Paper to be presented at

DRUID15, Rome, June 15-17, 2015

(Coorganized with LUISS)

The Dynamics of Market-Targeted Drug Development in Post-M&A Environments

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Abstract

M&As have several effects on merging firms and non-merging rivals and they can affect the merging firms' and rivals' innovation strategies.
We examine the impact of M&As on the merging firms' and rivals' product development efforts using data on the pharmaceutical industry.
We estimate the effects of M&As on drug development aggregated on narrowly defined pharmaceutical sub-markets where the effects depend on the merging firms' activities.
Non-merging rivals experience a 2.5% lower discontinuation rate of development projects and a 3% higher entry rate of newly started projects in post-merger periods in sub-markets in which the two merging partners overlap.
Merging firms' discontinuation rates do not significantly differ from their rivals' post-merger but the entry rate of merging firms' development rates rises by about 5%-7% in sub-markets with both merging firms active.
Overall we find a positive effect on the number of development projects in post-merger periods, especially in sub-markets in which both merging firms overlap in terms of their knowledge and development activities.

Jelcodes:L13,-

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February 27, 2015

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1 Introduction

Mergers and acquisitions (M&As) are a common strategic tool of firms to get access to markets, technologies and to obtain market power. M&As have several different effects on various factors, inter alia on innovation. Innovation as such, as well as product variety, is a key factor of economic growth, welfare and firm performance. Therefore, it is of substantial interest and importance to examine and to understand the impact of M&As and changes in market structure on innovation and product variety, especially from a competition policy and managerial perspective. Although innovation-related concerns of M&As receive increased attention at competition authorities, most concerns are not decision critical in merger proceedings, potentially also partly caused by the ambiguous evidence found so far [Veugelers (2012)]. The literature concerning the effects of M&As on innovation is broad and growing. It is accepted that mergers affect innovation, especially in knowledge-driven sectors. Most previous studies focus on R&D expenditures and patent counts on firm-level and use non-merging firms as a control group [e.g. Hall (1990, 1999), Hitt et al. (1991, 1996), Ornaghi (2009) and Valentini (2012)]. Nevertheless, the effects of M&As on innovative activities and outcomes are difficult to predict and ambiguous, even for the merging firms. For merging firms effects can be of both positive and negative nature and therefore partly counterbalancing [Cassiman et al. (2005)]. Only little empirical evidence exists on the dynamics of future market entries and product development by merging and non-merging firms, potentially affected by M&A activities. We attempt to fill this gap by addressing the research question whether and how M&As affect product development efforts of the merging firms and non-merging rivals on a well-defined sub-market level. We examine two different aspects: (i) how do merging firms adjust product development strategies post-merger and (ii) how do non-merging rivals strategically respond to a merger? We aim to analyse the restructuring efforts of the merging firms and outsiders' responses to this restructuring in terms of future product portfolios using data on the pharmaceutical industry.

While the expected effects on merging firms' innovative activities in terms of firm-wide

patenting and R&D expenditures, relatively to non-merging rivals, have been empirically addressed in sectorial and cross-sectorial studies[1], only limited research has been conducted on heterogeneous effects within merging firms and on strategic reactions of non-merging rivals.

First, it can be expected that merging multiproduct firms do not experience the same effects across all product markets. Due to the fact that most M&As do not necessarily incorporate two perfectly coinciding future partners, we consider two different possibilities: On the one hand sub-markets exist where synergies and increased productivity caused by economies of scale occur and the market structure significantly changes because both merging firms are active in the same sub-market. On the other hand there are sub-markets, in which only one of the two firms is active and has knowledge in, such that only limited indirect synergies can occur and no increase in market power is expected. Following the argumentation that synergies and market power and therefore future expected profits are heterogeneously affected across sub-markets, it is likely that different effects across these two possibilities can be found. Generally, it has been shown that the merging firms reshape their boundaries and restructure their product portfolio [Joshi et al. (2004, 2011), Gandhi et al. (2008), Draganska et al. (2009) and Maksimovic et al. (2011)]. Hence, given these considerations, we examine, in contrast to most previous studies, which analyse the effects on an aggregated firm-level, the effects of M&As on firms' strategies on a market-level.

Second, although strategic interactions between merging and non-merging firms are well established in standard models of oligopoly for price and quantity competition, only little attention has been paid to non-merging rivals' potential strategic responses to M&As in terms of innovative effort. Strategic responses are of particular importance to competition policy in order to examine whether potential anti-competitive effects can be partly counterbalanced or mitigated by the non-merging rivals. The effects on non-merging rivals' strategies might have implications for merger proceedings and welfare analysis. It can be argued that rivals adapt their R&D portfolio in response to a merger leading to a new market equilibrium, as

[1]Please see Schulz (2008) for a detailed survey.

it can be observed for pricing and quantity decisions. Contributions in the field of industrial organization show that firms reposition their product portfolio in post-merger periods and that a merger has an impact on product variety offered by the industry [Berry and Waldfogel (2001)].

We contribute to the understanding of the impact of M&As on future market entry and product development by examining the effects on pharmaceutical sub-market level and take strategic responses by non-merging rivals explicitly into account. We focus in our empirical exercise on the different effects across sub-markets where both or only one of the merging firms are active in and on whether and how rivals' product development activities are affected by those M&As. It is common practice in analysing the effect of M&As on prices and quantities to narrowly define relevant and affected product markets [European Commission (2004)] but, to the best of our knowledge, this article is the first contribution which attempts to apply those standardized procedures to examine post-merger product development efforts and potential market entry. We thus follow methodological approaches in retrospective M&A analyses on prices and quantities,[2] and we analyse the impact of M&As on market-level using well-defined product sub-markets as it is standard in merger and antitrust proceedings concerned about the pharmaceutical industry.

In sum, we attempt to shed some light on changes in internal strategies of the merging firms with an emphasis on the potential synergies generated by combined knowledge and market power and to analyse market-specific outsiders' responses by exploiting rivals' reactions in terms of discontinuation and start of drug development projects which target a specific sub-market.

We choos to examine the pharmaceutical industry for mainly three reasons: First, the pharmaceutical sector is characterised as an R&D intensive sector, where innovation is one of the main strategic dimensions of the market participants. Additionally, new developments in pharmaceutical research provide a dynamic environment in which the firms need to adopt their product and R&D portfolio constantly in order to be successful [Danzon et al. (2007)].

[2]See for example Hosken and Weinberg (2013).

Second, the pharmaceutical sector experienced major consolidations within the past decades. The numerous and in size significant M&As reshaped the industry and in particular some entire therapeutic fields in terms of market concentration. Third, the most important and pharmaceutical-specific argument, the pharmaceutical sector provides a clear definition of separated sub-markets. The pharmaceutical industry is complex and divided into numerous therapeutic fields and pharmacological sub-markets. Within a sub-market all products are substitute goods but cannot be replaced by preparations from different sub-markets which allows us to perform the analysis on market-level. Most firms are active in multiple sub-markets such that each firm must choose not only its level of R&D effort, but also the manner in which its R&D efforts should be divided among the various sub-markets [Sutton (1998)]. Consequently, this means that for the pharmaceutical industry we should analyse competition, market structure and innovation at the level of the sub-market instead of using firm-level aggregated measurements in order to get a detailed picture.

We use a database on worldwide drug development projects for the period 1992-2005. Each project can be linked to the sponsoring or research conducting firm. The database contains information on the state of development and start and ending (discontinuation or registration) events. All projects are classified using the Anatomic-Therapeutic Classification System (ATC), developed by the World Health Organization, which is used by competition authorities and the pharmaceutical industry for defining relevant product sub-markets in merger and antitrust proceedings with pharmaceutical firms involved. This data and classification scheme provides a unique link between measurements of a form of innovation - drug development in this case - and distinct product markets.

In general, there is a distinction between *research* and *development* in the pharmaceutical sector. Research can be seen as the innovative activity of basic exploration which identifies promising and potential compounds or preparations to treat a disease. Development in the pharmaceutical industry refers to the specific process aiming to advance and to test preparations in order to launch them to a pre-defined sub-market. Hence, development

projects are a clear and precise measure for the intention of a firm to enter a market with a new or at least own product.

Previous studies mostly used patent data without a clear link to product markets because it is often difficult to link a patent to product markets because patent classes do not correspond to market definitions. The link and identification of relevant product markets is essential for predicting post-merger outcomes because, as pointed out, a merger does not necessarily incorporate two perfectly coinciding firms which might cause heterogeneous effects across sub-markets. Especially in industries characterised by different sub-markets and multi-product firms, two merging partners mostly overlap in only a subset of sub-markets in which both firms are active in. The detailed project-level data gives us the opportunity to explore, retrospectively, the impact of M&As on market-level drug development, by estimating their effect on the number of discontinued and newly started projects, which is, to the best of our knowledge, a novel approach in analysing the impact of M&As on product development and potential market entry.

The remainder of the article is organized as follows: section 2 describes the pharmaceutical innovation process, section 3 is concerned with the creation of the dataset, and section 4 discusses the empirical strategy. Results are presented in section 5 and section 6 concludes.

2 The Pharmaceutical Innovation Process

Pharmaceutical research is a very costly and lengthy process involving multiple stages from identifying promising compounds and formulations, over pre-clinical trials, clinical studies for the verification of safety and efficacy and finalised by a registration and validation process by national authorities. Until the market launch of a new chemical entity a pharmaceutical company has spent 800 million US$ and on average 12 years pass by [DiMasi et al. (2003) and Pommoli et al. (2011)].

