivate's definition of those that have a suitable advantage. Here, primary patents are those identified as having a suitable advantage, while secondary patents are those that do not. The description and results of these event studies can be found in Section D.4 the Appendix. Overall, these results produce similar findings to those in Figure 4.

Overall, the results from Figure 4 and Section D.4 demonstrate the decline in patents from the average merged firm stems from a decrease in primary patents.These results confirm my initial insight into the role mergers and acquisitions play in a shifting innovation strategy. Acquirers substitute primary patents for new molecules with those discovered by targets. Subsequently, the consolidated entity elevates its investment to advance these innovative molecules to market. However, this alternative approach to substitution does not translate into any significant shifts in developmental milestones after the merger or acquisition, even with increased spending. Additionally, the rate of patenting new technologies diminishes in the years following the merger, signaling a net loss of new innovation.

6.1.3 Firm Heterogeneity and Effects on Innovation

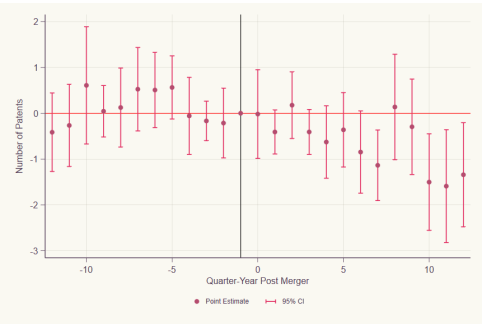
Next, I examine the differential effects of mergers and acquisitions based on the size of acquiring firms. I categorize larger acquiring firms as those with an average market value exceeding the median and smaller acquiring firms as those falling below the median.[37] Subsequent event studies replicate the analysis from

[37]Data on a firm's average market value come from Thompson/Refinitiv Mergers and Acquistions data.

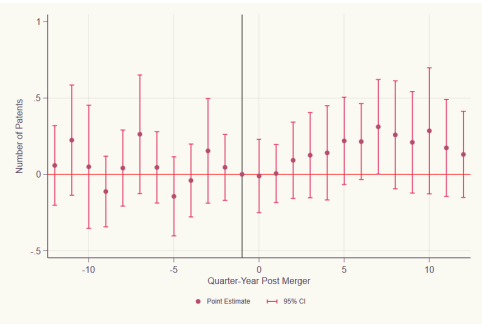
Figure 3, focusing on patents (Figure 5) and R&D spending (Figure 6). The results show that larger acquirers' behavior in terms of patents and R&D spending closely aligns with the baseline specification detailed in Figure 3. Larger acquirers tend to significantly reduce patent filings while simultaneously boosting R&D investments.

Conversely, smaller acquirers increase their R&D spending at a slower rate post-M&A and demonstrate little change in patent filing activity. These observations illuminate divergent strategic priorities between larger and smaller acquirers post-M&A. Larger firms perceive mergers primarily as a means of sourcing patents from smaller entities rather than generating their own (Cunningham et al., 2021). In the medium term, this leads to a decline in patent activities as larger firms allocate R&D resources toward advancing acquired molecules through clinical trials. Unlike their larger counterparts, smaller firms maintain a consistent internal development focus both in the pre- and post-period, as their M&A events typically involve similarly-sized target companies. Therefore, smaller firms continue to file patents at a comparable rate while also increasing R&D expenditures to advance new molecules through clinical trials.

Figure 4: Patents Filed Based on Acquiring Firm Size

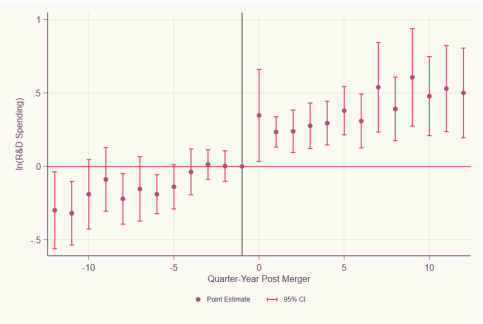


(a) Market Value: Above Median

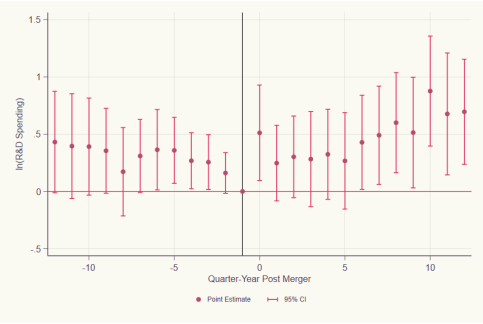


(b) Market Value: Below Median

Figure 5: R&D Spending Based on Acquiring Firm Size



(a) Market Value: Above Median



(b) Market Value: Below Median

Note: Figures 5 and 6 depict event studies resulting from the difference-in-differences regression of the effects of an M&A event on patents (Figure 5) and R&D spending (Figure 6) based on the average market valuation of a given firm. The effects from the baseline regressions on patents from the event study in Figure 5a and 6a are similar to those in Figures 3a and 3b, suggesting that these effects are focused on larger firms.

Subsequently, I analyze the variability in the effects of M&A events on innovation based on the target firm's industry. Pharmaceutical companies contend that the synergies resulting from M&A will catalyze innovation. Therefore, horizontal mergers—where there is more direct technological overlap—should theoretically yield greater innovative output compared to diagonal or vertical mergers, where such overlap is less pronounced. In the baseline specification, I combine both pharmaceutical and biotech M&A activities involving pharmaceutical acquirers. In subsequent event studies, I disaggregate pharmaceutical and biotechnology targets to differentiate the impacts between horizontal M&A (pharmaceutical firms acquiring pharmaceutical targets) and diagonal/vertical M&A (pharmaceutical firms acquiring biotech targets).[38] The outcomes of this analysis are detailed in Appendix Section D.5. Overall, the effects on innovation due to consolidation are more pronounced in pharmaceutical-to-pharmaceutical M&A compared to pharmaceutical-to-biotech M&A, corroborating my initial hypothesis.

In a comprehensive review of innovation, I find that, upon a merger or acquisition event initiated by a pharmaceutical company, the number of patents decrease while research and development spending increases. The majority of these effects are focused on larger pharmaceutical company acquirers usurping pharmaceutical targets. Despite these changes in patents and R&D spending, there is no significant change in the development or advancement of prospective molecules. The intuition for this impact is pharmaceutical companies change their innovation strategy post-M&A event. Instead of discovering their own molecules in-house, larger companies supplement innovation by acquiring molecules in development from other, smaller pharmaceutical firms. However, despite increasing spending on research and development post-M&A, there is no change in the progression of getting these new drugs through clinical trials and to consumers. These results raise questions regarding proclamations made by drug companies, who emphasize how consolidation improves pharmaceutical innovation. As more R&D spending occurs with no molecular advancement to show for it, the results also challenge the perception that mergers and acquisitions make firms more efficient.

6.2 Pharmaceutical Prices

The preceding discussion establishes that M&A activities do not generate appreciable improvements in several key innovation metrics. Next, I examine the impact of M&A on drug prices, as formally described in equations 7 and 8 from Section 5. Prior to the mid-1990s, and largely influenced by Robert Bork's work, both the FTC and DOJ used projected changes in price, as well as output, as a metric for consumer welfare to evaluate M&A (OECD, 2012). Therefore, I conduct an analysis to assess the ultimate impact of mergers and acquisitions on drug prices.

[38] Thompson/Refinitiv data specify the industries which acquirers and targets belong. In the original baseline specification, defined in Section 5, both biotech and pharmaceutical targets are included.

6.2.1 Primary Analysis

First, I estimate the effects of M&A on the net price for brand name drugs, adjusted for inflation. These net prices account for coupons, rebates, and other discounts and best reflect the price paid for by consumers. Similar to the events studies and regressions in Section 6.1, I look at the first instance of a merger or acquisition for each of the acquiring firms and analyze the effects 3 years (or 12 quarters) pre- and post-M&A event. I incorporate drug-level and quarter-year fixed effects and cluster standard errors at the firm level. I also match firms according to the propensity score matching procedure described in Section 5 to create a sample of controls most similar to the treatment firms. The event studies for these results are presented in Figure 7, while the results of the corresponding difference-in-differences regressions can be found in Table 4.[39] Examination of Figure 7 and Table 4 reveals that the log net price of brand name, non-generic drugs increases by around 19% per quarter after an M&A event.

Table 4: Regression Results: Effects on Drug Prices

	(1) ln(Price)
Merger == 1	0.191*
	(0.084)
By Portfolio Overlap:	
Portfolio overlap between acq. and target:	0.119*
	(0.0497)
No portfolio overlap between acq. and target:	0.705*
	(0.294)
Drug FE	X
Quarter-Year FE	X
PSM Match	X
Mean Price	255.7

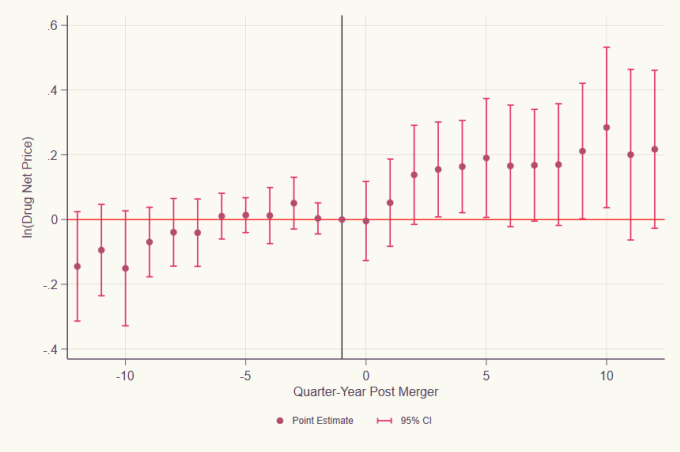
Standard Error in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Table 4 shows the results of the effects of a merger or acquisition event on the logarithmic price of a drug. This table also shows the results of the regressions on firms where the target and acquirer have therapeutic class overlap in their portfolios. The values in the parentheses are the standard error values of the regressions of the baseline difference-in-differences. Drug net price data come from SSR Health. Merger and aquisition data come from Thompson/Refinitiv. Difference-in-differences regressions are estimated with drug and quarter year fixed effects, with standard errors clustered at the firm level. Before the regressions, like firms were matched using a propensity score matching procedure as described in Section 5 to balance the control group.

[39] For the regressions including the full sample before the propensity score match, see Section E.1 of the Appendix. For results on the effect of M&A on levels of net drug prices, see Section E.2 of the Appendix

Figure 6: Effects on Drug Prices

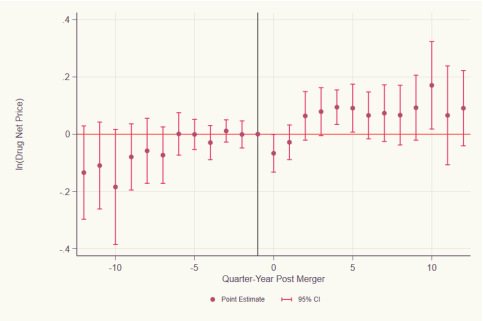


Note: Figure 7 depicts the event study results looking at the effects of M&A on the acquiring firm's non-generic net drug prices, after taking the log of the price. Before the event study, like firms were matched using a propensity score matching procedure as described in Section 5 to create a more balanced control group. Data on net prices of drugs come from SSR Health. M&A data come from Thompson/Refinitiv. Event studies were estimated with drug and quarter year fixed effects, with standard errors clustered at the firm level.

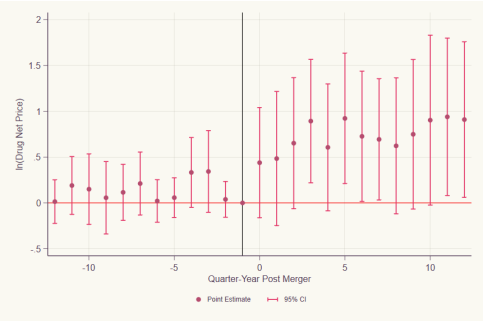
6.2.2 Drug and Firm Heterogeneity

Given the baseline results from Figure 7 and Table 4, I explore whether firm or drug heterogeneity contributes to the post-M&A price increase. To do this, I segment the baseline sample. First, I evaluate M&A events involving pharmaceutical companies with overlapping product portfolios. Pharmaceutical firms often justify mergers or acquisitions by claiming they enhance synergies and thereby result in consumer cost savings (Comanor and Scherer, 2013). If one accepted this explanation, given overlap exists, the technologies between targets and acquirers would be better matched to produce drugs more efficiently, resulting in lower prices for consumers. However, the presence of portfolio overlap also leads to acquirers gaining a greater market share in the corresponding therapeutic areas. This increasing market concentration empowers the acquirer to elevate prices within those therapeutic classes. As delineated in Section 4.3, a merger event is considered to have overlapping portfolios if, at the time of the merger, the target's portfolio contains either a launched drug or a drug in Phase I of FDA approval in the same therapeutic class, defined as in the same broad ICD-9 classification, as the acquirer. The outcomes of these event studies and the corresponding difference-in-differences analyses are illustrated in Figure 8 and Table 4, respectively.

