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Post-M&A Synergies and Changes in Development Trajectory of Pharmaceutical Firm

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Abstract

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1 Introduction

Acquisitions have long been said to be expensive and challenging to integrate, however the proclivity of acquisition activity indicates that executives believe that there is something to be strategically gained from purchasing another firm. The incentives for M&A activity range from empire-building motives, cost savings through increased efficiency, synergies to financial incentives [Trautwein (1990)]. The success and impact of M&As depend on manifold factors, as for example, integration processes and relatedness of the merging partners [Grimpe (2007)]. There is a significant body of work that has examined how the target firm may be related or unrelated to the parent, and potential performance outcomes of such acquisitions [Datta (1991); Salter and Weinhold (1979); Capron, Dussauge and Mitchell (1998); Karim and Mitchell (2000)]. Similarly, there have also been general studies (not specifically in the acquisition context) examining firms diversification strategies and outcomes of expansion into new, related and unrelated, areas [Rumelt (1974)]. Both sets of studies, general diversification and diversification via acquisition, have expressed the notion of synergies and efficiencies that are generated by expanding the pool of resources and knowledge [Goold and Campbell (1998)]. In this study we question whether and how (under what circumstances) the novelty of this knowledge and resources (coming from an external target) may influence acquirers' R&D trajectory and shift the focus of future innovation. We examine how M&A activity may provide acquirers an advantage at generating re-combinative synergies as compared to non-acquirers who are combining internal knowledge and resources that already reside within the firm.

Our context is the global pharmaceutical industry; we compare firms recombination of resources and activities from (earlier) development trial projects. Meder (2016) has shown that firms are more likely to merge if their overlap in pipeline and product portfolio increases. The increased likelihood to merge, subject to relatedness of portfolios, hints that firms seek to combine their assets and knowledge in a beneficial way, either through gaining market power or through complementarity in knowledge and resources. We use merging firms' drug

development activities at the time of the merger to identify the recombination and synergy potentials, as well as potential detrimental effects for rather peripheral therapeutic areas [Maksimovic et al. (2011)] or duplicative efforts and interruptions of processes [Cassiman et al. (2006); Grimpe (2007)]. We examine degrees of overlaps in project areas which are covered by the merging firms and neighbouring, related fields by using the World Health Organisations Anatomic-Therapeutic-Chemical classification (ATC) classification system. For the analysis, we use a novel and comprehensive dataset which combines information on clinical trial studies (AACT database) and drug launches (FDA Orange Book), both linked to the mentioned ATC system, for the period 2004-2015. Our identification strategy aims to evaluate heterogenous effects of mergers, depending on overlaps in the firms' activities, on the drug development initiatives, measured by newly initiated drug development projects.

The results from the empirical exercise show that merging firms change their research trajectory in post-M&A periods. More specifically, merging firms redeploy resources from overlapping fields in order to explore more uncovered therapeutic areas, relatively to non-merging firms.

This paper is structured as follows: section 2 positions the study in the related literature and discusses theoretical considerations, section 3 presents the data used and section 4 the proposed methodology. Results are described in section 5 and section 6 concludes.

2 Theoretical Background

Many scholars have examined the motives behind acquisitions. Trautwein (1990) identifies seven theories of merger motives found in the literature; he finds that valuation-theory, empire-building-theory and process-theory indicate the main incentives for firms to merge, followed by efficiency-theory and monopoly-theory. In addition to Trautweins seminal work that focuses on general merger motives, Higgins and Rodriguez (2006) and Christopher and Arishma (2013) analyze merger motives in the pharmaceutical industry. Higgins and Rodriguez (2006) examine 160 M&As between 1994 and 2004 for which they focus on patenting

and pipeline performance as main drivers of acquisitions. Arishma and Christopher (2013) study several cases involving Indian companies for the period 2008-2012 and emphasize financial characteristics and patent expirations. They found motives to include the weakening of competitors, increasing market power, faster global expansion, reduction in medical costs, making new technologies available, and offering a solution to the patent cliff by accessing new ideas and innovation. Their results indicate that acquisitions have the potential to change the development trajectory of a newly created firm because the strategic orientation of the pipeline portfolio plays an important role in M&A decisions. By focusing on core competences in overlapping and related fields, the parent firm is able to realize potential synergies and economies of scale and scope. These synergies and development efficiencies that emerge after acquisition may enable the parent firm to invest resources in new fields, changing their R&D development trajectory towards new, successful drugs and overcoming a patent cliff. Proximity measures for firm-pair dyads in product and pipeline space are calculated which characterise the pharmaceutical industry, utilizing the ATC classification system, to estimate the changes in the likelihood to merge. The results show that, the proximity in product and pipeline portfolio play an equally important and positive roles. This indicates that firms have a higher incentive to merge with another company if they the have overlapping knowledge. This suggests that firms seek substitutability and complementarity alike in order to strengthen their market position in the short-run and in the future. Furthermore, in the pharmaceutical and biotechnology industry, which we examine, Danzon et al. (2007) found that large firms pursue acquisitions as a response to expected excess capacity created by patent expirations and gaps in the product pipeline. In their study of 383 acquiring firms, Danzon and colleagues (2007) highlight that some acquisitions may be carried out as a response to poor performance but companies need to be aware that acquisitions can create a multitude of problems themselves.