R&D projects are always costly and, in the case of pharmaceutical R&D, become even more costly with the advancement of the study [DiMasi et al (2003)]. Each pharmaceutical

development project can be essentially divided into two parts, a research and a development phase. A project starts with the research phase in which numerous chemical compounds and their combinations with other compounds, targeting a certain disease, are identified. In laboratory tests the number of compounds is reduced to a small number of candidate compounds which seem to have the highest potential efficacy. Subsequently to this early stage, the project follows a strict regulatory framework required for market launch [Pomolli et al. (2011)]. Within this regulatory framework the drug is developed towards a product. In most cases the regulatory framework requires 4 consecutive trial phases, namely pre-clinical, Phase I, Phase II and Phase III clinical trials. Pre-clinical testing is used to ensure safety and non-toxicity for organisms (in-vitro and in-vivo testing) in which the so-called lead compound with the best expected trade-off between tolerance, safety and efficacy is identified. If the lead compound is identified and has shown sufficient non-toxicity and expected efficacy for the human organism, the development enters Phase I clinical trials. In Phase I the compound is tested in healthy volunteers for tolerability and non-toxicity for the human being. The research stage, preclinical and Phase I trials might add up to 8 years in total. After passing all requirements in the early development stages, the lead compound is further tested in more advanced stages, namely Phase II and Phase III clinical trials. Phase II and Phase III trials aim to test and to verify efficacy, tolerability with other drugs, optimal dosaging and adverse drug effects. Phase II trials test efficacy, tolerability and optimal dosaging in a sample of 70-100 patients with the disease prevalence. Phase III clinical trials test for efficacy, tolerability and adverse drug reactions in a large sample of 800-1000 patients with and without the prevalence of the disease, optimally in a double-blind randomized trial, in order to establish and fulfill all regulatory requirements for launching the product. The two last stages may take up to 5 years [Pomolli et al. (2011)]. The costs and success rate of each stage increase with the level of development. Early stage projects (pre-clinical and clinical Phase I) are less expensive, while late stages (Phase II and Phase III trials) consume a large amount of research funding and resources. At any point in time of the development process

a project can experience a technical failure and can be discontinued. While the early stages show a high failure rate, the likelihood of a successful finalisation of the whole project is high if the project has reached the Phase II trial stage and even higher if it entered Phase III trials. Furthermore, the research conducting and sponsoring firm can decide to discontinue the drug development for strategic reasons.

3 Data

In this section we describe the data sources and how the dataset for identifying effects of M&As on development projects in different markets, depending on the activities of the merging firms, is constructed. We combine the Pharmaceutical Industry Database (PhID), developed by the Institute for Markets and Technology at Lucca, Italy, and the SDC Platinum Database, developed and maintained by Thompson Financial Services.

3.1 Drug Development Data

The Pharmaceutical Industry Database (PhID) is used to identify firms and their research activities by sub-market. PhID combines data on more than 20,000 pharmaceutical research projects and drug development activities and collaborations. For each development project the data tracks the complete development history from discovery, over clinical trial stages to their market launch and the firm(s) involved in the development. PhID classifies each project according to the Anatomic-Therapeutic-Classification system (ATC) which links innovation and projects to distinct product markets. The ATC-system is segmented into five levels: the main anatomic group (ATC-1), the main therapeutic group (ATC-2), the pharmacological subgroup (ATC-3), the chemical subgroup (ATC-4) and the chemical substance level (ATC-5). The European Commission and pharmaceutical companies (mostly) define relevant product markets on ATC-3 level because a product in one ATC-3 class can usually be substituted by a product from the same ATC-3 class but not by a product form a

different one even if they both have the same indication on therapeutic field level (ATC-2). To give an example, ATC-1 *A* includes all products which regulate the alimentary tract and metabolism, ATC-2 *A10* includes all drugs used in diabetes, ATC-3 *A10A* describes insulins and analogues, while *A10B* incorporates blood glucose lowering drugs, excluding insulins. The markets *A10A* and *A10B* are mutually exclusive since diabetes products on insulin basis and non-insulin basis cannot be interchanged due to possible patient characteristics as e.g. insulin intolerance. The market definition on ATC-3 level will also be key to our analysis. Additionally, we observed that around 20% of the projects in PhID only have an incomplete development history due to non-reporting issues. For those projects we imputed missing development steps by randomly assigning development events based upon estimated duration of development steps.[3] For the analysis we exclude (i) projects which are solely sponsored and/or conducted by governmental institutes, universities, hospitals, foundations or other international and non-profit organizations in all development stages, (ii) projects with missing development-related information, and (iii) projects involving compounds which can only be linked to unspecific ATC-3 categories. Additionally, projects can also be classified in more than one ATC-3 class due to plurality in usage of the compound or a project focuses on interactions of simultaneously administered drugs in two different ATC-3 classes. Projects with more than one ATC-3 classification are considered as multiple projects according to the number of reported ATC-3 categories. As a robustness check, we also excluded all projects with multiple ATC-3 classes. Using only projects with single ATC-3 classes does not change the results significantly. After imposing all necessary restrictions the innovation data reports 11,551 projects with 14,090 unique project-market combinations[4], distributed over 2,303 firms and 178 distinct sub-markets for the period 1992-2005. Within the period we

[3]We used the following procedure: For each ATC-3 category a gamma distribution of the duration between the development steps was estimated using the observed durations. Based upon the parameters of the estimated distribution we imputed the missing information if necessary by randomly assigning duration between stages. We chose to perform this procedure on ATC-3 level in order take into account that duration between development stages can depend on the therapeutic field and/or disease. For example the clinical trial procedure for chronicle diseases generally takes longer than the procedure for fast-acting analgesics due to the characteristics of the treatment. As a robustness check we also performed the analyses only with the projects having a complete development history which holds qualitatively similar results.

[4]9,543 projects report single ATC-3 codes, 2,008 report multiple ATC-3 classes

observe that 7,081 projects have been discontinued, 9,706 projects have been started and 995 projects have been successfully completed. Figure 1 shows the total number of development projects, the number of newly started projects and the number of discontinued projects over time.

For the empirical analysis of the impact of M&As on market-level drug development, we aggregate the firm-project data on market level (ATC-3). The unit of observation for the empirical study is a market-quarter combination. For the analysis of the impact on rivals' development effort the data incorporates an initial estimation sample of 9,968 market-quarter observations over 178 markets and 56 quarters. Subsequently to the analysis of the impact on the rivals, we estimate the effects on merging firms' development efforts relatively to the affected rivals. For this empirical exercise the initial estimation sample consists of 9,347 market-quarter observations distributed over 152 markets and 54 quarters.

3.2 M&A Data

SDC Platinum reports M&A activities worldwide. Focusing on the pharmaceutical industry, we restrain the sample of potential M&As to all transactions where both firms are active in pharmaceutical related SIC codes, namely 2833 (Medicinal Chemicals and Botanical Products), 2834 (Pharmaceutical Preparations), 2835 (In Vitro and In Vivo Diagnostic Substances) and 2836 (Biological Products, Except Diagnostic Substances). During the period of interest, 1992-2005, SDC Platinum reports 4,331 announced deals. We generally categorise firms active in one of the four pharmaceutical related SIC codes as the following: (i) Pharmaceutical companies, active in manufacturing and R&D of compounds, i.e. Pfizer, Merck & Co., Sanofi-Aventis; (ii) generic drug companies, mainly active in manufacturing of licensed-in or off-patent pharmaceutical preparations and less active in pharmaceutical R&D, i.e. Mylan, Teva, Impax; (iii) pharmaceutical research firms, exclusively active in R&D of new chemical compounds and entities with the aim of engaging in licensing agreements either with pharmaceutical or generic drug companies; (iv) pharmaceutical manufacturing firms,

usually sub-contractors of pharmaceutical companies or generic drug companies, exclusively active in the production of pharmaceutical preparations, non-active in R&D. Since we are interested in the relationship of innovation and rivalry in the product and technology market, we restrain the full universe of transactions considered as having potentially an impact on market entry strategies in the pharmaceutical industry in two ways. Firstly, only M&As are considered in which both partners are capable to launch a product independently. Secondly, only M&As are considered in which both partners are capable to conduct pharmaceutical R&D. A firm's capability of launching a product is assumed to be given if a firm has ever launched a product in the period 1985-2005 in any OECD country. A firm's capability of conducting R&D is assumed to be given if a firm has ever conducted or participated in a drug development project. Thus, given our classification of pharmaceutical firms, we generally consider all mergers between two pharmaceutical companies, two generic drug companies and a pharmaceutical company and a generic drug producer. We exclude mergers with pharmaceutical research companies and manufacturing contractors because those types of companies do not intend to compete with pharmaceutical or generic drug manufacturers by entry into a product markets and those mergers are therefore not in line with the focus of this study. Furthermore, SDC Platinum also reports M&As which are announced - but withdrawn - and which feature only single assets or acquisitions of minority stakes. Announced but withdrawn M&As are never consummated and therefore cannot have an impact on drug development. Consequently, all announced but withdrawn deals are excluded. Additionally, all transactions in which the acquirer does not obtain corporate control over the target because the possibility to influence drug development activities are limited if corporate control is not obtained. In other words, M&As are not considered if the acquirer does not own more than 50 percent of the target after a partial acquisition. Deals, featuring the transactions of single assets, are removed from the sample of considered M&As if it involved plants, single brands or non-pharmaceutical assets. Transactions of assets are considered if complete pharmaceutical divisions of conglomerates are traded. Transactions which involved assets

were manually checked through press releases or financial service providers and were removed or remained in the sample according to this information. After restraining the universe of transactions to the above mentioned characteristics, the sample of considered transactions consists of 99 transactions in the period 1992-2005. Figure 2 displays the distribution of deals over time. Table 9 lists all transactions considered.

3.3 Generating Post-Merger Indicators

Essential for the empirical identification strategy is the definition of treatment and control groups. Combining the drug development data from PhID and SDC Platinum frames treatment and control groups with a market-quarter identifier. We use the drug development data for identifying treatment groups and the M&A data for identifying treatment periods.

We distinguish between two types of treatments given merging firms' development activities, according to our expected effect heterogeneity across markets in which both or only one of the merging firms is active. We generate two treatment indicators depending on a market's level of exposure to a merger, namely *directly affected* and *indirectly affected* observations. A market's level of exposure to a merger is defined by the development activities of the merging parties in a given market.

