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Abstract This dissertation consists of four chapters. Using data on firms in Switzerland, the first chapter shows that a reduction in trade barriers between Switzerland and the European Union results in firms which are on average less vertically integrated. This finding confirms recent work in international trade theory, predicting that a reduction in trade barriers makes vertical integration less attractive by thickening the market for intermediate input goods. The second chapter shows that a reduction in trade barriers increases concentration in certain industries. This finding supports the notion that fewer firms are able to survive as the toughness of price competition increases. The third chapter takes a closer look at mergers and acquisitions, which are an important vehicle for such changes in vertical or horizontal market structure. In the fourth chapter, recent developments in the market for Internet connectivity are analyzed.

Zusammenfassung Die vorliegende Dissertation besteht aus vier Kapiteln. Das erste Kapitel zeigt unter Verwendung von Schweizer Firmendaten, dass eine Senkung von Handelsbarrieren zwischen der Schweiz und der Europäischen Union zu Unternehmen führt, die einen geringeren Grad an vertikaler Integration aufweisen. Dieses Ergebnis bestätigt aktuelle Arbeiten aus der internationalen Handelstheorie, welche nahelegen, dass die Marktdichte für Zwischenprodukte steigt und so vertikale Integration weniger attraktiv wird. Das zweite Kapitel zeigt, dass im Zuge der Handelserleichterung die Konzentration in bestimmten Industrien zunimmt. Dies deutet darauf hin, dass europäische Firmen den Preiswettbewerb in der Schweiz verstärken und als Folge weniger lokale Firmen am Markt bestehen können. Das dritte Kapitel wirft einen genaueren Blick auf Fusionen und Übernahmen, welche ein wichtiges Vehikel für derartige Änderungen in der vertikalen oder horizontalen Marktstruktur darstellen. Das vierte Kapitel untersucht aktuelle Entwicklungen auf dem Markt für Internetverbindungen.

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Contents

Introduction

The focus of the four chapters of this dissertation is on the analysis of market structure and the impact of globalization. This introduction briefly summarizes their individual findings, methods, and contributions and highlights some linkages.

Chapter 1 is titled "Globalization and Vertical Structure: An Empirical Investigation" and is joint work with Stefan Bühler. The chapter empirically analyzes the impact of a reduction in international trade barriers—denoted as "globalization" in the literature—on vertical firm structure. Based on the Swiss Business Census and the Swiss Input-Output Table as provided by the Swiss Federal Statistical Office, we first calculate a binary measure of vertical integration for all firm establishments registered in Switzerland. We then estimate how an agreement on the elimination of technical barriers to trade between Switzerland and the European Union changed a firm establishment's probability of being vertically integrated.

The agreement we study as a "natural experiment" is a Mutual Recognition Agreement between the two regions which was signed in 1999, approved in 2000, and enacted in 2002 (EC, 2002). It stipulates the mutual recognition of conformity assessments for a large set of industrial products and thus reduces market-entry costs for affected firms considerably. Adopting a difference-in-differences approach, we find that the policy change reduced the probability of being vertically integrated by about 10 percent. Our results are largely consistent with the predictions of recent work in international trade theory, suggesting that a reduction in trade barriers makes vertical integration less attractive by "thickening" the market for intermediate input goods (McLaren, 2000), improving the search for contracting partners (Grossman and Helpman, 2002), and thus reducing the hold-up risk for firms when concluding (incomplete) contracts.

Chapter 2 is titled "The Impact of Trade Policy on Industry Concentration in Switzerland" and makes use of the Swiss Business Census to study industry concentration in the light of globalization. As a descriptive result it turns out that concentration converges to zero as market size increases—in industries with low expenditures on research and development (R&D). By contrast, concentration is bounded away from zero in industries with high R&D expenditures. This supports Sutton's (1991) notion that expenditures for research and development are endogenous sunk costs which escalate in larger markets and thus may prevent the entry of additional firms.

More importantly, Chapter 2 evaluates the impact of an increase in the toughness of price competition on industry concentration in Switzerland. Following our "natural experiment" of trade facilitation between Switzerland and the European Union, the five-firm concentration ratio in affected industries with low R&D expenditures increased by an average of 2.14 percentage points. This supports the notion that fewer firms are able to survive and thus exit the market or merge as it becomes easier for European firms to enter the Swiss market. Notably, however, concentration does not change significantly in affected industries with high R&D expenditures. These findings complement an empirical study by Symeonidis (2000), which finds an increase in concentration for both types of industries resulting from a strengthening in UK competition policy in the 1950's as an alternative type of (exogenous) shock to price competition.

Note that while a current research trend is to focus on individual industry studies, Chapter 1 and Chapter 2 both use the Swiss Business Census to provide a remarkably broad analysis by including all manufacturing industries in Switzerland. As Einav and Levin (2010) conclude in their progress report on the field of industrial organization, "after 20 years of industry studies, we know *a lot* about how specific industries work, but this knowledge is extremely disaggregated. (...) Industrial organization has ceded many of the interesting and important questions about the overall organization of production in the economy to other fields such as trade and macroeconomics." (p. 160). Chapter 1 and Chapter 2 contribute to such a more general perspective at the intersection of industrial organization and international trade. Furthermore, note that Chapter 1 and Chapter 2 look at two sides of the same coin—the vertical and the horizontal dimension of changes in market structure in Switzerland.

An essential vehicle for such changes in market structure are mergers and acquisitions, which are at the core of Chapter 3. Chapter 3 is titled "Employment Growth in the Course of Mergers and Acquisitions" and is joint work with Marco Helm. In the process of mergers and acquisitions, employees are an important stakeholder group. Previous research, however, is mostly concerned with the value creation for shareholders. Chapter 3 examines the effect of mergers and acquisitions on employees in newly acquired firm establishments. Based on the Swiss Business Census, we find that the relative size of a deal, acquiring in export-oriented industries, and acquiring in related industries have adverse effects on employment growth. We attribute the deal size effect to resource constraints of acquiring firms: with high acquisition costs hiring additional employees is restricted and vice versa. To cope with endogeneity concerns, in a robustness check we propose to look at a sub-sample of multi-plant mergers only. Chapter 3 also contributes to a controversial debate on firm growth in general by rejecting Gibrat's Law of proportionate growth for firm establishments in Switzerland (Sutton, 1997).

Finally, Chapter 4 is titled "Multihoming, CDNs, and the Market for Internet Connectivity" and is joint work with Thorsten Hau and Walter Brenner. It deals with another important aspect of globalization and market structure—the development of new telecommunication technologies which effectively decrease the barriers to transporting data worldwide through the Internet.

Peering points between different Internet service providers are among the bottlenecks of the Internet. Multihoming and content delivery networks (CDNs) are two technical solutions to bypass peering points and to improve the quality of data delivery. So far, however, there is no research that analyzes the economic effects of multihoming and content delivery networks on the market for Internet connectivity. Based on microeconomic theory, Chapter 4 develops a static market model with locked-in end users and paid content. It shows that multihoming and CDNs create the possibility for terminating Internet service providers to engage in monopolistic pricing towards content providers, leading to a shift of rents from end users and content providers to Internet service providers. Implications for future innovations in the market for Internet connectivity are discussed.

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Chapter 1

Globalization and Vertical Structure: An Empirical Investigation

Stefan Bühler and Dirk Burghardt

Abstract This chapter studies the effect of trade facilitation on vertical firm structure using plant-level data from Switzerland. Based on the Business Census and the Input-Output table, we first calculate a binary measure of vertical integration for all plants registered in Switzerland. We then estimate the effect of a Mutual Recognition Agreement with the European Union on the plants' probability of being vertically integrated. Adopting a difference-in-differences approach, we find that this policy change reduced the treated plants' probability of being vertically integrated by about 10 percent. Our results are consistent with recent work in international trade theory.

1.1 Introduction

What is the impact of trade policy on vertical firm structure? Building on the modern theory of the firm, the trade literature has studied several ways in which trade facilitation makes arm's-length transactions more attractive.[1] McLaren (2000, 2003) shows that a reduction in international trade barriers, also referred to as "globalization," thickens the market for inputs, thereby alleviating the opportunism problem with arm's-length transactions. Grossman and Helpman (2002, 2005) highlight that globalization facilitates the search for suitable contracting partners. Alfaro et al. (2012) emphasize that trade policy affects vertical firm structure via their effect on product prices: productivity gains from vertical integration have little value if prices are low, such that arm's-length transactions are attractive when tariffs are low, whereas vertical integration is attractive when tariffs are high. In contrast, Ornelas and Turner (2008, 2011) argue that trade liberalization must not necessarily make arm's-length transactions more attractive. In particular, they show that trade liberalization may be associated with a higher degree of vertical integration when there is a so-called trade volume effect (i.e., if trade volumes are higher under vertical integration). While there is thus an impressive body of theoretical work on the effect of trade facilitation on vertical firm structure, the empirical evidence is scant.

This chapter exploits a natural experiment in trade policy to estimate the causal effect of trade facilitation on vertical firm structure. Specifically, we study the impact of the Mutual Recognition Agreement (MRA) between Switzerland and the European Union (EU)—signed in 1999, approved in 2000, and enacted in 2002—on vertical firm structure in Switzerland. The MRA stipulates the reciprocal recognition of conformity assessments for a large set of industrial products. In particular, the MRA allows manufacturers to test their products for conformity with the relevant regulations (e.g., regarding product safety or environmental standards) by a single conformity assessment body located either in Switzerland or the EU. Before the MRA, any industrial product to be marketed both in Switzerland and the EU had to be tested twice for conformity with the relevant regulations (once for the Swiss market, and once for the European market). The MRA thus eliminated an important non-tariff barrier to trade.

It is worth emphasizing three features of the MRA which are key for the present study. First, while some firms are directly affected by the MRA, others are not. Using a

[1] See Whinston (2001), Aghion and Holden (2011), and Hart (2011) for critical assessments of the extensive literature on the theory of the firm. Antràs (Forthcoming) and Marin (2012) discuss the influence of Grossman and Hart (1986), a landmark contribution, on recent work in international trade.

difference-in-differences approach, we can thus compare affected firms after the treatment both with affected firms before the treatment and unaffected firms with similar characteristics. That is, we can account for a potential time trend in the degree of vertical integration. Second, the policy change under study is reasonably exogenous. The MRA between the EU and Switzerland, which was approved by a popular vote in Switzerland, is similar to earlier agreements which the EU concluded with important trade partners such as Australia, Canada, Israel, Japan, New Zealand, and the Unites States. It is thus unlikely that lobbying activities of Swiss firms or industries have systematically affected the contents of the MRA.[2] Third, the MRA is of great economic importance for Switzerland. With around eighty percent of Swiss imports coming from the EU and around sixty percent of Swiss exports going to the EU (Swiss Federal Customs Administration, 2012), the European Union is Switzerland's most important trade partner.

Building on Hortaçsu and Syverson (2007), we first construct a simple binary measure of vertical integration for the universe of plants registered in Switzerland from 1995 to 2008.[3] To do so, we rely on five waves of the Swiss Business Census (1995, 1998, 2001, 2005, and 2008) and the Swiss Input-Output Use Table for the year 2008 provided by the Swiss Federal Statistical Office. The pooled cross-sectional database contains more than 1.9 million plants with individual vertical integration status. Next, we employ a difference-in-differences approach to estimate the effect of the MRA on the probability of a plant being vertically integrated. While we examine alternative treatment and control groups, we maintain the key identifying assumption that the respective treatment and control groups experienced a common trend in the average degree of vertical integration (conditional on covariates).[4]

Our main results are the following. First, irrespective of the exact specification, we find that the trade facilitation via the MRA caused a significant reduction in the treated plants' average probability of being vertically integrated. This finding is consistent with the trade literature's notion that trade liberalization makes arm's-length trading more attractive and thus leads to *less* vertical integration. Although the raw data suggest that the effect tends to level out in the long run, our estimates do not reveal a significant leveling out.

[2]The MRA was certainly exogenous from an individual plant's point of view. Also note that, in contrast to a gradual reduction of tariffs, for instance, the MRA leaves little room for lobbying regarding the intensity of the market opening.

[3]We define a plant to be vertically integrated if it is owned by a firm which has at least one additional plant in a vertically related industry. Section 1.3.2 provides further details on our measure.

[4]Identification will be discussed in more detail in Section 1.4 below.

Second, we find that the effect of the MRA on vertical firm structure in Switzerland was economically significant, even though the size of the estimated effect varies to some extent across specifications. Our baseline estimation indicates that the MRA decreased the treated plants' average degree of vertical integration by about 10 percent. Based on a different composition of the control group, the results of our robustness analysis suggest that the effect might have been even larger.

Third, focusing on other outcome variables such as import and export activity (measured at the firm level), we find evidence that the MRA between Switzerland and the EU did indeed foster trade. This result further supports our view of the MRA as an important change in trade policy. Notice, though, that a more thorough analysis of the MRA's effect on international trade would have to focus directly on trade flow data, which is beyond the scope of this chapter.

This chapter contributes to three strands of the literature. First, we add to the analysis of the link between trade policy and vertical firm structure. To the best of our knowledge, this is the first policy evaluation study of the effect of trade facilitation on vertical firm structure.[5] As mentioned above, McLaren (2000, 2003), Grossman and Helpman (2002, 2005), and Ornelas and Turner (2008, 2011) have focused on the theoretical analysis of the link between trade policy and vertical firm structure. The paper closest to ours is Alfaro et al. (2012). These authors exploit cross-country and cross-sector variation in most-favored nation World Trade Organization (WTO) tariffs in 2004 to estimate the impact of product prices on vertical integration. Consistent with their model's prediction, they find that the higher the tariff applied by a country on the imports of a given product, the more integrated are the domestic producers of that product. In addition, they provide time-series evidence on the effect of China's accession to the WTO in 2001 which indicates that vertical integration has fallen more in sectors with larger tariff cuts. The key difference to their paper is that we provide a causal estimate of the effect of eliminating a non-tariff trade barrier on vertical firm structure.

There is arguably little further evidence on the link between trade policy and vertical firm structure. Chongvilaivan and Hur (2012) show that trade openness and the degree of vertical integration are negatively correlated, employing U.S. manufacturing data from 2002 to 2006. Yet, they do not discuss how their proxies for trade openness relate to trade policy. Breinlich (2008) demonstrates that the Canada–U.S. Free Trade Agreement

[5]Blundell and Costa Dias (2009), Imbens and Wooldridge (2009), and Angrist and Pischke (2009) provide recent surveys of the policy evaluation literature.

of 1989 lead to an increase in merger activity in Canada, but he does not distinguish between horizontal and vertical transactions. Finally, Toulan (2002) studies the outsourcing activities of a small sample of Argentinean firms after a period of market and trade liberalization. Out of 163 responding firms, 106 firms reported no change, while 46 (11, respectively) reported a decrease (increase) in vertical integration.

Second, we contribute to the broader literature on the effects of trade policy reforms. Specifically, we provide evidence that trade facilitation has a relevant effect on vertical firm structure. Previous work on the impact of trade liberalization has focused on other outcome variables measured at the firm or plant level (such as productivity, employment, or investment), and it has typically exploited tariffs as the source of variation rather than the elimination of non-tariff barriers to trade.[6] For instance, Bustos (2011) studies the impact of a change in Brazil's tariffs on the technology investment of Argentinean firms. Lileeva and Trefler (2010) and Trefler (2004) examine the responses of Canadian plants to the elimination of U.S. tariffs. Amiti and Konings (2007) disentangle the productivity gains from reducing tariffs on final goods and intermediate inputs, respectively, employing Indonesian manufacturing data. Pavcnik (2002) examines the impact of tariff reductions on the productivity of Chilean manufacturing plants. In this strand of the literature, the paper closest to ours is Buehler, Helm, and Lechner (2011). These authors employ a database similar to ours to quantify the impact of a bundle of treaties between Switzerland and the EU (the so-called "Bilateral Agreements I") on plant growth in Switzerland. It is important to note that none of these papers analyzes the impact on vertical firm structure.

Finally, we add to the extensive literature on vertical integration.[7] Our results show that trade policy is an important determinant of vertical firm structure. Previous work on the determinants of vertical integration has largely abstracted from the role of trade policy. Aghion, Griffith, and Howitt (2006) provide evidence for a non-linear relationship between vertical integration and the intensity of competition. In a prominent recent cross-country study, Acemoglu, Johnson, and Mitton (2009) "find greater vertical integration in countries that have both lower contracting costs *and* greater financial development" (p. 1251) and emphasize the interaction between these determinants. In a related study, Acemoglu et al. (2010) employ plant-level data from the UK manufacturing sector to study the determinants of vertical integration. They find that the likelihood of vertical integration is positively (negatively, respectively) correlated with the technology intensity

[6] See Bernard et al. (2007) and Tybout (2003) for useful surveys.

[7] See Bresnahan and Levin (Forthcoming), Lafontaine and Slade (2007), Joskow (2005) and Perry (1989) for surveys. Acemoglu et al. (2010) discuss the empirical literature on vertical integration.

of producer (supplier) industries. None of these papers discusses the role of trade policy.

The remainder of this chapter is structured as follows. Section 1.2 describes the MRA and the way we exploit it to estimate the effect of trade facilitation on vertical firm structure. Section 1.3 describes the database, explains how we measure vertical integration, and discusses some descriptive statistics. Section 1.4 sets out the econometric approach, focusing on the empirical model and identification, and Section 1.5 presents the estimation results. Section 1.6 provides a number of robustness checks, and Section 1.7 discusses the MRA's effects on other outcome variables. Section 1.8 concludes.

1.2 The Mutual Recognition Agreement

Our empirical analysis below will exploit the MRA between Switzerland and the EU—which was signed on June 21, 1999, approved by a popular vote on May 21, 2000, and enacted on June 1, 2002, as part of the Bilateral Agreements I—as a source of plausibly exogenous variation in trade policy.[8]

Switzerland is a small developed economy in Western Europe with a population of roughly eight million residents. It shares borders with Germany, France, Italy, Austria, and Liechtenstein, but it is not a member of the EU. The national currency is the Swiss Franc (CHF). Switzerland's relations to the EU are governed by numerous bilateral agreements which are of paramount importance for the Swiss economy. Since 1972, Switzerland has a Free Trade Agreement with the EU which prohibits customs duties or quotas on industrial products but is silent regarding non-tariff barriers to trade. On October 6, 1995, Switzerland issued a Federal Law on the Dismantling of Technical Trade Barriers (THG) which was enacted on July 1, 1996. This law, inter alia, enabled the Swiss government to negotiate international treaties eliminating non-tariff barriers to trade, such as the MRA studied in this chapter.[9] In doing so, the THG anticipated the trade liberalization later to be implemented by the MRA.

The MRA prescribes the mutual recognition of conformity assessments by Swiss and EU bodies for most industrial products. A conformity assessment determines whether a given product satisfies the relevant regulations and standards (e.g., regarding product safety or environmental standards) and is thus fit to be marketed. The MRA explicitly defines the areas in which Swiss and EU regulations are deemed equivalent, such that a

[8]Continuously updated information on the Bilateral Agreements I, and Swiss trade policy towards the European Union more generally, is available at www.europa.admin.ch.

[9]The recent amendment of the THG on July 1, 2010, is not covered by our observation period.

single conformity test is sufficient for determining whether a product may be marketed both in Switzerland and the EU.[10] The MRA thus eliminates an important non-tariff barrier to trade, reduces market-entry costs, and cuts red tape.

Table 1.1 reproduces the official list of the "product sectors" covered by the MRA. Each product sector covers a specific set of products which is defined in more detail in various Directives of the European Community. For instance, Article 1 of Directive 98/37/EC defines the scope of the product sector "Machinery", and it explicitly excludes certain products from this sector. We use these Directives, as provided in EC (2002) and EC (2003), to associate the various product sectors with the corresponding four-digit industries of the NOGA 2002 classification system used in our main data set.[11] Tables 1.7 and 1.8 in the Appendix provide the complete list of all four-digit industries covered by the MRA. The plants in these industries will form the treatment group in our empirical analysis below.

Table 1.1: Product sectors covered by the Mutual Recognition Agreement

1	Machinery
2	Personal protective equipment
3	Toys
4	Medical devices
5	Gas appliances and boilers
6	Pressure vessels
7	Telecommunications terminal equipment
8	Equipment and protective systems intended for use in potentially explosive atmospheres
9	Electrical equipment and electromagnetic compatibility
10	Construction plant and equipment
11	Measuring instruments and prepackages
12	Motor vehicles
13	Agricultural and forestry tractors
14	Good laboratory practice (GLP)
15	Medicinal products GMP Inspection and Batch Certification

Notes: Table 1.1 lists all "product sectors" which are covered by the MRA according to the official agreement text between Switzerland and the European Union (EC, 2002, p. 376). Tables 1.7 and 1.8 in the appendix translate these sectors into the industry classification used in our data set.

[10]Before the implementation of the MRA, a Swiss producer of dental implants, for instance, needed to have its products tested twice: first at a testing facility in Switzerland for the local market, and then at another facility in a EU member country for the European market.

[11]NOGA is the official abbreviation for the General Classification of Economic Activities ("Nomenclature Générale des Activités économiques") used in Switzerland. It is the counterpart of the SIC and NAICS classification used in the United States. Notice that the NOGA classification system is consistent with the NACE Rev. 1.1 system of the European Community up to the four-digit level.

The MRA between Switzerland and the European Union provides a unique opportunity to study the causal effect of trade facilitation on vertical firm structure. First, it represents a plausibly exogenous change in trade policy. Second, the MRA directly identifies the product sectors—and thus the four-digit industries—which are covered by the agreement, such that there is no judgement required to determine the treatment and control groups of affected and non-affected plants. Third, the policy change is very important for the Swiss economy, as the European Union is Switzerland's most important trade partner (Hertig and Meier, 2008).[12]

1.3 Data and Measurement

1.3.1 Data Sources

Our analysis is based on two data sources. First, we employ five waves of the Swiss Business Census (1995, 1998, 2001, 2005, and 2008), which covers the universe of plants (or "business establishments") with more than 20 weekly aggregate working hours in the manufacturing and the services sector. The agricultural sector is excluded. The census is compiled by the Swiss Federal Statistical Office, and participation is mandatory. It offers a wealth of information on the universe of plants registered in Switzerland, including firm ownership, industry classification, size, geographic location, etc. There are more than 350,000 plants per wave in our sample. Second, we employ Switzerland's Input-Output (I-O) Use Table for 2008, which is also provided by the Swiss Federal Statistical Office. It is used to determine the vertical linkages between the different industries, which are crucial for calculating our measure of vertical integration at the plant level (see below).

Our database is unique in that it covers the universe of plants of a developed economy over an observation period of more than ten years. It is worth noting that our database fully covers the services sector, which plays an important role in a developed Western European economy such as Switzerland.