Successful acquisitions can allow firms to exploit economies of scale, reduce expenditures, diminish risk, give access to new knowledge and processes, and reduce duplications. How-

ever, acquisitions can also have a negative effect and lead to reduction of R&D input and problems concerning knowledge transfer [Shibayama et al. (2008)]. For example, Shibayama and colleagues (2008) found in a qualitative case study on a Japanese company (Astellas Pharma) that the competitiveness of a company is highly dependent on the scientists that work in their R&D department. Different from previous studies where authors used firm level observations, they focused on the micro-organization on scientist-level observations. Monitoring human capital resources such as scientists (e.g. their behavior and satisfaction with the firms acquisition approach) is therefore necessary to avoid post-acquisition failure. Scholars pose that a key element for successful acquisitions is the level of post-merger integration [Dutta (1991)], defined by the Financial Times as the process of combining operations of both legacy companies. Because the pharmaceutical industry is highly research active, we focus on the level of R&D integration. Grimpe (2007) examines the ideal level of R&D integration of firms in a post-merger period in a survey study on 118 M&As between 1998 and 2001 of R&D active firms across industries. He characterizes three post-merger strategies: symbiosis of R&D transfers, absorption, and adjustment. A symbiosis strategy and absorption strategy seem to be ideal for technological success, while an adjustment strategy contributes to economic success. Grimpe (2007) illustrates the importance of context variables such as size and relatedness of markets and technology. Greater relatedness and a larger target are positively correlated to R&D success. These characteristics allow for a smooth transition into the parent firm and contribute to solving the productivity deficit in R&D. In our research we focus on potential R&D integration that stems from project synergies and/or duplication through the recombination of related or unrelated knowledge. This focus aims at the investigation of absorption and especially adjustment mechanism as argued by Grimpe (2007). When discussing relatedness between the resources of two firms, we make a distinction in terminology and refer to the degree of overlap - where high degree of overlap is indicative of resources and activities at both firms that are the same, or completely related, medium degree of overlap if activities are partly related and low overlap if the firms share

knowledge and resources but do not overlap in activities in a given field.[1] Cassiman et al. (2005) determine market relatedness by evaluating whether firms are competing in the same product market before the acquisition. They also examine technology-relatedness and define firms as technology-related if before the deal, they had R&D projects in the same technological fields and had developed capabilities in the same stages of R&D process. We measure relatedness by observing whether the firms have similar development projects. In studying post-acquisition outcome, Cassiman and colleagues (2005) examine the technological and market-relatedness between acquiring parent-target pairs at the level of R&D process for 31 in-depth cases using a survey questionnaire. Their results indicate that ex-ante relatedness of each firm has an influence on the post-merger outcome. Technologically complementary resources amongst firms tend to increase R&D efficiency post-acquisition while technologically substitutive resources often decrease their R&D inputs. This reduction is even more pronounced for firm pairs who have a history as competing rivals prior to the acquisition. Firms will generally try to exploit synergies through acquisitions with partners who possess complementary assets. Their findings indicate that M&As support a scope economies effect more so than a scale economies effect. There are several studies that consider a range of determinants that influence acquisition success through integration [Epstein (2004), Epstein (2005)]. Similar to Cassiman et al. (2005), many of these papers expand on our understanding of post-merger efficiency and indicate that redeployment and redirecting resources are of special interest in the M&A process.

We examine a different integration outcome of acquisition activity. In this study, we evaluate how the relatedness and overlap of parent-target pairs resources and strategic direction prior to acquisition influence their post-acquisition use of resources and strategic direction. In the context of the pharmaceutical industry, we refer to the strategic direction of a firm as its development trajectory and examine how acquisition activity that brings together new resources may retain or change this trajectory. A development trajectory is

[1]We define these three degrees of overlap as 1^{st}, 2^{nd} and 3^{rd} order of overlap, as we will precisely define in section 4.1.

considered changed when the parent firm invests (more) resources in different fields post-acquisition than it did prior to the acquisition. Retention of a development trajectory occurs when the focus remains on core competencies. There are several papers that have examined how acquirers may change trajectory or breadth post-acquisition. Karim and Mitchell (2000) investigate product line reconfiguration as addition, retention and deletion of product lines using data on more than 3000 firms active in the US health sector between 1978-1995. Resource deepening indicates the retention of acquired product lines that overlap with current ones and imply path-dependent change. Resource extension on the other hand involves retaining acquired product lines that are distinct from a firm's current product lines and suggests path-breaking change. The paper concludes that acquisition active firms add and drop more lines than non-acquirers, indicating that acquirers experience a higher amount of change than their non-acquiring counterparts. Further, they find that acquisitions result in both resource deepening and resource extension activities. Our objective in this paper is to build on the study by Karim and Mitchell (2000). Whereas their paper focused on the relatedness of parent-firm resources and studied the post-acquisition outcome as retention of product market activities, we also examine relatedness and overlap but study the outcome as entry into new project fields. Our first objective is to confirm the results by Karim and Mitchell (2000) that M&A active firms do change their strategic focus significantly more compared to non-merging firms as a counterfactual situation. Furthermore, because our dataset contains detailed and in-depth data on pharmacological sub-markets, we are able to more accurately examine spillovers and synergies that result across neighboring fields. Finally, whereas Karim and Mitchell (2000) are only able to observe product lines that are already commercialized and available on the market, we investigate development projects that are in earlier phases prior to reaching potential commercialization and aim therefore at the forward looking nature of the pharmaceutical industry.

A highly relevant paper is by Maksimovic et al. (2011) who examine the extent and direction of post-acquisition boundary restructuring. Building on previous studies by Porter

(1978) and Kaplan and Weisbach (1992) which focus on long-term target divestitures, their study observes the short-term evolution of target plant assets. Maksimovic et al. (2011) attempt to reject or confirm theoretical predictions that firms expand to exploit their comparative advantage. This theory indicates that firms will sell assets they do not have a comparative advantage in and keep assets where they do. The results indicate that an acquiring firm is likely to sell divisions of targets that are unrelated to their own. They will however keep the parts if they have skills in running the peripheral division. Maksimovic et al. (2011) find indications that comparative advantage is the main driver for the readjustment of firm boundaries, so the empire-building theory can (in most cases) be rejected.

Together, the conclusions from Karim and Mitchell (2000), Cassiman et al. (2005) and Maksimovic et al. (2011) form the basis of our research. These studies highlight that post-acquisition restructuring occurs and depends on the parent-target firms relatedness of resources and activities, and the potential comparative advantage reaped from these sources.