A *directly affected* market is a market in which both merging firms actively control at least one development project each in the quarter the merger is announced. In other words, a directly affected market is a market for which, everything else equal, a future increase in market power or higher concentration and potential sub-market specific synergies can be expected. Hence, for all observations in a given ATC-3 market, in which both merging firms are present, the indicator variable for *direct effect* is equal to 1, and 0 otherwise. The direct effect indicator captures effects due to the change in market structure, the potential change in the occurrence of a larger firm within a sub-market and potential synergies.

An *indirectly affected* market is a market in which only one of the merging firms actively sponsors a development project in the quarter of the merger announcement. In other words,

an indirectly affected market is a market with no increase in market power due to the merger but a firm with greater capabilities might occur. The *indirect effect* indicator captures potential effects of a merger on a market due to a change in firm size and research capacities of the merged entity. The indirect effect indicator is constructed analogously to the direct effect indicator.

The two treatment indicator variables are interacted with a set of post-merger indicators. We are interested in the short- and mid-term effects of M&As and the timing of decision mechanisms within firms. Especially, the timing of decision making in pharmaceutical firms are of concern since it is very likely that firms do not immediately respond to a change in market structure but within a year when board meetings or other decision mechanisms take place after learning about the potential consequences for their own development projects. Hence, the set of post-merger indicators consist of one indicator for the period of the merger and a set of indicator variables, one for each period up to 5 quarters after the transaction has been announced.[5] This implies that we use a dynamic set-up for the treatment and control groups, where sub-markets enter and leave treatment and control groups according to the occurrence or non-occurrence of M&As affecting this specific sub-market in the past 5 quarters. Additionally, we consider anticipation effects and construct lead indicators for the two preceding quarters before M&As in order to control for some self-selection into treatment.

In sum, we obtain two treatment groups, directly and indirectly affected sub-markets, and one control group, the non-affected sub-markets. Given our definition of treatment indicators, figure 3 displays the distribution of treated and non-treated (control) sub-market-quarter combinations. 4,555 sub-markets are not affected by any merger or acquisition in a given quarter. 5,413 sub-markets belong to the treatment groups, in which 3,636 sub-markets are indirectly and 1,777 sub-markets are directly affected by M&As at a certain point of time. Figure 4 shows the evolvement of the number of treatment and control markets over time,

[5]We experimented with various treatment-effect-time-windows for post-merger periods but did not find any effect and more explanatory econometric specifications when we included more than 5 quarters.

given a treatment-time-window of 5 quarters after a merger. Due to the potential occurrence of multiple mergers affecting a market within the treatment-time-window, a market-quarter observation can be simultaneously directly and indirectly affected.

4 Empirical Framework

Our empirical strategy is to examine drug development efforts at the market-level (ATC-3) by exploiting variation in exposure to M&As over time and across sub-markets. We are particularly interested in heterogeneous effects of M&As on sub-markets in which both merging firms are active and sub-markets in which only one of the merging firms is active. For the analysis of the reactions of non-merging rivals we estimate the effects relatively to sub-markets which do not experience any merger. In the analysis of the decisions of merging firms we estimate the effects relatively to affected non-merging rivals.

The identification of control groups in natural and quasi-experiments is always a challenge in treatment effect studies.[6] For both, the analysis of the effects on rivals' drug development efforts and the analysis of the effects on merging firms' efforts, the research design clearly determines treatment and control groups. This is assured by the indicators describing the level of exposure to a merger and the clearly defined independent sub-markets which allows us to use an adopted Differences-in-Differences approach.

For the analysis of the effect on the non-merging rivals, the sample incorporates two different treatment groups and one control group. The treatment groups consist of the market-quarter combinations for which at least one of the post-merger indicators, directly or indirectly, is equal to 1. The control group consists of the observations which are not influenced by M&As by any order of exposure and all post-treatment indicators are equal to 0. One aspect of this study is to examine potential reactions by non-merging rivals for both competition policy and managerial insights. Due to the fact, that we use aggregated data on market-level, it is necessary to exclude the projects of merging firms in order to isolate

[6] See Meyer (1995) and Bertrand et al. (2004) for a detailed discussion

the effect on the rivals and to answer the question on rivals' reactions. If merging firms' projects are incorporated in the analysis of the effects on the non-merging rivals, we cannot identify the effect since a change in development efforts might be driven by a change in merging firms' behaviour if aggregated on market-level. Controlling for other factors, as well as for market-fixed and time effects, the treatment indicators identify the potential effects of M&As on non-merging rivals in markets which are affected relatively to markets which are not affected.

Analysing the effects on the merging firms' drug development efforts, the treatment groups are observations informing on the merging firms' activities and which are affected either directly or indirectly by their own merger or acquisition and potentially directly or indirectly affected by M&As of two different firms. The control group, when analysing merging firms' efforts, consists of market-quarter combinations informing on activities of the affected non-merging rivals. In other words, each affected market-quarter combination, describing the merging firms' drug development efforts, is paired to the same market-quarter combination describing the potentially affected rivals' development efforts such that we estimate the effects on the merging firms relatively to the effects on the non-merging rivals.

Every observation of merging firms, aggregated over the merging firms in the case of simultaneous mergers, can simultaneously affected by its own merger or acquisition or by M&As of other firms in sufficiently close time periods. For instance, an observation on the merging firms is treated directly and/or indirectly by their own merger and potentially affected by a different merger in the same market in preceding or consecutive quarters such that at least one of the treatment indicators is equal to 1. For the identification of the effect on the merging firms it is substantial to control for the effect of additional M&As for which the observation on the merging firms is an affected rival because, if we agree on the premise that non-merging rivals are influenced, also a merging firm would be affected by another merger.[7] The observations on the in fact affected rivals serve as the corresponding control

[7]Consider the example of two mergers in two consecutive periods directly both affecting the same submarket m. Firms a and b merge in period t, firms c and d merge in period $t+1$. The observation on the merged firms ab is directly affected in t and $t+1$ by its own merger in t, and additionally affected by the

group and, in contrast to the analysis of the effects on the non-merging rivals' efforts, all treatment indicators are equal to 0 for the market-quarter combinations, informing on the affected rivals' development activities. Controlling for other factors, as well as for market-fixed and time effects, the treatment indicators identify the potential effects of M&As on merging firms' development efforts in affected sub-markets relatively to the affected rivals' in the same market-quarter combination.

Our main dependent variables are the discontinuation rate and the entry rate in a given market in a given quarter. Discontinuation and entry rates are defined as the number of discontinued projects, or newly started projects respectively, in a given sub-market g in quarter t divided by the number of ongoing projects in the same market in $t-1$. Due to the fact that, by definition, the calculation of discontinuation and entry rates is impossible, if the number of ongoing research projects in $t-1$ is equal to 0, these observations are excluded from the estimation sample.

We adopt a dummy-variable approach for treatment effect analysis and estimate equations the following form:

$$y_{gt} = \alpha_g + \lambda_t + \beta' \mathbf{X}_{gt} + \sum_{j=0}^{\tau} \delta_{j+1} dDIRECT_{gt} * POST_{t-j} + \sum_{j=0}^{\tau} \gamma_{j+1} dINDIRECT_{gt} * POST_{t-j} + \varepsilon_{gt},$$

where y_{gt} refers to our main variable of interest, the discontinuation and entry rate in market g in quarter t. α_g is a market-specific unobservable fixed effect, possibly correlated with the treatment indicators and λ_t is a set of quarter-dummy variables for capturing time-effects. $\mathbf{X}_{gt}$ is a vector of market-specific characteristics, mainly incorporating the ln(# of Projects in $t-1$) in order to control for sub-market development intensity. $dDIRECT_{gt} * POST_{t-j}$ and $dINDIRECT_{gt} * POST_{t-j}$ are the treatment-effect variables for the period of a merger and the 5 consecutive periods, as described above and ε_{gt} is the error term. The coefficients

merger *cd* in $t+1$ as a rival. Vice versa for firm *cd* which is influenced by its own transaction in $t+1$ and affected by *ab*'s merger in t as a rival. Hence, the treatment indicators for the observation informing on *ab*'s and *cd*'s efforts are equal to 1 in both periods and in $t+1$ for both timings, a merger in that period and the preceding period. The development efforts of the firms *ab* and *cd* are aggregated over the sub-market.

δ_{j+1} and γ_{j+1}, with $j = \{-1, 0, 1, 2, 3, 4\}$, reflect the change in the dependent variable of interest due to M&As which either directly or indirectly affect a market.

In general, we use the within and between group variation to identify the effect of M&As on efforts in market-level drug development. Sub-markets can incorporate persistent differences in discontinuation and entry rates associated with the therapeutic field or pharmacological sub-market. Although the regulatory guidelines and requirements for testing for superiority or non-inferiority in clinical trials are equal across therapeutic or pharmacological subgroups, there may exist differences in the average duration of development. For instance, drug development for chronicle, rare or long-lasting diseases may require more time than fast-acting emergency analgesics or pain relievers either due to bodily absorption time, action time or other pharmcokinetics or simply due to the rare availability of potential trial subjects. Additionally, some ATC-3 classes incorporate a higher risk of technical failure than other classes, e.g. biotechnology compounds for the treatment of cancer can be more complex than single-acting dermatological preparations. Due to the fact that differences in duration and general risk of technical failure are permanent and time-invariant because the disease does not change over time, the incorporation of sub-market-specific fixed effects should capture the differences. The within transformation captures all unobservable differences between sub-markets and returns consistent estimates if the assumption of strict exogeneity is fulfilled. We argue that our data only exhibits a limited risk of contemporaneous correlation between the residuals and the treatment indicators because the decision of two firms to merge can be assumed to be determined before at least the quarter the merger is announced or even earlier because M&As require preparation and negotiation time and are usually kept secret. Additionally, for the analysis of the non-merging rivals' reactions the dependent variables exclude merging firms' projects and, even if merging firms would prepare or adjust their drug development portfolio before a merger is announced, it is most unlikely that the non-merging rivals have any information about the planned transaction or can anticipate the change in market structure in periods before announcement with cer-

tainty. We are aware of the fact that hostile takeovers are public before the finalisation of the transaction but those kind of acquisitions are rare. One more concern are rumours of forthcoming M&As in the industry. We argue that this risk is rather minor because the rumours incorporate a large portion of uncertainty and therefore have only a small influence of non-merging rivals' pipeline portfolio. Nevertheless, we control with lead treatment indicators for potential anticipation effects.