1.3.2 Measuring Vertical Integration

We build on Hortaçsu and Syverson (2007) to construct a simple binary measure of vertical integration for each plant in our database. These authors study vertical integration

[12]According to the Swiss Federal Customs Administration (2012), Swiss imports amounted to 173.7 billion CHF with 82.7 percent from the European Union, and exports to 197.6 billion CHF with 60 percent to the European Union in 2011.

between the cement industry and the ready-mixed concrete industry, and they define a plant to be vertically integrated if it is owned by a firm that has plants in both industries. We adapt their approach to our setting with many industries, using Switzerland's I-O Use Table 2008 to determine the extent to which different industries are vertically related.[13]

More formally, we uniquely identify each plant in our database by the census year $t = \{1995, 1998, 2001, 2005, 2008\}$ and the index $i = \{1, ..., N_t\}$, where N_t is the total number of plants observed in census year t. We then construct the dummy variable

$$Integrated_{it} = \begin{cases} 1, & \text{if plant } i \text{ in census year } t \text{ is vertically integrated} \\ 0, & \text{otherwise} \end{cases} \tag{1.1}$$

which indicates for each plant in the database whether it is vertically integrated at the time of observation. The construction of this dummy variable relies on the following definitions:

Definition 1 (Vertically integrated plant) *A plant is vertically integrated if it is owned by a firm which has at least one additional plant in a vertically related industry.*

Definition 2 (Vertically related industries) *Two industries k and ℓ, $k \neq \ell$, are vertically related if commodities of industry k of a value of at least* 0.001 *CHF are required to produce* 1 *CHF of industry ℓ's output (or vice versa) according to Switzerland's 2008 Input-Output Use Table.*

Both the Business Census and the I-O Use Table classify industries according to NOGA system at the two-digit level. Unfortunately, for some industries, the I-O Use Table provides a combined estimate of product flows only. For food products and beverages (NOGA code 15) and tobacco products (NOGA code 16), for instance, only a single value of product flows to other industries is available.[14] Since no distinction is possible within these groups, we classify individual industries according to the combined estimate.

Based on the dummy variable defined in (1.1), it is straightforward to calculate the average value of vertical integration at time t for any group of plants. For the manufacturing sector, for instance, we find that the average value of vertical integration decreased from 1995 to 2008 by about 26 percent (from 0.053 to 0.039). In the services sector, in

[13] Acemoglu et al. (2010) use an analog measure translated to the firm-level. Alternative measures of vertical integration and relatedness are discussed in Davies and Morris (1995) and Fan and Lang (2000).

[14] A similar limitation holds for the following product groups (codes refer to the industries listed in Tables 1.7 and 1.8 in the Appendix): 23/24, 30/31, 40/41, 50-52, 60-62, 70/97, 71/74, 91-92, and 93-95.

turn, the average value of integration increased by 6 percent (from 0.100 to 0.106). We provide further information on the descriptive statistics in the next section.

1.3.3 Descriptive Statistics

It is well known that the validity of the difference-in-differences approach crucially depends on the comparability of treatment and control group. We need to control for differences in plant characteristics across these groups, if present.

Table 1.2 provides descriptive statistics for all plants in Switzerland in 1998, the last available census year for which it is reasonable to assume that plant characteristics were unaffected by the treatment. The first two columns, respectively, focus on the group of treated and the group of control plants in the manufacturing sector, whereas the third column focuses on the services sector in which no plants are treated by the MRA. The last column provides information on all plants in the data set. Shown is the percentage of plants that fall in each category of the available variables. Notice that the number of plants in the services sector is much larger than that in the manufacturing sector, such that characteristics of the full sample are strongly driven by services plants.[15]

A number of comments are in order. First, for the universe of Swiss plants, about 10.85 percent of the plants are vertically integrated (in other words, the average value for *Integrated*, our measure of vertical integration, is 0.1085). It is worth noting that this percentage is consistently lower in the manufacturing than in the services sector, and it is lower in the control (2.83 percent) than in the treatment group (6.15 percent).

Second, the distribution of plant size, as measured by the number of full-time equivalent employees and here split up into four size categories, shows that most plants are micro or small plants in all groups. However, there are considerable differences in magnitude between the manufacturing and the services sector and also the treatment and the control group of plants in the manufacturing sector. For example, the group of treated plants comprises a higher share of large and medium sized plants than the other groups. Third, it is worth noting that the frequency distribution for most of the remaining plant characteristics listed in Table 1.2 also vary across groups to some extent.

Summing up, we find that there is some variation in the plant characteristics across groups. In particular, we find that they vary across the treatment and the control group. We will therefore control for these plant characteristics in our empirical analysis below.

[15]For some of our estimations, we will add the services plants to the control group, increasing the number of plants observed over the five census years from 208,355 to 1,901,518 (see Section 1.6).

Table 1.2: Frequency distribution of plant characteristics in 1998 (percentages)

		Manufacturing			
Variable	Category	Treated	Control	Services	All
Integrated	1 = Yes	6.15	2.83	11.74	10.85
	0 = No	93.85	97.17	88.26	89.15
Size	Large (250 or more employees)	1.53	0.51	0.13	0.20
	Medium (50-249 employees)	7.29	3.71	1.30	1.69
	Small (10-49 employees)	18.48	14.83	9.60	10.31
	Micro (0-9 employees)	72.70	80.95	88.97	87.80
Region	Lake Geneva region	11.97	14.85	18.58	18.07
	Espace Mittelland	24.80	26.67	21.10	21.67
	Northwestern Switzerland	14.02	12.67	12.95	12.97
	Zurich	16.45	15.66	18.06	17.82
	Eastern Switzerland	18.35	16.67	14.73	15.01
	Central Switzerland	10.73	9.67	9.35	9.42
	Ticino	3.68	3.71	5.22	5.05
Municipality	Center	25.90	29.21	39.58	38.30
	Suburban	30.59	26.56	24.86	25.19
	High income	2.65	2.84	3.75	3.64
	Peri-urban	8.98	9.32	7.35	7.56
	Touristy	1.76	2.98	4.72	4.48
	Industrial	11.84	13.23	9.46	9.84
	Rural-commuter	7.28	6.84	4.51	4.79
	Agrarian-mixed	9.34	7.76	4.93	5.30
	Agrarian	1.67	1.27	0.85	0.91
Kind of Unit	Headquarter of multi-unit firm	5.67	3.36	4.31	4.28
	Branch of multi-unit firm	8.12	4.59	19.12	17.60
	Single-unit firm	86.21	92.05	76.58	78.12
Legal Form	Einzelfirma	37.13	49.19	46.57	46.46
	Kollektivgesellschaft	2.56	3.81	3.00	3.05
	Kommanditgesellschaft	0.61	0.69	0.51	0.52
	Aktiengesellschaft	50.50	38.83	26.09	27.9
	GmbH	4.67	5.12	5.04	5.03
	Genossenschaft	2.98	0.22	1.72	1.64
	Other	1.55	2.14	17.07	15.4
Observations		12,712	29,921	336,697	379,330

Notes: Table 1.2 compares the group of treated and control plants in 1998, before the treatment. For both groups it shows the percentage of plants which fall in each category of the available variables (thus, columns sum up to 100 percent for each variable). A number of differences in these distributions become apparent. To give an example, while 18.48 percent of all treated plants are small, only 14.83 percent of all control plants are small. Also information on the services and the full sample is provided.

1.4 Empirical Methodology and Identification

We pool the data from the five census years into a single database and employ a standard difference-in-differences approach to estimate the causal effect of trade facilitation on vertical integration (see, e.g., Imbens and Wooldridge, 2009). More specifically, we estimate the probability that a plant is vertically integrated using the linear model

$$\begin{aligned} \mathit{Integrated} = \alpha &+ \beta_1 \mathit{After} + \beta_2 \mathit{Treatment} + \beta_3 (\mathit{After} \times \mathit{Treatment}) + \\ &+ \gamma_1 y95 + \gamma_2 y05 + \gamma_3 y08 + X'\delta + u, \end{aligned} \tag{1.2}$$

where the dependent variable *Integrated* indicates whether a plant is vertically integrated, *Treatment* indicates whether a plant is covered by the MRA, *After* is a dummy variable that equals 1 for a plant observation after the treatment, and X' is a vector of covariates controlling for the plant characteristics. In particular, we include plant size and dummies for the greater region, the municipality type, the kind of unit, and the legal form of a plant (see Section 1.3.3 for further details). The variable u represents the error term.

Our variable of interest is the interaction term *After* $\times$ *Treatment*, whose coefficient β_3 measures the effect of the MRA on the probability of being vertically integrated. In line with our above discussion of recent trade theory, we hypothesize that the MRA caused a lower probability of being vertically integrated, that is, $\beta_3 < 0$.

The estimation of the causal effect of trade facilitation on vertical integration via the difference-in-differences approach just outlined relies on a set of identifying assumptions (see, for example, Lechner, 2010). Since it is not possible to test the validity of these assumptions directly, we discuss their plausibility in turn.

First, we must assume that one of the potential outcomes is observed for each plant in the database. This assumption is violated if the outcome variable of all plants (i.e., even of those in the control group) was affected by the MRA. As we pointed out in Section 1.2, the MRA targeted a well-defined subset of plants (only those operating in the product sectors listed in Table 1.1), which suggests that the assumption is reasonable for the MRA under study. Note that, in line with the trade literature, we abstract from interactions in integration decisions among affected and non-affected plants, effectively assuming that they are negligible for the effect to be estimated.[16]

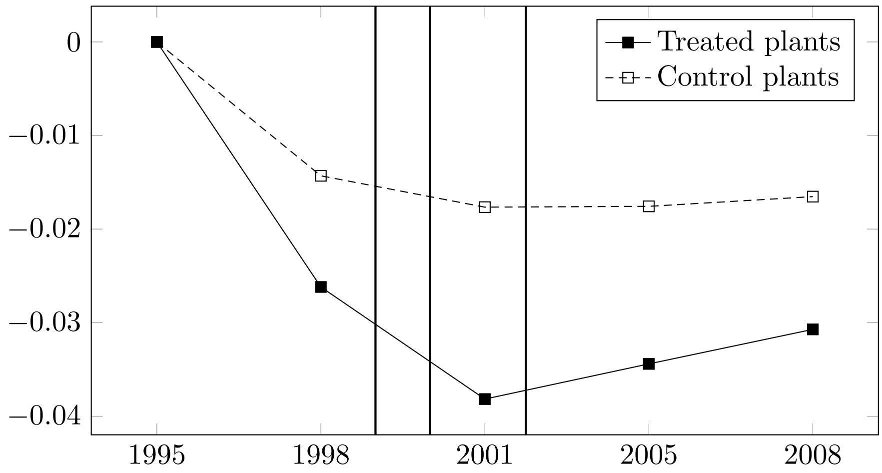
Second, the covariates X' need to be exogenous. In our specification, X' reflects

[16] Buehler and Schmutzler (2005), Buehler and Haucap (2006), and Buehler and Schmutzler (2008) study strategic interactions in vertical integration decisions from an industrial organization perspective.

the plant characteristics from 1995 until 2008. It seems safe to assume that the plant characteristics as of 1998 are exogenous, as they are measured well before the MRA became effective. Regarding the characteristics measured at later dates, exogeneity is less obvious. Even so, it is difficult to see how, say, a plant's geographic location (or any of the other characteristics captured in X') should be related to its vertical integration status. We therefore think that it is reasonable to assume that X' is exogenous.

Third, we require common support, that is, there must be a valid comparison group of non-treated (manufacturing) plants. Since our control group (29,921 plants in 1998) is more than twice as large as the treatment group (12,712 plants in 1998) and features the same list of plant characteristics (with at least similar summary statistics), we feel confident in making this assumption. If we further add the plants in the services sector to the control group, the latter becomes much larger. Yet, since services plants might generally not compare very well to manufacturing plants, our main results are based on manufacturing plants only, while the full-sample is examined in Section 1.6 on robustness.

Figure 1.1: Change in average vertical integration relative to 1995 (manufacturing)



Notes: Figure 1.1 shows the change in the average value of *Integrated*, relative to 1995, over time, for the treatment and control group, respectively. Vertical lines mark the dates when the Mutual Recognition Agreement was signed in 1999, approved in 2000, and enacted in 2002, respectively.

Fourth, we need to assume that, in the absence of the MRA, the treatment and the control group of plants would have experienced the same time trend in the outcome variable *Integrated*. To assess the plausibility of this assumption, it is useful to consider the change in the average value of *Integrated* for the treatment and the control group, relative to 1995, as illustrated in Figure 1.1.

Figure 1.1 shows that the change in the average value of *Integrated* relative to 1995 is slightly U-shaped both for the treatment and the control group. Importantly, it also indicates that, while the average value decreases for both groups from 1995 to 1998 (i.e., before the MRA was signed), the reduction is more pronounced for the treatment group. We believe that these reductions reflect the introduction of the THG (see Section 1.2), which enabled the Swiss government to negotiate international treaties such as the MRA to eliminate technical barriers to trade.[17] In our view, it is thus plausible to assume that the reductions in the average values of *Integrated* from 1995 to 1998 for the treatment and the control group reflect anticipation effects. The subsequent signing and approval of the MRA itself is associated with further reductions in the average values of *Integrated*. Again, the effect is more pronounced for the treatment group. Towards the end of the observation period, the average values of *Integrated* slightly pick up again for both groups. Our estimation results will shed further light on these patterns.

Summing up, the raw data depicted in Figure 1.1 suggest that the assumption of a common trend for the treatment and the control group is reasonable if one is willing to allow for anticipation effects before the implementation of the MRA. Such anticipation effects seem particularly plausible in our setting, since the introduction of the THG provides an institutional foundation for anticipation effects.

1.5 Results

Table 1.3 reports our estimates of the MRA's effect on the treated plants' probability of being vertically integrated. These estimates are based on the restricted sample of manufacturing plants only due to the concern that services plants might not compare very well to the treatment group of manufacturing plants and should therefore be excluded from the control group (estimates for the full sample will be discussed in Section 1.6).

We find the following key results. First of all, the coefficient of *After*$\times$*Treatment* is estimated to be negative and significant across all specifications (columns (1) to (4)). This suggests that the MRA caused a robust reduction in the treated plants' probability of being vertically integrated, which is in line with recent trade theory. Although the raw data displayed in Figure 1.1 suggest that the negative effect of the MRA on the average value of *Integrated* tends to level out in the long run, our estimates do not pick up such a leveling out (see column (4) in Table 1.3).

Second, the effect of the MRA on vertical firm structure is economically significant

[17]That is, the THG was an institutional pre-condition for the conclusion of the MRA.

in all specifications, even though the absolute value of the estimated coefficient varies considerably. With a limited set of controls (column (1)), the coefficient is estimated to be -0.0115. Adding plant characteristics to the covariates, as in our baseline estimation in column (2), halves the size of the coefficient to -0.0061. Further adding industry dummies only slightly reduces the coefficient to -0.0056 (column (3)). Finally, accounting for a potential leveling-out in the last observation period 2008 (column (4)) leads to a similarly-sized coefficient of *After*× *Treatment* (-0.0070) and detects no leveling out. Our baseline estimation indicates that the MRA increased the treated plants' average degree of vertical integration by about 10 percent. To see this, relate the estimated coefficient of -0.0061 to the treated plants' average value of *Integrated* before the MRA, which is 0.0615 in 1998 (see Table 1.2).

Table 1.3: Effects of globalization on vertical integration (manufacturing)

	Dependent variable: *Integrated*			
Independent variable	(1) Limited controls	(2) Baseline estimation	(3) Industry controls	(4) Long-term effects
After × *Treatment*	-0.0115***	-0.0061**	-0.0056**	-0.0070**
	(0.003)	(0.002)	(0.002)	(0.003)
y08 × *Treatment*				0.0028
				(0.003)
Constant, *After*, *Treatment*	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Plant characteristics (X')	No	Yes	Yes	Yes
Industry dummies	No	No	Yes	No
Observations	208,355	208,355	208,355	208,355
R-squared	0.008	0.410	0.413	0.410

Notes: Standard errors in parentheses are clustered at the industry level. *** p<0.01, ** p<0.05, * p<0.1. Coefficients for *After*× *Treatment* show the effect of the MRA on the treated plants' probability of being vertically integrated. Estimation (2) is our baseline estimation. Estimation (1) excludes the vector of plant characteristics X'. Estimation (3) includes industry dummies. Estimation (4) further includes the interaction *y08*× *Treatment*, providing information on a potential leveling out of the treatment effect.

1.6 Robustness

To check the robustness of our results, we perform two types of tests. First, we run a series of placebo experiments, again using the restricted sample of manufacturing plants only. Second, we re-run the above regressions to estimate the effect of the MRA based on the full sample, adding services plants to the control group.

The three placebo experiments that we conducted are summarized in Table 1.4. In each of these experiments, we estimate a slightly adapted version of our baseline model, pretending that the treatment occurred not at the actual time of treatment but at some other time during the observation period. Naturally, we expect to find no effect of the placebo intervention on the treated plants' probability of being vertically integrated.

In the first experiment (column (1)), we pretend that the MRA was introduced between 1995 and 1998 (rather than between 1998 and 2001) and adapt the set of year dummies accordingly. For this experiment, we find a negative and significant placebo effect before the actual introduction of the MRA. The placebo experiment thus seems to capture the difference in the reductions of the average value of *Integrated* between the treatment and the control group before the actual treatment (see Section 1.3.3), which is difficult to attribute to the MRA. In doing so, this placebo experiment lends further credibility to the view that the introduction of the THG anticipated (part of) the effect of trade facilitation.

In the other two experiments (columns (2) and (3)), we pretend that the MRA was introduced after the actual introduction (between 2001 and 2005 and between 2005 and 2008, respectively). For these two experiments we find, as expected, no significant placebo effect on the treated plants' probability of being vertically integrated.

Table 1.4: Placebo experiment regression results (manufacturing)

	Dependent variable: *Integrated*		
Independent variable	(1) Placebo 1995–1998	(2) Placebo 2001–2005	(3) Placebo 2005–2008
After × *Treatment*	-0.0105***	-0.0031	-0.0008
	(0.002)	(0.003)	(0.003)
Constant, *After*, *Treatment*	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Plant characteristics (X')	Yes	Yes	Yes
Industry dummies	No	No	No
Observations	208,355	208,355	208,355
R-squared	0.410	0.410	0.410

Notes: Standard errors in parentheses are clustered at the industry level. *** p<0.01, ** p<0.05, * p<0.1. Coefficients for *After*× *Treatment* show the effect of a placebo trade facilitation on the treated plants' probability of being vertically integrated. Estimations are a modifications of the baseline model (column (2) in Table 1.3), pretending that the trade facilitation took place at a different point in time.

Next, we estimate the effect of the MRA on the treated plants' probability of being vertically integrated based on the full sample rather than the manufacturing sample only. Notice that the control group is now much larger since it also includes services plants, whereas the treatment group remains unchanged. Table 1.5 provides the results.

Table 1.5: Effects of globalization on vertical integration (full sample)

	Dependent variable: *Integrated*			
Independent variable	(1) Limited controls	(2) Baseline estimation	(3) Industry controls	(4) Long-term effects
After × *Treatment*	-0.0300**	-0.0289***	-0.0284***	-0.0300***
	(0.012)	(0.010)	(0.010)	(0.011)
y08 × *Treatment*				0.0033
				(0.004)
Constant, *After*, *Treatment*	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Plant characteristics (X')	No	Yes	Yes	Yes
Industry dummies	No	No	Yes	No
Observations	1,901,518	1,901,518	1,901,518	1,901,518
R-squared	0.001	0.605	0.623	0.605

Notes: Standard errors in parentheses are clustered at the industry level. *** p<0.01, ** p<0.05, * p<0.1. Coefficients for *After*× *Treatment* show the effect of the MRA on the treated plants' probability of being vertically integrated. Estimation (2) is our baseline estimation. Estimation (1) excludes the vector of plant characteristics X'. Estimation (3) includes industry dummies. Estimation (4) further includes the interaction *y08*× *Treatment*, providing information on a potential leveling out of the treatment effect. While Table 1.3 only considers manufacturing, here also services plants are included in the control group.

Inspection of Table 1.5 suggests that the qualitative results are similar to those for the manufacturing sample, even though the numerical estimates are fairly different.[18] First, and most importantly, the coefficient of *After*×*Treatment* is still negative and significant across all specifications (columns (1)-(4)). That is, both for the restricted and the full sample, we find that the MRA caused a significant reduction in the treated plants' probability of being vertically integrated. Second, the economic significance of the effect is confirmed. In the baseline estimation, for instance, the coefficient is now -0.0289, which suggests a reduction in the treated plants' probability of being vertically integrated by about 47 percent.

[18]Notice that the differences in the numerical estimates are exclusively due to the different composition of the control group, which is now dominated by services plants.

1.7 Effects on Trade

Our main interest in this chapter lies in quantifying the effect of the Mutual Recognition Agreement on vertical firm structure. Yet, since the original objective of the MRA was to facilitate international trade, it is natural to ask whether the MRA actually led to an increase in international trade.[19] In this section, we attempt to answer this question by studying the impact of the MRA on a number of related outcome variables which are available at a disaggregated level.

We start with the exporting and importing activity observed in Switzerland. Specifically, we construct the dummy variable

$$Exporting_{it} = \begin{cases} 1, & \text{if plant } i\text{'s parent firm in census year } t \text{ is exporting} \\ 0, & \text{otherwise} \end{cases} \tag{1.3}$$

which indicates whether a plant's parent firm is exporting at the time of observation. Note that we associate a plant's export status with its parent firm's export status, as export status information is only available at the firm level. We then estimate the linear probability model

$$Exporting = \alpha + \beta_1 After + \beta_2 Treatment + \beta_3 (After \times Treatment) + X'\delta + u, \tag{1.4}$$

where the dependent variable *Exporting* indicates whether a plant belongs to an exporting parent firm, *Treatment* controls whether a plant is treated by the MRA, *After* is a dummy variable that equals one for a plant observation after the treatment, and X' is the vector of additional controls. The coefficient β_3 measures the treatment effect. We expect the MRA to have a positive effect on the exporting status of firms, i.e. $\beta_3 > 0$. The underlying idea is that the MRA renders exporting profitable at least for some non-exporting firms.[20] We estimate similar regression with the dependent variable $Importing_{it}$ indicating whether a plant belongs to an importing parent firm.

Before discussing the results, we want to point out the limitations of this approach.

[19] Recall that a change in vertical integration does not necessarily require an increase in international trade. According to McLaren (2000), for instance, the mere availability of an additional outside option reduces a firm's hold-up risk and thus its integration incentive.