Figure 7: Event Studies of the Effects of M&A Events on Prices: Portfolio Overlap



(a) ln(Net Drug Price): Overlap



(b) ln(Net Drug Price): No Overlap

Note: Figure 8 depicts the event study results from the regression of the effects of an M&A event on drug net prices after separating acquiring firms which have a product portfolio that has drugs of the same therapeutic class, as defined by the broad ICD-9 classification, as the target. The resulting event studies shows that net drug prices increase when the portfolios of targets and acquirers both have and do not have overlap.

In the case when the target and acquiring firm have overlapping product portfolios, I observe a significant increase in drug prices by almost 12%. This lends credence to the argument that heightened market concentration contributes to post-merger price escalations. Conversely, when the portfolios of the acquiring and target firms are disparate, prices of their products also significantly increase. However, the later result studying firms with non-overlapping portfolios require some considerations. First, only a limited number of drugs in the sample fall under this non-overlapping category, and those that do generally exhibit higher prices than the average.[40] Due to the small sample size, there should be caution exerted when interpreting these results. Second, the underlying motives for mergers and acquisitions with and without portfolio overlaps could differ. Large pharmaceutical companies might resort to M&A not to gain market share in particular therapeutic areas, but to expand their portfolio of products, increasing the overall size of the firm. Post-M&A, a large, mutliproduct firm would now have greater size-related leverage in bargaining with pharmacy benefit managers (PBMs). This size advantage, with potentially hundreds of products across several therapeutic classes, could be used to negotiate reduced rebates for their products (Danzon and Carrier, 2022). A decrease in rebates would result in an increase in net prices, as net prices for drugs take these discounts into account. In the context of this analysis, two of the three firms involved in this type of merger are among the top 10 pharmaceutical companies in terms of net revenues in 2018.[41] Thus, it is plausible that this leverage is the mechanism at play regarding the impact of these M&A events.

I also look at changes to pharmaceutical prices when a divestiture is required for a merger or acquisition to proceed. After conducting an economic analysis, the FTC or the DOJ determines whether a merger or acquisition will ultimately reduce competition. However, instead of blocking the M&A

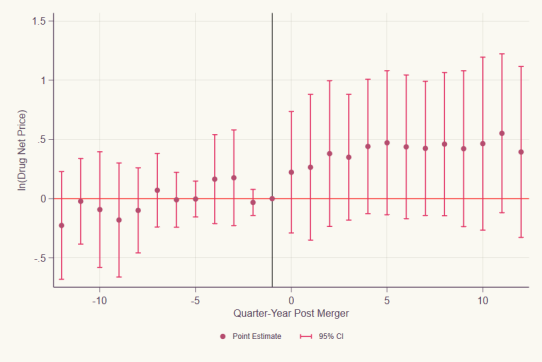
[40] See Table 2 for summary statistics on the net prices of drugs involved in mergers with non-overlapping portfolios.

[41] The three firms whose drug prices are being evaluated are Abbvie, Sanofi, and Bachem. As of the last year of the sample (in 2018), Sanofi is positioned 7th and Abbvie is positioned 8th as the largest pharmaceutical companies in regards to net revenue. See https://pharmaphorum.com/views-and-analysis/the-top-pharma-companies-by-revenue-2018

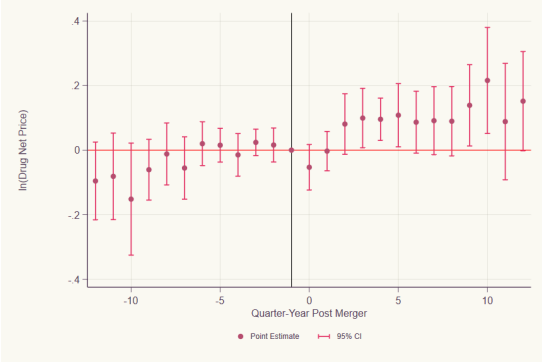
event altogether, the FTC or DOJ will often recommend a divestiture. In other words, the agencies will order the acquiring or target firm to transfer assets to a a non-merging firm. In the pharmaceutical industry specifically, with mergers involving brand name, market exclusive drugs, divestment typically translates to New Drug Applications (NDAs) in overlapping therapeutic classes transferred to other, non-merging firms. These divestments are conducted with the goal of maintaining competition in markets where regulators worry M&A will harm consumers (Hammoudeh et al., 2022). Divestitures are now a commonplace feature of antitrust cases, with some firms proactively suggesting products to divest to reduce the likelihood of an antitrust challenge (Gotts, 2006). Economic theory suggests that these divestments limit the price-increasing potential of M&A, a metric which, suggested in Section 2.1, has been used to determine effects to consumer welfare (Vergé, 2010).

In light of this, I stratify the results and assess the effects on pharmaceutical prices with and without divestitures, to determine whether these remedies have their intended effect. While I am able to see whether a divestment occurred or not, I am unable to categorize what assets specifically were divested. The results of this extension can be found in Figure 8 and Table . Looking at the results, I find that these pricing effects primarily occur in mergers and acquisitions where no divestiture is ordered (Figure 8b). On the other hand, there is no change to pharmaceutical prices when divestment occurs. This suggests that, in the case of pharmaceutical prices, divestments have their intended effect of limiting price hikes following consolidation. It also suggests that those cases where divestitures do not occur, particularly those on the margins of the required analysis threshold, need a closer analysis and evaluation.

Figure 8: Event Studies of the Effects of M&A Events on Prices: Divestment



(a) ln(Net Drug Price): Divestment



(b) ln(Net Drug Price): No Divestment

Note: Figure 8 depicts the event study results from the regression of the effects of an M&A event on drug net prices after separating mergers and acquisitions that required a divestment versus those that did not. The resulting event studies demonstrate that mergers and acquisitions where no divestment is required resulted in price increases, compared to those that did require divestment

Next, I turn my attention to the impact of M&A on drug prices across therapeutic classes for several key reasons. Firstly, as indicated in Table 2, drug prices exhibit considerable variance among different therapeutic classes. Existing research notes how firms set their prices differently depending on

the disease category a drug targets (Hernandez et al., 2020). Second, per Cunningham et al. (2021), the number of direct competitors varies across therapeutic markets, potentially causing prices to fluctuate differently. For example, therapeutic classes, such as statins, with more direct substitutes present, might be less sensitive to the effects of market consolidation than drugs in less competitive markets, such as cancer drugs. Therefore, I probe whether specific drug subgroups are more affected by M&A than others.

In this segment of the analysis, as elaborated in Section 4.3, broad therapeutic classes are defined based on the more detailed ICD-9 classification - or indications - of diseases that a drug treats according to its initial FDA approval. These indications are subsequently mapped to broader therapeutic classes via a crosswalk. The findings, which include the event studies and the associated aggregate difference-in-differences results, are detailed in Section E.3 of the Appendix. From these results, I discern no significant shifts in net prices after segmenting the market by therapeutic class.

Lastly, I assess whether the nature of the firm acquired — either a pharmaceutical or biotechnology company — influences post-M&A net drug prices. The prevailing industry argument posits that M&A generates synergies that ultimately benefit consumers through lower drug prices. Therefore, pharmaceutical-to-pharmaceutical mergers would logically be expected to result in more substantial price reductions, aligning with the idea of overlapping synergies. To test this hypothesis, I categorize my data into two types of mergers: those where the target is a pharmaceutical company and those where the target is a biotechnology firm. The outcomes, as outlined in Appendix Section E.4, indicate no statistically significant difference in post-M&A drug prices regardless of whether the target firm is a pharmaceutical or biotechnology company. This casts doubt on the often-cited rationale by companies of cost-saving synergies.

To summarize, the overall findings suggest that mergers and acquisitions by pharmaceutical companies exert a increase in net drug prices. Given the unique, noncompetitive markets in which brand name drugs operate — protected by FDA exclusivity and patents — these drugs are less reactive to M&A-induced price shocks. Yet, they do respond in a manner consistent with general economic theory, which posits that reduced competition among firms generally leads to increased product prices (Dafny et al., 2019). These insights raise questions about the adequacy of current regulatory assessments of M&A. Given the impact of mergers and acquisitions on net drug prices, especially in specialized markets protected by complex patent systems, there is a concern that regulatory bodies may be inadvertently permitting excessive M&A, thereby exerting a modestly negative influence on prices, alongside innovation. Moreover, these results also pose questions to pharmaceutical companies, who state that mergers and acquisitions, in increasing the efficiency of firms, will bring about lower drug prices. Given the results, it is suggested that consumers do not, in fact, see the savings resulting from M&A.

6.3 Robustness

To assess the robustness of the innovation and drug pricing results from Sections 6.1 and 6.2, I estimate several additional models that modify the primary assumptions delineated in the main empirical specifications from Section 5.

6.3.1 Second Versus First Merger

First, I adjust the selection of mergers and acquisitions in my sample by choosing the second occurrence of an M&A event. As specified in Section 5, I construct my sample by selecting the first instance of an M&A event if a pharmaceutical company has more than one during the treatment period.[42] One limitation of this empirical approach is the results on innovation and prices may arise due to the selection of chosen M&A events. To test this, I examine if and how the results differ when selecting a firm's second instance of a merger or acquisition as the treatment instead of the first. If a firm has only one M&A event in the sample period, that treatment remains consistent from the baseline sample. The findings from this robustness check are reported in Section F.1 of the Appendix. Based on this analysis, I conclude that the choice of the second merger instance versus the first does not significantly change or impact the results.

6.3.2 Staggered Timing and Differential Adoption

Second, I address concerns relating to staggered adoption and differential timing. The empirical specification detailed in Section 5 relies on merger and acquisition events occurring in different time periods to estimate their impact on innovation and prices. However, this approach raises potential issues due to differential timing and staggered adoption of the treated group, with concerns that the two way fixed effects (TWFE) estimator might be biased (Goodman-Bacon, 2019). To mitigate this, I substitute the standard difference-in-differences estimator with that first proposed by Callaway and Sant'Anna (2021). The Callaway and Sant'Anna (CS) estimator incorporates the group-time treatment effect into the model, which addressing potential bias from receiving the treatment effect at different moments. The results from this robustness check are detailed in Appendix Section F.2. A comparison of the coefficients from the baseline difference-in-differences estimator with those results from CS reveals no significant differences. This leads me to conclude that the baseline findings are not biased by differential timing effects.

6.3.3 Alternative Matching Specifications

Lastly, as specified in Section 5, I employ a probit nearest neighbor propensity score matching algorithm using yearly firm sales, revenue, assets, and the employee count two years prior to the M&A event as

[42] As specified in Section 5, a firm's merger or acquisition is only considered if 1) it is the first instance of the merger in the sample period and 2) the firm has not had a merger or acquisition in the pre-period of 2005 to 2006.

part of my empirical approach. However, the baseline results in Sections 6.1 and 6.2 might be contingent upon how I select the control group from the propensity score matching strategy. To test the robustness of my initial findings, I change the matching specification to a 1-to-1 Mahalanobis matching, again using yearly firm sales, revenue, assets, and number of employees two years before the M&A event to compute the distance between firms. Post-matching, the distance between all of the covariates fall below the 0.1 threshold. The results of this additional robustness check are available in Appendix Section F.3. The analysis indicates that modifying the matching specifications does not alter the study's key outcomes.

7 Conclusion

Regulators in both the United States and the European Union have expressed concerns about the effects of the surge in mergers and acquisitions, both broadly and in the pharmaceutical industry, on consumers. Meanwhile, prior literature, theoretical and empirical, and industry experts give conflicting information about the impact of consolidation. In an effort to disentangle these opposing viewpoints, this study concurrently assess the effects increasing pharmaceutical consolidation has on innovation and prices.