4.1 Econometric Challenges

First, a challenge, all empirical studies on the effect of mergers on innovation face, is the potential endogeneity of mergers. Innovation can be one of the motives to merge or to acquire a rival [Grimpe and Hussinger (2006)]. In the case of innovation driven mergers, the indicator variables may not be independent of unobserved transitory shocks which would cause a reverse causality problem. If the reverse causality is persistent, the results for the effect of mergers on innovation or drug development will be biased.

We claim that our research design mitigates the likelihood of the reverse causality problem due to our focus on the aggregated market-level and not on firm- or project-level. In general, the treatment indicators, independent of whether they describe potential direct or indirect effects, are market-specific and depend on the merging firms' activities in the 178 independent sub-markets. This means that we would incorporate an endogeneity problem if shocks on the discontinuation and entry rate of worldwide aggregated development projects within a sub-market would cause a specific merger or acquisition. In other words, we have to ask: does a change in the discontinuation or entry rate in period t in one independent sub-market influences the decision of two firms to merge in $t + 1$? This might be more likely if the pharmaceutical sector would be characterised by only single product and single project firms because single sub-markets are then of major importance to each firms. As argued before, the pharmaceutical sector is mainly characterised by multiproduct and multi-market firms. Descriptive statistics on the development activities of the merging firms undermines this

argument. For the 99 M&As considered, the two merging firms sponsor on average 104 parallel projects across 44 different sub-markets (ATC-3 classes). Only two out of the 99 mergers incorporate less than three projects and only influence a single ATC-3 sub-market.[8] All other M&As have an impact on multiple sub-markets, where over 90% of the considered mergers affect at least seven different sub-markets. The largest merger in this respect, Pfizer and Pharmacia Corporation in 2001q3, spans over 213 projects in 70 distinct ATC-3 sub-markets. Therefore, it is very unlikely that most mergers are motivated by changes in discontinuation and entry rates of development projects in single sub-markets. Additionally, the data incorporates solely development data and does not consider any product portfolios, manufacturing capacities and distribution channels which might be all important reasons and incentives to merge which do not influence the discontinuation or start of development projects. Additionally, we estimate the impact of M&As on drug development projects using a full set of ATC-3 sub-market indicators and control for time-varying changes in development intensity of a sub-market in order to capture market-specific characteristics. Hence, we might conclude from this argumentation that the potential endogeneity concern, which is a valuable argument for most studies which examine the impact of M&As on innovation on firm-level, is unlikely to influence our estimation given our research design and level of aggregation on ATC-3 sub-markets.

For the analysis of the effect on non-merging rivals we exclude all projects of merging firms in the calculation of the discontinuation and entry rates. As already mentioned above, if merging firms' projects are incorporated in the analysis of the effects on the non-merging rivals, we cannot identify the effect since a change in development efforts might be driven by a change in merging firms' behaviour if aggregated on market-level. Additionally, excluding those projects reduces the potential risk of endogeneity for this part of the empirical exercise because merging firms' projects, which might trigger M&As do not influence our dependent variables, neither the discontinuation nor the entry rate.

[8]The mergers between Chemex and Access in 1995q4 and between Orphan Medical and Jazz Pharmaceuticals in 2005q2.

Second, an important assumption for treatment effect estimation is the so-called common trend assumption. The common trend assumption assures that treatment and control groups are sufficiently comparable. Figures 5 and 6 show the average discontinuation and entry rate over time for non-affected, indirectly and directly affected markets for non-merging rivals projects. The figures suggest that there is no significant difference in trends between the treatment and control groups over time. Additionally, the conditional summary statistics, displayed in tables 1-3, and two-sided t-tests partly confirm the conjecture that there are no significant differences in means of discontinuation and entry rates for affected and non-affected non-merging rivals across treatment and control groups.

Figure 7 and 8 compare average discontinuation and entry rates over time by type of observation for the analysis of the effect on merging firms' development efforts. Except for a few outliers, the figures show the discontinuation and entry rates of merging firms and affected rivals are widely comparable over time and across treatment type and are also comparable to non-affected sub-markets. From the tables 1-3 we can note that there are significant differences in the average discontinuation and entry rates for the merging firms in directly and only indirectly affected sub-markets. Nevertheless, this problem is less severe since most directly affected sub-markets are simultaneously indirectly affected by other M&As in neighbouring periods.[9] Additionally, we estimate the effects on the discontinuation and entry rates which depend on the number of ongoing projects such that research activities in $t-1$ is accounted for in the calculation of the dependent variable.

[Table 1-3 about here]

Another point of concern is that larger markets are more likely to experience a merger event due to a higher number of firms. In our econometric specification we control for the number of ongoing research projects in order to control for possible dynamics of certain markets which become more active over time. If the assumption of strict exogeneity holds,

[9] 2,245 markets which are directly affected within our treatment-effect-time window are simultaneously directly and indirectly affected.

the market-specific effects, included in our econometric specification, partly take care of a possible self-selection of markets into the treatment group. We include the natural logarithm of the number of ongoing projects in $t-1$ as a control variable. This variable describes the development intensity of a given market g in $t-1$. It accounts for time-varying changes in therapeutic fields and sub-markets which are not captured by the set of indicator variables and should be widely unrelated to mergers. Those time-varying factors can include novel techniques and compounds, as for example biotechnological entities, introduced to a therapeutic field which makes failure more likely due to their novelty. Higher discontinuation rates due to increased risk of failure is rather associated with technical failure than to market structure and the impact of M&As.

Third, one might expect that risky sub-markets with many firms and development projects active are more likely to be exposed to a merger. This can be explained by the possibility that a sub-market is lucrative but risky. In the case of a successfully launched product, the winner will earn high profits which advocates the investments, even if the likelihood of failing projects is relatively high. The self-selection into treatment can be indeed true by construction since the likelihood of the occurrence of a merger is increasing in the number of firms due to more different possibilities of merging pairs. Consequently, this would mean that markets with higher discontinuation rates in $t-\tau$ are more likely to be selected into the treatment groups (affected markets). This would cause a reverse causality problem which would bias our results for the treatment effect estimation. We tested whether reverse causality is a problem by estimating binomial models with the treatment effect indicator as dependent variable and lagged discontinuation rates as explanatory variables and used an iterative process over all treatment indicators and up to four lagged periods before a treatment. We do not find significant coefficients for any of the lagged discontinuation rates which suggests that a higher discontinuation rate in $t-\tau$, which is possibly associated with more development-intense markets, does not cause merger activity. Hence, we might conclude that we do not necessarily incorporate a reverse causality problem and our results are

unbiased in this respect.

5 Results

5.1 Effects on Non-Merging Rivals

First, we want to discuss the results found for the effects of M&As on non-merging rivals' development efforts. The results from estimating our econometric model for identifying effects on non-merging rivals are presented in tables 5 and 6. The dependent variable in table 5 is the discontinuation rate, defined as the number of discontinued projects in market g in period t divided by the number of ongoing projects in market g in period $t-1$. The dependent variable in table 6 is the entry rate, defined as the number of newly started development projects in market g in t divided by the number of ongoing projects in market g in $t-1$.[10] The regressions in columns (1)-(3) of each table are estimated as Tobit regression models. We choose censored regressions models for the fact that we estimate rates which, by definition, cannot be smaller than 0 and for the discontinuation rate not be larger than 1. Therefore, regressions for the discontinuation rate feature a 2-sided Tobit model, regressions for the entry rate a 1-sided Tobit model. Despite the treatment indicators, all specifications include time effects in form of quarter-indicators and a control for the number of projects ongoing in sub-market g in $t-1$. All specifications are estimated with a full set of sub-market fixed effects on ATC-3 sub-market level. Additionally, we estimate standard errors clustered on the ATC-3 level, displayed below the coefficients, in order to take into account the potentially heterogeneous variation and serial correlation across and within sub-markets. We estimate three different specifications including no, one or two lead-indicators in order to control for potential anticipation effects of M&As. Column (1) of each table does not include any potential anticipation effect, column (2) includes a one quarter lead-indicator

[10] We define a newly started project as a project which appears for the first time in our database as a pre-clinical trial. We also tried other definitions the entry in Phase I clinical trials. A definition that a project started when entered Phase I clinical trials holds similar results.

and column (3) two lead indicators.

In the analysis of the discontinuation rate we can observe that the coefficients for directly affected markets are negative for all considered post-merger periods and across specifications. The coefficients of the direct treatment indicators in the third and fourth quarter are negative between -0.022 and -0.025 and significant on 10 and 5 percent significance levels. This indicates that on average a sub-market in which both merging firms are active the discontinuation rate of non-merging rivals' projects is around 2.5% lower in the third and fourth quarter after a merger occurred relatively to markets without any merger. This result, even if the effect is very small and not highly significant, support our hypothesis that non-merging rivals react strategically to a merger. The response in terms of decisions on continuing ongoing projects is positive. There is only little evidence that the discontinuation rate of non-merging rivals' development projects in indirectly affected markets is influenced by a merger or acquisition, except for a weak negative effect in the third quarter after M&As. Although we can observe an anticipation effect in the quarter before a merger occurs, the coefficients for the post-merger treatment indicators barely change across specifications which indicates that the anticipation is not influencing the decisions in post-merger period to a large extent.