The prevalence of strong heterogeneity across considered definitions of overlaps on firm, field and project levels can be vastly found in previous studies. On the one hand, firm-wide positive effects on innovation and R&D investments in terms of economies of scale and scope may occur, as well as positive effects on field and project level through a combined larger knowledge base and cross-fertilization in the long-run. On the other hand, negative effects from the disruption of R&D processes and the avoidance of duplications. We do not aim to make any predictions on the different effects of overlaps at the time of the merger and will examine heterogenous effects in an explorative way to open a discussion on the detailed examination of re-combination, reallocation and redeployment of resources in the light of the ambiguity of predictions for different layers of level of overlaps and aggregation. We may expect to find some evidence that merging firms are less likely to invest in and to initiate new projects where they are already active in and partly overlap due to the existing coverage of those fields and the deteriorating and disrupting characteristics of integration processes post-M&As. Contrarily, we think that the newly formed entity is enabled or more likely to

change development trajectory and may show a higher proclivity to enter new but related fields. In other words, we expect merging firms to be more likely to re-allocate resources from fields in which they overlap and which they are covering by existing projects to new fields for which the joined knowledge plays an important role in terms of recombination capabilities and the incentive to provide all-embracing solutions in a therapeutic field which aims at the empire-building motives for M&As and post-M&A behaviour [Trautwein (1990)].

3 Data

We use data consisting out of information retrieved from different data sources: (i) the Database for Aggregate Analysis of ClinicalTrials.gov by the Clinical Trials Transformation Initiative (CTTI) (ii) the FDA Orange Book by the U.S. Food and Drug Administration (FDA) , both combined with the ATC/DDD Index 2015 established by the World Health Organization (WHO) in collaboration with the University of Oslo and (iii) SDC Platinum Database on worldwide M&A deals from Thompson Reuters. Our data covers the period 2004-2015.

The unit of observation is defined at the level of a firm in a given market (pharmacological area) in a given quarter. The data set bases on the same data sources which can be also found in Meder (2016). A short summary of the database and the data set will be presented hereafter and the interested reader can find a detailed description of the underlying data sources and features of the data mining process in Meder (2016).

The Database for Aggregate Analysis of ClinicalTrials.gov (AACT) provides information on all ongoing clinical trial studies in OECD countries for the period 2004-2015. The data on clinical trials is used to identify which firms are actively pursuing drug development and which firms enter or exit a given pharmacological fields or sub-markets (ATC-3 level). Therefore the data is the base of the dependent variable, the initiation of drug development activities of merging and non-merging firms by pharmacological field, and also the base for the main triggering variables of interest, the overlap and partial overlap in activities

and knowledge of merging firms within pharmacological sub-markets and therapeutic fields generated by acquisition. For the analysis, we use 12,728 projects from AACT which can be linked to ATC-3 classes by exact text-matching, 9,653 of these are linked to a unique ATC-3 class. The remaining 3,075 can be linked to at least two different ATC-3 classes and are treated as multiple projects in different pharmacological ATC-3-markets. All these projects are either fully or partly sponsored by at least one out of 1,647 different private pharmaceutical companies.

The FDA Orange Book provides information on available products by firm and ATC-3 class in our analysis. In total the FDA Orange Book with the ATC/DDD Index provides information on 12,205 products[2], launched by 694 different firms, with 1,400 different unique compounds, assigned to 1,641 ATC-5 classes, 495 ATC-4 classes and 187 ATC-3 classes between 1992 and 2015. 8,183 products are assigned to a unique ATC-3 class, 7,828 to a unique ATC-4 class and 7,165 to a unique ATC-5 class. 9,069 products are based on a single ingredient/compound, 3,136 products are combinations or ingredients/compounds. 11,658 products were launched in 2004 or later. The FDA orange book is used to identify which firm is active in which market and to retrieve information on entry and exit of firms into or from specific pharmacological markets and/or chemical classes.

The information on M&A transactions is retrieved from SDC Platinum Database, provided by Thomson Reuters. 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 SDC Platinum reports *864* announced deals. We exclude M&As of pharmaceutical firms which do not pursue pharmaceutical drug development, according to the AACT data, because the focus of this study is pharmaceutical drug development and those deals do not have any influence on pipeline trajectories. Furthermore, we do not consider announced, but withdrawn M&As

[2]Please see Meder (2016b) for a detailed description of the data cleaning process.

and deals which feature only single assets or acquisitions of minority stakes. All transactions in which the acquirer does not obtain corporate control over the target are not considered. We assume that the influence on drug development activities is limited if corporate control ($> 50\%$) is not obtained. 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.

Combining the information of the above mentioned data sources, we initially constructed a dataset on quarterly firm-ATC-3 level with 311,127 observations. The dataset includes in total 1,382 different firms active in 198 different therapeutic/pharmacological subgroups (ATC-3), distributed over 87 therapeutic maingroups (ATC-2) and 14 anatomic groups (ATC-1). This comprehensive dataset includes all firms which have launched products after 1992q1 and/or initiated drug development after 2004q1. We restrict the initial dataset in two ways. First, we do not consider any firms which have never initiate a development project in our dataset. We do this to avoid including firms which would unlikely pursue any drug development. Those firms can be for example smaller generic drug manufacturer or only drug manufacturers which only produced licensed-in compounds from other pharmaceutical firms which are off-patent. This deletes 115,458 observations of 483 firms. Second, all firm-ATC-2 combinations for which firms have never been pursuing drug development in the ATC-2 maingroup are not considered. This excludes 104,285 observations, or 2,281 out of 5,255 unique firm-ATC-2 combinations respectively. We do reduce the dataset in this way because we consider for our analysis overlap and spillover effects on ATC-3 and ATC-2 level. If a firm has never been actively pursued drug development in a given ATC-2 maingroup at any point in the period 2004q1-2015q2, we must assume that the likelihood that a firm's intrinsic tendency to become active in this therapeutic class is marginal. If we include those

observations and firm-ATC-2 combinations, similarly to non-innovative drug manufacturers, we face the risk of a bias in results because of the inclusion of irrelevant firms and firm-ATC-2 combinations which caused an excess of *zeros* in our dataset which would potentially cause an upward bias. The initial estimation sample considered consists of 91,384 observations. It contains information on 899 distinct firms, partially active in 187 ATC-3 classes, 85 ATC-2 groups and 14 ATC-1 maingroups.