My results indicate that pharmaceutical companies have a clear, post-M&A response on innovation and prices. While mergers and acquisitions result in no significant change to new drug discoveries or advancement through clinical trials, pharmaceutical firms do increase spending on research and development afterwards. I also find that firms post-M&A decrease the amount of patents filed. This means that consolidated firms file less patents compared to separated targets and acquirers pre-M&A. Further testing on types of patents, types of mergers and acquisitions, and characteristics of the firms involved conclude that 1) the decline of patents comes largely from primary patents 2) these patterns of an innovation response post-M&A are primarily among large pharmaceutical companies with large amounts of capital at their disposal and 3) these patterns stem from M&A of other pharmaceutical companies rather than biotech. Taken all together, these results suggest that larger pharmaceutical companies supplement their research and development through the procurement of other, smaller target companies' patents. They subsequently dedicate funds in an effort to move those molecules through FDA clinical trials. Despite the increase in R&D spending by almost $400 million dollars per year, those efforts do not lead to a change in the prospective molecules progress through FDA clinical trials. This raises questions of the pharmaceutical industry, who regularly cite innovation efficiency gains resulting from M&A as evidence to convince regulators to allow consolidation that might otherwise be deemed anti-competitive.[43]

Along with these effects on innovation, my results also show that non-generic, brand name drug prices increase by 19% after an M&A event. These price increases occur primarily in instances where

[43] This is also known as the efficiency defense. The merger guidelines issued in 1992 jointly by the FTC and the DOJ state, "Some mergers that the Agency otherwise might challenge may be reasonably necessary to achieve significant net efficiencies. Cognizable net efficiencies include, but are not limited to, achieving economies of scale, better integration of production facilities, plant specialization, lower transportation costs, and similar efficiencies relating to specific manufacturing, servicing or distribution operations of the merging firms." See McFetridge (1996).

there are overlapping between a target and an acquirer. Upon further inspection of mergers of firms with non-overlapping portfolios, the results suggests that firms might have differing incentives to pursue consolidation. Some firms engage in mergers or acquisitions to reduce competitors and gain power in therapeutic markets, leading to price increases. Others, specifically larger megacompanies, use M&A to expand their product portfolio overall, increasing their negotiating power with insurance companies to lower rebates, increasing net price. These findings have implications for regulators and political leaders, who have made it a top priority in recent years to reign in high drug costs. The results on drug prices are also important for general public knowledge, as concern grows regarding prescription affordability. Recent polling suggests 8 in 10 Americans believe the cost of prescription drugs is unreasonable while 1 in 4 Americans state they cannot afford their medications. [44]

Overall, understanding the mechanisms of how competition and consolidation affect both innovation and prices provides insight to better regulate and enact policy regarding firm competition, particularly in high tech industries. Recent guidelines passed in 2023 by the DOJ and FTC demonstrate the commitment government agencies have to ensure a comprehensive evaluation of mergers and acquisitions beyond traditional measures of the past. This includes accounting for effects on innovation.[45] However, even with these updated guidelines in place, there is no guarantee all components of this outlined legal framework will be taken into account in merger and acquisition cases. As shown from the results, M&A thus far ultimately leaves consumers at a net loss, with higher drug prices and a pharmaceutical industry that is less efficient at producing the innovation that defines its business model. Therefore, it is critical that regulators seriously consider the impact consolidation has on innovation and prices when evaluating whether mergers and acquisitions are ultimately beneficial for consumers.

[44] See `https://www.kff.org/health-costs/poll-finding/public-opinion-on-prescription-drugs-and-their-prices`

[45] The 2023 Merger Guidelines state, with regards to innovation, "When a firm introduces a new product or improves a product's features, some of the sales it gains may be at the expense of its rivals, including rivals that are competing to develop similar products and features. As a result, competition between firms may lead them to make greater efforts to offer a variety of products and features than would be the case if the firms were jointly owned, for example, if they merged." See `https://www.justice.gov/d9/2023-07/2023-draft-merger-guidelines$_$0.pdf`

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Appendix

A Conceptual Framework Derivation

In Section 3, I present a theoretical model documenting the ambiguity of the outcome of a merger in a high tech industry (such as the pharmaceutical industry) taking into account cost reducing innovation. Updating the previous literature, this model demonstrates that mergers do not always harm consumer welfare. In fact, if cost reducing innovation is at a particular level, then the merger can be welfare inducing. This section presents the entirety of the derivation of the theoretical model.

To construct this framework, I start with a classic model of Cournot oligopoly with homogenous products and increasing marginal costs from Perry and Porter (1985). It is important to note that the findings of the theoretical model below will be more conservative than in a market of differentiated products. Similar to Denicolo and Polo (2021), I consider a homogeneous product industry with n firms where firm $i = 1, 2...n$. I assume that demand is linear and specified as

$$p = 1 - Q \tag{1}$$

where q_i is firm i's output and $Q = \sum_{i=1}^{n} q_i$ is the aggregate output of all firms n. I calculate firm i's individual cost function in the pre-merger phase as

$$C(q_i, x_i) = (c - x_i)q_i + \frac{v}{2}q_i^2 + \frac{\beta}{2}x_i^2 \tag{2}$$

Here, $v \geq 0$ is the slope of the marginal cost function written as $C'_{q_i}(q_i) = c + vq_i$. The cost function demonstrates diminishing returns at the firm level. x_i represents firm i's cost reducing, as bonded above by c. From the model, innovation is assumed to be a constant component of marginal cost c but not of slope v. Research and development costs are represented by the last term $\frac{\beta}{2}x_i^2$. $\beta \geq 0$ takes into account the costliness of innovation.[46]

Looking at Equation 2, I assume that each firm can use its innovation without infringing on any sort of intellectual property rights. In the case of the pharmaceutical industry, intellectual property rights refer to FDA exclusivity as well as patent protections. It is also assumed that all independent (i.e. non-merged) firms benefit from their own research, with no innovation sharing between competitors. In the case of the pharmaceutical industry, I presume there are no licensing deals. To avoid proliferation of cases, I assume

$$c < \frac{2 + v}{4 + v} \tag{3}$$

[46]It is well know that, especially in the pharmaceutical industry, the costliness of innovation, β, changes the further a drug moves through the FDA approval pipeline (HHS 2014).

which guarantees that all firms produce a positive amount in both pre- and post-merger equilibrium. Finally, I assume each firm chooses its output and research and development investment simultaneously and is not observed by its competitors. This eliminates potential spillover effects and mimicking by rival firms.

Now assume the merger case, where two firms k and j merge. Here, I assume the merged firms reallocate their aggregated output $q_k + q_j = q_M$. While they are able to freely distribute their output to either firm, I assume, with symmetric cost functions, $q_j = q_k = \frac{q_M}{2}$.[47]

Contrasting with the independent firms, I assume that merged firms share their innovative knowledge and apply their advanced technology across research units to both firms. I assume that research across firms is entirely duplicative, which provides the most conservative estimate. Thus, the cost reduction created by the merged parties can be written as

$$x_M = \max[x_k, x_j] \tag{4}$$

Since innovation is deemed deterministic, I assume that, upon the merger, the acquirer will decide that research will be conductive in the one laboratory that remains active, while the other will be shut down, rather than in two separate units. This is because, after the merger, research conductive in the target firm will be seen as duplicative in the acquiring firm (Denicolo and Polo, 2018). In order to combine both laboratories, the acquiring firm must pay an integration cost relevant to how much the merged firm's portfolios overlap. Firms where the technologies are more similar (and the overlap in their portfolio is greater) will have less of an integration cost and vice versa (Hoberg and Phillips, 2010; Cunningham et al., 2021). Thus, the new cost function of the merged entity can be written as

$$C^M(q_M, x_M) = \left[(c - x_M)q_j + \frac{v}{2}q_j^2\right] + \left[(c - x_M)q_k + \frac{v}{2}q_k^2\right] + \frac{(1 - \gamma_{j,k}) \cdot \beta}{2}x_M^2 \tag{5}$$

$$= (c - x_M)q_M + \frac{v}{4}q_M^2 + \frac{(1 - \gamma_{j,k}) \cdot \beta}{2}x_M^2 \tag{6}$$

Here, we introduce the degree of product overlap between firms j and k to the original, single firm innovation model in equation 2, $\gamma_{j,k}$, which is continuous where $0 \leq \gamma_{j,k} \leq 1$. If $\gamma_{j,k} = 0$, then no product overlap exists between firms, and the firms are exposed to the full integration cost. If $\gamma_{j,k} = 1$, then the target and acquiring firm share a full overlap of their portfolios and the cost to integrate is 0. Thus, the cost to integrate firms j and k is represented by the term f. From this, I compare the firm's equilibrium before and after the merger, focusing on total output. I use output to determine the impact on consumer surplus as well as on the welfare criterion. As seen above, the regulatory agencies

[47] This is a rather large assumption to make. We know, in the context of Cunningham et al. (2021) that acquiring firms tend not to distribute their output equally.

determine a merger to be pro-competitive if it increases overall consumer welfare, decreases prices, and, more recently, increases innovation. It is considered anti-competitive if the reverse is true.

Proposition. *A merger between two firms is pro-competitive if and only if*

$$v > \frac{2 - c(n+2)}{c} \tag{7}$$

and

$$\frac{1}{c(n+2+v)-1} < \beta < 1 \tag{8}$$

Proof When β is very small, profit maximization entails a corner solution where $x_i = c$ for all firms both in the case and not in the case of a merger. In this case, I revert back to the original Perry and Porter (1985) model with no innovation. As in that case, mergers are always found to be anti-competitive. Expanding on this, I now consider a case where β is sufficiently large and pre-merger equilibrium entails an interior solution where $x_i < c$.

In pre-merger equilibrium, firm i chooses q_i and x_i so as to maximize profit function $\pi_i = pq_i - C(q_i, x_i)$. Thus, the first-order condition can be written as

$$1 - 2q_i - Q_{-i} - (c - x_i) - vq_i = 0$$

Here Q_{-i} denotes the aggregate output of firm i's competitors and

$$q_i - \beta x_i = 0$$

The later condition implies that the optimal level of innovation is

$$x_i = \frac{q_i}{\beta} \tag{9}$$

which is proportional to the firm's output. I combine the two first-order conditions to get firm i's best response function

$$\tilde{q_i}(Q) = \frac{1 - c - Q}{1 + v - \frac{1}{\beta}}$$

Total output in the pre-merger equilibrium is then given by the solution to $n\tilde{q_i}(Q) = Q$ and is

$$Q^{*pre} = \frac{n(1-c)}{n + 1 + v - \frac{1}{\beta}}$$

Next, consider the case where firms j and k merge. The first order conditions for the merged entity

(again, assuming there is an interior solution) are

$$1 - 2q_M - Q_{-M} - (c - x_M) - \frac{v}{2}q_M = 0$$

and

$$q_M - (1 - \gamma_{j,k})\beta x_M = 0$$

where I get

$$\tilde{q}_M(Q) = \frac{1 - c - Q}{1 + \frac{v}{2} - \frac{1}{(1-\gamma)\beta}}$$

Looking at the above expressions, I see that $\tilde{q}_M(Q) > \tilde{q}_M(Q) > \tilde{q}_i(Q)$. From this, I see that the merged entity will have a greater incentive to invest in R&D than its competitors. This inequality is due to the innovation sharing effect and implies the merged entity's maximization problem could have a corner solution $x_M = c$ even if the outsider's solution is interior.[48] When $x_M = c$, I find the merged entity's best response function as

$$\hat{q_M}(Q) = \frac{1 - Q}{1 + \frac{v}{2}}$$

The merger will expand total output if

$$\tilde{q}_M(Q^{pre}) > 2\tilde{q}_i(Q^{pre})$$

where $x_M < c$ or if

$$\hat{q}_M(Q^{pre}) > 2\tilde{q}_i(Q^{pre})$$

where $x_M = c$. I see using simple algebra that the condition above reduces to

$$\beta < 1$$

and the later to

$$\beta > \frac{1}{c(n + 2 + v) - 1}$$

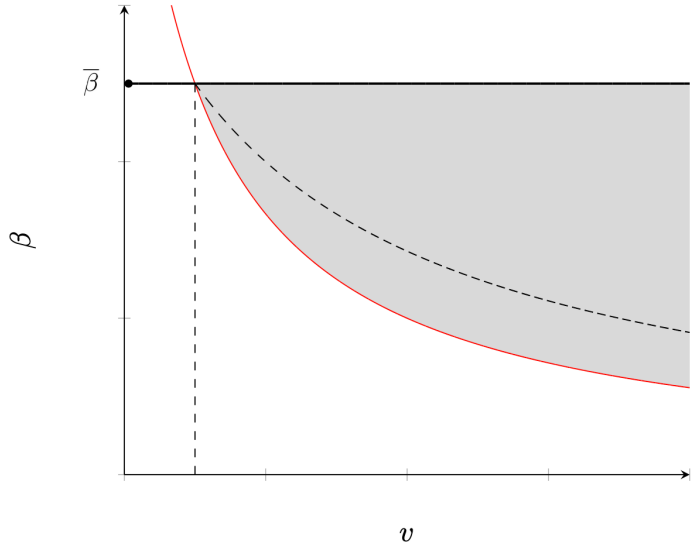
Where $\beta = \frac{1}{c(n+2+v)-1}$ the corner solution $x_M = c$ holds as long as $v > \frac{2-c(n+2)}{c}$ and similarly, at $\beta = 1$ the interior solution $x_M < c$ holds as long as $v > \frac{2-c(n+2)}{c}$, the region where mergers are pro-competitive are where (7) and (8) hold. Note that the nature of the portfolio overlap γ between the merged firm M drops out and does not have influence over whether levels of innovation make the merger pro-competitive.

I illustrate the results of the model and its solutions in Figure A.1 below.

[48] The merged entity has a corner solution at

$$\beta \leq \frac{4}{2 + 2v + c(2n + v) - \sqrt{2(1 + v)^2 + c^2(2n + v)^2 - 4c[2n + v(5 + v)]}}$$

Figure A.1: Graphical Representation of Theoretical Model



Note: Figure A.1 graphically illustrates the theoretical model. The gray shaded region represents the region determined by the theoretical model where the merger is considered pro-competitive. Condition (7) holds to the right of the dashed vertical line and condition (8) holds in the shaded region above the red line. The dashed curved line separates the regions where the equilibrium solution is either interior (i.e. above the curve) or is a corner solution at $x_m = c$ (i.e. below the curve). The figure has been drawn for the conditions $c = 0:3$ and n= 4.

