Globalization and Vertical Firm Structure: An Empirical Investigation*

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Abstract

This paper 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.

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Keywords: Vertical integration, hold-up risk, theory of the firm, outsourcing, globalization, technical trade barriers, natural experiment, plant-level data

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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 various ways in which trade policy shapes (vertical) firm boundaries.[1] Seminal work by 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) demonstrate that globalization facilitates the search for suitable contracting partners, which makes arm's-length transactions more attractive. Ornelas and Turner (2008, 2011), in turn, argue that trade liberalization does not necessarily reduce the incentive to integrate: if trade volumes are larger under integration, trade liberalization generates higher benefits under vertical integration (the so-called trade volume effect). There is thus an impressive body of theoretical work on the link between trade liberalization and vertical firm structure. In marked contrast, the empirical evidence is scant.

This paper exploits a major change in Switzerland's trade policy towards the European Union (EU) to quantify the effect of trade policy on firm boundaries. Specifically, we study the impact of a 1999 agreement on the dismantling of technical barriers to trade between Switzerland and the EU on vertical firm structure in Switzerland. This agreement, also known as the Mutual Recognition Agreement (MRA), was approved in Switzerland by a popular vote in 2000 and enacted in 2002 (see EC (2002) for the full text of the agreement). The MRA stipulates the mutual 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 standards (e.g., regarding product safety or environmental protection) 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 standards (once for the Swiss market, and once for the European market). The MRA thus eliminated an important technical barrier

[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 (2015) and Marin (2012) discuss the influence of Grossman and Hart (1986)'s landmark contribution on recent work in international trade.

to trade between Switzerland and the EU.

The adoption of the MRA provides an ideal setting to study the impact of a change in trade policy on firm boundaries. First, the MRA is of great economic importance for the Swiss economy: With four fifths of Swiss imports coming from the EU and two thirds of Swiss exports going to the EU (Swiss Federal Customs Administration, 2012), the EU is by far Switzerland's most important trade partner. The completion of the MRA should therefore be expected to have had a major impact on Swiss firms. Second, the MRA unambiguously identifies the industries which are subject to the agreement. This allows us to separate the firms directly affected by the MRA from others which are not. Using a difference-in-differences approach, we can 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. Third, it is reasonable to assume that the selection of industries covered by the MRA was unrelated to the pre-liberalization vertical firm structure across industries: the MRA is based on similar agreements that the EU had earlier concluded with other trade partners such as Canada and the Unites States (Swiss Federal Council, 1999, p. 6213), leaving little room for lobbying by Swiss interest groups. In this context, it is also worth noting that the EU insisted on the MRA's selection of industries to be smaller than that covered by the European Economic Area (EEA), presumably to avoid Swiss "cherry picking".

To estimate the impact of the MRA on vertical firm integration in Switzerland, we adopt the following empirical approach. First, building on Hortaçsu and Syverson (2007) and Atalay, Hortaçsu, and Syverson (2014), we construct a binary measure of vertical integration for the universe of plants registered in Switzerland from 1995 to 2008. Specifically, 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, and non-integrated otherwise. 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.[2]

[2]The Business Census allows us to observe the universe of plants and firms over time, while the Input-Output Table provides information about the extent to which industries are vertically related.

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. Finally, we consider various robustness checks and extensions of our analysis. Throughout, 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).

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. 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 paper.

This paper contributes to three related strands of the literature. First, we add to the scant empirical evidence on the link between trade policy and firm boundaries. Alfaro et al. (2014) is the paper closest to ours. These authors employ cross-country and time-series variation in most-favored nation World Trade Organization (WTO) tariffs to estimate the impact of product prices on vertical integration. 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 show that vertical integration has fallen more in sectors with larger tariff cuts after China's accession to the WTO in 2001. There are two key differences to their paper. First, Alfaro et al. (2014) rely on a positive relation between import tariffs and output prices (Legros and Newman, 2013) to quantify the impact of prices on vertical integration. In this paper, we use a change in Switzerland's trade policy as a "natural experiment," providing us with treatment and control groups which can be observed before and after the policy change.[3] Second, while Alfaro et al. (2014) analyze changes in WTO tariffs, in this paper we study the elimination of technical non-tariff barriers to trade. Our studies thus adopt different empirical approaches and complement each other.[4]

Second, we contribute to the more general empirical literature on the effects of trade liberalization on heterogeneous firms.[5] Specifically, we show that the elimination of technical barriers to trade may have a strong impact on vertical firm structure. Previous work has documented effects on alternative outcome variables, such as productivity (Pavcnik, 2002; Trefler, 2004; Amiti and Konings, 2007; Lileeva and Trefler, 2010; Topalova and Khandelwal, 2011), investment (Bustos, 2011), employment (Trefler, 2004), and wages (Kovak, 2013).[6] In this strand of the literature, the paper closest to ours is Buehler, Helm, and Lechner (2014). These authors employ a similar database to quantify the impact of a bundle of treaties between Switzerland and the EU on employment growth in Switzerland. It is important to note that none of these papers analyzes the impact on vertical firm structure.