4 Methodology

Our empirical strategy is to examine drug development efforts and initiatives at the firm-ATC-3 level, exploiting changes in both development activity and (re-)combinative potential by merging firms that varied over time, across firms and across firm-ATC-3 combinations. We are particularly interested in the effect of combinatorial power of product and pipeline portfolios of two merging firms on the newly formed entity's efforts in drug development and its interaction with its ongoing development and potential spillovers. For this purpose we establish distinct measures of pipeline overlaps of three different kinds. The following sub-section presents the definition and construction of these overlap measures, whereas the consecutive subsection explains the econometric identification strategy.

4.1 Treatment Indicators

We consider different types of overlaps in therapeutic-pharmacological fields which potentially affect development trajectory in post-M&A periods. Merging firms can overlap in content, namely in a therapeutic/pharmacological subgroup (ATC-3) and/or in a therapeutic main group (ATC-2).[3] We define three different possibilities of overlap in ATC-3 classes, namely the treatment variables 1^{st}, 2^{nd} and 3^{rd} order overlap. The three treatment variables consider the overlap and proximity to overlaps within the same ATC-2 class. Each of these

[3]We do not consider the broad overlap in the anatomic main group (ATC-1) due to the fact that the ATC-1 categorization only describes basic and constitutional terms of human part of the body and is not connected to therapeutic or pharmacological categorization of chemical compounds.

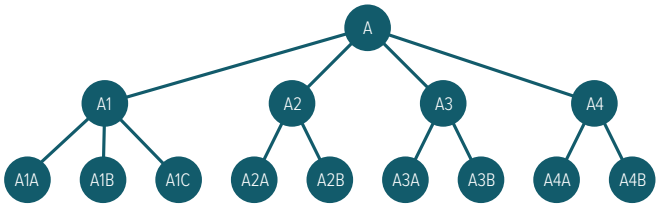
overlap definitions is ATC-3 class, firm and time specific, according to merging firms' product and pipeline portfolios at the time of announcement of the M&A. All measures defined are at the firm-ATC-3(-quarter) level.

- *Overlap in ATC-3 class,* 1^{st} *Order Overlap*: Both merging firms overlap in their activities in same ATC-3 class g.
- *Overlap in ATC-2 class,* 2^{nd} *Order Overlap*: One of merging firms is active in ATC-3 class g, and the other merging firm is active in ATC-3 class $-g$ within the same ATC2 class k, $\{g, -g\} \in k$.
- *ATC-3 overlap in neighbouring class* 3^{rd} *Order Overlap*: ATC-3 class g has a neigbouring class $-g$ in which both merging firms overlap on ATC-3 level, where $g, -g$ belong to the same ATC-2 class k, $g, -g \in k$.

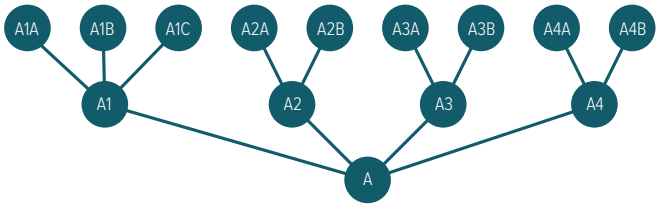
Figure 3.1 illustrates the construction of the overlap indicators. Each indicator is equal to 1 for the merging firms if the considered overlap, ATC-3/ATC-2, or from ATC-3 overlap in a neighbouring ATC-3 class is present and 0 otherwise.

The three treatment indicators are always equal to 0 for non-merging firms because we assume that firms permanently optimize their strategies regarding pipeline portfolio regarding their knowledge and potential synergies and only a sudden external event increasing the knowledge base and making the realisation of synergies possible, as a M&A transaction, has short-term adjustment effects in development trajectories and pipeline strategy [Grimpe (2007)]. All indicator variables and informing on the merging firms' activities, the three overlap indicators, are set equal to 1 given at the time of the transaction and consecutive quarters. We use four and eight consecutive quarters as treatment effect windows since we are interested in the short- and mid-term changes in pipeline portfolio trajectory and follow Maksimovic et al. (2011). Additionally, an iterative process of including or leaving out additional quarters in the estimations have not shown any significant effects in the estimation process such we remain with the initial idea of examining the first two years after M&As.

Figure 1: Construction of Overlap Indicators for Merging Firms



Firm 1 active	1	0	0	1	1	1	0	1	0
1st Order Overlap	1	0	0	1	1	0	0	0	0
2nd Order Overlap	1	0	0	1	1	1	1	0	0
3rd Order Overlap	0	1	1	1	1	0	0	0	0
Firm 2 active	1	0	0	1	1	0	1	0	0



The variables 1^{st}, 2^{nd} and 3^{rd} order overlap are the three treatment variables. Consider ATC-2 class *A1*, and its ATC-3 sub-classes *A1A*, *A1B* and *A1C*. Both merging firms, firm 1 and 2, are active in this field. Hence, the indicator for 1^{st} order overlap in ATC-3 class *A1A* is equal to 1. Due to the fact that neither firm 1 nor firm 2 is active in *A1B* or *A1C*, 1^{st} order overlap and 2^{nd} order overlap indicators for *A1B* and *A1C* are equal to 0. For ATC-3 classes *A1B* and *A1C* the spillover indicator from an 3^{rd} overlap resulting from a overlap in a neighbouring ATC-3 class is equal to 1 because of the ATC-3 overlap in *A1A*. Vice versa, the spillover indicator for *A1A* is equal to 0 because there is no overlap in *A1B* or *A1C*. ATC-2 class *A2* features activities of both firms in all downstream ATC-3 classes such that by definition all three overlap indicators are equal to 1. ATC-2 class *A3* shows activities of firm 1 and firm 2 but not in same ATC-3 classes. The cross-overlap from ATC-3 *A3A* and *A3B* causes that the 2^{nd} order overlap indicator for both ATC-3 classes is equal to 1 but no other overlap indicator of different order. For ATC-2 class *A4* all overlap indicators are equal to 0 since firm 2 is not active in this therapeutic field.