Here, a merger supports competition if it is in the shaded region. More specifically, the merger is pro-competitive if it is in the region below the horizontal line $\overline{\beta} = 1$, to the right of the vertical line $v = \frac{2-c(n+2)}{c}$, and above the red, decreasing curved line $\beta = \frac{1}{c(n+2+v)-1}$. These results make sense in the context of Figure A.1 and the model. For one, the optimal level of innovation, x, increases as a direct function of the firm's output. This is the main framework in describing cost reducing innovation. When a merger then occurs, the marginal cost curve shift downwards, generating an incentive for the merged firm to increase production. Therefore, I conclude that the merged firm, given any level of technology post-merger within the shaded region, will produce a greater output than it would before M&A. The merged firm is then able to apply cost-reducing innovation to a larger volume of output. This action further incentives the merged firm to increase R&D spending, and creates a cyclical increase in output, innovation, and R&D. Only under the conditions where the cyclical output is at its greatest are the negative anti-competitive effects from the merger overcome, resulting in a merger with a net benefit.

Here, a merger will be seen as pro-competitive for moderate effects of the costliness of innovation β, for large enough values of the rate of change of the marginal cost v, and as c and n increase. The intuition for these results are as follows. When the costliness of innovation, β, is small, firms have a large incentive to innovate regardless of whether a merger happens or not, as the price to innovate to reduce costs is small.[49] If the costliness of innovation is too large for a company to take on, then the company will just choose not to innovate in both the pre- and post-period. For both scenarios, a merger will have

[49] Mathematically in the model, x_i will be equal or close to c in any case. When β is sufficiently large, x_i will be close to 0 both before and after the merger.

little impact on innovation and the information sharing effect is either weak or fails to exist. However, if the costliness of innovation β is at a moderate level, then the firm might only choose to innovate if the streamlining, synergistic effect incentivizes R&D only post-merger. Considering the lack of cost-reducing innovation in the pre-period, this outcome would signal a positive effect resulting from the merger.

Mergers can also be seen as pro-competitive when v, the rate of change of marginal costs, is sufficiently large. The diminishing returns to cost grows larger as v increases. If the diminishing returns become large enough, then the firm, with the cost to produce more declining, is incentivized to manufacture more goods, increasing q beyond the pre-merger threshold.[50] As stated above, this increase in output means that the merged firm will be incentivized to apply innovation to get the costs from an increasing volume of q down and, therefore, increase R&D spending. According to equation 1, as demand is linear, an increase in q leads to a decrease in p, demonstrating that these merger effects could lead to a decline in prices after taking innovation into account. Finally, the region where a merger becomes pro-competitive becomes bigger when c increases. When the marginal cost c is small, I can infer that the product in question is relatively easy to produce. The merged firm has little technology on which to innovate to begin with and the effect of innovation on the cost of that product is small. The region also increases as the number of competitors n increases. When a merger occurs in a market with many competitors, there is less of an output reducing merger effect (Miller, 2013). Therefore, in a market with a large number of therapeutic competitors, the quantity reducing effects of a merger are limited, allowing for a merger to be potentially pro-competitive.

B Drugs Moving through the FDA Approval Process

Clarivate Cortellis Competitive Intelligence tracks drugs as they move through the FDA approval process. Once a new molecule exits the preclinical phase and becomes "discovered", it moves through three stages of clinical trials, named Phase I, Phase II, and Phase III, before being given full approval by the FDA and allowed to be sold on the US drug market. Firms might also cut drug development prematurely, either by formally announcing discontinuation or pausing development indefinitely. The line graphs below document the progression of drugs through each stage of this process, along with the total number of drugs either discontinued or ones where Clarivate scientists have determined "no development has been reported." Figure B.1 tracks the number of molecules that are discontinued, while Figure B.2 tacks the number of drugs that move through the pipeline.

[50] Mathematically, this is represented that, as v increases, the shaded region representing the pro-competitive area increases.

Figure B.1: Drugs that are Either Discontinued or "No Development Reported"

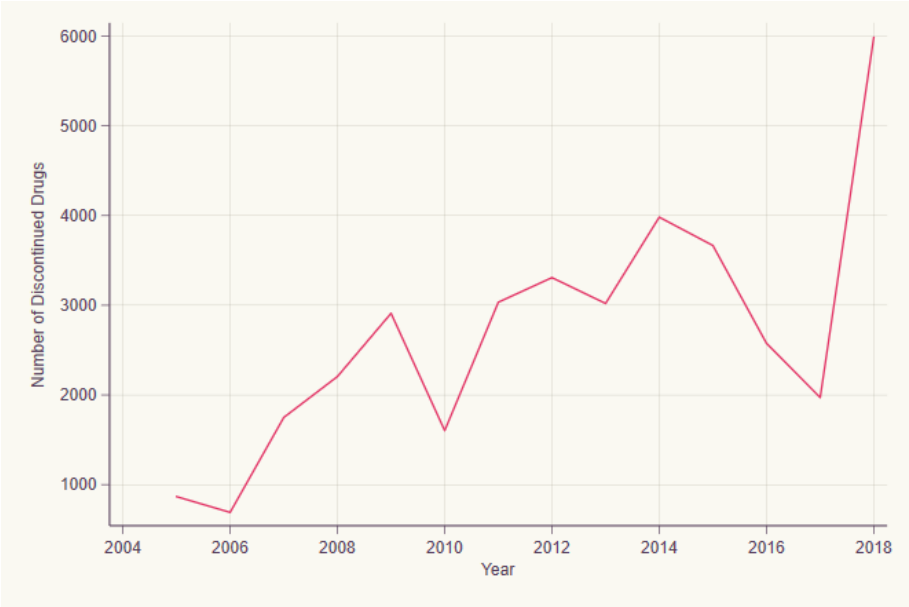
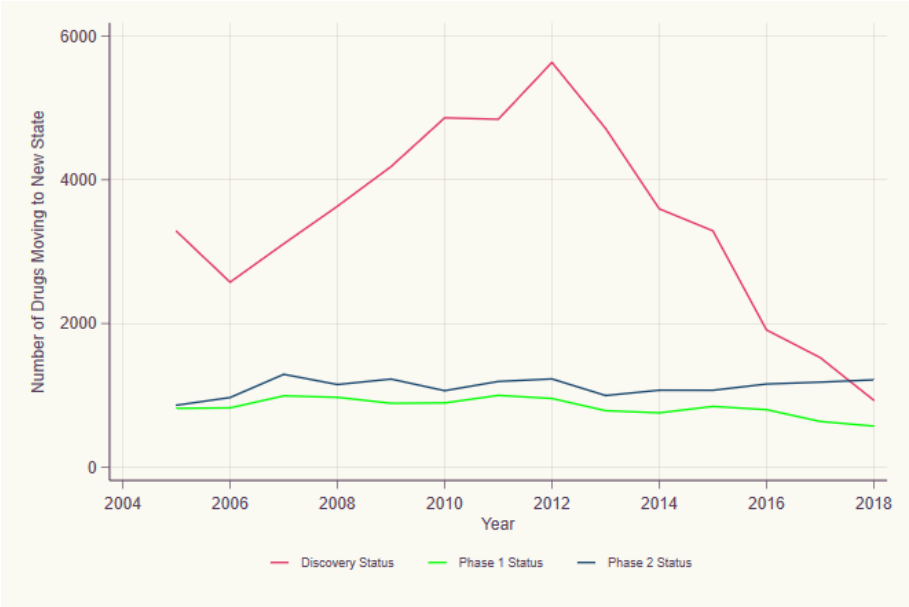


Figure B.2: Drugs Progression through the FDA Approval Process



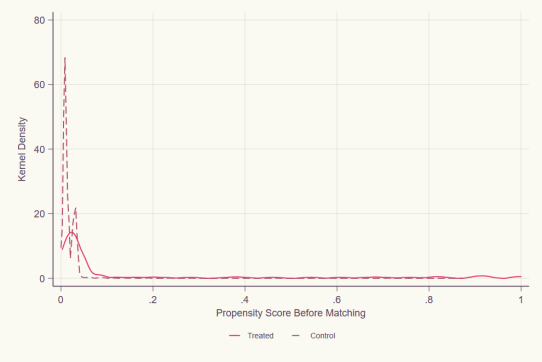
C Empirical Specifications

C.1 Results of Nearest Neighbor Propensity Score Match

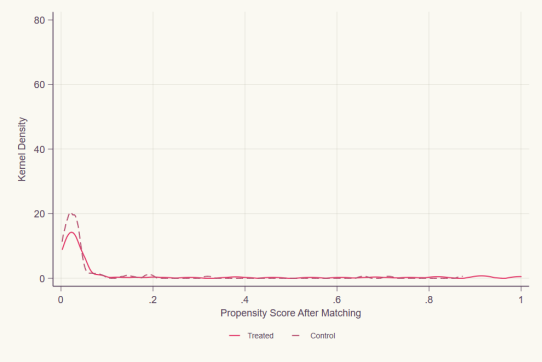
In the main specification of the empirical model, as specified in Section 5, I use a nearest neighbor match without replacement to match like firms and create a control group that best matches the treated group from their firm characteristics. This is to be sure that, during the analysis, there is a balanced set of control firms. Figure C.1 shows a density plot comparing the likeness of the treated and control sample

before and after matching. As shown, the matched control sample looks much similar to the treatment sample in Figure C.1.b when compared to the control sample before the match in Figure C.1.a. Figure C.1 demonstrates that the matched control sample becomes more balanced than before and a better match to those firms in the sample of treatment firms.

Figure C.1: Propensity Score Match



(a) Before Propensity Score Match



(b) After Propensity Score Match

D Extensions of Empirical Analysis: Innovation

D.1 Innovation Event Studies and Regressions using Full Sample

In the original empirical model, as specified in Section 5, I use a propensity score match to match target firms with control firms with similar characteristics. Alternatively, the results of the empirical model on innovation using the full control sample can be found in Table A.1 and Figure D.1 below.

Table A1: Innovation Results: Full Sample

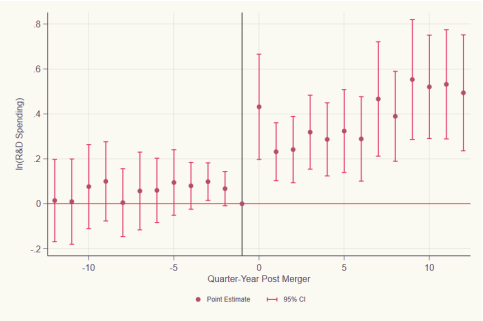
	(1) ln(R&D Spending)	(2) Patents	(3) Discoveries	(4) End Development	(5) Phase I	(6) Phase II	(7) Phase III
Merger == 1	0.466***	-1.362**	-0.096	0.181	0.00	-0.013	0.028
	(.121)	(0.417)	(0.061)	(0.117)	(0.035)	(0.033)	(0.044)
Firm FE	X	X	X	X	X	X	X
Quarter-Year FE	X	X	X	X	X	X	X
Mean of Outcome	406.6	6.45	2.98	1.66	1.44	1.34	.734
Number of Firms	740	740	446	299	181	181	181

Standard Error in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

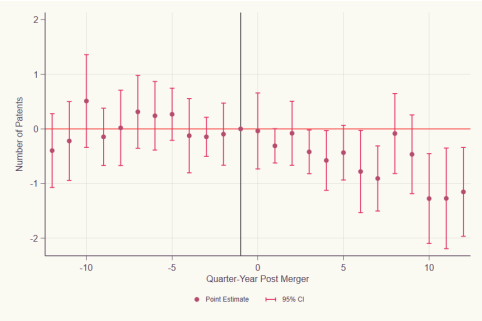
D.2 Acquirer Innovation as Outcomes

In my empirical analysis, I compare the sum of innovation of acquirers and targets to that of singular control firms, per the M&A literature. This is to compare how the firm post-M&A, consisting of target and acquirer, performs to how the two firms perform separately pre-merger. However, an alternative

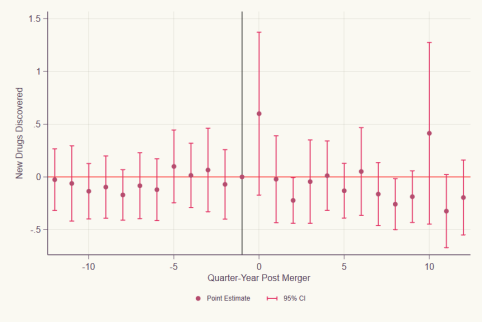
Figure D.1: Innovation Results: Full Sample



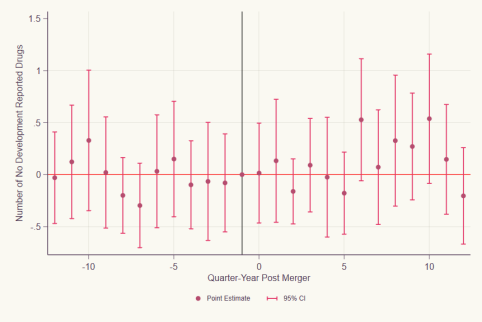
(a) R&D Spending



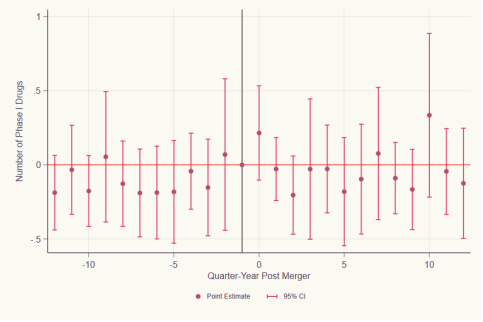
(b) Number of Patents



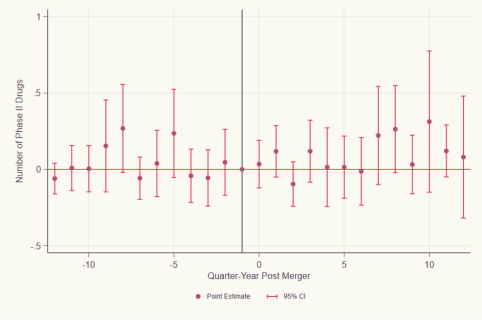
(c) New Drug Discoveries



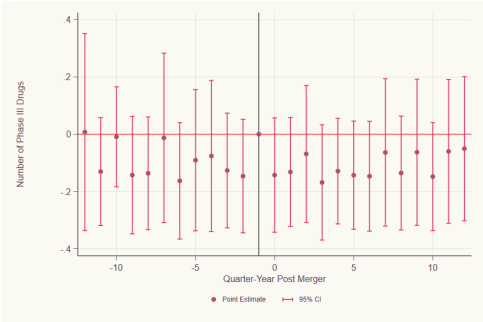
(d) Discontinued Drugs



(e) Drugs in Phase I



(f) Drugs in Phase II



(g) Drugs in Phase III

empirical specification is to measure the innovation outcomes of the acquirer compared to that of control firms. I do this to compare the outcomes of the acquiring firm, a single firm in the pre-period, to that of the singular control firms. The results from this specification can be found below in Table A.2 and Figure D.2 below. From the event studies and the coefficient results, I see that the results are similar between both specifications.