[20] Note that in addition to non-exporters who switch their status, for β_3 to be positive, it is also possible that (a) already exporting firms expand their production by more than non-exporters through the foundation or acquisition of new plants or (b) a disproportionate share of exporting firms newly enters the market.

First, as mentioned above, export status information is only available at the firm level. Yet, to maintain the composition of the treatment and control group, we need to perform the empirical analysis at the plant level. We therefore associate a plant's export status with the parent firm's status. Second, export status information was collected only in the census years 1995 and 2005, but not in 1998, 2001, and 2008. Our regression is thus restricted to these two periods, where 1995 is the census year before the treatment and 2005 is the census year after the treatment. As a third limitation, export status information may also refer to regions other than the European Union. Since the EU is Switzerland's most important trade partner, using export status information nevertheless seems to provide a reasonable approximation. Finally, not all firms answered the relevant questions in the questionnaire, leading to their exclusion from the regression and thus the possibility of a selection bias.

Table 1.6: Effects on export and import status (manufacturing)

	Dependent variable: *Exporting*		Dependent variable: *Importing*	
Independent variable	(1) Limited controls	(2) Baseline estimation	(3) Limited controls	(4) Baseline estimation
After × *Treatment*	0.0276**	0.0128	0.0350***	0.0228**
	(0.011)	(0.009)	(0.007)	(0.009)
Constant, *After*, *Treatment*	Yes	Yes	Yes	Yes
Plant characteristics (X')	No	Yes	No	Yes
Observations	76,997	76,997	76,651	76,651
R-squared	0.036	0.227	0.030	0.189

Notes: Standard errors in parentheses are clustered at the industry level. *** p<0.01, ** p<0.05, * p<0.1. Coefficients for *After*× *Treatment* show the effect of trade facilitation on the probability for a firm establishment's parent firm of being involved in exporting or importing. From a total of 83,992 observations in 1995 and 2005 together, in the exporting regression 6,995 observations and in the importing regression 7,341 were dropped due to the unavailability of the information.

Table 1.6 presents the regression results. All coefficients are estimated to be positive, suggesting that the MRA did indeed foster trade. While the effect on the export status becomes insignificant when plant characteristics are included, the effect on the import status stays significant at the five percent level. To evaluate the economic relevance of these results, note that 39.48 percent of the treated plants had an exporting parent firm in 1995.[21] The 1.28 percentage point increase predicted by baseline estimation (2) thus

[21] Firms that did not answer the relevant question are excluded from the sample.

corresponds to a 3.2 percent increase of that share. Correspondingly, 46.75 percent of the treated plants had an importing parent firm in 1995. A 2.28 percentage point increase as predicted by estimation (3) thus corresponds to a 4.8 percent increase of that share.

Obviously, a more thorough analysis of the MRA's effect on trade would employ data on actual trade flows, which is compiled by the Swiss Federal Customs Administration and Eurostat at the disaggregated product level. However, this data requires a treatment classification which is structurally very different from the NOGA industry codes employed in this study.[22] Therefore, this type of analysis is beyond the scope of the present chapter.

1.8 Conclusion

This chapter has estimated the causal effect of trade facilitation on vertical firm structure. Based on the Swiss Business Census and the Input-Output Use Table, we have constructed a binary measure of vertical integration for the universe of Swiss plants from 1995 to 2008. Viewing the Mutual Recognition Agreement with the European Union as a plausibly exogenous variation in trade policy, we have employed a difference-in-differences approach to estimate the effect of trade facilitation on the treated plants' probability of being integrated. We have found the following key results.

First, the trade facilitation via the MRA caused a significant reduction in the treated plants' probability of being vertically integrated. This finding is robust across all specifications, and it is consistent with the trade literature's prediction that trade liberalization makes arm's-length trading more attractive and thus leads to less vertical integration. Second, the effect of trade facilitation on vertical firm structure is economically significant. Our baseline estimation suggests that the MRA reduced the treated plants' probability of being vertically integrated by 10 percent. Alternative specifications and the robustness analysis suggest that the effect might have been even higher. Third, focusing on the effect on other outcome variables such as import and export activity, we have found evidence that the MRA between Switzerland and the EU did indeed foster trade. This result supports the view that the MRA represents an important change in trade policy.

There is ample scope for future research. Specifically, it would be interesting to make the measure of vertical integration more informative along two dimensions. First, a continuous (rather than a binary) measure of vertical integration which accounts for the

[22] Pierce and Schott (2012) present an approach to link trade data (using HS product codes) to data on US domestic economic activity (using SIC/NAICS industry codes). However, a gap to Swiss NOGA industry codes and accuracy concerns of using (multiple) concordance tables remain.

degree of vertical integration within a firm (cf. Davies and Morris, 1995) might provide a more accurate view of vertical integration at the firm level. Second, it would be desirable to use a more disaggregated I-O Use Table to detect vertical linkages among plants at the four-digit level which go unnoticed in our study. More generally, while our analysis has evaluated the causal effect of trade facilitation on vertical firm structure, it is not able to disentangle the various mechanisms discussed in trade theory that might generate this effect. We hope to address this issue in future research.

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Appendix

Table 1.7: Industries covered by the Mutual Recognition Agreement

Product sector		Corresponding Swiss NOGA 2002 industry codes
1	Machinery	29.12 Manufacture of pumps and compressors, 29.14 Manufacture of bearings, gears, gearing and driving elements, 29.2 Manufacture of other general purpose machinery, 29.32 Manufacture of other agricultural and forestry machinery, 29.4 Manufacture of machine-tools, 29.5 Manufacture of other special purpose machinery, 29.72 Manufacture of non-electric domestic appliances
2	Personal protective equipment	18.21 Manufacture of workwear, 18.24 Manufacture of other wearing apparel and accessories n.e.c, 25.24 Manufacture of other plastic products, 28.75A Manufacture of other fabricated metal products n.e.c., 33.40A Manufacture of glasses, 36.40 Manufacture of sports goods
3	Toys	36.50 Manufacture of games and toys
4	Medical devices	33.10 Manufacture of medical and surgical equipment and orthopaedic appliances
5	Gas appliances and boilers	28.22 Manufacture of central heating radiators and boilers, 28.30 Manufacture of steam generators, except central heating hot water boilers
6	Pressure vessels	28.30 Manufacture of steam generators, except central heating hot water boilers, 28.71 Manufacture of steel drums and similar containers with a capacity of 300 l or less
7	Telecommunications terminal equipment	32.20 Manufacture of telecommunication apparatus
8	Equipment and protective systems intended for use in potentially explosive atmospheres	28.2 Manufacture of tanks, reservoirs and containers of metal with a capacity of 300 l, of central heating radiators and boilers, 28.3 Manufacture of steam generators, except central heating hot water boilers, 29.23 Manufacture of non-domestic cooling and ventilation equipment, 29.24 Manufacture of other general purpose machinery n.e.c., 29.4 Manufacture of machine-tools, 31.61 Manufacture of electrical equipment for engines and vehicles n.e.c, 33.2 Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, 33.3 Manufacture of industrial process control equipment

Notes: See Table 1.8.

Table 1.8: Industries covered by the Mutual Recognition Agreement (contd.)

Product sector		Corresponding Swiss NOGA 2002 industry codes
9	Electrical equipment and electromagnetic compatibility	30 Manufacture of office machinery, data processing devices, 31 Manufacture of electrical machinery and apparatus n.e.c., 32 Manufacture of radio, television and communication equipment and apparatus
10	Construction plant and equipment	29.52 Manufacture of machinery for mining, quarrying and construction
11	Measuring instruments and prepackages	33.20 Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes
12	Motor vehicles	31.61 Manufacture of electrical equipment for engines and vehicles n.e.c., 34 Manufacture of motor vehicles, trailers and semi-trailers
13	Agricultural and forestry tractors	29.31 Manufacture of agricultural and forestry machinery
14	Good laboratory practice (GLP)	15 Manufacture of food products and beverages, 24.1 Manufacture of basic chemicals, 24.20 Manufacture of pesticides and other agro-chemical products, 24.42 Manufacture of pharmaceutical preparations, 24.51 Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations, 24.52 Manufacture of perfumes and toilet preparations
15	Medicinal products GMP Inspection and Batch Certification	24.42 Manufacture of pharmaceutical preparations

Notes: Tables 1.7 and 1.8 provide the list of all "product sectors" covered by the Mutual Recognition Agreement and then assign the originating NOGA 2002 industries to each of them. Product sector descriptions are taken from the agreement text, see EC (2002, p. 376); NOGA industry descriptions are taken from the complete list of NOGA industries, see Swiss Federal Statistical Office (2002). For the matching we made use of the various Directives of the European Community as listed in the agreement, as well as more detailed descriptions of the NOGA industries as provided by the Swiss Federal Statistical Office. In cases where industries are listed at a general level, all subcategories are included.

Chapter 2

The Impact of Trade Policy on Industry Concentration in Switzerland

Dirk Burghardt

Abstract This chapter studies the impact of trade policy on industry concentration. Based on the Swiss Business Census, concentration levels for all four-digit manufacturing industries in Switzerland are calculated. Then the effect of a bilateral reduction in technical barriers to trade with the European Union is estimated. Adopting a difference-in-differences approach, it turns out that concentration in affected industries with low R&D intensity increased significantly following the policy change. This supports the notion that fewer firms are able to survive as the toughness of price competition increases. The effect on industries with high R&D intensity is found to be insignificant.

2.1 Introduction

Industry concentration is a key variable to describe the structure of markets. While some industries consist of many firms with small market shares, others are dominated by a few large incumbents. What determines industry concentration in Switzerland and in general? Does an increasing openness to trade and a concurrent increase in the toughness of price competition affect concentration in Switzerland? This chapter makes use of a framework by Sutton (1991) to provide empirical evidence on these questions.

Modern microeconomic theory with its game-theoretical foundations provides industrial economists with an invaluable toolbox for analyzing the functioning of markets. An impressive variety of different models allows theorists to take the specificities of industries into account. Empirical studies combine these models with customized data sets and the latest econometric techniques. Such often sophisticated studies of individual industries are also referred to as the New Empirical Industrial Organization. Unfortunately, as Einav and Levin (2010) put it, "after 20 years of industry studies, we know *a lot* about how specific industries work, but this knowledge is extremely disaggregated" (p. 160). Few attempts have been made to aggregate the available knowledge. A notable exception is the work of Sutton (1991).[1] Sutton's approach is to formulate a number of results which hold across a broad range of game-theoretically sound models. As general as these results are in theory, they should also be robust across various industries empirically.[2] Still, empirical evidence on Sutton's framework is very limited so far.

A basic idea of Sutton's (1991) framework is the distinction between two types of industries: "exogenous sunk cost industries" and "endogenous sunk cost industries". In industries where sunk cost are exogenous, the sunk costs a firm has to incur when entering the market are independent of market size. This could be a minimum investment in infrastructure and employees. In industries where sunk costs are endogenous, by contrast, the sunk costs a firm has to incur to be able to compete for customers are higher for larger markets. Endogenous sunk costs are, for example, advertising or R&D expenditures. As market size increases, it becomes beneficial for firms to increase such expenditures and to serve a larger number of customers. In other words, endogenous sunk costs escalate in larger markets. The distinction between exogenous and endogenous sunk cost industries

[1] See Sutton (1998, 2007) and Shaked and Sutton (1982, 1987) for closely related studies.

[2] Cross-industry studies also evolved around the Structure–Conduct–Performance paradigm of Bain (1956). Most of these earlier studies, however, lacked the game-theoretical foundations and in particular the ability to take endogenous changes in market structure (such as concentration) into account.

has strong implications for the level of concentration. In exogenous sunk cost industries, as market size increases, more firms enter the market and concentration decreases. In very large markets, concentration thus is expected to converge to zero (Prediction 1). In endogenous sunk cost industries, however, this is not the case. As market size increases, also the sunk costs needed for entering the market increase. Thus, the number of firms in the market does not necessarily increase with market size and concentration does not decrease. Instead, concentration is bounded away from zero (Prediction 2).

A further prediction of Sutton's framework relates to the effects of (exogenous) changes in the toughness of price competition. Such changes may originate from changes in competition policy or international trade policy, for example. For exogenous sunk cost industries, it is predicted that an increase in the toughness of price competition moves the lower bound to industry concentration upwards. For a given market size, fewer firms are able to survive and exit the market or merge with other firms. As a consequence, industry concentration increases (Prediction 3).

This chapter provides empirical evidence on the robustness of Sutton's three predictions by using a unique full-sample of firms in Switzerland. First, concentration levels for 250 manufacturing industries at the four-digit level for the years 1995, 1998, 2001, 2005, and 2008 are calculated. Then, lower bounds to concentration are estimated. For R&D intensive industries it turns out that concentration is bounded away from zero as market size increases, while it converges to zero in other industries. This supports the notion that R&D expenditures are endogenous sunk costs which escalate in larger markets.

Subsequently, a "natural experiment" of trade facilitation is studied. Specifically, a Mutual Recognition Agreement (MRA) between Switzerland and the European Union (EU) is analyzed. Signed in 1999, approved in 2000, and enacted in 2002, the MRA eliminated important non-tariff barriers to trade between the two regions and justifiably increased price competition for firms in Switzerland (and, to a lesser extent, in the EU). As only a subgroup of industries is covered by the agreement, a difference-in-differences approach can be used to evaluate the impact of this increase in European competition on industry concentration in Switzerland. In line with Sutton's predictions, it turns out that concentration in affected industries with low R&D expenditures increased following the policy change. This supports the notion that fewer firms are able to survive and thus exit the market or merge. Remarkably, and in contrast to findings of previous empirical work (Symeonidis, 2000), concentration in affected industries with high R&D expenditures does not change significantly.

Previous studies have evaluated the robustness of Sutton's predictions in a number of settings. Concerning the first two predictions, Sutton (1991) presents evidence on twenty food and beverage industries, for which he compares concentration and market size across major economies. A study by Robinson and Chiang (1996) finds support using data on firms from a broader set of U.S. manufacturing industries, while Lyons, Matraves, and Moffatt (2001) analyze manufacturing industries in the European Union. All three studies rely on differences in advertising or R&D intensity to separate exogenous from endogenous sunk cost industries. Balasubramanian and Lieberman (2011) find evidence for a tighter lower bound to concentration for industries in which learning-by-doing is important, suggesting that learning-by-doing can be seen as an endogenous sunk cost, too. Turning to rather focussed industry studies, Berry and Waldfogel (2010) analyze concentration among restaurants and daily newspapers across U.S. metropolitan areas of varying size. In contrast to restaurants, for the newspaper industry it turns out that there is a lower bound on concentration as market size becomes large. The authors argue that newspaper quality is mostly produced with (endogenous) fixed costs such as a high number of good reporters. In a similar way of comparing geographical sub-markets, Ellickson (2007) and Dick (2007) show that Sutton applies to supermarkets and retail banking, respectively. Bronnenberg, Dhar, and Dubé (2009, 2011) study branded fast-moving consumer goods.

Finally, concerning Sutton's third prediction, Symeonidis (2000) analyzes the impact of price competition on industry concentration. Using the abolition of cartels in U.K. manufacturing industries around 1959 as a natural experiment, he finds that an increase in the intensity of price competition increases concentration in exogenous as well as endogenous sunk cost industries. Early evidence on a positive impact of competition on concentration through European integration is provided by Sleuwaegen and Yamawaki (1988). However, the study does not distinguish between the two types of industries.

The present chapter contributes to the existing literature with some important features. While most previous work studies Sutton's first two predictions, this chapter builds on an exogenous change in the toughness price competition to also study the effects of price competition on industry concentration. As in Symeonidis (2000), a rare "natural experiment" is exploited. Still, this chapter is different in two dimensions. While Symeonidis (2000) uses changes in competition policy as an exogenous shock to price competition, this chapter analyzes changes in international *trade* policy, where the toughness of price competition increases through an easier access to local markets for foreign firms.

Furthermore, while Symeonidis (2000) analyzes data on the United Kingdom from 1958 to 1977, this chapter analyzes very recent data on Switzerland from 1995 to 2008. It turns out that some results can be confirmed, while others are different to what Symeonidis (2000) finds. In sum, the present study constitutes a highly complementary piece of evidence.

The remainder of this chapter is organized as follows. Section 2.2 presents the data and introduces how variables are measured. Section 2.3 estimates lower bounds to concentration for different groups of industries in Switzerland. Section 2.4 evaluates the impact of an increase in price competition through European firms on industry concentration. Section 2.5 concludes and identifies potentially fruitful directions for future research.

2.2 Data and Measurement

The main data source used in this study is the census of all firm establishments in Switzerland, conducted by the Swiss Federal Statistical Office. For each establishment, it includes information on the number of employees, its firm affiliation (an anonymous identifier), and the industry it operates in. Industries are classified according to a five-digit level NOGA code. NOGA stands for Nomenclature Générale des Activités économiques (or General Classification of Economic Activities) and is the Swiss counterpart of the SIC and NAICS classification used in the United States. Up to the four-digit level, which is employed in this study, it is consistent with the NACE Rev. 1.1 system of the European Community. Years of observation are 1995, 1998, 2001, 2005, and 2008.

For each industry i and census year t, $Market\ Size_{it}$ is measured by the total number of full-time equivalent employees in that industry and that year. To measure industry concentration, a five-firm concentration ratio, $CR5_{it}$, defined as the sum of the market shares of the five largest firms in an industry, is calculated. Market shares are calculated by the number of full-time equivalent employees a firm has in all her plants taken together in a certain industry. Finally, for each industry i and census year t, $Setup\ Costs_{it}$ for a firm are measured by the size of the average plant operating in an industry in terms of full-time equivalent employees. Note that the five-firm concentration ratio is chosen to measure industry concentration in order to make this study best comparable to previous work. Section 2.4.3, however, also evaluates alternative measures of concentration.

To get an overview about market structure in Switzerland, Table 2.1 provides summary statistics for these variables, split up into manufacturing and services sector. The

Table 2.1: Summary statistics for concentration, market size, and setup costs

Manufacturing sample							
Variable	Year	Min.	Median	Mean	Std. Dev.	Max.	Obs.
CR5	1995	0.04	0.64	0.63	0.28	1.00	250
	1998	0.04	0.67	0.65	0.29	1.00	250
	2001	0.03	0.68	0.64	0.29	1.00	246
	2005	0.04	0.69	0.65	0.29	1.00	242
	2008	0.04	0.72	0.66	0.28	1.00	248
Market Size	1995	1.00	1,194.13	2,818.35	4,638.53	34,038.07	250
	1998	1.00	1,178.00	2,654.29	4,318.44	29,712.14	250
	2001	1.00	1,160.06	2,785.70	4,648.06	33,076.96	246
	2005	1.26	1,051.19	2,668.80	4,694.81	34,867.21	242
	2008	0.61	1,108.95	2,833.70	5,423.39	47,023.96	248
Setup Costs	1995	1.00	18.62	35.15	60.73	681.14	250
	1998	1.00	21.03	34.87	43.26	335.89	250
	2001	0.82	22.99	32.29	33.86	225.08	246
	2005	1.20	22.25	31.42	33.79	245.31	242
	2008	0.61	22.20	32.16	34.30	225.00	248
Services sample							
Variable	Year	Min.	Median	Mean	Std. Dev.	Max.	Obs.
CR5	1995	0.02	0.27	0.34	0.26	1.00	235
	1998	0.02	0.29	0.36	0.26	1.00	235
	2001	0.02	0.30	0.36	0.25	1.00	235
	2005	0.02	0.30	0.36	0.25	1.00	235
	2008	0.02	0.30	0.36	0.25	1.00	235
Market Size	1995	18.47	3,334.31	10,113.02	18,701.72	120,366.00	235
	1998	2.00	3,267.68	9,924.94	17,540.36	112,724.30	235
	2001	2.00	3,524.89	10,515.50	18,321.76	116,709.20	235
	2005	10.29	3,513.88	10,607.92	18,405.95	125,960.10	235
	2008	18.00	3,890.74	11,462.62	19,688.94	133,396.30	235
Setup Costs	1995	1.28	5.91	10.25	15.82	199.04	235
	1998	1.18	5.95	10.82	16.26	188.50	235
	2001	1.07	6.00	12.60	26.37	290.47	235
	2005	1.31	6.20	12.80	24.65	248.44	235
	2008	1.33	6.66	13.35	25.45	307.36	235

Notes: Table 2.1 presents basic summary statistics for the five-firm concentration ratio *CR5*, market size, and setup costs. The sample is split up into manufacturing and services sector; for each sector, the table presents an industry minimum, median, mean (with standard deviation), and maximum by year. An observation corresponds to one four-digit NOGA industry. All measures are calculated based on the number of full-time equivalent employees in an industry. In some years, there were no active firms in a few manufacturing industries, leading to a number of observations lower than 250.

manufacturing sample comprises 242 to 250 four-digit NOGA industries, depending on the year (in some years, there were just no active firms in a few industries). In the year 2001, for example, the five-firm concentration ratio among 246 industries ranges from 3 to 100 percent. The median industry has a five-firm concentration ratio of 68 percent. Market size ranges from 1 to about 33,077 full-time equivalent employees, with a median of 1,160. Setup costs range from 0.82 to about 225 full-time equivalent employees, with a median of 23. The services sample comprises 235 four-digit industries. In the year 2001, the five-firm concentration ratio ranges from 2 to 100 percent, with a median of 30 percent. Market size ranges from 2 to 116,709 full-time equivalent employees, with a median of 3,525. Setup costs range from 1.07 to about 290 full-time equivalent employees, with a median of 6. Overall, the median services industry has about three times the market size as the median manufacturing industry, while the median concentration is less than half as high. Median setup costs in the services sample are only one quarter of those in the manufacturing sample.

In line with previous work, this study refers to ln(*Market Size/Setup Costs*) as an adjusted measure of market size to make market size comparable across industries. In a similar manner, it refers to concentration as $\ln\left(CR5/(1-CR5)\right)$, a logit transformation of *CR5*. Observations with $CR5 > 0.99$ are dropped from the sample to allow for the transformation. This reduces the sample by up to 38 industries per Census year, but dropped industries are typically not decisive for the lower bounds that are estimated.

Some data limitations should be noted. First of all, variables are measured by the number of full-time equivalent employees due to the fact that sales figures are unavailable. As noted by Sleuwaegen and Yamawaki (1988), who also rely on employment measures, this might understate the true level of concentration. Industries with high concentration and large firms are typically less labor-intensive than industries with low concentration and small firms. As a second limitation, measuring variables at a country-wide four-digit industry level might not capture the relevant market exactly in all cases. Having such limitations in mind, however, the present data set allows a highly comprehensive and "transparent" analysis.