The results considering two years as treatment effect window, namely the 8 quarters post-M&A, can be found in appendix C (table C.4 for the estimation results and table C.5 for the marginal effects) of this thesis. Results are robust to the window length and do not differ qualitatively from the considered 1-year effect window presented in section 3.5.

4.2 Empirical Model

We start with a basic model relating drug development projects and potential combination and synergies from overlapping pipeline portfolios, and subsequently decompose potential effects by ongoing development activities and interactions of different layers of recombination possibilities. The unit of analysis throughout is the firm-ATC-3-quarter. We estimate the relationship between started drug development initiatives by a merged entity and overlap in pipeline portfolios in ATC-3 classes after the M&A announcement, relatively to non-merging firms and pre-merger situations in an adapted Difference-in-Differences approach. To estimate those effects the following general specification is used:

$$\begin{aligned} y_{igt} = \alpha_0 + \alpha_g + \lambda_t \\ + \gamma TREATMENT_{igt} + \beta' \mathbf{X}_{igt} + \varepsilon_{igt} \end{aligned} \tag{1}$$

where y_{igt} is a measure of drug development initiatives of firm i in ATC-3 class g in quarter$t$, $TREATMENT_{igt}$, is the indicator informing on overlap and potential effects for firm i in ATC-3 class g in quarter t as described in the subsection above.[4] $\mathbf{X}_{igt}$ is a vector of time-varying ATC-3 class, firm or ATC-3-firm specific controls and α_g and λ_t measure ATC-3 class fixed effects and time-effects. The treatment indicators are not mutual exclusive but by estimating each effect separately on well-defined subsamples[5] we try to ensure the identification of each impact by avoiding reciprocal interactions between the treatment indicators. All specifications are estimated using Probit regression models with a full set of ATC-3 class indicators, quarterly effects indicators and robust standard errors.

[4] Please also see figure 3.1.

[5] Please see sub-section 4.3 for a detailed description of their construction.

For all specifications we include several control variables, describing time-varying firm, ATC-3, ATC-2 and firm-ATC-3 specific characteristics. At the firm level, we include the total number of development projects and total number of products across all ATC-3 or ATC-2 classes. The total number of projects describes a firm's general proclivity and tendency to independently conduct drug development projects and gives and indication whether a firm is relatively more active in R&D. The total number of products indicates a firm's size. With these variables we want to control for the possibility that firms with a high tendency towards own drug development are more likely to start new projects than firms with less projects. We also include a variable describing whether a firm is an active participant in the M&A market in the period 2004-2015. We aim to control for potential higher or lower tendency towards own drug development by acquiring firms as it is described in Higgins and Rodriguez (2006). Additionally, we include the total number of projects within an ATC-2 and ATC-3 class across all firms, in order to characterize pharmacological/therapeutic subgroups and therapeutic fields as development intensive or non-intensive. ATC-3 and ATC-2 classes with many ongoing development projects may be more attractive for firms to enter due to potential market size or recent advances in treatments such that every firm is more likely to initiate drug development projects in these ATC-3 and ATC-2 classes. Last, we use a firm-ATC-3 specific indicator, informing on whether a firm has an ongoing drug development project in a given ATC-3 class g at time t. This indicator controls for the potential effect on the start of new projects when the firm already is active in development. The presence of an ongoing project may cause that the firm is less likely to start new initiatives in order to avoid duplicative effort [Cassiman et al. (2006)] or a firm is more likely to start new initiatives for spreading risk over multiple projects and focus on the given ATC-3/ATC-2 class [Danzon et al. (2007)].

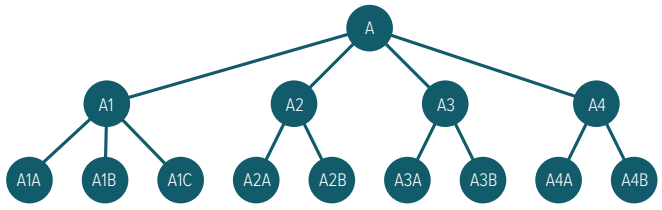
4.3 Estimation Samples

For each analysis of the three different *TREATMENT* indicators we construct a unique control group aiming to have comparable observations of the merging and non-merging firms. The general approach to analyse the effects on drug development trajectories of merging firms and potential effects from overlaps is based on a reduced-form Differences-in-Differences methodology where we restrain the control group qualitatively to the most comparable situation in non-merging firms' pipeline portfolios. Therefore, our approach can be seen as strongly related to conditional Differences-in-Differences approaches. The difference to matching estimators is that we qualitatively condition the control group instead of using quantitative estimation techniques. We focus on the pipeline characteristics of the merging and non-merging firms in order to identify the effects of the M&As and a quantitative approach to reduce the sample in the spirit of conditional Differences-in-Differences methods may be too restrictive and potentially reduces the sample in a too drug development unspecific manner.

As mentioned, we use for each level of analysis a clearly defined treatment and control group which corresponds to the *TREATMENT* indicators. For the analysis of the effects from a direct overlap (1^{st} order overlap) of the two merging firms in the same ATC-3 class g we only consider observations of the merging firms according to the treatment indicator and as a counterfactual of non-merging firms which have at least 2 projects in a ATC-3 class which is not influenced by other projects in neighbouring ATC-3 classes. In other words, we only use observations which are not influenced by projects within the same ATC-2 class - no other treatment indicator should be equal to 1 for the merging firms and the non-merging firms do not actively pursue drug development in neighbouring classes. We construct the estimation sample for the analysis of the effects of the 2^{nd} order overlap of merging firms relatively to non-merging rivals analogously. For this task, we create a subsample of observations for which either the 2^{nd} order treatment indicator is equal to 1, while all others are 0, or non-merging firms' observations which feature one project in ATC-3 g,

one project in ATC-3 $-g$ within the same ATC-2 category and no neighbouring ATC-3 class features 2 or more projects. Last, the analysis of the 3^{rd} order overlap uses observations for which the corresponding treatment indicator is equal to 1 and all other indicators are 0 and non-merging firms' observations which have one neighbouring ATC-3 class with at least two or more projects but no other neighbouring class with any project. Figure 3.2 illustrates which characteristics non-merging firms' observations must feature to be considered in the analysis as control group observations.