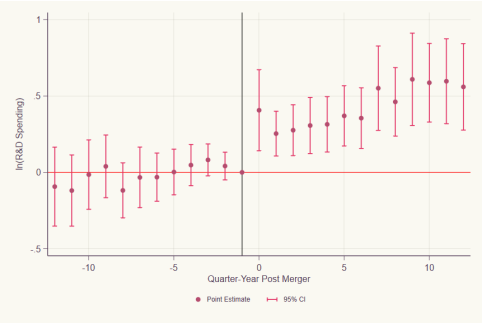
Table A2: Innovation Results: Acquirer Only

	(1) ln(R&D Spending)	(2) Patents	(3) Discoveries	(4) End Development	(5) Phase I	(6) Phase II	(7) Phase III
Merger == 1	0.443***	-0.747*	-0.023	-0.150	0.074	0.028	0.001
	(.121)	(0.331)	(0.106)	(0.171)	(0.048)	(0.044)	(0.019)
Firm FE	X	X	X	X	X	X	X
Quarter-Year FE	X	X	X	X	X	X	X
Mean of Outcome	232.1	1.48	0.555	1.386	.118	.109	.058
Number of Firms	108	108	40	73	43	43	43

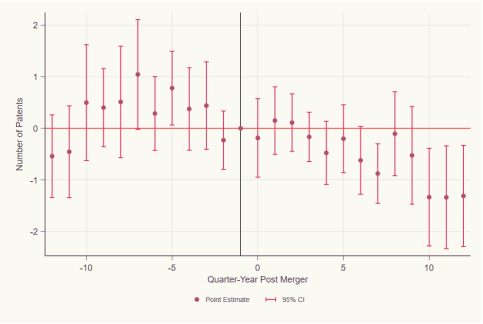
Standard Error in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

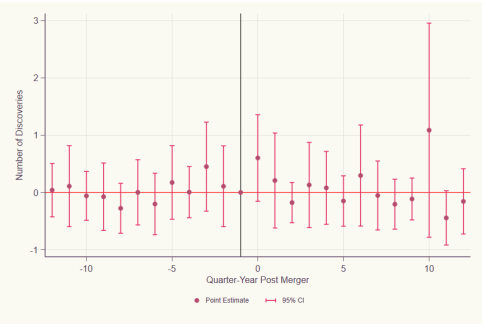
Figure D.2: Innovation Results: Acquirer Only



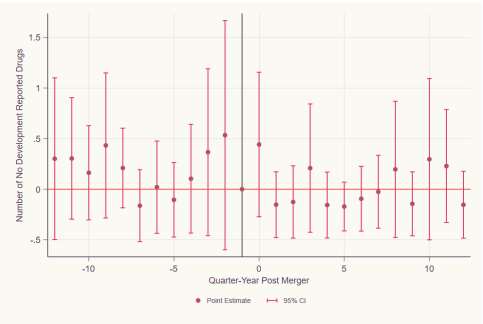
(a) R&D Spending



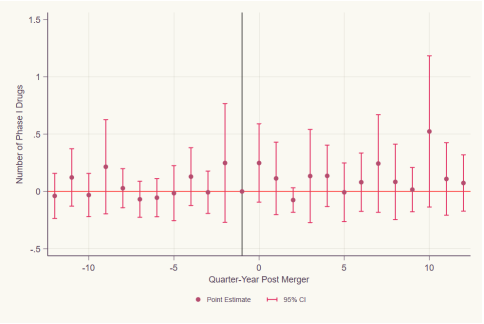
(b) Number of Patents



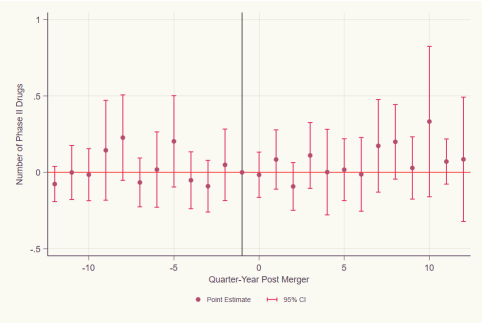
(c) New Drug Discoveries



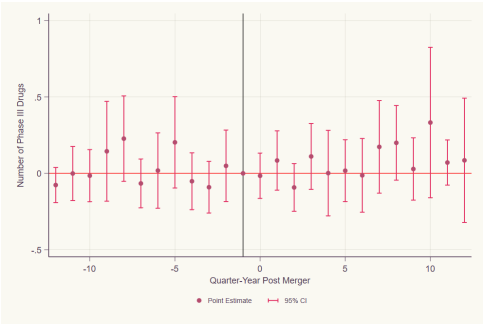
(d) Discontinued Drugs



(e) Drugs in Phase I



(f) Drugs in Phase II



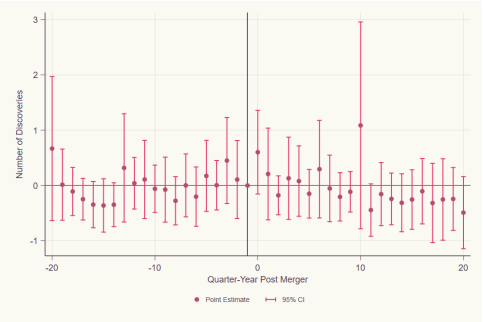
(g) Drugs in Phase III

D.3 Three Years versus Five Years Post-M&A

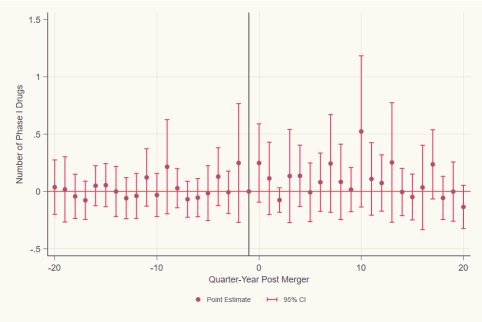
In the main specifications in Section 6.1, I look at the effects of innovation 12 quarters, or three years, post-M&A event. However, some of the innovation effects might take more time for the effects to be

seen, as their development might take, on average, more than three years. Therefore, I change the empirical specification for these measures to extend the post period analysis to five years, or 20 quarters, which accounts for these longer periods spent in clinical trials. I present the results in Figure D.3. Even extending the event studies out for five years, or 20 quarters, the M&A effects on these measures of innovation still remain pretty flat.

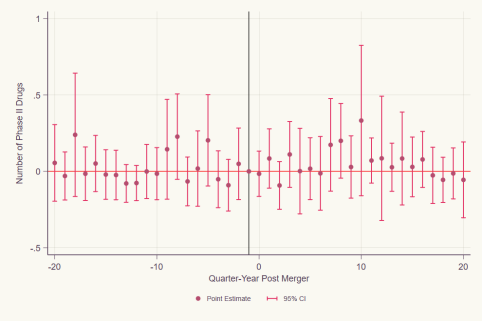
Figure D.3: Effects on Innovation: Five Years



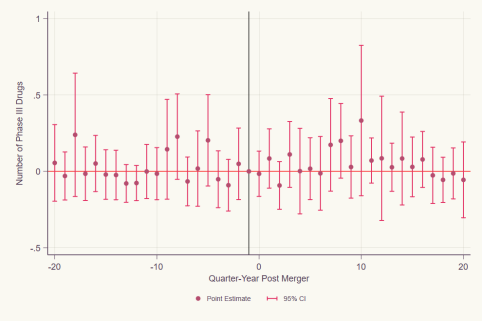
(a) New Drug Discoveries



(b) Phase I



(c) Phase II



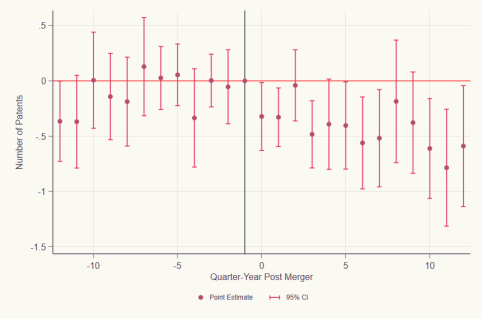
(d) Phase III

D.4 Innovative Patents: Does it Have an "Advantage"

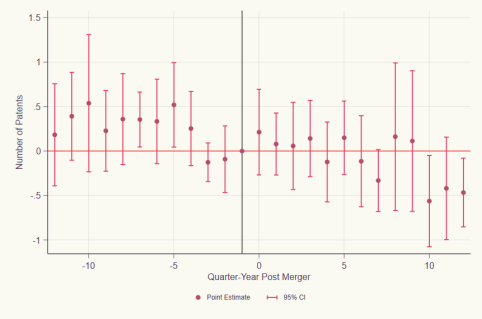
To identify how consolidation affects innovative patents versus not, I assess the effects of consolidation on primary and secondary patents. As stated above in Section 6.1.2, I define primary patents as those product patents without existing patents present and define secondary as those formulation or new use patents filed for molecules with existing product patents. As stated above, pharmaceutical firms are given space on patent documentation to explain how the drug is advantageous to existing drugs on the market. Cortellis parses out this information from the patent into a separate variable explaining if the drug has an advantage or if "no suitable advantage is given." Using this information, I separate patents into two groups. In the first group, I include patents identified having "no suitable advantage given." In the second group, I include drugs where some sort of advantage is listed on the patent. The results of the event study shown in Figure D.4. Looking at these two sets of graphs using advantage as an identifier for innovation, it seems there is a similar, but slightly stronger decrease for those patents that have a discernible advantage identified. It is important to note that using advantageous to define primary and

secondary patents could result in an over-exaggeration of the results. As demonstrated in the literature, pharmaceutical companies might be incentivized to exaggerate their patent has some sort of advantage to get the drugs covered by these new patents re approved under FDA protection (Feldman, 2018). These results also might not fully capture advantageous or non advantageous patents, as some of the fields for certain drugs are blank.

Figure D.4: Innovative Patents: Measured on "Advantage"



(a) Change in "Advantageous" Patents

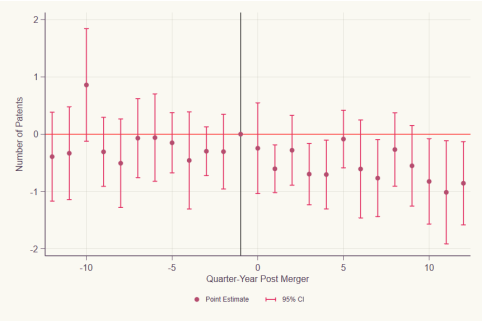


(b) Change in "Non-Advantageous" Patents

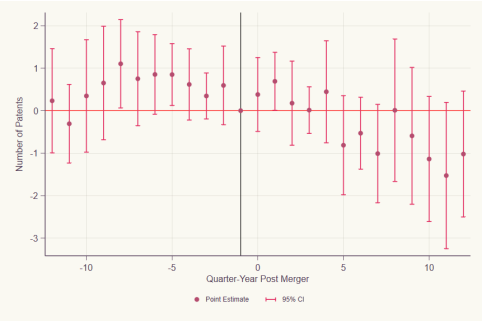
D.5 Innovation Based on Firm Type: Pharmaceutical or Biotech

The results of the event studies depicting pharmaceutical-pharmaceutical M&A events versus pharmaceutical-biotech on both patents and R&D spending are found in Figure D.5. As seen in the event studies, there is a slightly more dramatic effect on both the decrease in patents and decrease in R&D spending pharma-pharma M&A versus pharma-biotech. This might be due to the technology and product overlap present in pharma-pharma M&A, where pharmaceutical companies are better able to substitute technology within their own pipelines.