The predictions this chapter analyzes depend on the nature of sunk costs in an industry. To distinguish between exogenous sunk cost industries and endogenous sunk cost industries in the manufacturing sector, this chapter relies on a Eurostat/OECD classification as presented in Table 2.6 in the appendix. Manufacturing industries at the three-digit NACE/NOGA level are classified into four groups of technology intensity:

High-technology, Medium-high-technology, Medium-low-technology, and Low-technology. Technology intensity is calculated by the ratio of R&D expenditure to value added in each industry. In the following, industries from the High-technology group are referred as endogenous sunk cost industries. Alternatively, industries from the Medium-high-technology group are also included in the group of endogenous sunk cost industries to check the robustness of this classification. Industries without R&D information are dropped from the sample (which are up to 5 further industries per year). Note that this classification results from European averages of R&D expenditures and might not exactly match corresponding values in Switzerland. As only an ordinal ranking of industries is required here, this should be less of an issue, however.

A final data source used in this study is the list of industries which are covered by the Mutual Recognition Agreement between Switzerland and the European Union. The original list is provided in the official agreement text, EC (2002). Using further documentations, this list of industries has been carefully matched to corresponding Swiss NOGA industries at the four-digit level in Chapter 1 of this dissertation, which is ultimately also used in the present study to classify industries as either "treated" or "not treated". More on the underlying agreement can be found in Section 2.4.

2.3 Lower Bounds to Industry Concentration

In this section lower bounds to the level of industry concentration are calculated. These bounds are intended to provide evidence on the validity of two predictions: First, the lower bound to observed concentration across a group of exogenous sunk cost industries converges to zero as market size increases. Second, across endogenous sunk cost industries, this lower bound is tighter for larger market sizes and does not converge to zero.

To begin with, assume a scatter plot of industries, where the y axis shows a measure of concentration and the x axis a measure of market size for each industry. This chapter first follows Sutton (1991) and imposes $y = a + b/x$ as the functional form of the lower bound, where a and b are parameters to be estimated. In particular, the following constraint optimization problem for a scatter plot of N industries is solved (Giorgetti, 2003):

$$\begin{aligned} \min_{a,b} \quad & \sum_{i=1}^{N} (y_i - a - b/x_i) \\ \text{s.t.} \quad & y_i - a - b/x_i \geq 0, \forall i = 1...N \end{aligned} \tag{2.1}$$

where $y_i = \ln(CR5_i/(1 - CR5_i))$ and $x_i = \ln(Market\ Size_i/Setup\ Costs_i)$. Technically, Matlab's `linprog` function, using a simplex algorithm, can solve such a problem.

Figure 2.1 presents a scatter plot of Swiss manufacturing industries, where industries are split up into two groups.[3] The first group contains manufacturing industries with typically high R&D expenditures (or at least medium-high R&D expenditures as in the lower illustration). Industries in that group can be classified as endogenous sunk cost industries. The second group contains manufacturing industries with typically low or medium-low R&D expenditures. As advertising-intensive industries are not excluded due to data limitations here, not all industries in that group can be classified as exogenous sunk cost industries. However, all exogenous sunk cost industries should be in that group. For both groups a lower bound for the level of concentration is estimated following the preceding method.

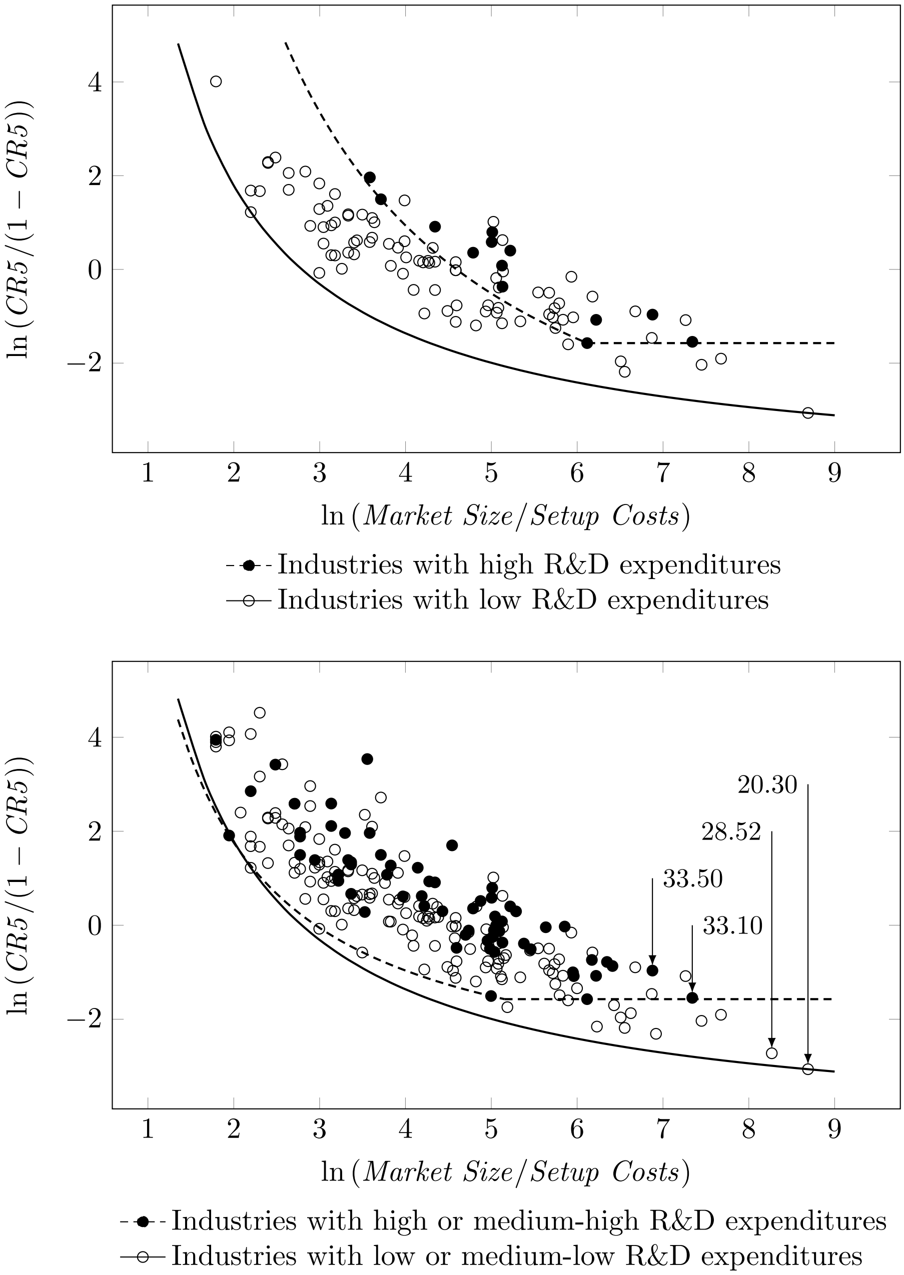
For the group of industries with low or medium-low R&D intensity, the estimated lower bound follows the function $y = -4.5138 + 12.6016/x$. From a visual observation it turns out that the fit of this function (illustrated as a solid line) is appropriate for the data. According to the estimated function, the five-firm concentration ratio converges to a value 0.01 as market size over setup costs approaches infinity.[4] Note that the smallest *observed* CR5 value in the evaluated group is 0.04. Notably, it belongs to the industry with the largest market size over setup costs ratio.

For the group of industries with high R&D intensity, i.e. the group of endogenous sunk cost industries, the lower bound estimated by the above method would follow the function $y = -6.3180 + 29.0211/x$. If medium-high R&D intensive industries are included in this group it would follow $y = -3.6845 + 10.8844/x$. As Figure 2.2 in the appendix illustrates for the latter case, taken as is, both functions seem to be an inappropriate fit to the scatter plot in the light of Sutton's theory, however. A potential lower bound can hardly be captured by the imposed functional form. The problem to fit a function of the form $y = a + b/x$ to endogenous sunk cost industries has already been encountered by Robinson and Chiang (1996). In their paper, the authors suggest to estimate a function of the form $y = a + b/x + c/x^2$ instead. This does not solve the problem in our case, however. Also an attempt to follow Giorgetti's (2003) approach and using quantile regression instead of the above method leads to unsatisfactory results (again, see Figure 2.2 in the appendix).

[3] Figure 2.1 is based on 1995 data. As Figure 2.3 in the appendix shows, results are qualitatively the same for the other available census years, 1998, 2001, 2005, and 2008.

[4] The function $y = \ln(CR5/(1 - CR5)) = -4.5138 + 12.6016/x$ converges to $a = -4.5138$ as x approaches infinity. The value to which $CR5$ converges as market size over setup costs gets large can thus be calculated by rearranging $\ln(CR5/(1 - CR5)) = -4.5138$ to $CR5 = e^{-4.5138}/(1 + e^{-4.5138}) \approx 0.01$.

Figure 2.1: Lower bounds to industry concentration by R&D expenditures in 1995



Notes: Figure 2.1 shows the estimated lower bounds to industry concentration for different groups of Swiss manufacturing industries in the year 1995. While in the first illustration high and low R&D expenditure industries are compared, in the second illustration also industries with medium-high and medium-low R&D expenditures are included. The five-firm concentration ratio for high R&D industries, the group of endogenous sunk cost industries, is clearly bounded away from zero (at $CR5 = 17.2$ percent) as market size over setup costs increases. This is not the case for the group of other industries. The two largest industries in each group are highlighted by their NOGA code (see main text for details).

Ultimately, this paper proposes a lower bound function with two domains of definition to get a more appropriate fit to the present data: The function follows the simplex estimated function up to the lowest observed concentration level and then takes the form of a straight line for higher values of market size over setup costs. Although this is not overly elegant in terms of computation, it is in line with Sutton's broader idea and convenient for the objective of this section to provide descriptive evidence. The result is presented in Figure 2.1. Overall, the observed lower bound is well in line with Sutton's prediction: concentration is bounded away from zero at a five-firm concentration ratio of $CR5 = 17.2$ percent.

Finally, to make the analysis in this section more transparent, it seems worthwhile to reveal the identity of some industries which play a decisive role. As highlighted in Figure 2.1, for the group of endogenous sunk cost industries with high or medium-high R&D intensity, the largest industries are "Manufacture of medical and surgical equipment and orthopaedic appliances" (NOGA industry code 33.10) and "Manufacture of watches and clocks" (33.50). For other industries, these are "Manufacture of builders' carpentry and joinery" (20.30) and "General mechanical engineering" (28.52).

2.4 The Impact of Trade Policy on Concentration

This section studies the impact of European competition on industry concentration in Switzerland. A general prediction of Sutton's (1991) theory is that an (exogenous) increase in the toughness of price competition shifts the lower bound to industry concentration upwards. An increasing openness of the local market to foreign firms is one institutional channel through which price competition might increase.[5] Thus, an increasing European competition is predicted to increase concentration in Swiss industries which are affected.

Here, a natural experiment is studied where trade barriers for firms operating in certain industries have been reduced. As indicated in Sections 2.1 and 2.2, between Switzerland and the European Union a Mutual Recognition Agreement (MRA) has been

[5]As indicated before, a second channel would be an increase in the toughness of competition policy, as studied by Symeonidis (2000). In the time period relevant to this study, however, it is reasonable to assume that competition policy only played a negligible role for the manufacturing sector. A report by Worm et al. (2009) analyzes the outcomes of the Swiss Cartel Act between 1999 and 2006 and shows that nearly all investigation openings related to "unlawful agreements affecting competition" (Art. 5 CartA) or "unlawful practices by dominant undertakings" (Art. 7 CartA) took place in the services sector (p. 50). Buehler, Kaiser, and Jaeger (2005) evaluate the impact of changes in Swiss competition law in 1996 on the exit rates of firms. Significant effects that would persist from 1995 to 1998 do not become apparent.

signed in 1999, approved in 2000, and enacted in 2002. The MRA eliminated important non-tariff barriers to trade, which are related to the conformity assessment of products. To insure consumer safety and environmental standards, before the MRA products had to be certified in both regions individually to be marketed. With the MRA, one assessment became enough, considerably reducing market-entry costs for affected firms. Presumably, price competition increased for firms operating in Swiss industries which were covered by the agreement. Chapter 1, which studies vertical integration decisions of firms in the light of the MRA, provides a more detailed description of the agreement. This also includes a careful classification of all Swiss four-digit manufacturing industries into industries which are covered by the agreement ("treated"), and industries which are not covered by the agreement ("not treated"). The same classification is used here.

As the previous section confirmed some fundamental differences between industries with high and low R&D intensity, also this section distinguishes between the two types. In particular, results are reported separately for the two sub-samples of industries.

2.4.1 Empirical Methodology

Turning to the econometric approach, the five census year data sets are pooled as independent cross-sections into a single data set. Then, to identify the effect of interest a difference-in-differences approach is used. In particular, a linear model of the form

$$\begin{aligned} \mathit{CR5} = \alpha &+ \beta_1 \mathit{After} + \beta_2 \mathit{Treatment} + \beta_3 (\mathit{After} \times \mathit{Treatment}) + \\ &+ \beta_4 \ln(\mathit{Market\ Size}) + \beta_5 \ln(\mathit{Setup\ Costs}) + \\ &+ \gamma_1 y95 + \gamma_2 y05 + \gamma_3 y08 + X'\delta + u \end{aligned} \tag{2.2}$$

is estimated, where *CR5* denotes the five-firm concentration ratio, *Treatment* indicates whether an industry is affected by trade facilitation or not, *After* denotes a dummy variable that equals 1 for an observation after the treatment (2001 or later), ln(*Market Size*) measures market size, ln(*Setup Costs*) measures the setup costs in an industry, and X' is a vector of additional controls, including dummy variables for all four-digit NOGA industries. The variable of interest is the interaction term *After* × *Treatment* whose coefficient β_3 measures the effect of trade facilitation on average industry concentration. Corresponding to our hypothesis, it is expected that $\beta_3 > 0$, that is, trade facilitation leads to a higher level of industry concentration. u denotes an error term.[6]

Finally, an important assumption which is made by using the above model should be noted. While Sutton's theory refers to lower bounds to industry concentration, here it is assumed that corresponding effects can also be seen in average industry concentration.[7]

2.4.2 Results

Table 2.2 presents the baseline regression results, whereby the sample has been split up into industries with low or medium-low R&D intensity and industries with high or medium-high R&D intensity. For both sub-samples, it turns out that market size has a negative impact on concentration, while setup costs have a positive impact on concentration. Thus, the downward sloping property of the lower bounds that are estimated above is also reflected in averages. Most notable, the coefficient for *After* × *Treatment* is positive and significant for low or medium-low R&D industries, indicating that the trade facilitation under study lead to an average increase in the five-firm concentration ratio of about 2.41 percentage points. For industries with high or medium-high R&D intensity, the effect is insignificant. This is in contrast to Symeonidis (2000), who finds a positive effect on concentration for exogenous *and* endogenous sunk cost (high R&D) industries.

Table 2.2: Effects of European competition on industry concentration (manufacturing)

	Dependent variable: *CR5*	
	(1)	(2)
Independent variable	Low or medium-low R&D	High or medium-high R&D
After × *Treatment*	0.0241**	0.0034
	(0.011)	(0.014)
ln(*Market Size*)	-0.1518***	-0.0751***
	(0.014)	(0.022)
ln(*Setup Costs*)	0.2266***	0.2021***
	(0.017)	(0.027)
Constant, *After*, *Treatment*	Yes	Yes
Year dummies	Yes	Yes
Industry dummies	Yes	Yes
Observations	712	326
R-squared	0.968	0.962

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

[6]Note that a fixed-effects model using panel data leads to very similar results. Furthermore, as revealed by a Hausman test, a random-effects model is less appropriate for most specifications.

[7]Note that Symeonidis (2000) and Sleuwaegen and Yamawaki (1988) also rely on averages.

For the group of industries with low or medium-low R&D intensity, Sutton's (1991) theory as sketched above provides a convincing explanation of these results. Trade liberalization increases the toughness of price competition for firms in Switzerland. Thus, fewer firms are able to compete and exit the market or merge with other firms. As a consequence, industry concentration increases. For the group of industries with high or medium-high R&D intensity, things are less obvious. As already noted by Symeonidis (2000), previous theory is inconclusive about the effects of competition on concentration in endogenous sunk cost industries. Loosely speaking, if R&D expenditures would not change, the same prediction as for other industries should hold and concentration should increase. However, if the endogenous sunk costs decrease simultaneously with trade barriers, concentration might well decrease or not change at all, depending on which effect dominates. Given the ordinal and time-invariant nature of how R&D intensity is measured here, a more detailed analysis has to be reserved for future work with very detailed information on R&D expenditures.

2.4.3 Robustness

In the following three robustness checks are performed. First, it is evaluated whether results are consistent for alternative split-ups of the sample. Second, evidence on the validity of the common trend assumption, that underlies the baseline specification, is provided. Third, alternative measures of concentration are evaluated.

Table 2.3: Effects on industry concentration by R&D expenditure (detailed)

	Dependent variable: *CR5*			
Independent variable	(1) Low R&D	(2) Med.-low R&D	(3) Med.-high R&D	(4) High R&D
After × *Treatment*	0.0221*	0.0145	0.0106	0.0018
	(0.013)	(0.023)	(0.015)	(0.033)
ln(*Market Size*)	-0.1783***	-0.1268***	-0.0899***	0.0004
	(0.019)	(0.019)	(0.022)	(0.062)
ln(*Setup Costs*)	0.2710***	0.1836***	0.1967***	0.1979**
	(0.024)	(0.022)	(0.027)	(0.074)
Constant, *After*, *Treatment*	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes
Observations	429	283	261	65
R-squared	0.960	0.978	0.966	0.948

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2.3 splits up industries into four, more detailed sub-samples: industries with low, medium-low, medium-high, and high R&D intensity. The coefficient for *After* × *Treatment* is very small and insignificant for the group of industries with high R&D intensity (0.0018). The magnitude of the coefficient increases when looking at industries with medium-high (0.0106) and medium-low R&D intensity (0.0145), being the highest for industries with low R&D intensity (0.0221). In the latter sub-sample, in addition, the effect gets significant at the ten percent level. These patterns of increasing magnitude are well in line with the theory outlined above. Remarkably, for high R&D industries, the negative relationship between market size and concentration breaks down; the coefficient gets almost zero and highly insignificant. The latter phenomenon has also been observed by Symeonidis (2000).

Table 2.4: Effects on industry concentration over time

	Dependent variable: *CR5*	
	(1)	(2)
Independent variable	Low or medium-low R&D	High or medium-high R&D
y98 × *Treatment*	0.0092	-0.0041
	(0.018)	(0.024)
y01 × *Treatment*	0.0304*	-0.0052
	(0.017)	(0.024)
y05 × *Treatment*	0.0238	-0.0092
	(0.018)	(0.025)
y08 × *Treatment*	0.0318*	0.0187
	(0.019)	(0.026)
ln(*Market Size*)	-0.1517***	-0.0747***
	(0.014)	(0.022)
ln(*Setup Costs*)	0.2265***	0.2022***
	(0.017)	(0.027)
Constant, *Treatment*	Yes	Yes
Year dummies	Yes	Yes
Industry dummies	Yes	Yes
Observations	712	326
R-squared	0.968	0.963

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 2.4 shows the results for a modified specification that is more flexible in the time dimension. In particular, it provides evidence on the validity of the common trend assumption, which underlies the econometric specification employed in the baseline model. It is assumed, that if there were no treatment, the group of treated and control industries would have experienced the same common trend in industry concentration. This common trend assumption is important for having a valid comparison group but, as the policy change actually took place, can never been proven. Still, by looking at pre-treatment outcomes, at least some validity check can be provided. With the results shown in Table 2.4, for the group of low or medium-low R&D intensive industries, it turns out that before the treatment (from 1995 to 1998), changes in concentration for treated industries are only very small and insignificant. After the treatment, by contrast, the largest increase in concentration between census years takes place between 1998 and 2001. This is very much in line with the notion that the increase in concentration is indeed caused by the policy change under study and does not result from general trends in concentration levels. Finally, note that concentration in treated industries does never become significantly different from 1995 levels, when looking at high or medium-high R&D intensive industries. It thus seems unlikely, for example, that in endogenous sunk cost industries, there is just a time lag in the adjustment of concentration.

Table 2.5: Effects on alternative measures of industry concentration

	Independet variable: *After* × *Treatment*	
Dependent variable	(1) Low or medium-low R&D	(2) High or medium-high R&D
CR1	0.0209	-0.0035
	(0.016)	(0.021)
CR2	0.0228*	0.0042
	(0.014)	(0.020)
CR3	0.0192	0.0075
	(0.013)	(0.017)
CR4	0.0210*	0.0061
	(0.012)	(0.015)
CR5 (baseline specification)	0.0241**	0.0034
	(0.011)	(0.014)
CR6	0.0228**	0.0041
	(0.010)	(0.014)
CR7	0.0234**	-0.0021
	(0.010)	(0.013)
CR8	0.0233**	-0.0005
	(0.009)	(0.013)
CR9	0.0227***	-0.0009
	(0.008)	(0.012)

Notes: Table 2.5 reports the coefficient for *After* × *Treatment* when estimating equation (2.2) with alternative dependent variables. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. While significance levels vary, magnitudes are fairly robust across alternative concentration measures.

Finally, a concern might be that the results of the above baseline specification are only valid for the specific concentration measure that is employed. Table 2.5 thus explores different measures of industry concentration. In addition to the treatment effect on the five-firm concentration ratio (0.0241), it also shows the effect on eight alternative concentration ratios. Overall, while significance levels vary (for one- and three-firm concentration ratios the effect is insignificant, for the nine-firm concentration ratio it is significant at the one percent level), magnitudes turn out to be fairly robust across alternative concentration measures.

2.5 Concluding Remarks

This paper provided empirical evidence on the robustness of Sutton's (1991) "bounds" prediction, using a unique and recent data set on manufacturing industries in Switzerland. As predicted, for R&D intensive industries it turns out that concentration is bounded away from zero as market size increases, while it converges to zero in other industries. With industries classified at the four-digit NOGA level and concentration measured by a five-firm concentration ratio, the lower bound for R&D intensive industries lies between 17.2 and 19.2 percent, depending on the year of observation. This supports the notion that R&D expenditures are endogenous sunk costs which escalate in larger markets.

This paper also evaluated the impact of an increase in the toughness of European competition on industry concentration in Switzerland. Following a natural experiment of trade facilitation between Switzerland and the European Union, concentration in affected R&D intensive industries does not change significantly, while it increases in affected industries with low R&D intensity. In the policy change under study, the increase in industry concentration amounts to up to 2.41 percentage points. This result is well in line with the idea that with an increase in price competition through foreign firms, fewer local firms are able to survive and thus exit the market or merge with other firms. Results turn out to be robust to an alternative, more detailed split-up of industries, and also effects over time are in line with the interpretation. Findings for alternative measures of industry concentration turn out to be comparable in magnitude and mostly significant.