[Table 4 about here]

In general, most of the quarter dummy-coefficients are significant, as are many of the sub-market fixed effects indicator coefficients. Controlling for the development intensity in $t-1$ is of particular interest for the avoidance of the above mentioned reverse causality problem. We observe a fairly stable and significant coefficient of about 0.093 which indicates that markets with more development projects show on average a higher discontinuation rate. The coefficient partly captures the time-variant characteristics of a given sub-market in terms of development intensity. We are concerned that markets with many firms active and potentially an increased risk in failure causes M&A activity. As described above, by including development intensity, we partially control for the fact that many firms in a sub-

market potentially increase the risk of a self-selection bias. By including the number of ongoing projects as a proxy of the number of firms active we account for markets with many firms and the increased likelihood of being affected.

For the analysis of the entry rate of projects by non-merging rivals we obtain mostly positive coefficients for the merger-treatment indicators across all specifications in directly affected markets. The coefficients for the second and third quarter after a directly affecting merger are positive and significant at a 5 and 10 percent significance level. The coefficients have values between 0.026 and 0.032 and are fairly constant across specifications. The results indicate that markets which are directly affected have on average an about 3% higher entry rate by non-merging rivals compared to non-affected markets. Indirectly affected markets do not seem to experience major changes in decisions to enter affected sub-markets relatively to non-affected sub-markets. The signs of the coefficients are inconclusive and most coefficients are not significant different from 0, except a negative effect in the fourth quarter after a sub-market is potentially affected by one merging party. For the entry rate we do not obtain any significant coefficients for potential anticipation effects.

[Table 5 about here]

The results for the effects of M&As on the entry rate confirms the results for the discontinuation rate. In sum we can state that we find some evidence that mergers and acquisitions do seem to have a positive impact on rivals' drug development activities relatively to efforts in non-affected markets. On the one hand we find a lower rate of discontinuation in both directly and indirectly affected markets. On the other hand we estimated that in post-merger periods the entry rate is higher in at least directly affected markets. The absence of large effects in general might indicate that rivals do react but not to a great extent. Additionally, the non-existence of effects in indirectly affected sub-markets hints that our research design to analyse effects on market-level is more suitable to draw conclusive pictures on the impact of M&As on development projects than aggregating on firm-level. An aggregation would potentially diminish the found effects in the directly affected sub-markets if the average of

directly and indirectly affected sub-markets would be considered. Although the effects are very small, which can be expected when aggregating worldwide drug development efforts on pharmacological sub-markets, the result of an overall positive effect of M&As on rivals' development activities are stable and significant across model specifications.

Regarding the timing of non-discontinuation and entry decisions, we observe that the most persistent results are in the third and fourth quarter after the occurrence of M&As. This result is in line with the argumentation that firms need some time to learn about the influence of a merger on their own projects and maybe about the impact on the merging firms' decisions in post-merger periods. Additionally, decision processes may take some time until discussion and board meetings have taken place.

5.2 Effects on Merging Firms

For the analysis of the effects on merging firms' development efforts, we estimate the effects relatively to the treated non-merging rivals using the same econometric techniques as for the previous examination of effects on the non-merging rivals.

Regarding the discontinuation rate of merging firms' projects, we estimate across all specifications that the merging partners do not discontinue relatively more projects in directly affected markets than their non-merging rivals, except for the fifth quarter after the merger. Comparing these results to the effects on the non-merging rivals, which experience a lower discontinuation rate relatively to non-affected firms and sub-markets, we can state that, at least for the second, third and fourth quarter after a merger, a slightly lower discontinuation rate of merging firms' projects relatively to a non-merger situation can be expected. For indirectly affected markets we observe significant higher discontinuation rates in the third quarter after the merger of about 3.9%. Due to the fact that we found lower discontinuation rates for the non-merging rivals in the same quarter, the positive and negative effects in indirectly affected markets are partly counterbalanced. For both, directly and indirectly affected sub-markets, we do not find any anticipation effects. We also include an indicator to charac-

terise merging firms' observations which is negative and significant. This coefficient captures potentially persistent differences in discontinuation rates of merging and non-merging firms. Additionally, including this variable mitigates the potential endogeneity problem as it was described above.

[Table 6 about here]

Regarding the entry rate of new projects, we find the following results: Merging firms start significantly more projects in sub-markets in which they overlap and have common knowledge, the directly affected sub-markets, in the quarter of the merger and the first, third and fourth quarter post-merger. We estimate that in those quarters the entry rate is between 4.8% and 7.2% higher relatively to the entry rate of the non-merging rivals. Given that the non-merging rivals experience a slightly higher entry rate in directly affected markets as well, we might conclude that the effects in markets which are directly affected by M&As are of positive manner in terms of newly started projects. As for the indirectly affected sub-markets, we do not find any significant higher or lower entry rates relatively to the ones of the indirectly affected non-merging rivals, except a weak significant higher rate in the third quarter after the merger. We estimate a positive anticipation effect in directly and indirectly affected markets two quarters before a merger but including this anticipation indicator does not have a significant influence on the treatment effects in post-merger periods.

[Table 7 about here]

In sum we do not find a higher likelihood of discontinuation of merging firms' projects in markets in which the two firms overlap. Additionally, our estimates indicate that there are positive effects on the number of new projects in directly affected sub-markets which might be caused by increased research productivity due to shared knowledge and collaboration. Furthermore, it might be the decision of the merging firms to focus on the sub-markets in which the expected gains from co-operation are large which is caused by economies of scope and scale and cost synergies in those fields. Concentrating on those markets can also

be partly explained by the incentive to strengthen the market position in which the merged new entity potentially already possesses some market power which increased with the merger.

6 Conclusion

M&As and strategic interactions between firms in a given market are a well-known and thoroughly addressed topic in economic research. One important dimension, especially in high-technology sectors, are firms' decisions to invest in new products. Dynamic sectors, as it is the pharmaceutical industry, undergo multiple changes in market structure and incorporate permanent product innovations. We address the question whether and how non-merging rivals and merging firms react to M&As in the pharmaceutical sector by estimating effects of M&As on development projects in narrowly defined sub-markets. We investigate the different effects given merging firms' development activities.

Our results indicate that the discontinuation rate of development projects by non-merging firms is 2.3% lower and the entry rate is 2.6% to 3.0% higher about 1 year after a merger occurred for sub-markets in which both merging firms are active. The discontinuation rate of merging firms' projects does not increase in post-merger period relatively to affected non-merging firms. The estimations show that especially the merging firms start significantly more projects in markets, in which they overlap, within post-merger periods. Merging firms' entry rate of new projects is about 6% higher in sub-markets in which synergies of shared knowledge and collaboration can be expected. Evidence on existing effects in indirectly affected markets is weak for both, merging and non-merging firms. These results indicate that in sum there are positive effects of M&As on rivals' and merging firms' product development efforts in post-merger periods.

Our results can thus be summarized in the following two points: First, we find evidence that rivals discontinue less and start more projects in markets in which the future number of competitors is reduced. Second, merging firms do not discontinue more projects relatively to their non-merging rivals but start significantly more new projects in markets where they

overlap in post-merger periods.

The results are consistent with the possible explanations of the incentives for market-entry due to increased market power for all firms and synergies, obtained market power and positive effects of scale and scope for the merging firms.

The contributions of this empirical exploratory exercise can be summarized as the following: First, by showing that heterogeneous effects across differently affected markets exist, it can be stated that aggregation of innovative efforts and neglecting heterogeneous effects across sub-markets might cause misleading results. Second, non-merging rivals react strategically to M&As in terms of future sub-market entry by drug development. Third, merging firms may experience some increased research productivity due to synergies and economies of scale and scope in markets where they can easily combine their knowledge and experience. Fourth, even if some anti-competitive effects on drug development and innovation might exist, those negative effects are overcompensated by non-merging rivals' repositioning and future entry and by increased development activities by the merging firms in the mid- and long-run.

Nevertheless, our analysis incorporates some limitations. We use aggregated data on worldwide drug development projects in OECD countries. Competition authorities analyse competitive effects of M&As in narrowly defined product and geographic markets. Further research needs to be conducted whether our results on aggregated data holds for national markets. Additionally, the aggregation on market-level does not give any indication whether substantial differences between types of firm drive the results. For effect heterogeneity on different firms a firm-market-level analysis can be applied in future research. Additionally, given our research design we cannot answer for example whether the positive effect is driven by large direct competitors or smaller specialized pharmaceutical firms. One additional limitation is that we cannot apply any quality measurement for development projects. Although one can expect that less promising projects get strategically discontinued, projects at the margin which are not discontinued post-merger are unlikely to provide great quality

improvements in the treatment of diseases.

At any rate, our results show some positive impact on market-entry strategies for both, merging firms and non-merging rivals, in post-merger periods on market-level induced by M&As and may shed some light on strategic responses by non-merging rivals and the potential synergies merging firms can experience.