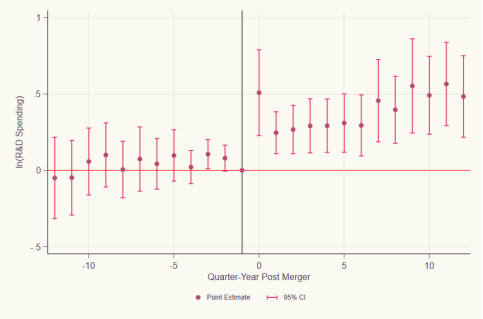
Figure D.5: Innovation Based on Firm Target Type (Pharmaceutical or Biotech)



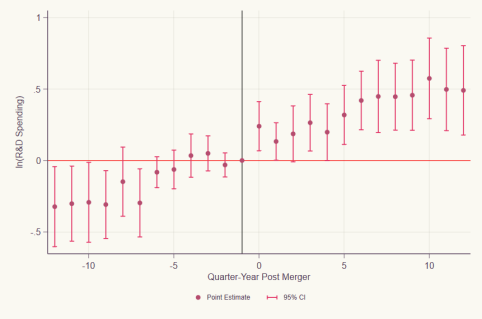
(a) Patents: Pharmaceutical Target



(b) Patents: Biotechnology Target



(c) R&D Spending: Pharmaceutical Target



(d) R&D Spending: Biotechology Target

E Extensions of Empirical Analysis: Pharmaceutical Prices

E.1 Event Studies and Regressions with Full Sample

In the original empirical model, as specified in Section 5, I use a propensity score match to match target firms with control firms with similar characteristics. Alternatively, the results of the empirical model on innovation using the full control sample can be found in Table A.3 and Figure E.1 below.

Table A3: Full Sample of Drug-Level Controls

	(1) Price	(2) ln(Price)
Merger == 1	55.77	0.134
	(40.41)	(0.0819)
By Portfolio Overlap:		
Portfolio overlap between acq. and target:	7.92	0.0592
	(18.60)	(0.0481)
No portfolio overlap between acq. and target:	382.0*	0.620*
	(152.5)	(0.289)
Drug FE	X	X
Quarter-Year FE	X	X
PSM Match	X	X
Mean Value	251.6	X

Standard Error in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

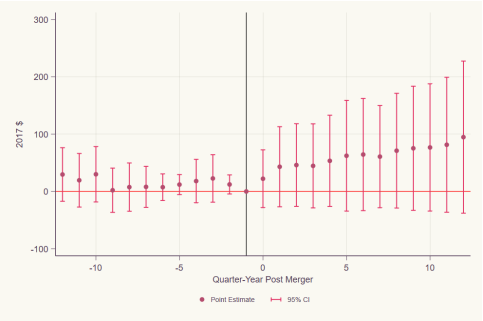
Table A4: Effects of M&A on Prices: Price Levels

	(1) Price
Merger == 1	44.76
	(0.084)
By Portfolio Overlap:	
Portfolio overlap between acq. and target:	-0.128
	(20.00)
No portfolio overlap between acq. and target:	363.7*
	(149.8)
Drug FE	X
Quarter-Year FE	X
PSM Match	X
Mean Price	255.7

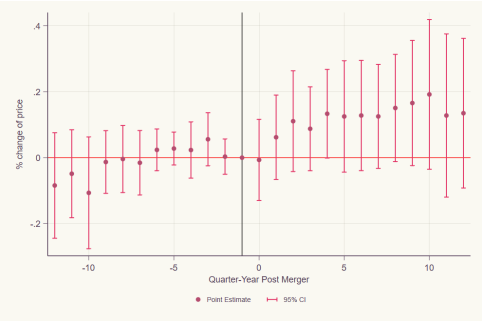
Standard Error in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure E.1: Pharmaceutical Prices: Full Sample



(a) Net Drug Price

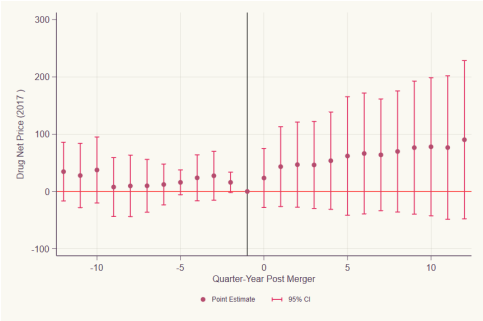


(b) ln(Net Drug Price)

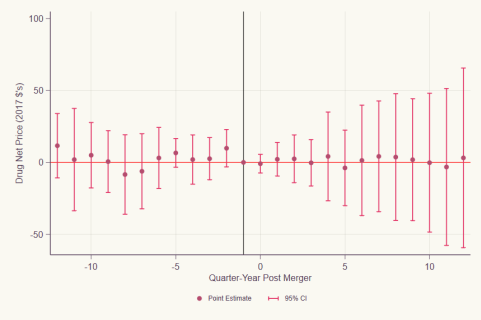
E.2 Pharmaceutical Prices: Effects on Levels of Net Price

The main specification of the results described in Section 6.2.1 uses logarithmic price as the outcome. Here, I present the event studies depicting the effects of M&A on the levels of net drug prices, along with whether or not there are overlapping portfolios between the target and the acquirer. The results can be found below in Figure E.2 and Table A.4.

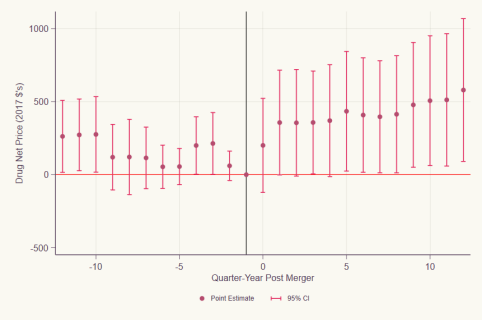
Figure E.2: Event Studies of the Effects of M&A Events on Prices: Price Levels



(a) Net Drug Price: Baseline Specification



(b) Net Drug Price: Overlap

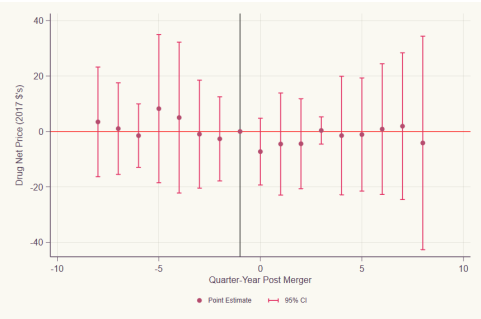


(c) Net Drug Price: No Overlap

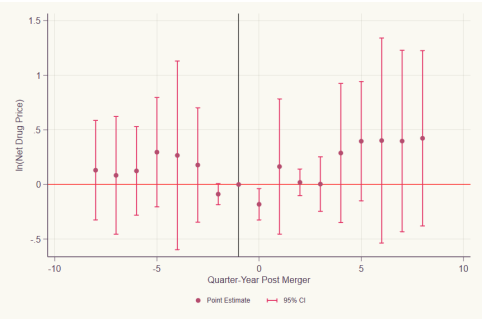
E.3 Pharmaceutical Prices based on Therapeutic Class

The results of the event studies looking at how consolidation affects drug prices after stratifying on therapeutic class can be found below in Figure E.3 through E.16. Figure (a) of each subset denotes the change in the level of net price while Figure b denotes the change in logarithmic net price in each therapeutic class. The coefficients for these results can be found in Table A.5. As described above, there are no discernible significant effects on price when distinguishing between different therapeutic classes of drugs. See Section 6.2.2 for details.

Figure E.3: Pharmaceutical Prices: Allergy Drugs

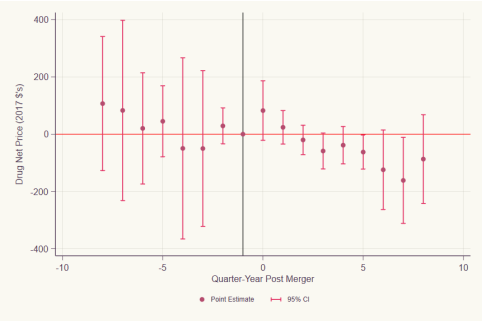


(a) Net Drug Price

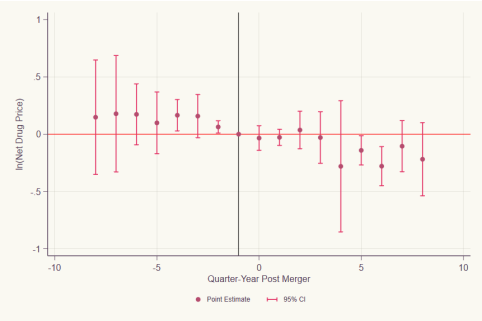


(b) ln(Net Drug Price)

Figure E.4: Pharmaceutical Prices: Autoimmune/Inflammatory Drugs

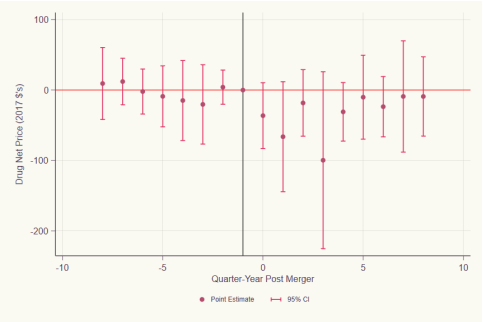


(a) Net Drug Price

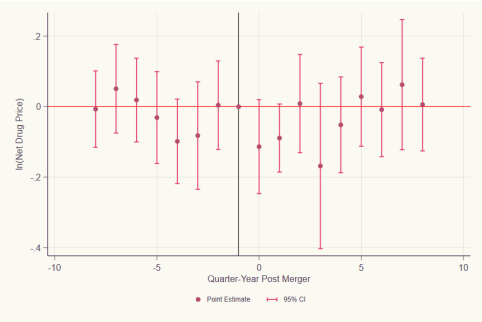


(b) ln(Net Drug Price)

Figure E.5: Pharmaceutical Prices: Cancer Drugs

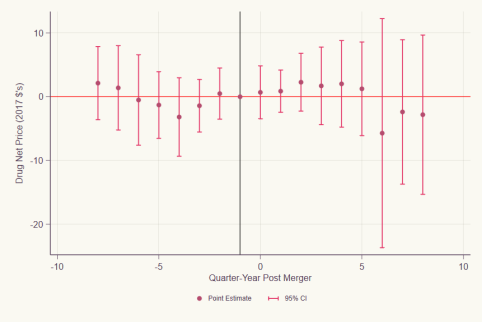


(a) Net Drug Price

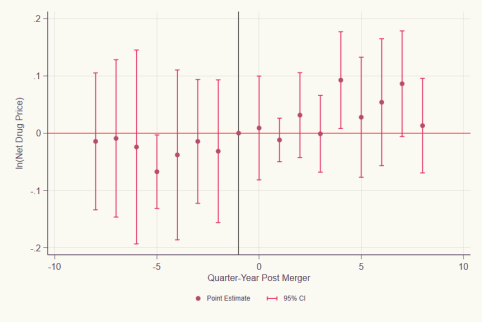


(b) ln(Net Drug Price)

Figure E.6: Pharmaceutical Prices: Cardiovascular Drugs

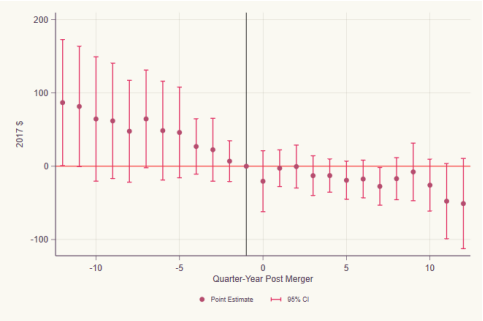


(a) Net Drug Price

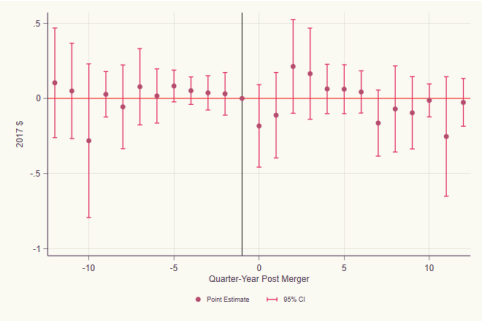


(b) ln(Net Drug Price)

Figure E.7: Pharmaceutical Prices: Central Nervous System Drugs

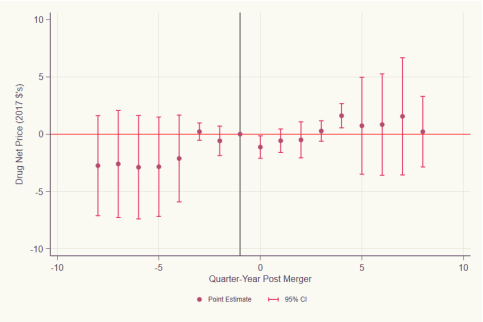


(a) Net Drug Price

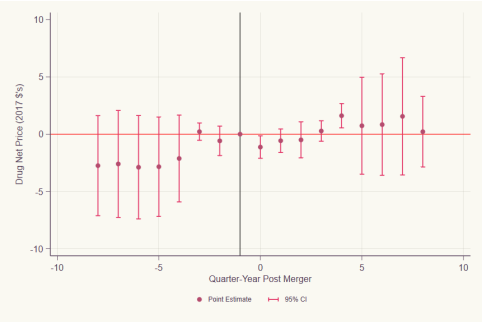


(b) ln(Net Drug Price)