A question which remains open to future research is why there is no significant change for endogenous sunk cost industries with high R&D expenditures. While Symeonidis (2000) finds a positive effect of competition on concentration for both types of industries, this study can only confirm such an effect for industries with low R&D intensity. To answer the question, more detailed data on R&D expenditures, including their changes over time, would be helpful. Also the consideration of advertising expenditures as an alternative type of endogenous sunk costs, could provide valuable further insights.

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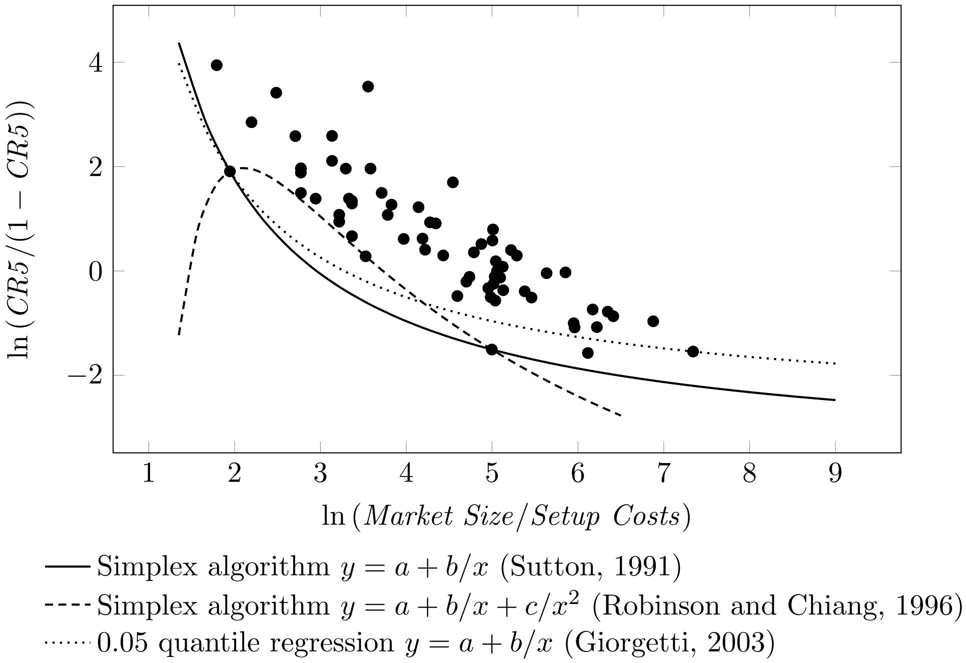
Appendix

Table 2.6: R&D intensity classification of manufacturing industries

Technology intensity	Industries
High-technology	24.4 Manufacture of pharmaceuticals, medicinal chemicals and botanical products; 30 Manufacture of office machinery and computers; 32 Manufacture of radio, television and communication equipment and apparatus; 33 Manufacture of medical, precision and optical instruments, watches and clocks; 35.3 Manufacture of aircraft and spacecraft
Medium-high-technology	24 Manufacture of chemicals and chemical product, excluding 24.4 Manufacture of pharmaceuticals, medicinal chemicals and botanical products; 29 Manufacture of machinery and equipment n.e.c.; 31 Manufacture of electrical machinery and apparatus n.e.c.; 34 Manufacture of motor vehicles, trailers and semi-trailers; 35 Manufacture of other transport equipment, excluding 35.1 Building and repairing of ships and boats and excluding 35.3 Manufacture of aircraft and spacecraft.
Medium-low-technology	23 Manufacture of coke, refined petroleum products and nuclear fuel; 25 to 28 Manufacture of rubber and plastic products; basic metals and fabricated metal products; other non-metallic mineral products; 35.1 Building and repairing of ships and boats.
Low-technology	15 to 22 Manufacture of food products, beverages and tobacco; textiles and textile products; leather and leather products; wood and wood products; pulp, paper and paper products, publishing and printing; 36 to 37 Manufacturing n.e.c.

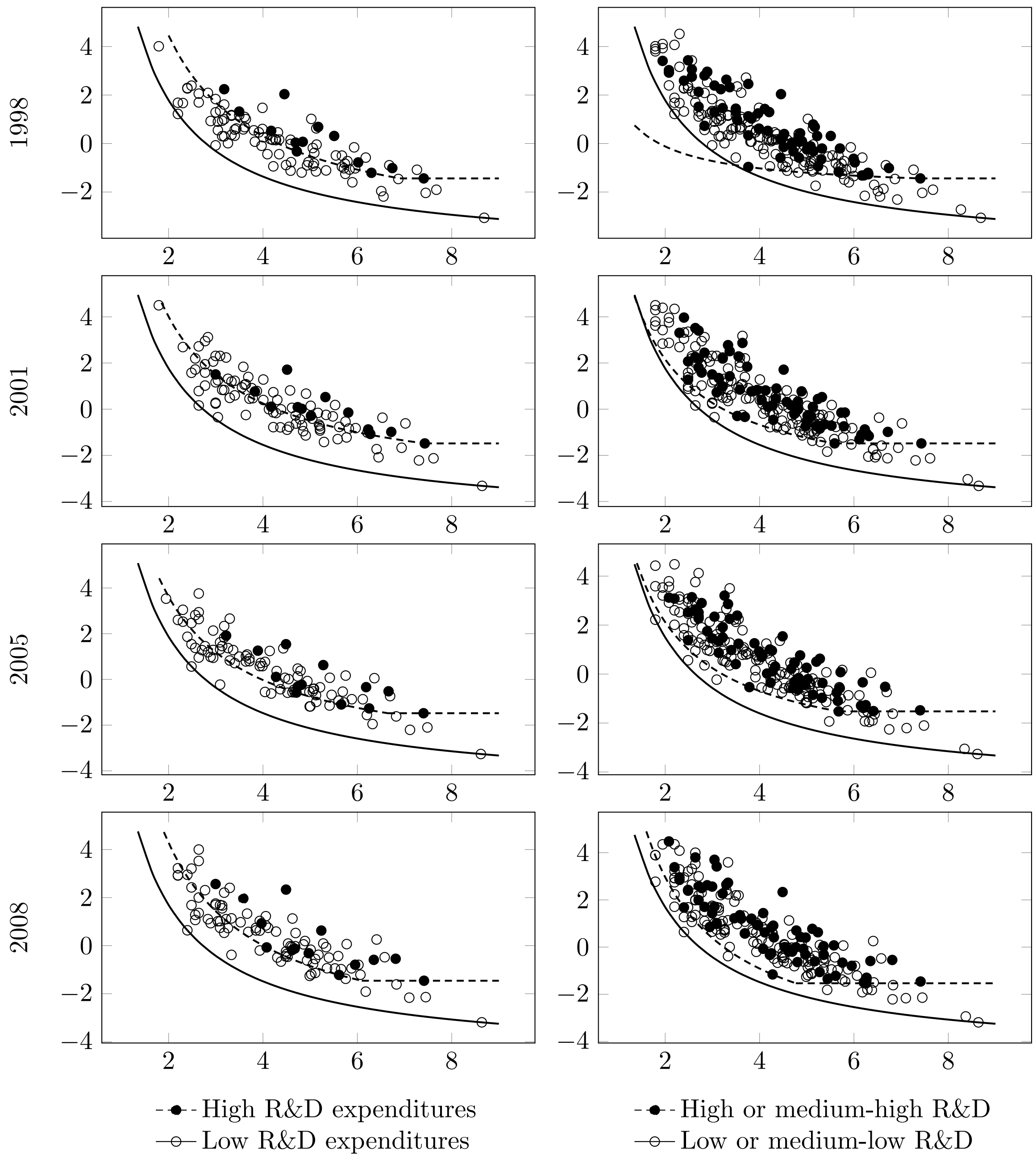
Notes: Table 2.6 shows the OECD/Eurostat classification of manufacturing industries into global levels of technology intensity, measured by the ratio of R&D expenditure to value added. Source: Eurostat (2011); also see Hatzichronoglou (1997) for details on the calculation method.

Figure 2.2: Lower bounds for R&D intensive industries (alternative estimates)



Notes: Figure 2.2 shows alternative lower bound estimates to concentration for the group of endogenous sunk cost industries (with high or medium-high R&D expenditures) in the year 1995. The estimation methods applied follow the ideas of Sutton (1991), Robinson and Chiang (1996), and Giorgetti (2003). For the present data, it seems that none of the techniques can capture a sharp lower bound appropriately.

Figure 2.3: Lower bounds to industry concentration in 1998, 2001, 2005, and 2008



Notes: Figure 2.3 reports lower bounds to industry concentration for the years 1998, 2001, 2005, and 2008. As in Figure 2.1, which shows the corresponding picture for 1995, industries are split up by R&D expenditures. For each year and industry, the vertical axis shows the concentration measure $\ln(CR5/(1-CR5))$, while the horizontal axis shows the adjusted market size measure $\ln(\textit{Market Size}/\textit{Setup Costs})$. It turns out that the distinctive appearance of low and high R&D industries remains robust over the analyzed period of 13 years: while the lower bound for low R&D industries converges to zero (*CR5*), for high R&D industries it is bounded away from zero as market size increases. The minimum *CR5* values for high R&D industries in 1998, 2001, 2005, and 2008, are 19.2, 18.5, 18.5, and 18.9 percent, respectively.

Chapter 3

Employment Growth in the Course of Mergers and Acquisitions

Dirk Burghardt and Marco Helm

Abstract In the process of mergers and acquisitions, employees are an important stakeholder group. Previous research, however, is mostly concerned with the value creation for shareholders. This chapter examines the effect of mergers and acquisitions on employees in newly acquired firm establishments. Using a unique census data set on firms in Switzerland, we find that the relative size of a deal, acquiring in export-oriented industries, and acquiring in related industries have adverse effects on employment growth. Being new to the literature we attribute the deal size effect to resource constraints of acquiring firms: with high acquisition costs hiring additional employees is restricted and vice versa. This chapter also contributes to a controversial debate on firm growth in general by rejecting Gibrat's Law of proportionate growth for firm establishments in Switzerland.

3.1 Introduction

A firm's employees are an important stakeholder group in the process of mergers and acquisitions. Acquiring firms are concerned about the cultural fit between old and new parts of the workforce, and additional employees increase management complexity. Furthermore, new points of personal contact and cooperation need to be established. At the same time, the employees of the target firm undergo reorganizations and face a new employer with different standards and expectations. The resulting insecurity is even more intense with the involvement of foreign investors. In some cases, the situation even turns into a public policy concern through public demonstrations by employees who feel threatened with mass layoffs. Apart from anecdotal evidence, however, very little is known about how mergers and acquisitions affect the employment in newly acquired target firms.[1]

This chapter uses a unique complete inventory count of firm establishments in Switzerland to study the changes in employment in the course of mergers and acquisitions.[2] Out of about 350,000 establishments that constitute the Swiss services and manufacturing sector in the year 2001, we identify 5,389 firm establishments that were acquired by another firm in the subsequent four years. This number also includes very small plants, which are typically disregarded in other studies. Our empirical model relates the growth in employment of each establishment to a number of explanatory variables: at first, variables which have been identified as general growth determinants by the literature, such as the initial size or the age of an establishment, are included. More importantly, we investigate how the status of being "recently acquired" influences growth outcomes. To cope with endogeneity concerns, in a robustness check we employ the idea that among multi-plant mergers—where not just one but several different plants are acquired at the same time—the acquisition of an individual plant can be treated as exogenous.

Four results stand out. First, we find that the growth of (surviving) firm establishments decreases with their initial size and age. For establishments in Switzerland, we can thus reject Gibrat's Law of proportionate growth. The next section will show how this result contributes to an ongoing discussion on the growth of firms and firm establishments in general. Second, turning to the analysis of mergers and acquisitions, we find that the

[1] A vast amount of research does exist, however, on the effects of mergers and acquisitions on shareholder value. This includes Fuller, Netter, and Stegemoller (2002), Graham, Lemmon, and Wolf (2002), and Moeller, Schlingemann, and Stulz (2005). See Martynova and Renneboog (2008) for a survey.

[2] By firm establishment, establishment or plant the present study refers synonymously to a building or building complex of a firm which can either be a single-plant firm, the headquarters of a multi-plant firm, or a companion plant of a multi-plant firm.

size of the acquiring firm is positively related to the growth of a newly acquired plant, while the (combined) size of the newly acquired establishments is negatively related to its growth. In other words, the size differential between acquirer and target is an important determinant for the internal growth of a newly acquired establishment's workforce. This finding is new to the literature. There are several possible explanations, such as that the acquiring firm has constrained resources, which means that with high acquisition costs, hiring additional employees is financially restricted and with lower acquisition costs, hiring additional employees is comparatively unrestricted. Furthermore, managerial capacities may be exhausted and thus hiring tasks delayed. It is also possible that with relatively large acquisitions, firms simultaneously increase their market power to a larger extent. Subsequent production is thus reduced, requiring less employees. Third, mergers and acquisitions in export-oriented industries and within related industries are associated with adverse effects on employment growth. These findings may result from a higher competitive pressure in export industries and more possibilities for streamlining measures when similar businesses merge. Fourth, we find that foreign-owned plants on average grow more rapidly than other plants which might be related to a technology transfer from their foreign owners. Foreign acquisitions of previously Swiss owned plants do not exhibit significant differences in growth outcomes compared to other acquisitions.

The remainder of this chapter is structured as follows. Section 3.2 presents some theoretical considerations and provides a brief review of the strands of literature this study contributes to. Section 3.3 describes our data. Section 3.4 introduces the empirical model. Section 3.5 provides our regression results and their discussion. Section 3.6 presents some further robustness checks. Section 3.7 concludes, and suggests directions for future research.

3.2 Related Literature

Our first result—on the relationship between the growth of an establishment and its initial size and age—contributes to an ongoing discussion on the growth of firms and firm establishments in general. It is preparatory to analyzing how mergers and acquisitions are related to growth outcomes. The debate on firm growth may have started with the formulation of Gibrat's Law of proportionate growth in 1931. Gibrat (1931) stated that the growth of a firm or of an establishment is uncorrelated with its initial size. This (nonexisting) relationship between initial size and growth was intended to be helpful for the mathematical modeling of firm dynamics. Indeed, Gibrat (1931) found it to be empirically true for his data on French manufacturing establishments in 1920 and 1921. Other early studies accepted his findings at least as a first approximation (see Sutton (1997) for a survey).

Later studies, by contrast, tend to find an inverse relationship between growth and size or age—at the firm level (Hall, 1987; Evans, 1987a,b; Dunne and Hughes, 1994; Harhoff, Stahl, and Woywode, 1998) as well as at the level of individual establishments (Dunne, Roberts, and Samuelson, 1989; Blonigen and Tomlin, 2001).[3] An explanation for this inverse relationship is the theory of learning over time, as proposed by Jovanovic (1982). This study is the first to provide empirical evidence for Switzerland. In addition, it is one of the few that also take into account the services sector and very small firms.

Our second result—on the effect on employment growth of the size differential between the acquirer and the target—extends the previous empirical literature which analyzes the employment effects of mergers and acquisitions by an important determinant. So far, a coherent theory that predicts the employment effects of mergers and acquisitions does not exist. The reason might be that it is indeed difficult to capture all relevant mechanisms within a single theoretical model. Individual mergers take place for different motives, implying also different effects on employment. A study by Andrade, Mitchell, and Stafford (2001) classifies the possible reasons for mergers and acquisitions into five categories: 1. efficiency related reasons, 2. the creation of market power, 3. market discipline, 4. agency costs, and 5. opportunities for diversification. Suppose, for example, a merger takes place for efficiency related reasons. Typically, this implies that there exist overlapping job functions that can be cut. In the course of the merger, employment then gets reduced in order to realize the intended efficiency gains. Suppose, by contrast, two businesses merge because of the empire building tendencies of their managers as a particular form of agency costs. The managers are then interested in hiring even more employees for the newly acquired plant. Suppose, as a third example, firms use mergers as a vehicle to diversify their range of products. In an extreme case of very different products, there are no overlapping job functions that could be cut. For such mergers, we would expect that employment does not change at all.

Previous empirical studies indeed provide a mixed picture concerning the overall effect of mergers and acquisitions on employment. A number of studies find negative effects

[3]Note that total firm growth can be decomposed into internal establishment growth and external growth through the acquisition of additional establishments. Thus, the results for aggregate internal establishment growth are not necessarily equivalent to firm growth.

of corporate takeovers on employment. Conyon et al. (2002) suggest that firms in the United Kingdom reduce joint output as well as their overall use of labor after a merger. For related firms and hostile mergers, these effects are found to be particularly strong. Gugler and Yurtoglu (2004) find no significant effect for firms in the United States, but negative effects for firms in Europe. They attribute this difference to more rigid labor markets in Europe. Also a study by Bhagat et al. (1990) falls into the group of studies which find negative employment effects of corporate takeovers. In addition, they observe that white-collar employees are disproportionately affected by layoffs, many of them due to consolidations of headquarters. In a similar manner, Lichtenberg and Siegel (1990) differentiate between production establishments and auxiliary establishments where top managers, administrators, and R&D personnel are employed. According to their study, ownership changes lead to a much lower employment growth in auxiliary establishments compared to production establishments.

Mixed effects depending on the type of acquisition are found in a sample of US manufacturing firms in the state of Michigan by Brown and Medoff (1988). They define three types of acquisition: asset-only sales, where ownership changes take place without integration with another firm; simple sales, where firms acquire assets of other firms without absorbing the workforce; and mergers, where most workers of the acquired firm are absorbed or combined with those of the acquirer. For firms that are part of simple sales or mergers, they find that employment decreases. For firms that are part of asset-only sales, they find the opposite.

A number of other studies tend to find positive effects of acquisitions on employment. According to an early study by Green and Cromley (1982), employment increases in the period following a horizontal merger. Using plant-level data for the US manufacturing sector, McGuckin and Nguyen (2001) find positive overall effects of changes in ownership on jobs and wages as well. However, this finding does not hold for the group of larger plants where ownership changes are actually associated with job losses. Furthermore, acquired plants are found to have a smaller probability of closing.

Our data set reveals that newly acquired firm establishments on average grow more slowly than other establishments. This puts our study into the first group of the articles described above. However, just looking at the overall effect hides some important heterogeneity. In particular, we find that the size differential between the acquiring firm and the newly acquired establishments matters for the growth of these establishments. On the one hand, establishments that were acquired by larger acquiring firms grow more rapidly than establishments that were acquired by smaller firms. On the other hand, we find that establishments acquired by acquiring firms that have to integrate a large combined size of new establishments grow less rapidly than establishments with acquirers of the opposite type. In sum, the size differential between the acquiring firm and the total integration size matters for the growth of an acquired establishment: those establishments profit that get acquired by a firm that is considerably larger than their own size plus the size of the other plants the firm acquired. This distinction is new to the literature.

We explain our finding by financial constraints through market imperfections (e.g., limited liability and moral hazard risk). Investment possibilities depend on internal firm resources. Thus, if (financial) resources are exploited for external firm growth through mergers and acquisitions, there only remains a low potential for internal growth through hiring additional employees.[4] As a result, a high integration size compared to the size of the acquirer should lead to lower employment growth in the acquired plants. Another explanation is constrained managerial capacity, leading to a delay in hiring tasks.

As a third key result, we observe important industry specific differences in the relationship between mergers and acquisitions and employment growth. First, compared to other industries, mergers and acquisitions in export-oriented industries are associated with adverse effects on employment growth. This result might be driven by the more competitive environment for firms in sectors with exposure to international trade (as modeled by Melitz (2003), for example). In the course of acquisitions, more synergy effects are realized than in environments with less competitive pressure. Second, mergers and acquisitions within related industries have adverse effects on employment growth. In this case, higher synergy effects might get realized not because of competitive pressure, but because of the greater possibilities for rationalization which firms obtain when merging with similar businesses. This result is consistent with what Conyon et al. (2002) find. Another explanation is the creation of market power, allowing the merging firms (insiders) to internalize their competitive externalities in the product market through a reduction in output (Farrell and Shapiro, 1990). Simultaneously, outsiders have an incentive to expand output, implying lower market shares for the insiders. A recent study by Gugler and Siebert (2007) investigates the trade-off between market power and efficiency effects through changes in market shares, and finds the latter to be prevalent in the semiconductor industry.

[4]For surveys on financing constraints and firm dynamics see, e.g., Hubbard (1998) and Stein (2003).

3.3 Data

3.3.1 Data Source and Data Preparation

Our analysis is based on a complete inventory count of Swiss firms in the secondary and tertiary sector, collected by the Swiss Federal Statistical Office (BFS). The goal of the regular collection of this data is the registration of all economic production units with their economic, social and geographical characteristics. Collection takes place via a questionnaire that is mailed to the firms. Participation is mandatory for all firms in Switzerland. The survey captures, among other things, the location and sector of economic activity of individual units as well as the number of employees by level of employment, gender and nationality. In this chapter we use data from 2001 and 2005.

For both years, we observe the unique identification number of a plant as well as the number of the firm which the plant belongs to. An acquisition is identified in the data by the change of the firm number of an individual plant from 2001 to 2005. In addition, the resulting firm must consist of at least two plants in 2005. This additional requirement is used to distinguish acquisitions where a plant gets integrated into a new institutional unit from simple ownership changes.

3.3.2 Descriptive Statistics

Using the above definition of mergers and acquisitions, we next present some descriptive statistics to get an impression what kind of acquisitions this study is actually based on. Table 3.1 presents the total number of plants in 2001, the number of plants acquired between 2001 and 2005, and the acquisition rate for the manufacturing sector, split up by individual industries at the two-digit level. Table 3.2 does the same for the services sector. We define the acquisition rate as the number of plants that are acquired from 2001 to 2005, divided by the total number of plants in 2001.