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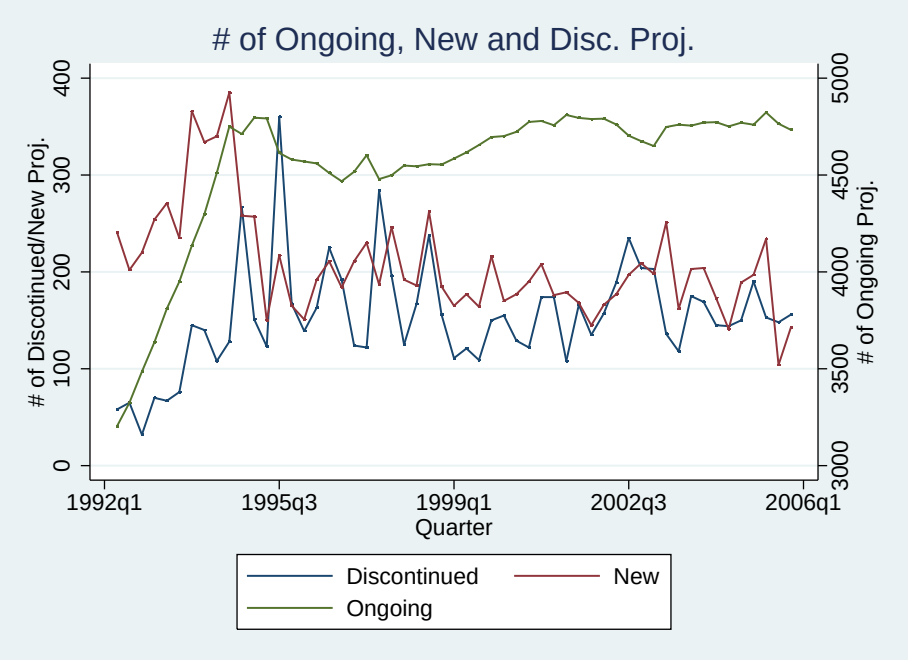