Figure E.8: Pharmaceutical Prices: Dermatology Drugs

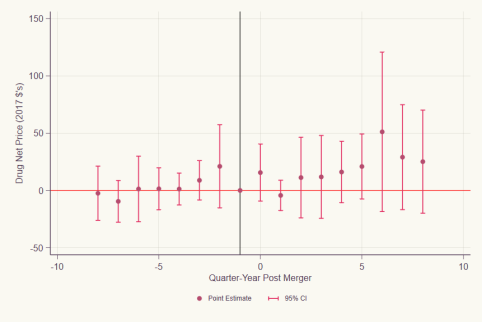


(a) Net Drug Price

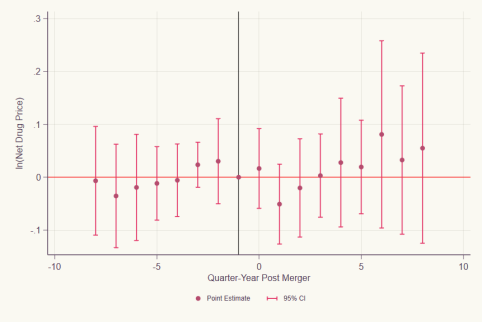


(b) ln(Net Drug Price)

Figure E.9: Pharmaceutical Prices: Endocrine/Metabolic Drugs

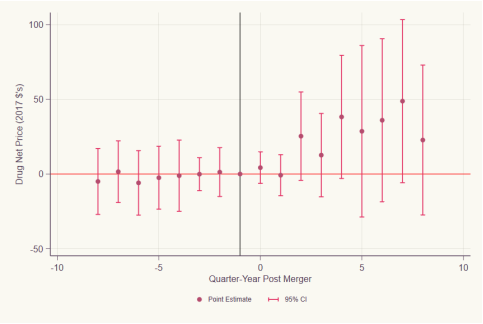


(a) Change in Price

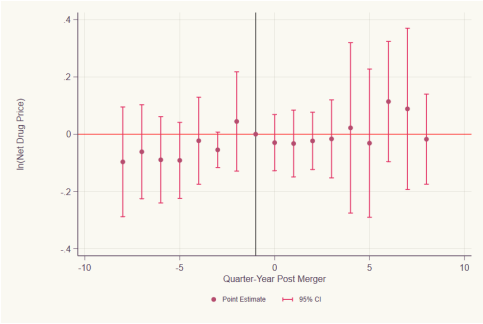


(b) ln(Net Drug Price)

Figure E.10: Pharmaceutical Prices: Gastrointestinal Drugs

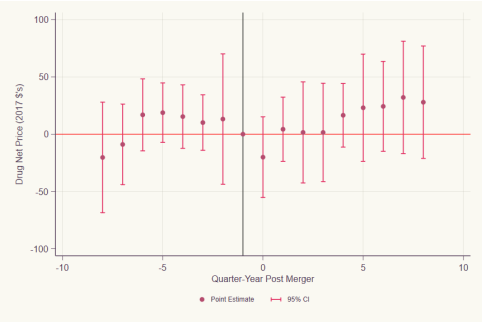


(a) Net Drug Price

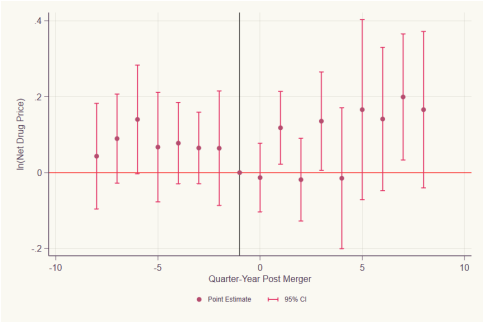


(b) ln(Net Drug Price)

Figure E.11: Pharmaceutical Prices: Gynecological/Urinary Drugs

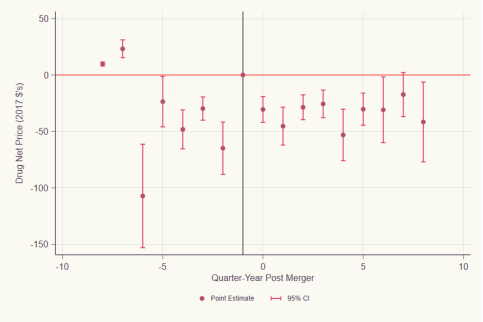


(a) Net Drug Price

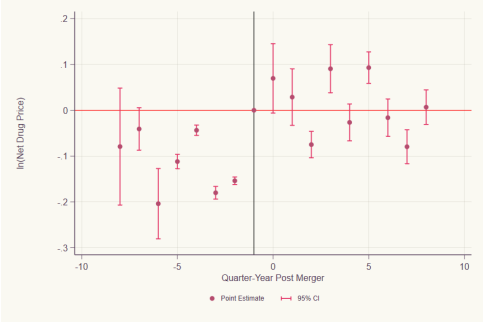


(b) ln(Net Drug Price)

Figure E.12: Pharmaceutical Prices: Hematologic Drugs

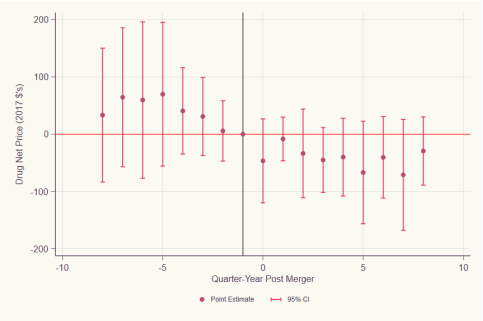


(a) Net Drug Price

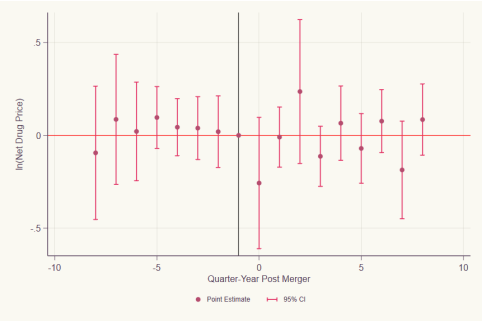


(b) ln(Net Drug Price)

Figure E.13: Pharmaceutical Prices: Infection Drugs

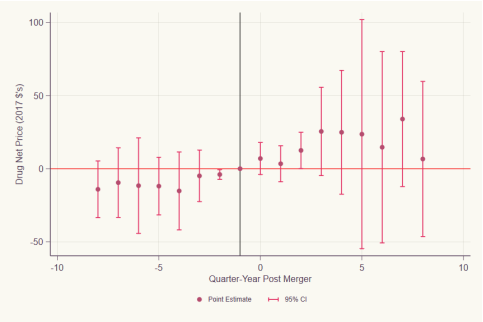


(a) Net Drug Price

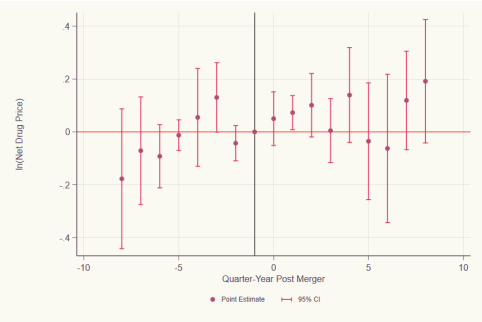


(b) ln(Net Drug Price)

Figure E.14: Pharmaceutical Prices: Other/Unknown Drugs

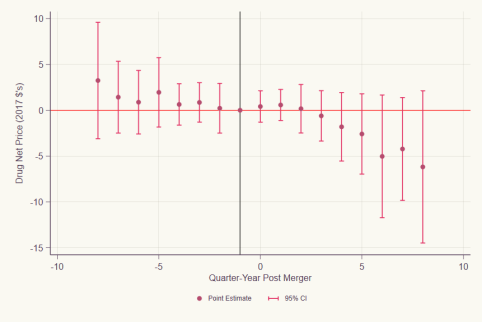


(a) Net Drug Price

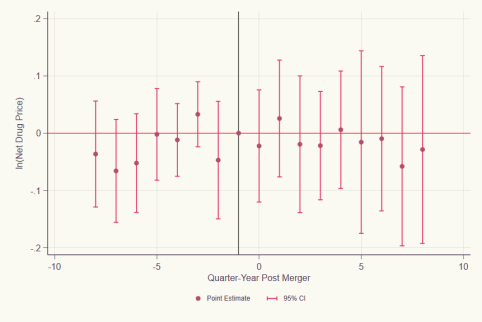


(b) ln(Net Drug Price)

Figure E.15: Pharmaceutical Prices: Psychiatric Drugs

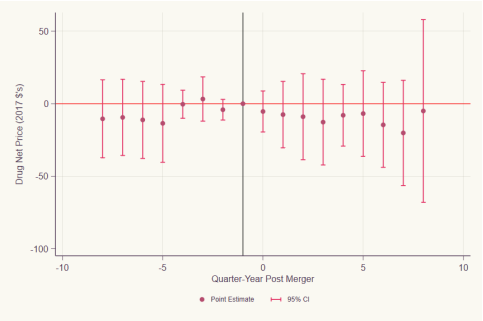


(a) Net Drug Price

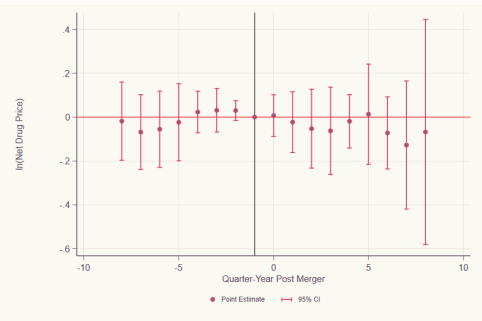


(b) ln(Net Drug Price)

Figure E.16: Pharmaceutical Prices: Respiratory Drugs



(a) Net Drug Price



(b) ln(Net Drug Price)

Table A5: Regression Results: Therapeutic Class

	(1) Price	(2) ln(Price)
By Therapeutic Class:		
Allergy	-10.39	0.188
	(13.26)	(0.122)
Autoimmune/Inflammatory	-192.8	0.0140
	(98.14)	(0.100)
Cancer	11.95	0.0596
	(32.72)	(0.0749)
Cardiovascular	-1.339	0.0755
	(3.222)	(0.0637)
Central Nervous System	-7.717	-0.132
	(5.154)	(0.0863)
Dermatologic	1.194	0.101
	(0.948)	(0.0765)
Endocrine	15.34	0.00517
	(10.73)	(0.0671)
Gastrointestinal	37.99	0.132
	(21.93)	(0.0988)
Gynecologic/Urologic	26.47	0.104
	(23.47)	(0.106)
Hematologic	-57.64***	-0.0101
	(10.45)	(0.0153)
Infectious	-130.6	-0.0968
	(87.19)	(0.0828)
Other/Unknown	27.52	0.0823
	(17.19)	(0.0774)
Psychiatric	-7.194	-0.0148
	(4.873)	(0.0592)
Respiratory	6.049	0.0932
	(15.36)	(0.151)
Drug FE	X	X
Quarter-Year FE	X	X
PSM Match	X	X

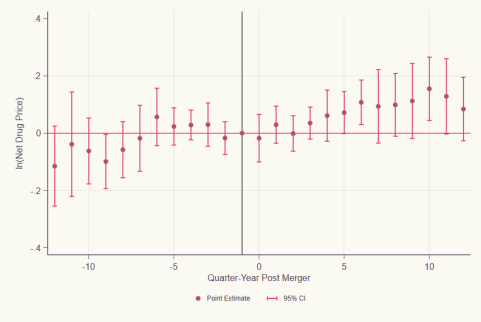
Standard Error in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

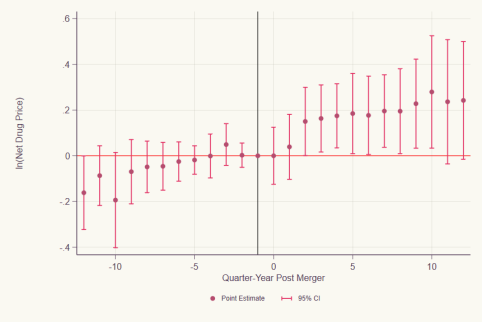
E.4 Pharmaceutical Prices based on Firm Type: Pharmaceutical or Biotech

Similar to the innovation results above, I evaluate the results of the pharmaceutical-pharmaceutical M&A events versus pharmaceutical-biotech on pharmaceutical net prices. The results of these event studies can be found below in Appendix Figure E.17. Similar to the original event studies on pharmaceutical prices, there is no discernible difference between mergers with pharmaceutical companies and with biotech companies as the target.