In the manufacturing sector, 382 plants out of 43,071 plants were acquired, leading to an acquisition rate of 0.89 percent. The highest number and also rate of acquisition can be found in the industries for food products and beverages and chemicals. In the services sector, 5,007 out of 305,410 plants were acquired, leading to an acquisition rate of 1.64 percent, almost twice as much as in the manufacturing sector. Here, the highest acquisition rates can be found in the industries for post and telecommunications, banks, and insurance companies. Retail trade is the industry with the highest number of acquired

Table 3.1: Firm establishment acquisitions in the manufacturing sector

Industry		Plants	Acquisitions	Percentage
15	Manufacture of food products and beverages	3,188	107	3.36
16	Manufacture of tobacco products	18	0	0.00
17	Manufacture of textiles and textile products	766	4	0.52
18	Manufacture of wearing apparel	983	19	1.93
19	Manufacture of luggage, handbags, saddlery	309	0	0.00
20	Manufacture of wood and of products of wood	6,578	13	0.20
21	Manufacture of pulp, paper and paper products	251	3	1.20
22	Publishing, printing; reprod. of recorded media	4,697	30	0.64
23	Manufacture of coke, refined petroleum products	11	0	0.00
24	Manufacture of chemicals and chemical products	1,143	36	3.15
25	Manufacture of rubber and plastic products	894	6	0.67
26	Manufacture of other non-metallic mineral prod.	1,521	32	2.10
27	Manufacture of basic metals	296	5	1.69
28	Manufacture of fabricated metal products	8,253	27	0.33
29	Manufacture of machinery and equipment n.e.c.	3,689	32	0.87
30	Manufacture of office machinery	145	0	0.00
31	Manufacture of electrical machinery	1,142	13	1.14
32	Manufacture of radio, television	689	8	1.16
33	Manufacture of medical and optical instruments	3,552	29	0.82
34	Manufacture of motor vehicles, trailers	195	1	0.51
35	Manufacture of other transport equipment	424	3	0.71
36	Manufacture of furniture, jewellery, toys	3,970	10	0.25
37	Recycling	357	4	1.12
All manufacturing industries		43,071	382	0.89

Notes: Table 3.1 splits up the sample of plants operating in the Swiss manufacturing sector into different industries at the two-digit level, following the NOGA 2002 industry classification used by the Swiss Federal Statistical Office. For each industry, it then shows the number of plants in 2001, the number of acquisitions that took place between 2001 and 2005, and the resulting percentage of acquired plants.

Table 3.2: Firm establishment acquisitions in the services sector

Industry		Plants	Acquisitions	Percentage
40	Electricity, gas, steam and hot water supply	453	19	4.19
41	Collection, purification and distribution of water	29	0	0.00
45	Construction	36,108	162	0.45
50	Sale, maintenance and repair of motor vehicles	15,308	138	0.90
51	Wholesale trade and commission trade	20,877	249	1.19
52	Retail trade; repair of household goods	46,453	1,103	2.37
55	Hotels and restaurants	26,974	676	2.51
60	Land transport; transport via pipelines	8,579	89	1.04
61	Water transport	102	0	0.00
62	Air transport	240	6	2.50
63	Supporting and auxiliary transport activities	3,996	183	4.58
64	Post and telecommunications	1,170	188	16.07
65	Monetary intermediation	3,951	488	12.35
66	Insurance (except compulsory social security)	2,823	290	10.27
67	Activities auxiliary to financial intermediation	3,718	65	1.75
70	Real estate activities	4,480	22	0.49
71	Renting of machinery and equipment	1,012	19	1.88
72	Computer and related activities	11,519	39	0.34
73	Research and development	497	5	1.01
74	Other business activities	64,983	670	1.03
80	Education	4,913	37	0.75
85	Health, veterinary and social work	23,016	283	1.23
90	Sewage and refuse disposal, sanitation	468	8	1.71
91	Activities of membership organizations n.e.c.	3,667	135	3.68
92	Recreational, cultural and sporting activities	6,014	36	0.60
93	Other service activities	14,060	97	0.69
All services industries		305,410	5,007	1.64

Notes: Table 3.2 splits up the sample of plants operating in the Swiss services sector into different industries at the two-digit level, following the NOGA 2002 industry classification used by the Swiss Federal Statistical Office. For each industry, it then shows the number of plants in 2001, the number of acquisitions that took place between 2001 and 2005, and the resulting percentage of acquired plants. Note that missing industry codes in the series of numbers either relate to public activities and thus are excluded (75, Public administration and defence), or are not defined (all others, for example 42, 43).

plants, however. In sum, Switzerland had 348,481 plants in 2001, of which 5,389 were newly acquired by another firm between 2001 and 2005.

Figure 3.1 shows the frequency distribution of the relative integration size, divided into four acquirer size groups. Overall, we can say that most acquiring firms acquire targets which are in sum smaller than themselves (relative integration size smaller than one). Still, patterns are somewhat different depending on the size group the acquirer belongs to. While more than 60 percent of large acquiring firms acquire targets which are in sum smaller than 25 percent of their initial own size, the distribution broadens considerably for smaller acquirers: many micro acquirers also acquire targets which have in sum up to 50, 75, or 100 percent of their own size. Some targets are even larger than the acquirers themselves (relative integration size larger than one). A first explanation might be a better availability of relevant targets.

3.4 Empirical Model

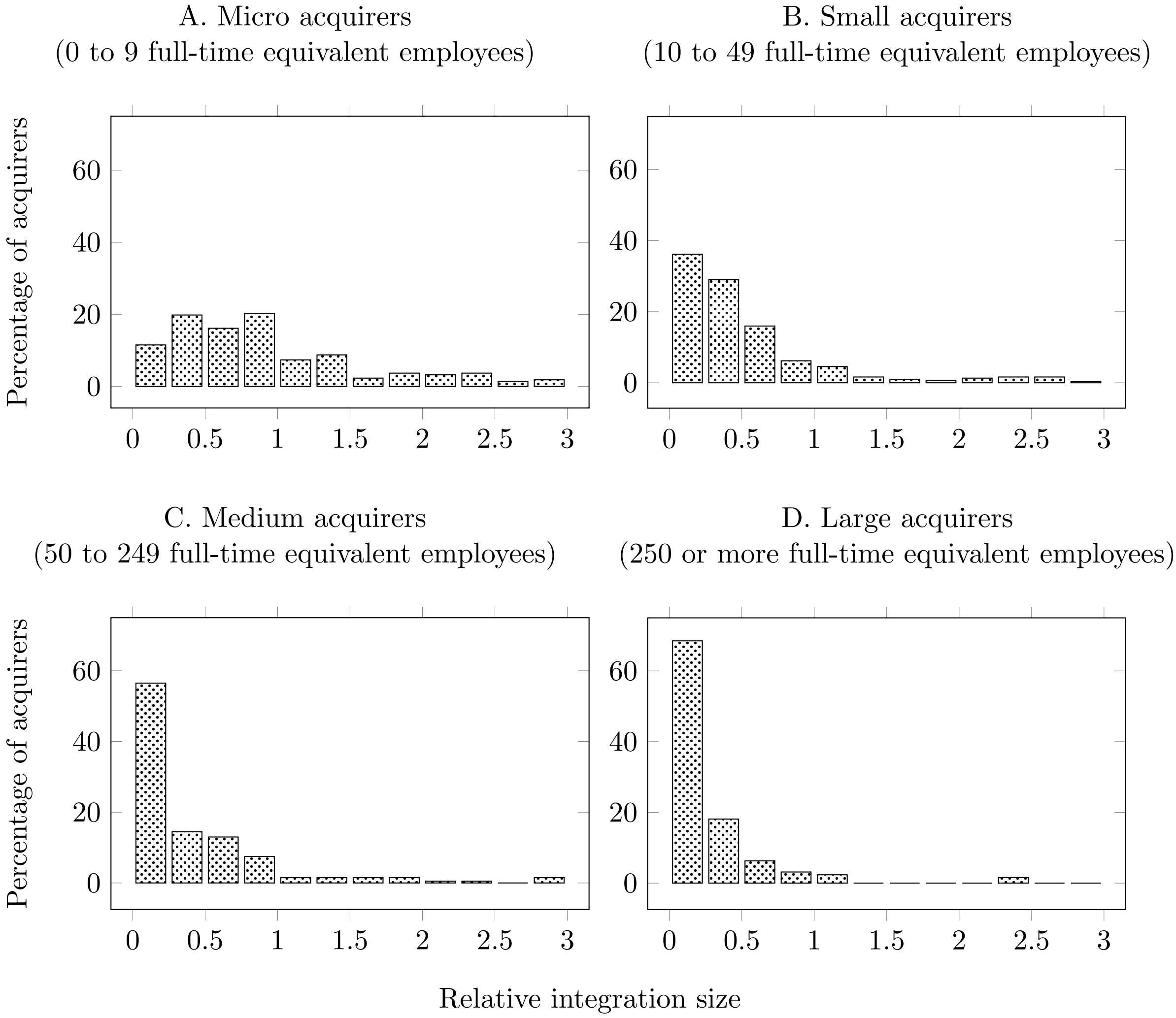
Our empirical model is an OLS specification similar to that of Brown and Medoff (1988) and McGuckin and Nguyen (2001). In its main version, it takes the form

$$\begin{aligned}
\ln\left(\tfrac{\textit{Size 2005}}{\textit{Size 2001}}\right) = \beta_0 \quad &+ \quad \beta_1 A + \beta_2 \ln(\textit{Size 2001}) + \beta_3 \ln(\textit{Size 2001})^2 + \beta_4 \textit{Age7} + \\
&+ \quad \beta_5 \textit{Age10} + \beta_6 \textit{HQ} + \beta_7 \textit{Foreign Capital} + \\
&+ \quad \beta_8 \textit{Export Industry} + \beta_9 A \times \ln(\textit{Acquirer Size}) + \\
&+ \quad \beta_{10} A \times \ln(\textit{Integration Size}) + \beta_{11} A \times \textit{Age7} + \\
&+ \quad \beta_{12} A \times \textit{Age10} + \beta_{13} A \times \textit{HQ} + \beta_{14} A \times \textit{Foreign Capital} + \\
&+ \quad \beta_{15} A \times \textit{Export Industry} + \beta_{16} A \times \textit{Related Industry} + \\
&+ \quad \textstyle\sum_{d=1}^{26} \beta_{17,d} \textit{Industry}_d + \sum_{g=1}^{7} \beta_{18,g} \textit{Region}_g + \epsilon \qquad (3.1)
\end{aligned}$$

where the dependent variable reflects the growth of a plant in terms of employment from 2001 to 2005: We divide the size of a plant in 2005 by the size of that plant in 2001, with size measured by the number of full-time equivalent employees. Then, the logarithm of the resulting expression is taken in order to get an approximate percentage effect.

As explanatory variables we have, first of all, A, which is a dummy denoting the acquisition status of a plant: it equals 1 if a plant was acquired between 2001 and 2005, and zero if not. *Size 2001* is the total number of employees of a plant in 2001 measured in full-time equivalents. We then take the natural logarithm of this value since we want

Figure 3.1: Frequency distribution of relative integration size (by acquirer size)



Notes: Figure 3.1 splits up the sample of acquiring firms into four size groups, determined by their rounded number of full-time equivalent employees: micro, small, medium, and large acquirers. Within each group, it then shows the frequency distribution of the acquirers' relative integration size, which is defined as *Integration Size* in 2001-2005 divided by *Acquirer Size* in 2001. It turns out, for example, that among large acquirers 68.5 percent only acquire and integrate firm establishments which sum up to less than 25 percent of their initial own size (first bar in the chart on the bottom right). Almost no firm in that size group acquires firms larger than themselves, i.e. with a relative integration size larger than one. Patterns in smaller size groups are similar but way less pronounced. Note that only acquirers which started operating before September 2001 and with a relative integration size below 3 are considered.

to talk about growth rates and also include the square of the logarithm in order to take non-monotonic behavior into account. Next, there are three *Age* dummies, which are constructed as follows: *Age4* equals 1 if a plant began operation between October 1998 and September 2001, that is, if it had been in existence from 4 to 7 years by 2005. *Age7* equals 1 if a plant began operation between October 1995 and September 1998, that is, if it had been in existence from 7 to 10 years by 2005. *Age10* equals 1 if a plant began operation before October 1995, that is, if it had been in existence for 10 years or more by 2005. Otherwise the dummy equals zero. Note that *Age4*, which equals 1 for the youngest plants in this analysis, is used as a reference variable and thus is not included in equation (3.1). In order to find out a plant's age, we check the existence of a plant in surveys from 1995 and 1998 (due to changes in the coding system of firm numbers, we could not use these survey years for other parts of the analysis). *HQ* is a dummy which catches the headquarters status of a plant in 2001. It equals 1 if a plant is a single-plant firm or the headquarters of a multi-plant firm, and zero otherwise. *Foreign Capital* is a dummy which equals 1 if a plant is owned (at least partly) by foreign capital in 2001, and zero if not (or if foreign ownership is unknown, as in some cases). Finally, *Export Industry* is a dummy which equals 1 if a plant belongs to an industry in which an above average share of the firms exports, and zero otherwise.

In addition to these individual variables, nine other variables are included in interaction with A, the acquisition status variable of a plant. $A \times \ln(\textit{Integration Size})$ denotes the interaction with the integration size, that is, the sum of the number of employees (in full-time equivalents) in 2001 of all plants the acquirer of a plant acquired between 2001 and 2005. $A \times \ln(\textit{Acquirer Size})$ is the interaction of being acquired with the acquirer size, that is, the total number of employees of the acquiring firm of a plant in 2001. Loosely speaking, these two interactions terms are used to relate the internal growth of a plant which was acquired to the size differential between its acquirer and the total size of all of the targets (acquisitions) this acquirer has to integrate.

Furthermore, interactions of A with *Age7* and *Age10* are included. $A \times \textit{HQ}$ and $A \times \textit{Foreign Capital}$ are interactions of A with the headquarters status and foreign ownership status as defined above. $A \times \textit{Export Industry}$ is the interaction of A with a dummy which equals 1 if a plant belongs to an export-oriented industry as defined above and zero otherwise. It thus catches acquisitions in industries which are open to international trade. $A \times \textit{Related Industry}$ refers to acquisitions in related industries. *Related Industry* equals 1 if the headquarters plant of the acquiring firm operates in the same industry in

2001 as a plant which was acquired. Finally, we include 26 industry and 7 greater region dummies. Such a dummy equals 1 if a plant operates in a certain industry or region and zero if not.

We estimate four models. As a start, model (1) is a restricted estimation without interaction terms, to identify an overall effect of being acquired, $A = 1$, on plant growth in terms of employment. model (2) is our main model, including all interaction variables. Finally, there are two estimations with a restricted sample. model (3) only includes firms from the manufacturing sector; model (4) only includes firms from the services sector.

Before we present the results, two limitations of our approach should be noted. First, it is important to keep in mind that we interpret a special part of the sample. To calculate growth rates we restricted our analysis to plants that existed at both points in time, 2001 and 2005. Small firms with slow or negative growth might be more likely to close than large firms with these characteristics, i.e., disappear from the sample in 2005. We thus might have a sample selection which biases the growth of small firms upward, because the worst performing ones drop out.

Second, a general concern with this type of study is endogeneity. Our estimates are consistent if A is not correlated with the error term, that is, if it is an exogenous variable. This assumption might be invalid. Previous studies have mostly ignored this issue. Only McGuckin and Nguyen (2001) provide a solution, by using an instrumental variable estimation with relative plant productivity growth as an instrument for their equivalent of our A variable. In Section 3.6, we suggest a different but related robustness check by looking at a sub-sample of "complete multi-plant mergers" only. For these mergers, it is particularly reasonable to assume that the takeover of an individual plant is exogenous, since merger decisions will typically be related to the advantages of the overall package the target is perceived to come with.

3.5 Results and Discussion

3.5.1 Establishment Growth and Size and Age

Table 3.3 presents our estimates for equation (3.1) and its modifications. A first result contributes to an ongoing debate on the growth of firms and firm establishments in general. We find that plant growth decreases with plant size and plant age (at a decreasing rate) (Result 1). Throughout all regressions we find negative coefficients that are statisti-

Table 3.3: Employment growth regression estimates

	Dependent variable: ln (*Size 2005* / *Size 2001*)			
	(1)	(2)	(3)	(4)
Independent variable	All industries	All industries	Manufacturing	Services
ln(*Size 2001*)	-0.1704***	-0.1708***	-0.1191***	-0.1814***
	(0.002)	(0.002)	(0.005)	(0.002)
ln(*Size 2001*)^2	0.0273***	0.0276***	0.0176***	0.0302***
	(0.001)	(0.001)	(0.001)	(0.001)
Age7	-0.0437***	-0.0432***	-0.0615***	-0.0407***
	(0.004)	(0.004)	(0.010)	(0.004)
Age10	-0.0562***	-0.0558***	-0.0924***	-0.0509***
	(0.003)	(0.003)	(0.008)	(0.003)
HQ	-0.0412***	-0.0411***	-0.0073	-0.0443***
	(0.003)	(0.004)	(0.013)	(0.004)
Foreign Capital	0.0460***	0.0449***	0.0047	0.0538***
	(0.007)	(0.007)	(0.017)	(0.008)
Export Industry	-0.1211***	-0.1151***	-0.0028	-0.1597***
	(0.029)	(0.029)	(0.012)	(0.047)
A	-0.0342***	0.1636***	0.0178	0.1647***
	(0.007)	(0.037)	(0.198)	(0.038)
A × ln(*Acquirer Size*)		0.0300***	0.0146	0.0310***
		(0.004)	(0.020)	(0.005)
A × ln(*Integration Size*)		-0.0468***	-0.0417**	-0.0485***
		(0.004)	(0.017)	(0.004)
A × *Age7*		-0.0272	-0.3311**	-0.0180
		(0.025)	(0.134)	(0.026)
A × *Age10*		-0.0259	-0.0089	-0.0266
		(0.019)	(0.093)	(0.020)
A × *HQ*		-0.0332*	0.0501	-0.0304*
		(0.017)	(0.062)	(0.018)
A × *Foreign Capital*		0.0003	0.2957***	-0.0357
		(0.034)	(0.110)	(0.036)
A × *Export Industry*		-0.1051***	-0.0452	-0.0954***
		(0.016)	(0.137)	(0.016)
A × *Related Industry*		-0.0667***	-0.1158	-0.0649***
		(0.020)	(0.073)	(0.022)
Constant	0.3339***	0.3273***	0.1649***	0.3312***
	(0.028)	(0.028)	(0.017)	(0.028)
Industry dummies	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes
Observations:	262,032	262,032	33,457	228,575
R-squared:	0.047	0.048	0.039	0.049

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Only surviving plants are considered. To account for cases where the acquirer didn't exist in 2001 and values for *Acquirer Size* and *Related Industry* are unavailable, missing dummies are included.

cally significant for the size of a plant in 2001, ln(*Size 2001*). Furthermore, the coefficients for ln(*Size 2001*)^2 turn out to be positive, indicating a decreasing negative impact of size on growth for larger plants. Our coefficients for the plant age dummies, *Age7* and *Age10*, suggest the same type of relationship between growth and age. For plants in Switzerland we can thus reject Gibrat's Law of proportionate growth (which states that growth is independent of size, see Gibrat (1931) and Sutton (1997)). By contrast, our results confirm more recent studies that find an inverse relationship between growth and size or age (Dunne, Roberts, and Samuelson, 1989; Blonigen and Tomlin, 2001). An explanation for the relationship is the theory of learning over time (Jovanovic, 1982). Note, however, that plant growth is different from total firm growth. Total firm growth can be decomposed into internal (plant) growth and external growth through mergers and acquisitions. While our results do not contradict studies that find an inverse relationship between growth and size or age for firms so far (Hall, 1987; Evans, 1987a,b; Dunne and Hughes, 1994; Harhoff, Stahl, and Woywode, 1998), taking external growth into account might still do so, since we found that mergers and acquisitions are more prevalent among large firms. For example, Geroski and Gugler (2004) find Gibrat's Law to hold for large and mature companies and confirm simultaneously an inverse relationship for small and young ones. We leave this point open to further research.

3.5.2 The Size Differential Between Acquirer and Target Plants

Looking at the coefficient for A in regression (1), we find that, overall, acquired plants grow less rapidly than other plants (Result 2a). Such an adverse effect of acquisitions on growth is in line with Conyon et al. (2002), Gugler and Yurtoglu (2004), Bhagat et al. (1990), and Lichtenberg and Siegel (1990) as outlined above. However, this finding hides some important heterogeneity in the data which will be discussed in the next sections by introducing additional variables.

As a main result, we find that the larger the acquiring firm is compared to the combined size of the plants to be integrated, the stronger the plants grow following an acquisition (Result 2b). From the positive coefficients for $A \times \ln(\textit{Acquirer Size})$, i.e., the interaction of acquisition status with acquirer size, we can draw the following conclusion: plants which were acquired by larger acquiring firms grew more rapidly than plants which were acquired by smaller acquiring firms. From the negative coefficients for $A \times \ln(\textit{Integration Size})$, i.e., the interaction of acquisition status with the combined size of the plants to be integrated by a certain plants' acquirer, we can conclude that plants which were acquired by acquiring firms that have to integrate a large combined size of plants grew less rapidly than plants with acquirers of the opposite type. In sum, and as a central result, the size differential between the acquiring firm and the total integration size matters for the internal growth of an acquired plant: those plants profit which are acquired by a firm that is considerably larger than their own size plus the size of the other plants the firm acquired.

Our findings may well be explained by financial constraints through market imperfections (e.g., limited liability and moral hazard risk). Investment possibilities of firms depend on their internal resources. If these resources are exploited for external firm growth (i.e., through acquisitions), there only remains a low potential for internal growth through hiring additional employees. Limited internal resources may also include, for example, managerial capacities, which are exhausted in the course of new acquisitions. Hiring tasks are delayed. As a result, a high integration size compared to the size of the acquirer should lead to lower internal employment growth in the (acquired) plants.

Looking at the case where $\ln(\textit{Acquirer Size})$ equals $\ln(\textit{Integration Size})$, that is, a firm doubles its size through acquisitions, there is still an adverse effect on growth. The realization of synergy effects in the form of rationalizing overlapping employee positions is a reasonable explanation. The effect becomes positive as soon as $\ln(\textit{Integration Size})$ is at least 25 percent smaller than $\ln(\textit{Acquirer Size})$. This might especially represent the case where mature firms buy smaller highly innovative firms with few overlapping functions but strong growth potentials.

3.5.3 Acquisitions in Export-Oriented and Related Industries

In addition to the previous results, we observe important industry specific differences in the relationship between mergers and acquisitions and employment growth. First, compared to other industries, mergers and acquisitions in export-oriented industries are associated with adverse effects on employment growth (Result 3a). This result in particular holds for the services sector: the coefficient of $A \times \textit{Export Industry}$ is negative and highly significant. For the manufacturing sector the coefficient turns out to be negative, but insignificant. This result might be driven by the more competitive environment for firms in sectors with exposure to international trade (as modeled by Melitz (2003), for example). In the course of acquisitions, more synergy effects are realized than in environments with less competitive pressure. Recent empirical evidence on the existence of a relationship between the intensity of competition and mergers has been provided by

Buehler, Kaiser, and Jaeger (2005), finding this relationship to be positive.