Figure 2: Selection of Control Group Observations



1st Order Overlap	1	0	0	1	1	0	0	0	0
2nd Order Overlap	1	0	0	1	1	1	1	0	0
3rd Order Overlap	0	1	1	1	1	0	0	0	0
# of Projects Firm i	2	0	0	2	2	1	1	1	0

Consider firm i as a potential control firm. For ATC-3 class *A1A* firm i has 2 projects ongoing which characterise the situation of two merging firms, both active in this class, 1^{st} order overlap indicator is equal to 1. Firm i in *A1B* and *A1C* features a comparable characteristic to an 3^{rd} overlap resulting from an overlap of the merging firms in a neighbouring ATC-3 class, namely *A1A*. The cross-overlap in firm i's activities from ATC-3 *A3A* and *A3B* are analogous to 2^{nd} order overlap indicators for merging firms. The observations of the merging firms and non-merging firms for ATC-3 classes *A1A*, *A1B*, A1C, *A3A* and *A3B* are used for the analysis while all remaining ATC-3 observations from firm i are not used in the analysis because other activities make a clear identification of an effect impossible.

5 Results

The two following subsections present the results of the regression analysis and the subsequent interpretation of marginal effects.

5.1 Regression Results

The effects of different orders of overlap are estimated separately using clearly defined treatment and control groups. Table 3.1. represents the regression results of the analyses for the

start of early stage projects. Column 1 shows the coefficients of the estimated Probit model for the 1^{st} order overlap (merging firms have projects in the same ATC-3 class), the second column for the analysis of the 2^{nd} order overlap (merging firms overlap within ATC-2 classes) and column 3 for the influence of a 3^{rd} order overlap (ATC-3 overlap in a neighbouring ATC-3 class).

Before discussing the results, it is important to note that we do not attempt to estimate or cannot draw any conclusions on whether merging firms do more or less drug development post merger. We rather focus on the likelihood of initiating new drug development projects depending on the overlap with ATC-2 classes and therefore on the trajectory and direction of additional spending on drug development. The total amount of drug development may stay unchanged but the question, we examine, is where the firms are more likely going to place investments next.

Examining the estimations for the effects of 1^{st} order overlap, i.e., both merging firms have at least one project in the same ATC-3 class g, we find a strong negative effect on the likelihood to initiate new drug development. The coefficient is equal to -0.3833 and is statistically significant different from 0 at the 5% level. This means that merging firms which overlap directly in the same ATC-3 class g are less likely to start a new project in the same area, relatively to non-merging rivals which have at least two projects in an ATC-3 class and therewith experience comparable effects from multiple projects and deepened knowledge in a specific pharmacological field g. The negative effects found can be partly explained by theories on the disruption of R&D processes and the duplication of efforts which make additional investments less likely because the joined entity needs to re-organize tasks and re-coordinate efforts in the short-run to fully integrate [Cassiman et al. (2006), Grimpe (2007)].

We also find a negative effect of -1.5628, significnat at the 5% level, from the 2^{nd} order overlap within the same ATC-2 categories on the drug development initiation in a given ATC-3 class. The intuition for the reason of the negative effect is similar to the one for

the 1^{st} order overlap. The disruption and duplication of efforts and their subsequent re-organisation of the mid-term strategic orientation outweighs the potential positive effects of combined R&D in the first year after a merger.

The third part of our analysis is the explicit consideration of effects of overlaps in ATC-3 classes which may affect the trajectory within an ATC-2 class, or the effect of the integration of overlapping knowledge and resources on neighbouring and related but, until now, not covered ATC-3 classes. The intuition behind is that firms, which join their ideas and capacities, may initiate more projects in different classes in which they have a comparative advantage from their previous knowledge but now have, due to the merger, the incentives and capabilities to explore and redeploy resources to those fields in which they have not been active in before. We find a strong positive and significant effect on the likelihood of initiating new development projects in non-covered fields before the merger if the merging firms do overlap in a neighbouring class. This means, that firms seem to attempt to enter new fields to cover an entire ATC-2 class when they already have common knowledge in that therapeutic ATC-2 field. In other words, the combination of knowledge encounters the proclivity to change development trajectory with the goal to explore neighbouring ATC-3 classes induced by the merger and in conjecture with the negative effects from 1^{st} and 2^{nd} order overlaps a redeployment of resources in post-merging periods seems to be likely.

The estimates presented in table 3.1. present the coefficients of the Probit model and do not directly allow to quantify the size of the but already give an indication on the direction of the effects. We try to quantify the effects on the likelihood of drug development projects by calculating marginal effects at the mean, relatively to the average likelihood to start new projects in the following subsection.