Figure E.17: Pharmaceutical Prices: Pharmaceutical vs Biologic Targets



(a) Biotechnology Target Mergers and Acquisitions



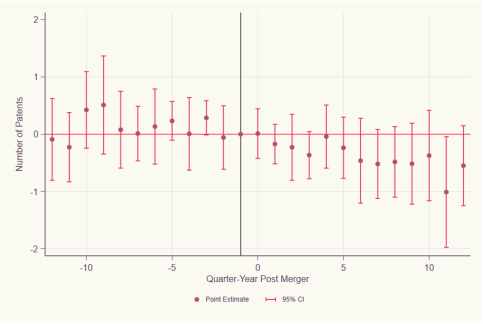
(b) Pharmaceutical Target Mergers and Acquisitions

F Robustness Checks

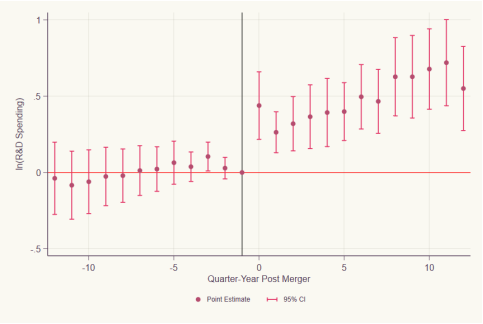
F.1 Second Merger versus First Merger

In the main empirical specification of the model, I use the first instance of an M&A event by an acquiring firm to see whether consolidation affects innovation and prices. As a robustness check to all of the main results, I use the second instance of an M&A event by an acquiring firm to assure that the results still hold, even when the subsets of mergers has changed. The event studies from this robustness check can be found in Figures F.1 and F.2 below. Comparing these results to those found in Sections 6.1 and 6.2, there does not seem to be any significant difference made to the innovation and price results by changing the subset of mergers and acquisitions.

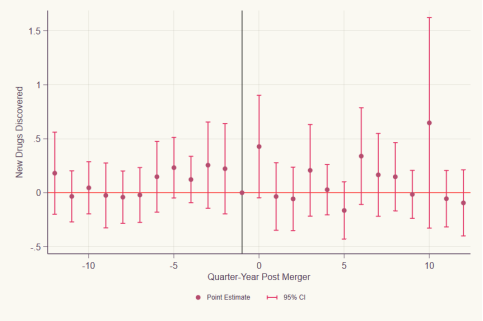
Figure F.1: Innovation: Results Based on Second Merger



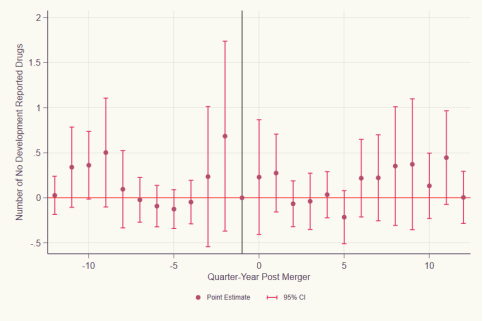
(a) Number of Patents



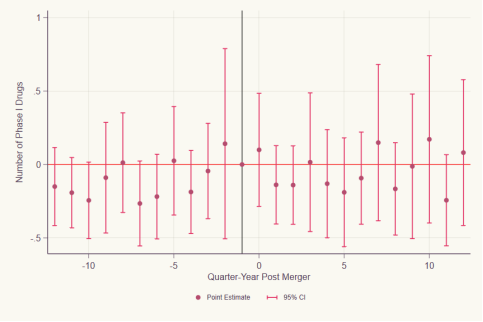
(b) R&D Spending



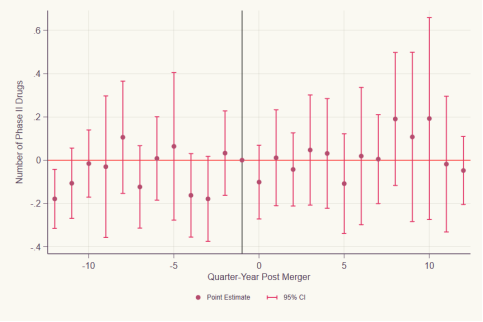
(c) Number of Discoveries



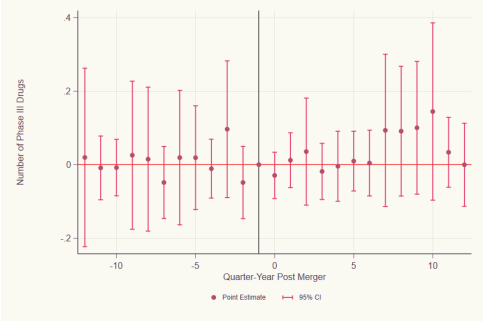
(d) Number of Discontinuations



(e) Drugs in Phase I

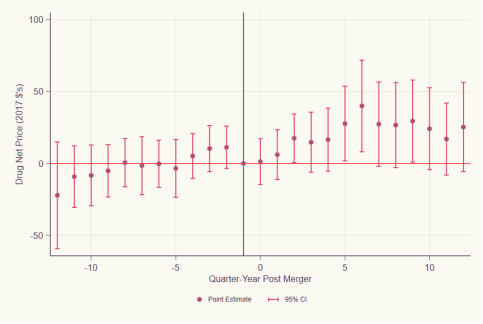


(f) Drugs in Phase II

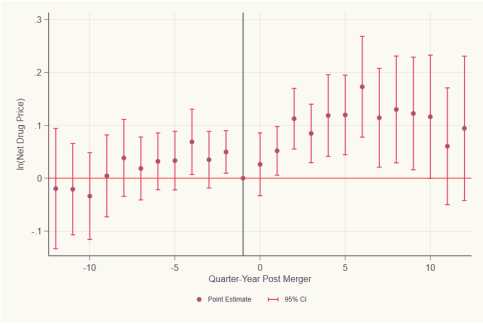


(g) Drugs in Phase III

Figure F.2: Pharmaceutical Prices: Results Based on Second Merger



(a) Net Drug Price



(b) ln(Net Drug Price)

F.2 Addressing Staggered Adoption and Differential Timing

In my empirical analysis, I rely on M&A events occurring in different time periods to estimate the impact consolidation has on innovation and prices. Goodman-Bacon (2021) raises concerns that, in difference-in-differences models with differential timing and staggered adoption, the two way fixed effects (TWFE) estimator might be biased due to heterogeneous treatment effects.

To address potential bias and taking into consideration the staggered adoption of the treated group, I use the estimator as described by Callaway and Sant'Anna (2021) as a robustness check for my primary regression findings to estimate the average treatment effect. Comparing Table A.6 below with Table 3 in Section 6.1.1 and Table 4 in Section 6.2.1, there is relatively little change in the estimators of the main specification for innovation and prices versus those estimated with consideration for heterogeneous treatment effects.

Table A6: Regression Results: Callaway and Sant'Anna Estimator

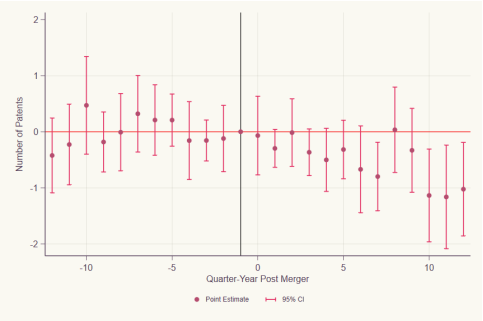
	(1) ln(R&D Spending)	(2) Patents	(3) Discoveries	(4) Discontinuations	(5) Price	(6) ln(Price)
Merger == 1	0.521***	-1.19	-0.711***	0.099	64.03	0.218***
	(.106)	(0.691)	(0.167)	(0.234)	(41.73)	(0.038)
Drug FE					X	X
Firm FE	X	X	X	X	X	X
Quarter-Year FE	X	X	X	X	X	X
Mean of Outcome	232.1	1.48	0.555	1.386	251.6	X

	(7) Phase I	(8) Phase II	(9) Phase III
Merger	-0.242	-0.017	-0.053
	(.223)	(0.134)	(0.206)
Drug FE			
Firm FE	X	X	X
Quarter-Year FE	X	X	X
Mean of Outcome	0.118	0.109	0.058

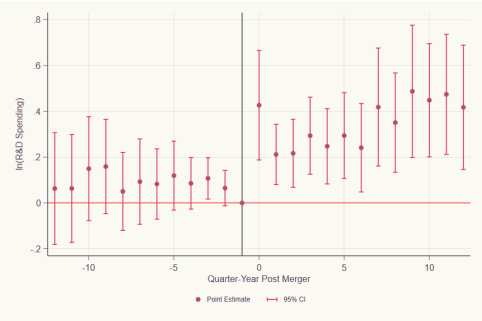
F.3 Alternative Matching Specifications

In the main specification of the empirical model, I use a nearest neighbor match without replacement to match like firms and create a more balanced control group based on the characteristics of treated firms. However, as discussed in Section 6.3.3, these results could be driven by the matching procedure I choose to implement as the main specification. Therefore, I use an alternative matching procedure, 1-to-1 Mahalanobis matching, incorporating the same firm characteristics from the prior matching procedure, and compare it to the results from Section 6. The results using the 1-to-1 Mahalanobis matching procedure can be found below for innovation and prices in Figures F.3 and F.4, respectively. From these results, there is no discernible difference between the results by implementing a different matching procedure.

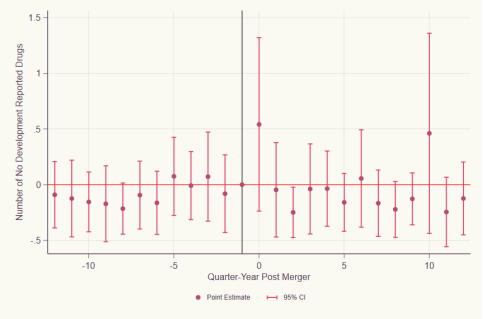
Figure F.3: Innovation: Results Based on Alternative Matching



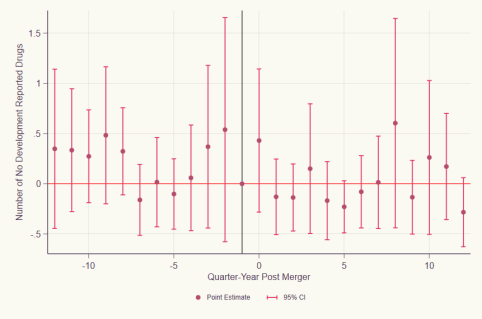
(a) Number of Patents



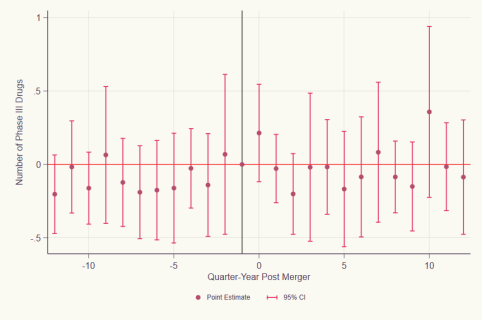
(b) R&D Spending



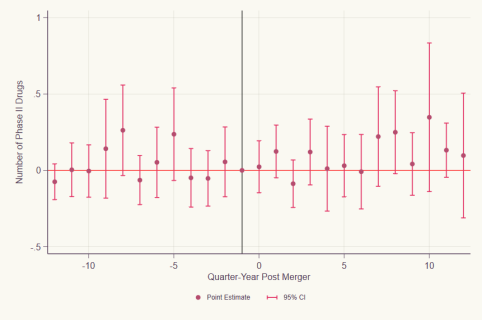
(c) Number of Discoveries



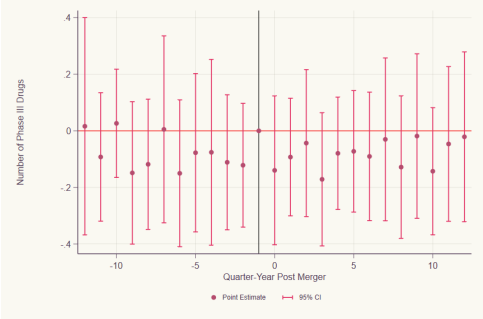
(d) Number of Discontinuations



(e) Drugs in Phase I

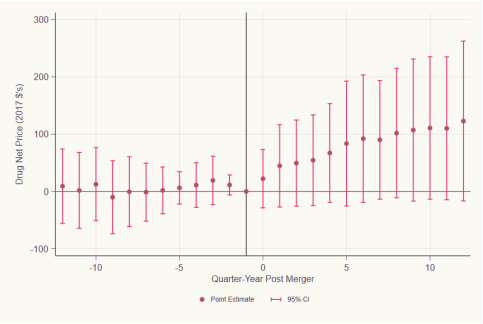


(f) Drugs in Phase II

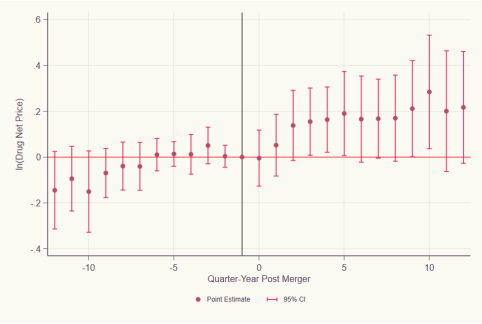


(g) Drugs in Phase III

Figure F.4: Pharmaceutical Prices: Results Based on Alternative Matching



(a) Net Drug Price



(b) ln(Net Drug Price)