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

[4]There is little further evidence on the link between trade policy and vertical 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 of 1989 lead to an increase in merger activity in Canada, but this author 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.

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

[6]In a recent paper, Khandwal, Schott, and Wei (2013) show that trade liberalization can yield higher than expected gains if trade barriers are managed by inefficient institutions.

Finally, we add to the vast literature on vertical integration.[7] Our results support the notion that trade policy is an important determinant of vertical firm structure. Previous empirical work on the determinants of vertical integration has 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 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 of producer (supplier) industries. None of these papers discusses the role of trade policy.

The remainder of this paper is structured as follows. Section 2 provides the necessary background on Swiss trade policy towards the EU. It discusses the MRA, the (plausible) exogeneity of the industry selection, and how we exploit the MRA to estimate the effect of trade facilitation on vertical firm structure. Section 3 describes the database, explains our measurement of vertical integration, and discusses some descriptive statistics. Section 4 sets out the econometric approach, focusing on the empirical model and identification, and Section 5 presents the estimation results. Sections 6 and 7 provide a number of robustness checks and extensions. Section 8 concludes.

2 Switzerland and the European Union

Switzerland is a small industrialized economy in Western Europe with a population of roughly eight million residents. It shares borders with Austria, France, Germany, Italy, and Liechtenstein, but it is neither a member of the EU nor the EEA. The country's relations to the EU are governed by various bilateral agreements which are of paramount importance for the

[7] See Bresnahan and Levin (2013), Lafontaine and Slade (2007), Joskow (2005) and Perry (1989) for surveys.

Swiss economy. Since 1972, Switzerland has a Free Trade Agreement with the EU which prohibits customs duties or quotas on industrial products, but leaves technical trade barriers unaffected. 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 enabled the Swiss government to negotiate international treaties eliminating non-tariff barriers to trade, such as the MRA studied in this paper.[8] In doing so, the THG anticipated the trade facilitation later to be implemented by the MRA.

2.1 The Mutual Recognition Agreement

The Mutual Recognition Agreement (MRA) between Switzerland and the EU 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. It prescribes the mutual recognition of conformity assessments by Swiss and EU bodies for most industrial products (EC, 2002). A conformity assessment determines whether a given product satisfies the relevant standards (e.g., regarding product safety or environmental protection) 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 single conformity test is sufficient for determining whether a product may be marketed both in Switzerland and the EU.[9] The MRA thus eliminates an effective technical barrier to trade, reduces market-entry costs, and cuts red tape.

Table 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

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

[9] 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 the EU for the European market.

classification system used in our main data set.[10] Tables 7 and 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: 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 lists all "product sectors" which are covered by the Mutual Recognition Agreement according to the official agreement text between Switzerland and the European Union (EC, 2002, p. 376). Tables 7 and 8 in the appendix translate these sectors into the industry classification used in our data set.

2.2 Exogeneity of the Agreement's Industry Coverage

We view the completion of the Mutual Recognition Agreement between Switzerland and the EU as a plausibly exogenous change in trade policy and exploit it to estimate the effect of trade facilitation on vertical firm structure in Switzerland. This approach requires the MRA's selection of industries to be uncorrelated with the pre-liberalization vertical structure of firms across industries. That is, we must exclude the possibility that industries were endogenously selected based on their vertical firm structure.

[10]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.

There are strong indications that the selection of industries covered by the MRA was indeed exogenous. First, as mentioned above, the MRA is similar to agreements that the EU had earlier reached with trade partners such as Canada and the United States, and the MRA's selection of industries was explicitly limited by those covered by the EEA. It is thus unlikely that lobbying (Grossman and Helpman, 1994; Goldberg and Maggi, 1999) by Swiss interest groups has been able to systematically influence the selection of industries. Second, when entering into negotiations with the EU, the Swiss government publicly announced that it intended the MRA to cover *all* industrial products for which the EU had issued harmonized regulations and required a conformity assessment (Swiss Federal Council, 1999, p. 6213). The fact that the final agreement does not contain all products suggests that the selection of industries was (at least partially) imposed on Switzerland. Third, we are not aware that the vertical firm structure in Switzerland ever played a role in the public debate on the completion or the coverage of the MRA.