As for the additional variables, we found the following results: The firms' total number of projects in an ATC-3 class (# Proj., Firm-ATC-3) has a positive influence on the likelihood of initiating new development projects in the analysis of the 1^{st} and 2^{nd} order effects. This should be generally true because of specialisation and economies of scale and scope effects

Table 1: Probit Model, y = Indicator for Newly Started Phase I Project, $t = 1, 2, 3, 4$

Variable	1^{st} order effects	2^{nd} order effects	3^{rd} order effects
Overlap-ATC3$_{igt}$	-0.3833**		
	(0.0332)		
Overlap-ATC2$_{igt}$		-1.5628**	
		(0.0178)	
Overlap Neigb. ATC3$_{igt}$			1.4952***
			(0.0047)
# Proj., Firm-ATC3$_{igt}$	1.4834***	0.1462***	0.0590
	(0.0000)	(0.0003)	(0.1912)
# Proj., Firm-ATC2$_{ikt}$	-1.4585***	0.0515	-0.0117
	(0.0000)	(0.1654)	(0.3791)
# Proj., Firm$_{it}$	-0.0001	0.0018	0.0063
	(0.9289)	(0.3428)	(0.1426)
# Proj. ATC3$_{gt}$	0.0036	0.0012	-0.0197**
	(0.2080)	(0.2520)	(0.0414)
# Proj. ATC2$_{kt}$	-0.0014	-0.0009	-0.0143***
	(0.4543)	(0.4215)	(0.0017)
# Prod., Firm-ATC3$_{igt}$	-0.0079	-0.1400*	-0.1315*
	(0.4024)	(0.0744)	(0.0598)
# Prod., Firm-ATC2$_{ikt}$	0.0023	-0.0090	0.0353**
	(0.7230)	(0.6191)	(0.0111)
# Prod., Firm$_{it}$	0.0003	0.0031	-0.0025
	(0.2424)	(0.1969)	(0.1071)
Product Stock in 2004q1$_i$	-0.0001	-0.0050*	0.0020
	(0.8878)	(0.0734)	(0.1483)
dAcquirer$_i$	0.0490	0.2323	
	(0.6140)	(0.1070)	
Intercept	-1.7959***	-1.0176*	-0.2562
	(0.0000)	(0.0661)	(0.8465)
pseudo R^2	0.110	0.195	0.323
Log(ℓ)	-2024.1	-309.1	-40.21
N clusters	106	35	9
N	10594	1812	249

p-values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

of both merging and non-merging firms. These results are also in line with the idea that firms specialize in fields in which they have a comparative advantage or which are core to their business lines, both generally and induced by mergers [Erickson and Jacobson (1992), Maksimovic et al. (2011)]. The reason why there is no significant effect found for the analysis of the 3^{rd} order effect may be caused by definition. Observations with a 3^{rd} order effect, and the corresponding observations of non-merging firms, can barely have ongoing projects by construction. Those observation cannot have multiple projects in the same field because they would otherwise belong most likely to a 1^{st} order effect or 2^{nd} order effect analysis. Hence, the non-significance of this coefficient is not surprising by construction. The number of a firms' ongoing projects in an ATC-2 category (# Proj., Firm-ATC-2) only seem to have a negative impact in the specification of the 1^{st} order overlap. It indicates that firms which are active with multiple projects in the higher ATC-2 level are less likely to start a new project in a given ATC-3 class. The occurrence of multiple projects on ATC-2 level may cause that the firm is already actively spreading the risk over multiple classes within the same ATC-2. The variable additionally does not mean necessarily that a firm is already active in the given ATC-3 class which makes the initiation of a new project less likely as seen above from the control variable measuring the number of ongoing projects in a given ATC-3 class. These two features may explain why the number of ongoing projects on ATC-2 level has a negative influence on the initiation of new development activities. The total of numbers of project sponsored by a firm (# Proj., Firm) does not have a significant impact on the likelihood of initiating new projects in any of the three specifications, meaning that the relative size of R&D departments does not seem to make new development initiatives more likely in a given ATC-3 class. The total number of projects in an ATC-3 (# Proj., ATC-3) or ATC-2 (# Proj., ATC-2) class only influence negatively the likelihood of a new drug development project if a firm is not already sponsoring R&D activities relatively to other pharmacological fields. This can be explained by the fact that entering a new field already encounters some risk for any firm and a high number of projects in that field may

decrease the expected return such that the initiation in those fields is less likely.

Turning to the variables describing the current product portfolios of firms and on ATC-3 (# Prod., Firm-ATC-3) and ATC-2 level (# Proj., Firm-ATC-2), the results reveal that there are barely any significant effects of the product portfolios on the future pipeline portfolios. This indicates that product portfolios and initiation of new development projects are relatively independent form each other. A drug development project from initiation till market launch usually takes eight to twelve years on average which makes it likely that the current marketed projects of a firm are not available anymore at the time of launching the product under development.

Furthermore, the product stock in 2004 (Product Stock in 2004q1), which we use to characterize successful firms in the past as a kind of pre-sample fixed effects indicator, and the indicator identifying acquiring firms (dAcquirer) do not have statistically significant effects, meaning that neither larger and previously successful firms and M&A active firms are not more likely to start projects. This result is slightly in contradiction the idea that firms with large financial capabilities due to their past success and innovative background are more likely to be innovative in the future [Blundell et al. (1999)]. Lastly, most of the time-effects, quarterly indicators and many of the time-invariant ATC-3 class indicators are significant.

5.2 Marginal Effects

We are mainly interested in the change of the probability of starting new or advancing projects, potentially induced by M&As. In order to quantitatively interpret the coefficients from the estimations, we calculate marginal effects for our main variables of interest.

Table 3.2 shows the estimated marginal effects for the three different specifications. As the estimated coefficients in table 3.1 suggest, also the marginal effects for the effect of the 1^{st} order overlap in the ATC-3 class g of two merging firms does show a significant and negative impact on the newly started drug development initiatives by the merged entity in ATC-3

class g. The marginal effect on the probability of initiating a new project from ATC-3 overlap is about -3%. This means that the likelihood that the merging firms start a new project in a class in which they have jointly at least two projects decrease by about 3% compared to non-merging firms which have at least two ongoing projects within the year after the merger. The average probability to initiate a new project in the estimation sample of the specification which examines the impact of the 1^{st} order overlap is about 5.5%. Analysing the estimated marginal effects relatively to the average probability of product initiation, the merger decreases the average likelihood by about 55% for the merging firms.

For 2^{nd} order overlap, the ATC-2 overlap, we find significant negative marginal effects of about 5.9%. In perspective of the average probability of starting a new project, 6%, we may conclude that merging firms which overlap on ATC-2 level experience a 100% decrease in the likelihood of initiating a new drug development project in the same field.