Second, mergers and acquisitions within related industries have adverse effects on employment growth (Result 3b). As for the previous result, we find a negative and highly significant coefficient for $A \times$ *Related Industry* for the services sector and a negative but insignificant coefficient for the manufacturing sector. In this case, higher synergy effects might be realized not because of competitive pressure, but because the greater possibilities of rationalization which firms obtain when merging with similar plants. This is consistent with Conyon et al. (2002). Another explanation is the creation of market power allowing the merging firms to internalize their competitive externalities in the product market through reduced production.

3.5.4 The Role of Foreign Investors and Further Results

It also turns out that headquarters of multi-plant firms grow less rapidly than their other plants. In addition, acquired plants with headquarters status grow less rapidly than other acquired plants (Result 4). In all regressions, the coefficient for *HQ* is negative. It is highly significant for the regression which includes all industries, as well as for the services sector alone. A reason might be that auxiliary headquarters services (such as marketing or accounting) usually do not need to grow as rapidly as the full institutional unit when expanding production and services to serve additional customers. Surprisingly, however, the effect is statistically insignificant in the manufacturing sector alone.

Furthermore, acquired plants with headquarters status, i.e., where $A \times HQ$ equals 1, grow less rapidly than other acquired plants. This result is consistent with Bhagat et al. (1990) and Lichtenberg and Siegel (1990), who find that in particular white-collar worker and auxiliary plants are affected by layoffs following mergers and acquisitions. However, the coefficient in the regression with only the manufacturing sector is insignificant.

As a last result, we find that foreign-owned plants grow more rapidly than plants endowed with domestic capital only. Compared to Swiss plants, the acquisition of foreign-owned plants is positively related to their growth in the manufacturing sector (Result 5). The coefficient for $A \times$ *Foreign Capital* is positive and highly significant for this sector. In all regressions, the coefficient for the *Foreign Capital* variable is positive. However, it is not statistically significant for the manufacturing sector alone. Thus, this result again especially holds for the services sector. An explanation might be that foreign-owned plants benefit from technology transfer from their foreign owners. While increasing productivity, firms have high incentives to keep their employees: first, training staff in new technologies is costly, and second, technology spill-over effects to competitors can be constrained (see, for example, Teece (1986), Görg and Strobl (2005), or Görg and Greenaway (2004)).

3.6 Complete Multi-Plant Mergers

As indicated in Section 3.4, a concern with our regression model is the potential endogeneity of the acquisition variable A, which would lead to regression estimates that are not consistent. In particular, we think of omitted variables (or unobserved heterogeneity) as the channel for endogeneity. Omitted variables could be variables on relevant plant characteristics, such as an indicator for the talent of a plant's management. Talented management might be crucial for the growth of a plant. At the same time, talented management in a target plant might also be decisive for the acquisition status: acquirers might want to select specifically those plants as a target which have exceptional growth prospects thanks to their management. If this were true, and if we can not control for talent in our regression, A would be correlated with the error term ϵ and our regression estimates would be inconsistent. In the example of talented management, the coefficient for A would be biased upwards.

A potential solution to this concern is an instrumental variable estimation. Unfortunately, an ideal instrumental variable for A is typically not readily available for our kind of study. Most previous studies actually ignored this issue. However, a related possibility is to exclusively look at acquired plants which are part of a "complete multi-plant merger". We define such a merger as a standard merger which fulfills two additional conditions. First, the merger includes the takeover of at least one complete firm, that is, a firm with all of its plants. Second, the target firm consists of at least four individual plants. The underlying idea is to avoid cherry-picking with regard to the unobserved heterogeneity at the plant level: For complete multi-plant mergers it is particularly reasonable to assume that the takeover of an individual plant is exogenous, since merger decisions will typically be related to the advantages of the overall package the target is perceived to come with. Note that concerning our definition of complete multi-plant mergers, there is a trade-off. On the one hand, requiring a higher number of plants to be part of the target makes the selection of a specific plant more random. On the other hand, the observed sub-sample of acquired plants shrinks with a more rigorous definition. In the end, requiring at least four plants seems to be appropriate: out of 5,389 plants that were acquired according to our standard merger definition, 271 plants still fulfilled our additional requirements.

Table 3.4 presents the regression results for such complete multi-plant mergers, that is, other mergers are excluded. As in model (1), model (5) does not include interaction terms. It turns out that the regression coefficient for A has a somewhat higher magnitude, but is still comparable to that in model (1). It is still negative and significant (-0.0523, significant at the 10 percent level compared to -0.0342, significant at the 1 percent level in model (1)). Thus, our results as derived above can be qualitatively confirmed. In addition, the stronger magnitude of the coefficient for A suggests that unobserved characteristics may indeed play a role and the previous result in Table 3.3 may actually constitute a lower bound for the overall employment loss. Estimation (6) includes all interaction terms as in estimation (2) above. There is almost no change in the coefficients for establishment size, age, headquarters status, ownership of foreign capital, or export-orientation. The coefficients for the acquisition status and its interaction terms with size, however, now become insignificant. The same holds for the other interaction terms. Presumably the reduced number of mergers that we look at plays a major role. We obtain very similar results (which are available upon request) when changing the number of plants that the target firm is required to consist of.

3.7 Conclusion

This chapter examined how mergers and acquisitions affect employment growth in newly acquired plants. Previous research has been concerned mostly with value creation for shareholders. Based on comprehensive plant-level data from Switzerland, this chapter sheds light on employees as an important stakeholder group. Our main aim is a better understanding of the future (employment) prospects from an employee's perspective in the course of a merger or acquisition.

Our findings show that the size differential between the target and the acquirer is an important determinant for employment growth. In particular, we find that a larger size of the acquiring firm has a beneficial effect on employment growth, while a larger size of the acquired plants (target) has an adverse effect. We offer several explanations such as constraints on the financial resources of the acquiring firm: high acquisition costs restrict the potential of hiring additional employees and with lower acquisition costs, hiring additional employees is comparatively unrestricted. Other explanations include market power effects and exhausted managerial capacities. While this distinction is new to the literature, we also confirm some important findings of previous studies. Concerning the

Table 3.4: Supplementary regression estimates

Independent variable	Dependent variable: ln (*Size 2005*/*Size 2001*) (5) Complete multi-plant mergers	(6) Complete multi-plant mergers
ln(*Size 2001*)	-0.1733***	-0.1733**
	(0.002)	(0.002)
ln(*Size 2001*)^2	0.0294***	0.0294***
	(0.001)	(0.001)
Age7	-0.0428***	-0.0429**
	(0.003)	(0.003)
Age10	-0.0563***	-0.0563**
	(0.003)	(0.003)
HQ	-0.0410***	-0.0410**
	(0.003)	(0.003)
Foreign Capital	0.0379***	0.0378***
	(0.007)	(0.007)
Export Industry	-0.1005***	-0.0996**
	(0.029)	(0.029)
A	-0.0523*	0.0009
	(0.030)	(0.287)
A × ln(*Acquirer Size*)		0.0057
		(0.056)
A × ln(*Integration Size*)		-0.0185
		(0.033)
A × *Age7*		0.0936
		(0.114)
A × *Age10*		-0.0646
		(0.074)
A × *HQ*		0.0996
		(0.086)
A × *Export Industry*		-0.1091
		(0.067)
A × *Related Industry*		0.0097
		(0.045)
Constant	0.3119***	0.3109***
	(0.028)	(0.028)
Industry dummies	Yes	Yes
Region dummies	Yes	Yes
Observations:	256,914	256,914
R-squared:	0.046	0.046

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Only surviving plants are considered. To account for cases where the acquirer didn't exist in 2001 and values for *Acquirer Size* and *Related Industry* are unavailable, missing dummies are included. Acquired plants which are not part of a merger with at least four target plants are excluded from the sample in estimations (5) and (6).

general relationship between plant characteristics and plant growth, three results stand out. First, we find that the plant growth decreases with plant size and plant age. Thus, Gibrat's Law of proportionate growth can be rejected for plants in Switzerland. Second, headquarters of multi-plant firms grow more slowly than other plants of multi-plant firms. We suppose that these headquarters usually conduct auxiliary tasks such as marketing or accounting. Hence, if the firm expands, these plants usually do not need to grow at a similar pace as, for example, the production units. Third, foreign-owned plants grow more rapidly than other plants. This suggests that these plants have access to (advanced) foreign technology and benefit from a knowledge transfer. Finally, the results provide evidence for adverse effects on employment growth in the course of mergers and acquisitions in export-oriented firms and in firms where the acquirer and the target are in a related industry. An explanation for the first finding is the more competitive environment for firms in the export-oriented industries and the resulting pressure to realize more synergy effects. Whereas in related industries, it is not the competitive pressure, but instead synergy effects will rather be implemented by exploiting rationalization possibilities through overlapping (job) functions if similar businesses merge.

Future research might further explore our key finding, that the size differential between target and acquirer is a determinant for the growth of employment in the course of mergers and acquisitions. In particular, the analysis of financial data could provide additional support for our suggestion that financing constraints are an explanation for this result.

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Chapter 4

Multihoming, CDNs, and the Market for Internet Connectivity

Thorsten Hau, Dirk Burghardt and Walter Brenner

Abstract Peering points between different Internet service providers (ISPs) are among the bottlenecks of the Internet. Multihoming (MH) and content delivery networks (CDNs) are two technical solutions to bypass peering points and to improve the quality of data delivery. So far, however, there is no research that analyzes the economic effects of MH and CDNs on the market for Internet connectivity. This chapter develops a static market model with locked-in end users and paid content. It shows that MH and CDNs create the possibility for terminating ISPs to engage in monopolistic pricing towards content providers, leading to a shift of rents from end users and content providers to ISPs. Implications for future innovations are discussed.

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4.1 Introduction

Research on pricing of data transport has its roots in the literature on telecommunications. Early work on pricing of voice communications established the corner-stones of our thinking about communications pricing. A prominent example for this is the focus on access charges (Laffont, Rey, and Tirole, 1998), that is, the price one provider pays to the other for the termination of traffic with an end user. The present paper departs from this "classical" view on communications pricing by also considering content providers (CPs), end users, and content delivery networks (CDNs) instead of only the inter carrier settlement. This issue is not covered in the existing literature. We show how an Internet service provider (ISP) with access to end users can discriminate against CPs and charge monopoly prices for termination. The discussion is related to and uses results from research on one- and two-way access (Buehler and Schmutzler, 2006; Gans, 2006), strategic network pricing (Shrimali, 2008), two sided markets (Armstrong, 2006; Rochet and Tirole, 2006), vertical integration (Rey and Tirole, 2007; Tirole, 1988), telecommunications pricing (Laffont et al., 2003; MacKie-Mason and Varian, 1995; Shakkottai and Srikant, 2006), net neutrality (Crowcroft, 2007; Sidak, 2006; Wu, 2003) and quality of service (QoS) (Soldatos, Vayas, and Kormentzas, 2005; Wang, 2001).

The existing literature on telecommunications pricing has ignored the possibility that CPs and terminating ISPs directly interconnect. In contrast, consider the following two situations: First, it is commonplace that CPs directly buy transit from terminating ISPs, thus effectively paying them for preferential access to end users. This practice is called multihoming (MH) and plays a role in the exponential growth of routing tables (Bu, Gao, and Towsley, 2004). Second, CDNs are a popular way to enhance the flow of information on the Internet. A CDN uses local caches to keep distributed images of content close to end users without the need to traverse several ISPs' networks (Pathan and Buyya, 2007; Vakali and Pallis, 2003). Both technologies provide viable means to improve the speed and reliability of data transport from a CP's website to end users. This is due to the fact that peering points, that is, the points of interconnection between the networks of two ISPs are among the notorious bottlenecks of the Internet (Akella, Srinivasan, and Shaikh, 2003). Both technologies serve as ways to bypass peerings and to gain more direct access to end users, thus increasing the probability of timely delivery of data to the end user.

The remainder of this chapter is structured as follows: Section 4.2 explains the relevant entities of the Internet that we need for a formal model. Section 4.3 presents a formalized treatment of six scenarios that shows how MH and CDNs affect ISPs' incentives to price traffic in comparison to the standard situation with peering. The model is static with locked-in end users who cannot switch their provider. In section 4.4 we discuss the consequences of our model and sketch out an agenda for further research.

4.2 The Market for Internet Connectivity

Figure 4.1: Interconnection structure of the Internet

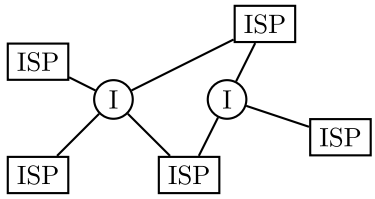


Figure 4.2: Hierarchical structure of the Internet

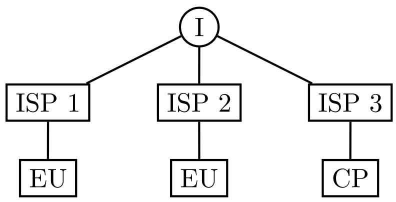


Figure 4.1 and Figure 4.2 show in an idealized manner the structure of the Internet (Shakkottai and Srikant, 2006; Uludag et al., 2007). Figure 4.1 focuses on the interconnection aspect. Several ISPs interconnect with each other through points of interconnection (denoted by "I"). Figure 4.2 focuses on the hierarchical structure of the Internet. Data first flows up the hierarchy from a CP to its ISP and across a peering point back down via an ISP to the end user (EU). A common approximation (Laffont et al., 2003) we will use is that CPs (web sites) only send traffic and end users only receive traffic. This approximation is justified by the real traffic patterns on the Internet which show that downstream data transmission volume to end users is much bigger than that upstream. This assumption excludes peer to peer relationships from the analysis.

4.2.1 Internet Service Providers

ISPs provide connectivity to end users and CPs. They interconnect at peering points and the originating ISP pays an access fee a to the terminating ISP. In Figure 4.2, ISP 3 would pay ISP 2 for delivering data from the content provider to the end user it is connected to. We assume that ISPs have no lack of bandwidth on their backbones and could provide quality assurance to traffic either through excess capacity or network management techniques. Managing capacity on the backbone is within the ISPs' power and there are no interdependencies with other ISPs. Further bandwidth bottlenecks may be present in the peering points and in the access network. We ignore possible problems due to constrained access bandwidth and concentrate on the peering points.

4.2.2 Points of Interconnection

In Figure 4.1 and Figure 4.2 the circles with an "I" represent points of interconnection or peering points where different ISPs interconnect their networks to form the Internet. There are two dominant modes of interconnection: Peering and transit. Peering (Shrimali and Kumar, 2008) is a settlement free agreement to exchange traffic while transit involves payments for exchanged data. Typically peering agreements are used between ISPs of similar size while transit is paid from small ISPs to larger ISPs.

Peering points with peering agreements are among the major bottlenecks of the Internet (Akella, Srinivasan, and Shaikh, 2003). There are several reasons for this. First it always takes both parties in a peering agreement to agree on an extension of a peering point in order to increase its usable capacity (Cremer, Rey, and Tirole, 2000). Since a capacity extension is costly for both parties, in general the lower of both capacity requirements is realized. See Economides (2002) and Cremer, Rey, and Tirole (2000) for a controversial discussion and also Armstrong (1998), Badasyan and Chakrabarti (2008), Cremer, Rey, and Tirole (2000) and Foros, Kind, and Sand (2005) for further details on interconnection practices. Ways for CPs to bypass overloaded peerings are multihoming and the use of CDN services.

Transit on the other hand involves a payment from one ISP to the other for the delivery of traffic. With such an agreement a guaranteed bandwidth is bought. The biggest networks (called tier 1 networks) only peer among themselves and charge smaller networks for sending traffic to them. Since small ISPs have to pay for sending traffic to larger networks which is necessary to reach the whole Internet, they optimize their outpayments for transit fees by buying the least amount of bandwidth their users will tolerate. It follows that peerings with peering as well as transit agreements are bandwidth bottlenecks. With transit this is a conscious choice of the buyer, with peering it is a result of non-cooperative behavior.

4.2.3 Content Providers

Content providers are websites or other service providers that buy connectivity to the Internet from an ISP. CPs are able to multi-home which means they can buy connectivity for one fraction of their traffic from ISP 1 and the rest from ISP 2. Furthermore, they can buy connectivity to the Internet from any ISP anywhere in the world. Therefore, CPs face a market price for ordinary Internet connectivity which is based on perfect competition. This price only includes unprioritized traffic across peering points. Canonical analysis as in Laffont and Tirole (2000) and Laffont et al. (2001, 2003) assumes the following model of payments between network providers:

$$\text{CP} \longrightarrow \text{ISP}_o \xrightarrow{a} \text{ISP}_t \longleftarrow \text{EU} \tag{4.1}$$

(t=terminating, o=originating, a=access charge). This scheme ignores where the CP gets funding from and emphasizes the analysis of the inter ISP settlement a which has an influence on the prices paid to the ISPs. In contrast, this work focuses on content related charges. We model the payment flows according to the content delivery value chain:

$$\text{ISP}_t \xleftarrow{a} \text{ISP}_o \xleftarrow{p_w} \text{CP} \xleftarrow{p} \text{EU} \tag{4.2}$$

Ignoring payments from the end user to the terminating ISP for access to the Internet, payments flow from the end user along the value chain of content delivery to the terminating ISP. Here p is the price paid by the end user for viewing content, p_w is the price paid by the CP to the ISP for reaching the end user. If the ISP that receives p_w cannot terminate the traffic it has to pay an access charge to another ISP that is able to terminate the traffic.

This paper is about two alternatives to this "ordinary" way to deliver data over the Internet. The two variations we will consider are MH and CDNs. With MH, the terminating ISP is directly connected with the CP (Figure 4.3) while with CDNs a third party mediates between CP and ISP_t (Figure 4.4). Under MH, payment flows are:

$$\text{ISP}_t \xleftarrow{p_w} \text{CP} \xleftarrow{p} \text{EU} \tag{4.3}$$

and the originating ISP is eliminated from the delivery chain. With CDN, payments are:

$$\text{ISP}_t \xleftarrow{p_w} \text{CDN} \xleftarrow{p_w+m} \text{CP} \xleftarrow{p} \text{EU} \tag{4.4}$$

The Charge $p_w + m$ levied by the CDN implies that we do not consider the CDN's pricing decision explicitly but let it add a given markup m to its cost for interconnection with the terminating ISP and charge the sum of cost and markup to the CPs.

Figure 4.3: Hierarchical structure of the Internet with MH

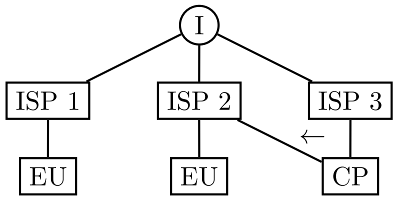
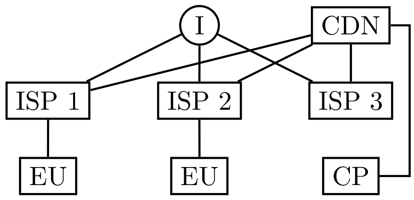


Figure 4.4: Hierarchical structure of the Internet with CDN



4.2.4 End Users

Unlike CPs, end users cannot divide their traffic amongst several ISPs and are immobile. They cannot choose their provider globally but need to choose among a small number of local ISPs. In the static model end users are bound to their ISP, providing the ISP with a monopoly over terminating traffic to them.

4.2.5 Content Delivery Networks

CDNs (Pathan and Buyya, 2007; Vakali and Pallis, 2003) consist of a network of servers that are distributed around the Internet within many ISPs' infrastructures (Figure 4.4). A CDN takes content from a CP and caches it on those distributed servers which has two effects: First, content is brought closer to the end user without passing through inter ISP peerings thus making its delivery faster. Second, the CDN has a contractual relationship with the ISP where it needs to terminate traffic. The CDN delivers the cached content from the mirror site to the end user. By using the services of a CDN, a CP does not need to multihome with every possible network.

The pricing decisions of a CDN most probably deserve an article of their own since there are several reasonable approaches to model the CDN decision problem. One perspective is that a CDN simply takes its cost for presence at ISPs' sites as given and then optimizes the prices it charges to its customers. From this point of view the CDN's pricing would depend on the competitiveness of the market for its services. On the other hand, a CDN could also be considered a platform that needs to get ISPs (through access to their network, specific contracts and hardware at their computing sites) as well as content providers (as customers hosting content on the CDN servers) on board. Now a two-sided market approach might be feasible since the CDN needs to optimize across two distinct but interdependent customer groups. The present analysis ignores the complexity of that decision through the assumption that the CDN charges w_p plus an additive constant m per unit of content or bandwidth to its customers. For simplicity, we actually ignore m in the formal model below as it has no qualitative effects on our conclusions.

4.2.6 Quality of Service

Quality of service (QoS) refers to technologies that enable the Internet to guarantee certain bounds on technical parameters of packet transmission such as packet loss, delay and jitter. By tagging each data packet on the internet with a quality label, routers are able to prioritize packets with higher quality requirements (Wang, 2001). The quality differentiation capabilities of the Internet protocol are currently not being used in the public Internet. In economic terms, traffic differentiation and price discrimination based on the type of data being transported is not practiced on the Internet. Since the Internet cannot assure constant quality levels but there is a demand for improved quality, MH and CDN are used by commercial CPs as means to bypass the main bottlenecks.

4.3 A Model

In the following we develop a simple model of the market for Internet connectivity as described intuitively above. It allows a rigorous analysis of how MH and CDN affect ISPs' incentives to price traffic in comparison to the standard situation with peering. We consider two degrees of competition that content providers might face: content competition and content monopoly. These polar cases can be seen as a benchmark for further analysis with intermediate degrees of competition. In total, we thus compare six situations:

1. Content competition without MH or CDN
2. Content competition with MH
3. Content competition with CDN
4. Content monopoly without MH or CDN
5. Content monopoly with MH
6. Content monopoly with CDN

For the analysis we assume that the degree of competition and the type of interconnection are exogenously given. In each situation, we then look at the price building mechanism and see whether the different firms are able to generate positive profits through price discrimination or not.

Suppose there are n markets. In the three situations of content competition all n markets are served by many CPs. In the three situations of content monopoly each of the n markets is served by one CP. For simplicity, assume one terminating ISP (ISP_t) and many originating ISPs (generically denoted by ISP_o). While this is a bit unorthodox, it captures the fact that the end user is locked with the terminating ISP while content providers may freely switch among originating ISPs. (An alternative way is to assume that each market has a unique terminating ISP which would lead to the same results.) Moreover, suppose that inverse demand in market i is given by

$$p_i = \alpha_i - \beta_i q_i \tag{4.5}$$

where q_i is the quantity of bandwidth or content consumed by the end users in that market in a particular period of time and p_i is the price per unit consumed. α_i and β_i are parameters valid for that particular market i. Intuitively, higher prices would discourage Internet services consumption and result in lower bandwidth consumption and vice versa.