Figure 1: Number of Ongoing, Discontinued and New Projects

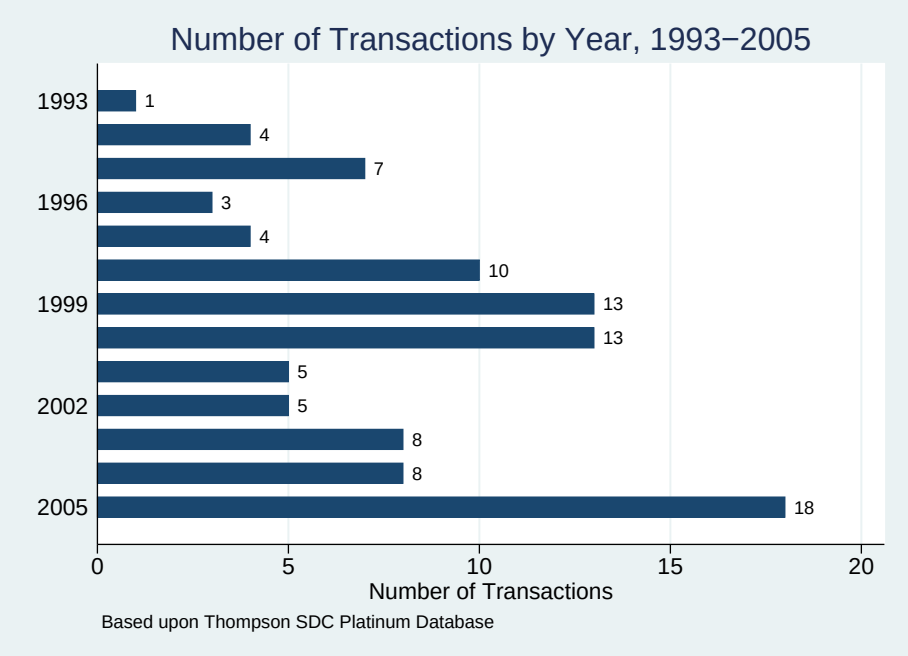

Figure 2: Number of Transactions by Year

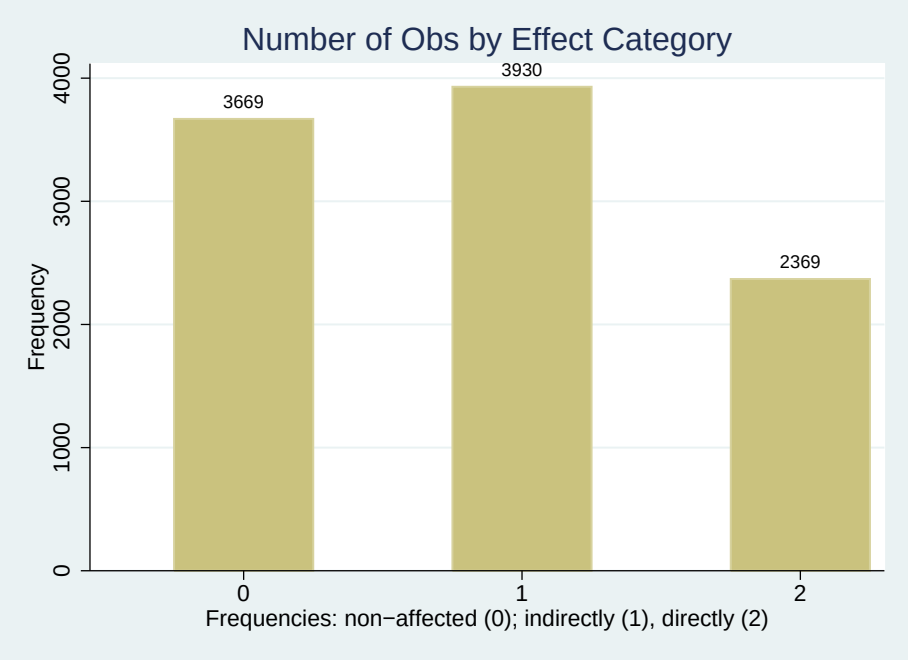

Figure 3: Distribution of Market-Quarter Combinations by Effect-Category

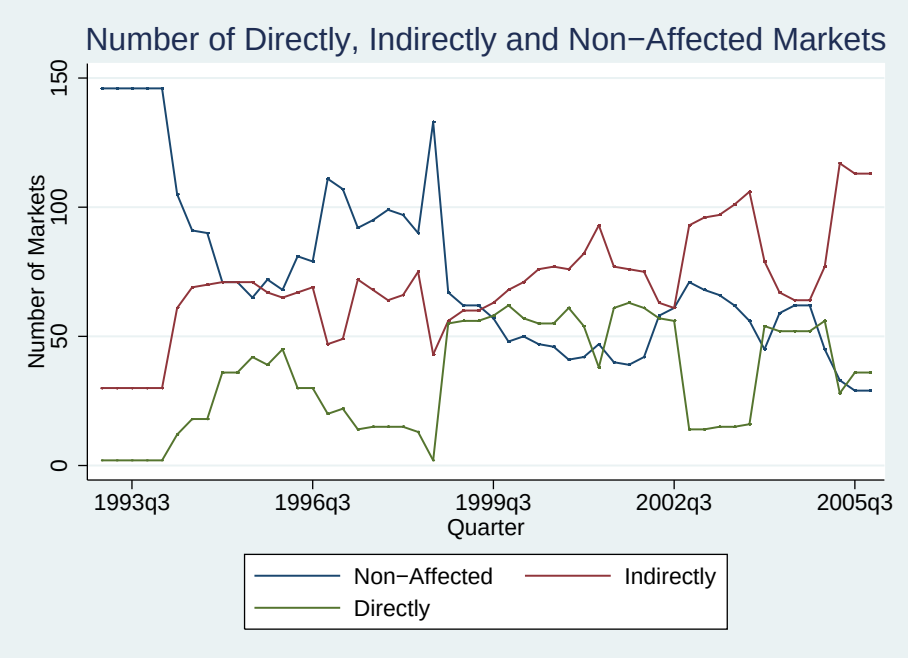

Figure 4: Distribution of Markets by Effect-Category over Time

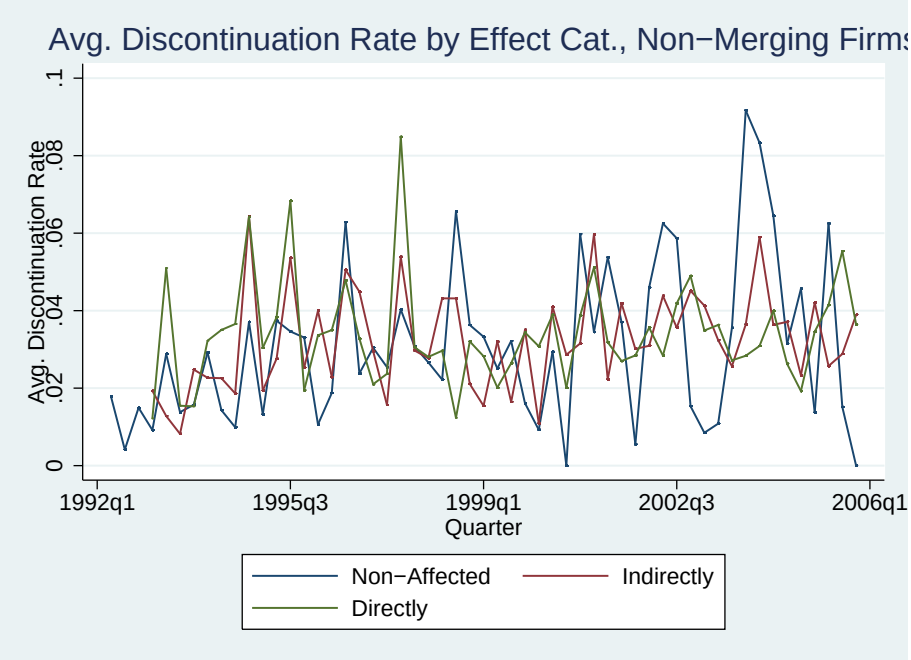

Figure 5: Average Discontinuation Rates by Effect-Category, Non-Merging Rivals

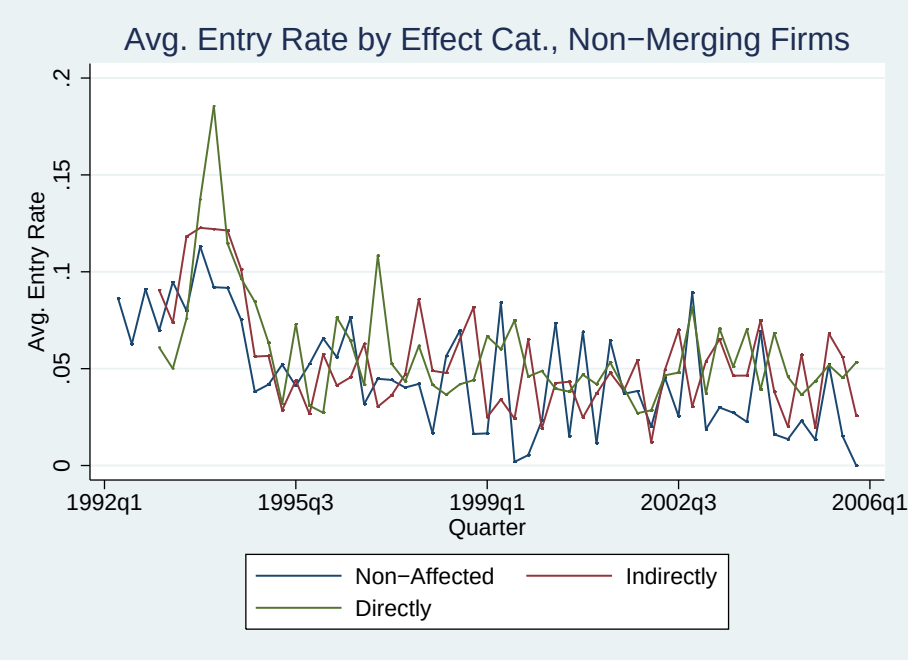

Figure 6: Average Entry Rates by Effect-Category, Non-Merging Rivals

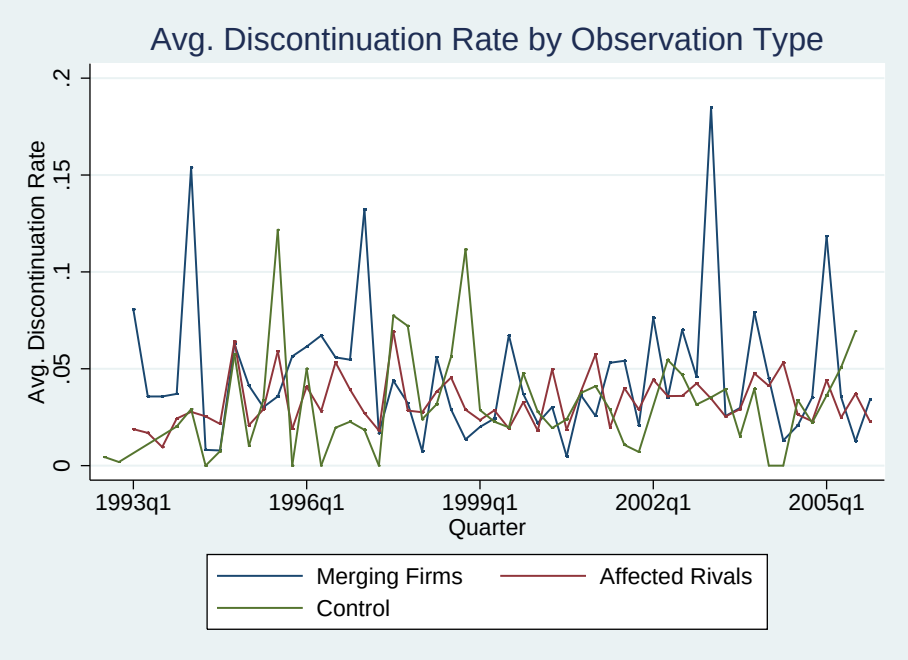

Figure 7: Average Discontinuation Rates by Type of Observation

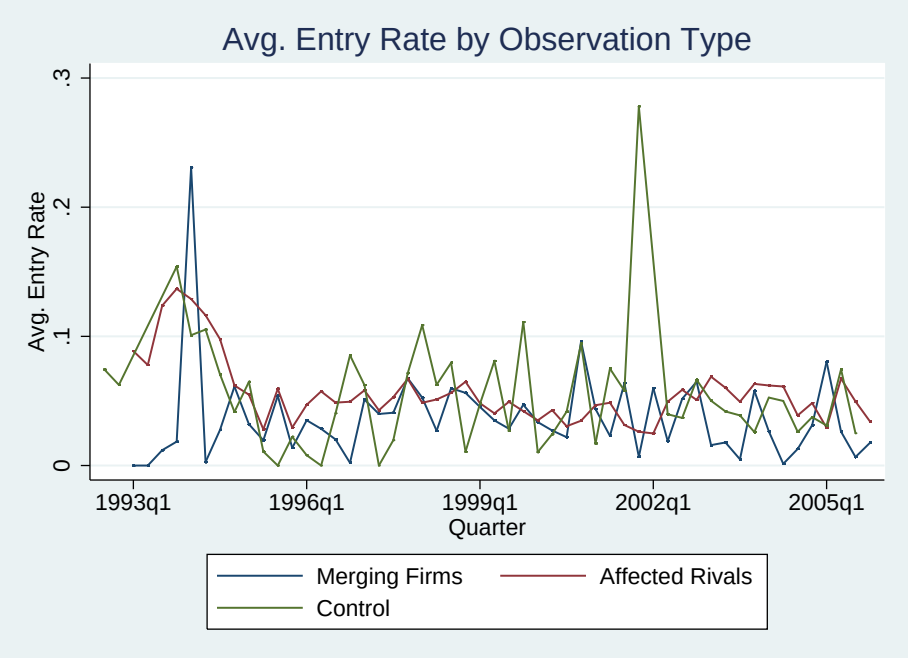

Figure 8: Average Entry Rates by Type of Observation

Table 1: Summary Statistics for Non-Affected Markets

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**	**N**	**# markets**
Discontinuation Rate	0.028	0.122	0	1	2406	178
Entry Rate	0.055	0.171	0	2	2406	178
# of projects in (t-1)	7.56	14.68	0	156	3491	178

Table 2: Summary Statistics for Only Indirectly Affected Markets

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**	**N**	**# markets**
Non-Merging Rivals						
Discontinuation Rate	0.032	0.085	0	1	1897	147
Entry Rate	0.053	0.14	0	2	1897	147
# of projects in (t-1)	12.88	14.16	0	167	1897	147
Merging Firms						
Discontinuation Rate	0.039	0.156	0	1	2649	150
Entry Rate	0.024	0.132	0	2	2649	150
# of projects in (t-1)	3.95	3.60	0	47	3039	150

Table 3: Summary Statistics for Directly Affected Markets

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**	**N**	**# markets**
Non-Merging Rivals						
Discontinuation Rate	0.035	0.060	0	1	2094	94
Entry Rate	0.050	0.083	0	1.5	2094	94
# of projects in (t-1)	42.35	40.91	0	254	2094	94
Merging Firms						
Discontinuation Rate	0.045	0.111	0	1	2288	94
Entry Rate	0.041	0.141	0	3	2288	94
# of projects in (t-1)	11.46	9.63	0	53	2291	94

Table 4: Discontinuation Rate, Non-Merging Rivals; 2-Sided Tobit

	(1)	**(2)**	**(3)**
DIRECT in t-0	-0.012	-0.013	-0.012
	0.012	0.012	0.013
DIRECT in t-1	-0.004	-0.005	-0.006
	0.011	0.011	0.012
DIRECT in t-2	-0.014	-0.016	-0.020*
	0.013	0.013	0.012
DIRECT in t-3	-0.022*	-0.023*	-0.025**
	0.012	0.012	0.012
DIRECT in t-4	-0.022*	-0.023**	-0.025**
	0.012	0.011	0.012
DIRECT in t-5	0.010	0.008	0.007
	0.012	0.012	0.012
DIRECT in t+1		-0.024**	-0.026**
		0.012	0.012
DIRECT in t+2			-0.012
			0.011
INDIRECT in t-0	0.007	0.007	0.005
	0.010	0.010	0.010
INDIRECT in t-1	-0.017*	-0.013	-0.014
	0.009	0.009	0.009
INDIRECT in t-2	0.006	0.004	0.005
	0.010	0.010	0.010
INDIRECT in t-3	-0.016	-0.016*	-0.017*
	0.010	0.010	0.010
INDIRECT in t-4	-0.000	-0.000	0.000
	0.010	0.010	0.010
INDIRECT in t+5	-0.006	-0.007	-0.008
	0.009	0.009	0.009
INDIRECT in t+1		-0.003	-0.004
		0.010	0.010
INDIRECT in t+2			-0.004
			0.009
ln(# projects) in t-1	0.092***	0.093***	0.096***
	0.011	0.012	0.011
Constant	-0.329***	-0.345***	-0.349***
	0.054	0.057	0.056
σ	0.226***	0.225***	0.224***
	0.009	0.009	0.009
Fixed Effects	Yes (ATC-3)	Yes (ATC-3)	Yes (ATC-3)
Time Effects	Yes	Yes	Yes
Pseudo R^2	0.30	0.30	0.30
N	8324	8179	8035
Uncensored	2246	2204	2158
Left Censored	6046	5945	5848
Right Censored	32	30	29
Log(ℓ)	-1844.88	-1794.38	-1752.35

Clustered standard errors below
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Entry Rate, Non-Merging Rivals; 1-Sided Tobit

	(1)	**(2)**	**(3)**
DIRECT in t-0	-0.000	0.001	0.005
	0.012	0.012	0.012
DIRECT in t-1	0.014	0.015	0.018
	0.013	0.013	0.013
DIRECT in t-2	0.027*	0.025*	0.022
	0.014	0.014	0.014
DIRECT in t-3	0.030**	0.032**	0.032**
	0.013	0.014	0.013
DIRECT in t-4	0.012	0.014	0.014
	0.013	0.014	0.013
DIRECT in t-5	0.003	0.002	0.002
	0.014	0.014	0.014
DIRECT in t+1		0.012	0.011
		0.013	0.013
DIRECT in t+2			0.009
			0.012
INDIRECT in t-0	0.017	0.018	0.017
	0.011	0.011	0.011
INDIRECT in t-1	0.017	0.017	0.014
	0.011	0.011	0.011
INDIRECT in t-2	-0.004	-0.006	-0.004
	0.012	0.012	0.011
INDIRECT in t-3	0.015	0.016	0.014
	0.011	0.011	0.011
INDIRECT in t-4	-0.022**	-0.022**	-0.023**
	0.011	0.011	0.011
INDIRECT in t-5	-0.003	-0.004	-0.006
	0.011	0.012	0.011
INDIRECT in t+1		-0.001	-0.002
		0.012	0.012
INDIRECT in t+2			0.016
			0.011
ln(# projects) in t-1	-0.060***	-0.063***	-0.066***
	0.013	0.014	0.014
Constant	0.067	0.106	0.181***
	0.057	0.066	0.061
σ	0.280***	0.281***	0.278***
	0.010	0.010	0.010
Fixed Effects	Yes (ATC-3)	Yes (ATC-3)	Yes (ATC-3)
Time Effects	Yes	Yes	Yes
Pseudo R^2	0.25	0.25	0.25
N	8324	8179	8035
Uncensored	2899	2855	2815
Left Censored	5425	5324	5220
Log(ℓ)	-2474.90	-2448.16	-2364.53