In sum, we can conclude for the 1^{st} and 2^{nd} order overlap that the merging firms are significantly less likely to initiate drug development projects compared to situations without a merger. Merging firms do not necessarily do any drug development in those fields but the merger makes it rather unlikely that merging firms invest in new projects in the year after the transaction. These results can not be seen as a pure negative effect on the firms' drug development efforts since our data does not allow us to draw conclusion about the ongoing drug development investments of merging firms. Our analysis is only aiming at giving an indication in which field merging firms are more likely going to invest in the year after the merger and not investigating the total amount of drug development by any firm.

Novel in our study is the attempt to investigate whether firms, which recombine knowledge and resources through merging, have an increased proclivity or tendency to enter new fields where they have not been active before. The marginal effects for the 3^{rd} order overlap indicate that the likelihood of initiating a new drug development project in an ATC-3 class which has a neighbouring class with direct overlap, resulting from a merger increases by about 12.4%, relative to comparable non-merging situations. In the estimation sample for

the 3^{rd} order overlap analysis the average likelihood to initiate a new project is 6.4%. Given the estimated marginal effect, relative to the average probability, the merger makes a new project initiation 194% more likely than in the situation when the merger would not have occurred.

Table 2: Marginal Effects, y = Indicator for Newly Started Phase I Project, $t = 1, 2, 3, 4$

	(1) b/p	(2) b/p	(3) b/p
Overlap-ATC3$_{igt}$	-0.0295**		
	(0.0103)		
Overlap-ATC2$_{igt}$		-0.0586***	
		(0.0000)	
Overlap Neigb. ATC3$_{igt}$			0.1241***
			(0.0003)
# Proj., Firm-ATC3$_{igt}$	0.1496***	0.0131***	0.0051
	(0.0000)	(0.0003)	(0.1823)
# Proj., Firm-ATC2$_{ikt}$	-0.1471***	0.0046	-0.0010
	(0.0000)	(0.1604)	(0.3699)
# Proj., Firm$_{it}$	-0.0000	0.0002	0.0005
	(0.9289)	(0.3456)	(0.1269)
# Proj., ATC3$_{gt}$	0.0004	0.0001	-0.0017**
	(0.2193)	(0.2471)	(0.0334)
# Proj., ATC2$_{kt}$	-0.0001	-0.0001	-0.0012***
	(0.4584)	(0.4218)	(0.0022)
# Prod., Firm-ATC3$_{igt}$	-0.0008	-0.0126*	-0.0113*
	(0.4064)	(0.0720)	(0.0630)
# Prod., ATC2$_{kt}$	0.0002	-0.0008	0.0030***
	(0.7234)	(0.6175)	(0.0086)
# Prod., Firm$_{it}$	0.0000	0.0003	-0.0002*
	(0.2515)	(0.1932)	(0.0934)
Product Stock in 2004q1$_i$	-0.0000	-0.0004*	0.0002
	(0.8878)	(0.0707)	(0.1392)
dAcquirer$_i$	0.0049	0.0221	
	(0.6106)	(0.1264)	
N	10594	1812	249

p-values in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6 Conclusion

We analyse whether and how relatedness of two merging firms influences the short-term initiation of drug development of pharmaceutical firms. We focus on the pharmacological fields in which both merging firms are active, partly active and non-active but active in related classes as a third option.

Using a comprehensive data set on drug development initiatives, enables us to shed some light on the impact of merging frims' overlap in therapeutic fields and pharmacological subgroups on the newly formed entity's post-M&A strategic focus of its pipeline activity. We defined measures of the merging firms' potentials and capabilities from recombinations of knowledge and from joint expertise. The overlap effects are created along the Anatomic-Therapeutic-Chemical classification system of the WHO and are, to the best of our knowledge, novel in the investigation of post-M&A outcomes in economic and managerial literature. The results of the empirical exercise show that merging firms adjust their pipeline portfolio post-M&A, relatively to non-merging firms. We analyse the likelihood of the initiation of new drug development by the merging firms in the light of overlap possibilities within ATC-3 and ATC-2 categories and find a negative effect for ATC-3 classes which experience a direct overlap. The econometric analysis let us quantify the decrease in the likelihood of about 3% or 55% of the average probability to start a new project. Additionally, we find a negative effect on the likelihood of newly started projects if the two merging firms overlap on ATC-2 level of 5.9% or almost 100% of the average probability. The negative effects in overlapping pharmacological fields can be explained by the disruption of R&D processes, potential duplications and delays caused by the integration processes as also described before by other scholars [Cassiman et al. (2006); Grimpe (2007)]. On the other hand, merging firms are much more likely to explore or enter fields which are related but in which they have not been active before the transaction. We find a strong increase in the likelihood of entering neighbouring but pre-M&A non-covered pharmacological fields. Merging firms are 12.4% more likely to initiate a drug development project or experience an increase of almost 200% of the average likelihood to become active in a field which has been related but neglected before. This indicates that the merging firms either use their re-combinative strengths and/or strategically attempt to expand their pipeline and future product portfolio in an entire therapeutic area (ATC2 category). In sum, we may conclude that merging firms redeploy resources from overlapping fields to uncovered areas, which are

related to their combined knowledge base as a consequence of improved capabilities and synergies.

This research emphasizes that M&As have the potential to change the pipeline trajectory of the merged firm. It is shown that it is of importance that different definitions and dimensions of overlaps are considered since the results show heterogeneity across the definitions applied. This study cannot conclude on the net effect and on the quantitative effects on the changes in the direction of the pipeline portfolio because it does not analyse the discontinuation of projects in the spirit of Maksimovic et al. (2011) but it clearly shows that a merged firm makes strategic decisions on in which field to initiate more or less drug development as a proxy for synergies and re-combinatory power, depending on the joint pre-M&A pipeline portfolios of the two, formerly independent firms.

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