Content providers have marginal costs c_i in market i and zero fixed costs. Let the total marginal cost of the traffic in market i by the content provider be $\hat{c}_i$. This includes both its own marginal cost c_i as well as the price per unit of traffic levied by the ISP it is connecting to. Let the marginal cost of ISP_t be c_t and the marginal cost of ISP_o be c_o per unit of traffic.

We are considering a two-stage game. In the first stage, content providers decide on the type of connection. Here there are three choices: without MH/CDN, MH, CDN. While it is likely that multihoming and content delivery networks provide a better quality of service, we abstract from such quality issues and focus purely on the possibility of discrimination that multihoming or content delivery networks make possible. In the standard case without multihoming or content delivery networks, all the content providers connect to ISP_o. So the ISP_t who has monopoly power over the end user cannot identify the source of traffic. In case of multihoming, the content providers connect directly to the ISP_t. In case of content delivery networks, all content providers connect to the content delivery network, so the ISP_t again cannot identify the specific market the traffic is coming from.

4.3.1 Content Competition

In a competitive market, CPs set their price for end users equal to their total marginal costs $\hat{c}_i$. Quantities arise according to our demand function given by equation (4.5). In the second stage of the game we thus have:

$$p_i^* = \hat{c}_i \tag{4.6}$$

$$q_i^* = \frac{\alpha_i - \hat{c}_i}{\beta_i} \tag{4.7}$$

In the following we look at the first stage of the game to determine the price setting behavior of the ISPs and thus the cost $\hat{c}_i$ the content provider faces in the second stage.

Content Competition without MH or CDN

Consider a standard Internet interconnection situation of content competition (CC) where CPs do not use multihoming or content delivery networks. ISP_o has no market power and thus charges their total marginal cost $p_w = a + c_o$ to CPs, that is, the access charge a he has to pay to ISP_t for terminating the traffic plus his own marginal cost c_o. Their profits are zero. ISP_t cannot identify the traffic and levies a fee at marginal cost as well:

$$a^{CC} = c_t \tag{4.8}$$

As a result, the ISP_t's profits are zero. The total marginal cost for a CP can now be written as $\hat{c}_i = p_w + c_i = a^{CC} + c_o + c_i = c_t + c_o + c_i$. CPs charge a competitive price from end users that is equal to this total marginal cost. Thus, the CPs' profits are zero as well. By using the expression we found for $\hat{c}_i$ in equations (4.6) and (4.7), the market outcome in a situation of content competition without MH or CDN can finally be summarized as:

$$
\begin{aligned}
p_i^{CC} &= c_i + c_o + c_t && (4.9)\\
q_i^{CC} &= \frac{\alpha_i - (c_t + c_o + c_i)}{\beta_i} && (4.10)\\
\pi_{CP,i}^{CC} &= 0 && (4.11)\\
\pi_{ISP_o}^{CC} &= 0 && (4.12)\\
\pi_{ISP_t}^{CC} &= 0 && (4.13)
\end{aligned}
$$

Intuition: This is our benchmark situation. All prices and charges are at set to a competitive level at total marginal costs and all firms earn zero profits in equilibrium. In the context of this paper the central point is that ISP$_t$ has no contractual counterpart from which rents could be extracted.

Content Competition with Multihoming

Now, consider a situation of content competition (CC) where CPs use multihoming (MH). The ISP$_t$ can now identify the traffic and would levy access charges to maximize its profits. Suppose it levies a fee a_i in market i. Then, the CP will charge a competitive price given by $p_i = \hat{c}_i = a_i + c_i$. Their profits are zero. Taking demand from equation (4.5) into account, the total profit of the ISP$_t$ (including all n markets) can be written as:

$$
\pi_{ISP_t} = \sum_{i=1}^{n} \left[(a_i - c_t) \underbrace{\left(\frac{\alpha_i - (a_i + c_i)}{\beta_i} \right)}_{q_i} \right] \tag{4.14}
$$

As first order condition for a maximum of this expression we have:

$$
\frac{\partial \pi_{ISP_t}}{\partial a_i} = \frac{\alpha_i - 2a_i - c_i + c_t}{\beta_i} \stackrel{!}{=} 0 \tag{4.15}
$$

Solving for a_i gives us the optimal access charge per unit of traffic in market i:

$$
a_i^{CC,MH} = \frac{\alpha_i - c_i + c_t}{2} \tag{4.16}
$$

By using $\hat{c}_i = a_i + c_i$ combined with (4.16) in equations (4.6) and (4.7) we find the equilibrium prices and quantities; using (4.16) in (4.14) gives us the ISP$_t$'s profit in equilibrium. The market outcome in a situation of content competition with MH can thus be summarized as follows:

$$p_i^{CC,MH} = \frac{\alpha_i + (c_t + c_i)}{2} \tag{4.17}$$

$$q_i^{CC,MH} = \frac{\alpha_i - (c_t + c_i)}{2\beta_i} \tag{4.18}$$

$$\pi_{CP,i}^{CC,MH} = 0 \tag{4.19}$$

$$\pi_{ISP_t}^{CC,MH} = \sum_{i=1}^{n} \left[\frac{(\alpha_i - (c_t + c_i))^2}{4\beta_i} \right] \tag{4.20}$$

Intuition: By comparing the profit of the ISP_t with the situation from above we see that multihoming and the possibility to identify traffic allow the ISP_t to convert each competitive market into a perfect monopoly and to extract the monopoly profit while the CPs still make zero profits.

Content Competition with Content Delivery Networks

Now, consider a situation of content competition (CC) where CPs use content delivery networks (CDN) for interconnection. In this case, the traffic comes under the filter of the CDN so the ISP_t is forced to levy a uniform access charge a across all markets (in technical terms, a has no index i anymore). A CP in market i passes this access charge on to the end user so the price charged is $p_i = \hat{c}_i = a + c_i$. Their profits are zero. Taking demand from equation (4.5) into account, the total profit of the ISP_t (including all n markets) can be written as:

$$\pi_{ISP_t} = (a - c_t) \sum_{i=1}^{n} \left[\underbrace{\left(\frac{\alpha_i - (a + c_i)}{\beta_i} \right)}_{q_i} \right] \tag{4.21}$$

As first order condition for a maximum of this expression we have:

$$\frac{\partial \pi_{ISP_t}}{\partial a} = \sum_{i=1}^{n} \left(\frac{\alpha_i - 2a - c_i + c_t}{\beta_i} \right) \stackrel{!}{=} 0 \tag{4.22}$$

Solving for a yields the optimal access charge per unit of traffic:

$$a^{CC,CDN} = \frac{\sum_{i=1}^{n} ((\alpha_i - c_i + c_t)/\beta_i)}{2 \sum_{i=1}^{n} (1/\beta_i)} \tag{4.23}$$

Note again that this access fee, in contrast to the multihoming case, is uniform across all markets. By using $\hat{c}_i = a + c_i$ combined with (4.23) in equations (4.6) and (4.7) we find the equilibrium prices and quantities; using (4.23) in (4.21) gives us the ISP$_t$'s profit in equilibrium. The market outcome can thus be summarized as follows:

$$p_i^{CC,CDN} = a^{CC,CDN} + c_i \tag{4.24}$$

$$q_i^{CC,CDN} = \frac{\alpha_i - p_i^{CC,CDN}}{\beta_i} \tag{4.25}$$

$$\pi_{CP,i}^{CC,CDN} = 0 \tag{4.26}$$

$$\pi_{ISP_t}^{CC,CDN} = \left(a^{CC,CDN} - c_t\right) \sum_{i=1}^{n} \left[q_i^{CC,CDN}\right] \tag{4.27}$$

Intuition: In this situation the ISP$_t$ has an intermediate degree of discriminatory power compared to the two previous situations. The ISP$_t$ can differentiate prices among different CDNs but it cannot discriminate against every single CP.

4.3.2 Content Monopoly

Having analyzed the case of content competition above, we now look at three situations where CPs are monopolists in each market. Consider a content provider who is a monopolist in a local market i. Irrespective of the type of connection they choose, their profit in the second stage can be written as

$$\pi_{CP,i} = (p_i - \hat{c}_i) \underbrace{\left(\frac{\alpha_i - p_i}{\beta_i}\right)}_{q_i} \tag{4.28}$$

by taking market demand from equation (4.5) into account. The first order condition for a maximum of (4.28) is given by:

$$\frac{\partial \pi_{CP,i}}{\partial p_i} = \frac{\alpha_i - 2p_i + \hat{c}_i}{\beta_i} \overset{!}{=} 0 \tag{4.29}$$

Rewriting this expression leads us to the price p_i^{**} the content provider charges end users in equilibrium, the quantity q_i^{**} that is supplied, as well as the profit of the content provider $\pi_{CP,i}$ in equilibrium:

$$p_i^{**} = \frac{\alpha_i + \hat{c}_i}{2} \tag{4.30}$$

$$q_i^{**} = \frac{\alpha_i - \hat{c}_i}{2\beta_i} \tag{4.31}$$

$$\pi_{CP,i} = \frac{(\alpha_i - \hat{c}_i)^2}{4\beta_i} \tag{4.32}$$

In the following we look at the first stage of the game to determine the price setting behavior of the ISPs and thus the cost $\hat{c}_i$ the content provider faces in the second stage.

Content Monopoly without MH or CDN

Consider a standard Internet interconnection situation of content monopoly (CM) where CPs do not use multihoming or content delivery networks. ISP_o has no market power and charges their total marginal cost $p_w = a + c_o$ from CPs, that is, the access charge a they have to pay to ISP_t for terminating the traffic plus their own marginal cost c_o. Their profits are zero. ISP_t cannot identify the traffic and thus levies a fee at marginal cost as well:

$$a^{CM} = c_t \tag{4.33}$$

As a result, the ISP_t's profits are zero. The total marginal cost for a CP can now be written as $\hat{c}_i = p_w + c_i = a^{CC} + c_o + c_i = c_t + c_o + c_i$. By using this expression in equations (4.30), (4.31) and (4.32), the market outcome in a situation of content monopoly without MH or CDN can finally be summarized as follows:

$$p_i^{CM} = \frac{\alpha_i + (c_t + c_o + c_i)}{2} \tag{4.34}$$

$$q_i^{CM} = \frac{\alpha_i - (c_t + c_o + c_i)}{2\beta_i} \tag{4.35}$$

$$\pi_{CP,i}^{CM} = \frac{(\alpha_i - (c_t + c_o + c_i))^2}{4\beta_i} \tag{4.36}$$

$$\pi_{ISP_o}^{CM} = 0 \tag{4.37}$$

$$\pi_{ISP_t}^{CM} = 0 \tag{4.38}$$

Intuition: In contrast to the three situations of content competition, in a standard Internet interconnection situation of content monopoly CPs are able to earn positive profits. These profits cannot be extracted by any of the downstream parties: ISP_o faces a competitive environment and ISP_t has no means of discrimination against the source of traffic.

Content Monopoly with Multihoming

Now, consider a situation of content monopoly (CM) where CPs use multihoming (MH). The CP in market i connects directly with ISP_t while there is no ISP_o in the market. The ISP_t can identify the CP where the traffic is coming from. Assuming that the ISP_t levies a two-part tariff, it will set the per unit traffic rate at:

$$a_i^{CM,MH} = c_t \tag{4.39}$$

Hence, CPs face total marginal costs of $\hat{c}_i = c_t + c_i$ and without any other fees, following (4.32), their profits would be $(\alpha_i - (c_t + c_i))^2/(4\beta_i)$. ISP_t, however, will set a fixed lump-sum fee at exactly this value to maximize their profits:

$$A_i^{CM,MH} = \frac{(\alpha_i - (c_t + c_i))^2}{4\beta_i} \tag{4.40}$$

Thus, the CPs' actual profits turn out to be zero. The ISP_t's profit, by contrast, is the sum of all n lump-sum fees. By using $\hat{c}_i = c_t + c_i$ in equations (4.30) and (4.31) we find the equilibrium prices and quantities. In sum, the market outcome in a situation of content monopoly with multihoming is as follows:

$$p_i^{CM,MH} = \frac{\alpha_i + (c_t + c_i)}{2} \tag{4.41}$$

$$q_i^{CM,MH} = \frac{\alpha_i - (c_t + c_i)}{2\beta_i} \tag{4.42}$$

$$\pi_{CP,i}^{CM,MH} = 0 \tag{4.43}$$

$$\pi_{ISP_t}^{CM,MH} = \sum_{i=1}^{n} \left[\frac{(\alpha_i - (c_t + c_i))^2}{4\beta_i} \right] \tag{4.44}$$

Intuition: End users still pay the monopoly price to the CP (now excluding the ISP_os cost). Multihoming, however, allows the ISP_t to extract all the profits from the CP by levying a two-part tariff. This can be a problem because monopoly profits could be the reward for innovation and if these profits are taken away from the CP, its ambitions to innovate might be suppressed.

Content Monopoly with Content Delivery Networks

Now, consider a situation of content monopoly (CM) where CPs use content delivery networks (CDN) for interconnection. The traffic is coming through the filter of the CDN so the ISP_t cannot identify individual traffic. It has to levy uniform fees for all CDN traffic. We cannot assume that levying a two-part tariff is possible because that itself requires identification of the traffic source. Let a be the fee per unit of traffic. Now, assuming that $a^{CM,CDN} < \alpha_i - c_i$ for all n markets, we get the following prices, quantities and profits:

$$p_i^{CM,CDN} = \frac{\alpha_i + (a + c_i)}{2} \tag{4.45}$$

$$q_i^{CM,CDN} = \frac{\alpha_i - (a + c_i)}{2\beta_i} \tag{4.46}$$

$$\pi_{CP,i}^{CM,CDN} = \frac{(\alpha_i - (a + c_i))^2}{4\beta_i} \tag{4.47}$$

$$\pi_{ISP_t}^{CM,CDN} = (a - c_t) \sum_{i=1}^{n} \left[\frac{\alpha_i - (a + c_i)}{2\beta_i} \right] \tag{4.48}$$

Note that these expressions still depend on a and only hold if all CPs stay in their respective market. For an equilibrium access charge of $a^{CM,CDN} > \alpha_i - c_i$, the quantity demanded in market i as given by equation (4.46) would become negative. As a result, CP_i would exit the market. At the same time, the ISP's total profit as given by equation (4.48) would decrease: profits could only be generated in a subset of markets that is smaller than n. Thus, to decide on the optimal value of the access charge, the ISP does not only have to take the direct positive effect of increasing a into account but also an indirect negative effect that comes from a smaller number of markets to serve.

We could solve the ISP's optimization problem and present a full equilibrium outcome by imposing further assumptions on the parameters in the model. For the following discussion this is of little value, however. It is rather important to see the general characteristics of this situation: On the one hand, for a given a, there may be CPs that do not face any demand. These CPs exit the market and thus earn zero profits. On the other hand, there are CPs that stay in the market and earn positive profits thanks to their positions as monopolists.

Intuition: In sum and on average CPs still earn positive profits in this situation. Also the ISP earns positive profits. For those markets that do not shut down the literature refers to such a situation as "double marginalization": there are two independent firms,

Table 4.1: Profit generation along the content delivery value chain

	Without MH/CDN	MH	CDN
Content Competition (CC)	ISP_t charges competitive price (their total marginal costs) to ISP_o as does ISP_o to CP and CP to end users $\pi^{CC}_{ISP_t} = 0$, $\pi^{CC}_{ISP_o} = 0$ $\pi^{CC}_{CP,i} = 0$	ISP_t charges monopolistic access fee to CP in each individual market, CP charges competitive price to end users $\pi^{CC,MH}_{ISP_t} > 0$ $\pi^{CC,MH}_{CP,i} = 0$	ISP_t charges uniform monopolistic access fee through the CDN to CP, CP charges competitive price to end users $\pi^{CC,CDN}_{ISP_t} > 0$ $\pi^{CC,CDN}_{CP,i} = 0$
Content Monopoly (CM)	ISP_t charges competitive price to ISP_o and ISP_o to CP, CP charges monopoly price to end users $\pi^{CM}_{ISP_t} = 0$, $\pi^{CM}_{ISP_o} = 0$ $\pi^{CM}_{CP,i} > 0$	ISP_t charges two-part tariff to CP to extract all profits the CP gets by charging monopoly price to end users $\pi^{CM,MH}_{ISP_t} > 0$ $\pi^{CM,MH}_{CP,i} = 0$	ISP_t charges uniform monopolistic access fee through the CDN to CP, CP charges monopoly price to end users $\pi^{CM,CDN}_{ISP_t} > 0$ $\sum_{i=1}^{n} \pi^{CM,CDN}_{CP,i} > 0$

upstream and downstream, CP_i and ISP, that both have market power and price at a markup over their cost.

4.3.3 Summary and Implications for Future Innovations

Table 4.1 summarizes the profit generation along the content delivery value chain. Six situations are presented as derived above. In the first three of them we assumed that there is competition among content providers. In a standard Internet interconnection situation with content competition, ISPs as well as CPs make zero profits. In a situation of content competition where CPs use MH, the ISP is able to charge monopolistic access fees from CPs in each individual market, leading to positive profits for the ISP. Facing competition, CPs cannot charge more than their total marginal cost from end users and thus make zero profits as without MH. In a situation where CPs use CDNs, the ISP can differentiate prices among different CDNs but it cannot discriminate against every single CP. As a result, the ISP only has an intermediate degree of discriminatory power but still makes positive profits. CPs make zero profits.

In three further situations we assumed that content providers are monopolists in their market. In a standard Internet interconnection situation with content monopoly, ISPs make zero profits while CPs use their monopoly power to earn positive profits. In a situation where CPs use MH, the ISP is able to charge CPs a two-part tariff to extract all monopoly profits that the CPs get from end users. In contrast to the ISP, CPs thus make zero profits in the end. In a situation of content monopoly where CPs use CDNs, the ISP charges the CPs a uniform monopolistic access fee trough the CDN. CPs, in turn, charge end users monopoly prices. There is thus a "double marginalization" situation where both, ISP and CPs (in sum), make positive profits.

In a nutshell, multihoming gives the ISP monopoly power to exploit their access monopoly over end users. This holds in the case of content competition as well as in the case of content monopoly. Content delivery networks give the ISP some monopoly power as well. However, since ISPs cannot discriminate against every single CP it is less pronounced than with multihoming.

Note that these results may have strong implications for future innovations. Under both assumptions for the degree of competition among content providers, full competition and monopoly, MH and CDNs allow the ISP to earn positive profits while without these technologies their profits are zero. These positive profits may well be used to finance future innovations which may have not been possible without MH or CDNs. For CPs, however, we get a different picture. Under the assumption of content competition nothing changes for CPs with the introduction of MH or CDNs. Their profits are zero in all three situations. Under the assumption of content monopoly, by contrast, all profits of the CPs are shifted away to the ISP with the introduction of MH. With the introduction of CDNs, individual CPs' profits may decrease. In sum and on average, however, CPs' profits remain positive.

In a nutshell, our model suggests that the introduction of MH or CDNs increases the potential to finance future innovations for the ISP. The CPs' potential to innovate, by contrast, remains unchanged or decreases.

4.3.4 Limitations of the Model

To put the results of our model into perspective it is important to be aware of the limitations of their applicability. First, the assumption that end users are perfectly locked in with their ISP can be challenged. Consumers that are able to switch their ISP will probably not tolerate monopoly prices for content in the long run if the total price for content differs between ISPs. Furthermore, they might not tolerate low quality access to certain content and thus force the ISP to invest in its standard peerings.

Second, a large part of the content business is financed by advertisements. The presented analysis relies on the exchange of money between end user and CP. Since this is not the case in ad-financed business models, the presented analysis cannot be applied to websites that base their business model on selling banner space.

Third, we only analyze two polar cases concerning the degree of competition that CPs might face. Usually, markets are neither pure monopolies nor perfectly competitive. Thus, realistic outcomes will fall somewhere in between the analyzed situations. The assumption of content monopoly may be in part justified by considering temporal monopolies gained through innovation and patents. However, more realistic modeling assumptions should take into account the role of substitutes.

Finally, it is only through the use of MH and CDNs that ISPs are put in a position to exploit their access monopoly and to create monopolies from otherwise competitive markets. The self selective nature of this phenomenon—CPs have to actively choose to give the ISP that power—makes it likely that CPs still get positive payoffs from doing so. Therefore, there are probably other effects at play that create more balanced outcomes than those of the pure MH or CDN situation which have not been captured by the model.

4.4 Conclusion and Further Research

The central insight of this work is that price discrimination is possible in today's Internet. The lever for ISPs to practice this price discrimination is not differentiation of data packets in the style of DiffServ (Wang, 2001) or a congestion based pricing mechanism like Odlyzko's Paris Metro Pricing (Odlyzko, 1999). Rather, differentiation is achieved indirectly through offering enhanced modes of interconnection. The reason for ISPs collaborating with CDNs can thus in part be attributed to the revenue potential ISPs see in it. Furthermore the claim that all data that is transported on the Internet is equal (Wu, 2003) must be rejected after considering the above analysis. The possibility to offer differentiated quality levels of data transport does exist on the Internet and it has not led to a breakdown of connectivity or other adverse developments. Rather, different quality and price levels are evolving on the Internet. Differentiated product offerings are generally thought to be welfare enhancing. However, with monopolistic firms one also has to watch their incentives to migrate customers to the more profitable service classes. The possibility that ISPs degrade standard peering quality to move customers to MH or CDN clearly exists.

As mentioned above, the assumptions about the competitiveness of markets made in this work are quite strong. To mend these limitations further research could firstly introduce more sophisticated modes of competition. Horizontal product differentiation in a Hotelling (1929) framework could offer a starting point for such an analysis. Limiting the termination monopoly power of ISPs could involve the introduction of switching costs (Klemperer, 1995). A further limitation of this work is that it is only applicable to paid content. With today's prevalence of advertisement financed business models, the exploration of two-sided market models (Armstrong, 2006; Rochet and Tirole, 2006) should yield further insights into the matter of pricing Internet traffic. In a two-sided market it would even be possible that end users get subsidized access to the Internet from their ISP since they are valuable assets. The terminating ISP needs to get end users on its network in order to be attractive to content providers.

Future research should also focus on the problem of the still existing lack of guaranteeable QoS. What can be learned from the success of CDNs and MH and how could these technologies be combined with other technology to further improve QoS on the Internet? Furthermore, the question about the economic efficiency of CDNs and MH must be answered. Under which circumstances are these technologies efficient? Is a global QoS regime—based for example on DiffServ—desirable in the light of the availability of these methods? Can CDNs and MH fully replace inter carrier agreements on quality parameters of traffic? Assuming the business model of providing data transport on the Internet changes towards more CDNs and MH, which effects will this have on the Internet as a whole beyond growing routing tables?

We have shown that incentives to degrade standard peering and transit do exist. Further research should refine our result to go beyond the politicized net neutrality debate.

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