Clustered standard errors below
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Discontinuation Rate, Merging Firms, relatively to Treated Rivals; 2-Sided Tobit

	(1)	**(2)**	**(3)**
DIRECT in t-0	0.025	0.023	0.023
	0.018	0.018	0.018
DIRECT in t-1	-0.011	-0.011	-0.009
	0.016	0.016	0.016
DIRECT in t-2	-0.008	-0.007	-0.011
	0.017	0.017	0.017
DIRECT in t-3	0.019	0.017	0.014
	0.014	0.014	0.014
DIRECT in t-4	-0.018	-0.019	-0.020
	0.018	0.018	0.018
DIRECT in t-5	0.040***	0.040***	0.037**
	0.015	0.015	0.015
DIRECT in t+1		-0.005	-0.008
		0.016	0.016
DIRECT in t+2			0.016
			0.017
INDIRECT in t-0	-0.003	-0.002	-0.003
	0.014	0.014	0.014
INDIRECT in t-1	-0.008	-0.008	-0.007
	0.014	0.014	0.014
INDIRECT in t-2	-0.006	-0.005	-0.008
	0.014	0.014	0.014
INDIRECT in t-3	0.041***	0.040***	0.039***
	0.015	0.015	0.015
INDIRECT in t-4	0.002	0.002	0.002
	0.013	0.013	0.013
INDIRECT in t-5	0.016	0.016	0.015
	0.013	0.013	0.014
INDIRECT in t+1		0.015	0.013
		0.014	0.014
INDIRECT in t+2			0.024
			0.015
ln(# projects) in t-1	0.074***	0.074***	0.076***
	0.014	0.014	0.014
dMERGINGFIRM	-0.015	-0.021	-0.026
	0.024	0.026	0.027
Constant	-0.277***	-0.273***	-0.272***
	0.053	0.054	0.054
σ	0.265***	0.265***	0.265***
	0.021	0.021	0.021
Fixed Effects	Yes (ATC-3)	Yes (ATC-3)	Yes (ATC-3)
Time Effects	Yes	Yes	Yes
Pseudo R2	0.22	0.22	0.22
N	8811	8811	8811
Uncensored	2495	2495	2495
Left Censored	6258	6258	6258
Right Censored	58	58	58
Log(ℓ)	-2516.81	-2516.14	-2514.04

Clustered standard errors below
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Entry Rate, Merging Firms, relatively to Treated Rivals; 1-Sided Tobit

	(1)	**(2)**	**(3)**
DIRECT in t-0	0.053***	0.050**	0.048**
	0.020	0.020	0.020
DIRECT in t-1	0.066**	0.066**	0.072***
	0.027	0.027	0.027
DIRECT in t-2	0.008	0.010	0.001
	0.020	0.020	0.020
DIRECT in t-3	0.068***	0.063***	0.056**
	0.022	0.023	0.024
DIRECT in t-4	0.059***	0.054***	0.052***
	0.018	0.018	0.018
DIRECT in t-5	-0.003	-0.004	-0.010
	0.024	0.024	0.024
DIRECT in t+1		0.028	0.023
		0.022	0.022
DIRECT in t+2			0.043**
			0.020
INDIRECT in t-0	0.023	0.022	0.020
	0.017	0.017	0.018
INDIRECT in t-1	0.011	0.010	0.013
	0.020	0.020	0.020
INDIRECT in t-2	-0.011	-0.010	-0.016
	0.020	0.020	0.020
INDIRECT in t-3	0.036**	0.032**	0.029*
	0.016	0.016	0.017
INDIRECT in t-4	0.025	0.023	0.024
	0.017	0.017	0.017
INDIRECT in t-5	-0.018	-0.017	-0.021
	0.017	0.017	0.018
INDIRECT in t+1		0.029*	0.025
		0.016	0.017
INDIRECT in t+2			0.054***
			0.021
ln(# projects) in t-1	-0.043***	-0.045***	-0.042***
	0.011	0.011	0.011
dMERGINGFIRM	-0.314***	-0.329***	-0.343***
	0.033	0.034	0.035
Constant	0.020	0.033	0.035
	0.044	0.045	0.045
σ	0.276***	0.276***	0.276***
	0.022	0.022	0.022
Fixed Effects	Yes (ATC-3)	Yes (ATC-3)	Yes (ATC-3)
Time Effects	Yes	Yes	Yes
Pseudo R2	0.31	0.31	0.31
N	8811	8811	8811
Uncensored	2627	2627	2627
Left Censored	6184	6184	6184
Log(ℓ)	-2296.41	-2293.25	-2283.87

Clustered standard errors below
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Mergers Considered

Target	**Acquirer**	**Year**
FARMITALIA CARLO ERBA	KABI PHARMACIA	1993
CYANAMID	AMERICAN HOME PRODUCTS	1994
SYNTEX	ROCHE	1994
BOOTS	KNOLL	1994
KODAK	SANOFI	1994
WELLCOME	GLAXO	1995
KABI PHARMACIA	UPJOHN	1995
BLOCK DRUG	SCHWARZ	1995
FISONS	RHONE-POULENC RORER	1995
MARION MERRELL DOW	HOECHST	1995
UNIVAX	NABI	1995
ACCESS	CHEMEX	1995
OCLASSEN	WATSON	1996
CIBA-GEIGY	SANDOZ	1996
PHARMACOPEIA	DAIICHI	1996
BOEHRINGER MANNHEIM	ROCHE	1997
TROPHIX	ALLELIX	1997
GREEN CROSS	YOSHITOMI	1997
NYCOMED	AMERSHAM	1997
OHMEDA	BAXTER	1998
SYNTHELABO	SANOFI	1998
ASTRA	ZENECA	1998
NEUREX	ELAN	1998
DEPOTECH	SKYEPHARMA	1998
THERATECH	WATSON	1998
SEQUUS	ALZA	1998
RHONE-POULENC RORER	HOECHST MARION ROUSSEL	1998
PENEDERM	MYLAN	1998
PHARMCHEMIE	TEVA	1998
ALLELIX	NPS	1999
WARNER LAMBERT	PFIZER	1999
UNIMED	SOLVAY	1999
AGOURON	WARNER LAMBERT	1999
CENTOCOR	JOHNSON & JOHNSON	1999
TANABE	MITSUBISHI	1999
US BIOSCIENCE	MEDIMMUNE	1999
ROBERTS	SHIRE	1999
PHARMACIA & UPJOHN	MONSANTO	1999
NEXSTAR	GILEAD SCIENCES	1999
SPARTA	SUPERGEN	1999
NORTH AMERICAN VACCINE	BAXTER	1999
NOVOPHARM	TEVA	1999
KINETIX	AMGEN	2000
CISTRON	GENZYME	2000
SMITHKLINE BEECHAM	GLAXO WELLCOME	2000
LIPOSOME	ELAN	2000
FUJIREBIO	UCB	2000
GELTEX	GENZYME	2000
PATHOGENESIS	CHIRON	2000
COULTER	CORIXA	2000
BIOCHEM	SHIRE	2000

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Target	Acquirer	Year
KNOLL	ABBOTT	2000
DURA	ELAN	2000
SCHEIN	WATSON	2000
MITSUBISHI-TOKYO	WELFIDE	2000
IMMUNEX	AMGEN	2001
HOKURIKU	ABBOTT	2001
AVIRON	MEDIMMUNE	2001
ALZA	JOHNSON & JOHNSON	2001
DUPONT MERCK	BRISTOL-MYERS SQUIBB	2001
MATRIX	CHIRON	2002
TRIANGLE	GILEAD SCIENCES	2002
MEMORY	ROCHE	2002
ORAPHARMA	JOHNSON & JOHNSON	2002
PHARMACIA	PFIZER	2002
BIOGEN	IDEC	2003
SCIOS	JOHNSON & JOHNSON	2003
SANGSTAT	GENZYME	2003
APPLIED MOLECULAR EVOLUTION	LILLY	2003
POWDERJECT	CHIRON	2003
BEHRINGWERKE	CSL	2003
SICOR	TEVA	2003
IDENIX	NOVARTIS	2003
FUJISAWA	YAMANOUCHI	2004
TULARIK	AMGEN	2004
LAXDALE	AMARIN	2004
ZYCOS	MGI PHARMA	2004
ILEX ONCOLOGY	GENZYME	2004
ACCESS	KERYX	2004
AVENTIS	SANOFI-SYNTHELABO	2004
AESGEN	MGI PHARMA	2004
NIHON	RANBAXY	2005
TRANSKARYOTIC	SHIRE	2005
XENOVA	CELTIC PHARMA	2005
GUILFORD	MGI PHARMA	2005
ID BIOMEDICAL	GSK	2005
CORIXA	GSK	2005
IVAX	TEVA	2005
BONE CARE	GENZYME	2005
VICURON	PFIZER	2005
DAIICHI	SANKYO	2005
FOURNIER	SOLVAY	2005
EYETECH	OSI PHARMACEUTICALS	2005
PENINSULA	JOHNSON & JOHNSON	2005
INKINE	SALIX	2005
HEXAL	NOVARTIS	2005
CHIRON	NOVARTIS	2005
ORPHAN MEDICAL	JAZZ PHARMACEUTICALS	2005
NEOGENESIS	SCHERING-PLOUGH	2005