3 Data and Measurement

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.[11] Second, we employ Switzerland's Input-Output (I-O) Use Table for 2008, which is also provided by the Swiss Federal Statistical Office. The table is used to determine the vertical linkages between the different industries, which are crucial for

[11] See Burghardt and Helm (2015) for a recent study that provides further insights into this data.

calculating our measure of vertical integration at the plant level (see Section 3.2 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.

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 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 the different industries are vertically related.[12]

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

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

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*

[12] 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).

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.[13] Since no distinction is possible within these groups, we classify individual industries according to the combined estimate. Overall, the above definition classifies about 58% of all industry pairs as vertically linked.

Based on the dummy variable defined in (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 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.

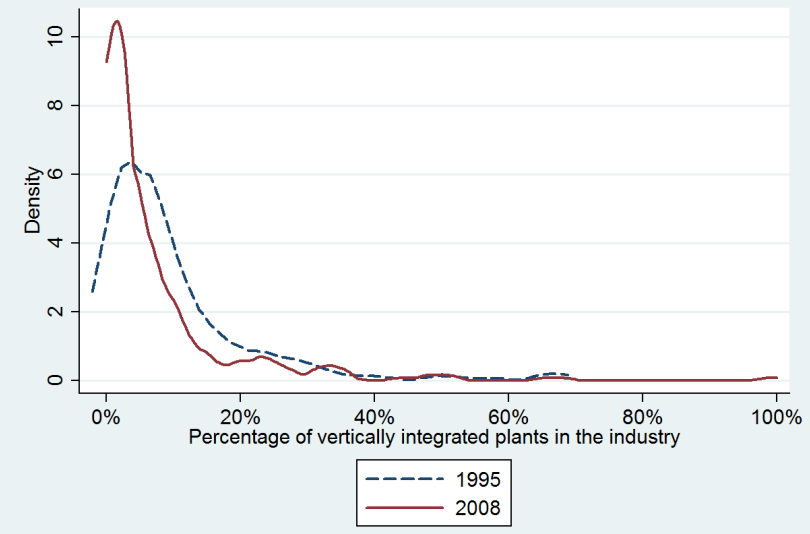
3.3 Descriptive Statistics

To get a more detailed picture about changes in vertical integration in Switzerland, we also calculate the average value of integration for all 4-digit manufacturing industries (NOGA 2002 classification). Due to our measure of vertical integration these averages also describe the percentage of plants in an industry that are vertically integrated. Based on these industry averages, Figure 1 shows a kernel density estimates for the years 1995 and 2008. It turns out that the kernel density estimate has shifted to the left from 1995 to 2008, indicating that over time the number of industries with a very low percentage of vertically integrated plants has increased in Switzerland.

It is well known that the validity of the difference-in-differences approach crucially de-

[13] A similar limitation holds for the following product groups (codes refer to the industries listed in Tables 7 and 8 in the Appendix): 23/24, 30/31, 40/41, 50-52, 60-62, 70/97, 71/74, 91-92, and 93-95.

Figure 1: Vertical integration of manufacturing industries in Switzerland by year



Notes: For each 4-digit NOGA 2002 manufacturing industry in Switzerland the percentage of plants which are vertically integrated has been calculated ($n = 238$ industries). Figure 1 shows the respective Epanechnikov kernel density estimates with a bandwidth of 2.12 percentage points for the years 1995 and 2008. It turns out that the kernel density estimate has shifted to the left from 1995 to 2008, indicating that over time the number industries with a very low percentage of vertically integrated plants has increased in Switzerland.

pends on the comparability of treatment and control group. We therefore need to control for differences in plant characteristics (if any) across these groups.

Table 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.[14]

A number of comments are in order. First, for the universe of Swiss plants, about

[14]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 6).

10.85 percent of the plants are vertically integrated (i.e., 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 sector than in the services sector, and it is lower in the control group (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 (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 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 distributions for most of the remaining plant characteristics listed in Table 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 the plant characteristics vary substantially across the treatment and the control group. We will therefore control for these plant characteristics in our empirical analysis below.

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

$$\begin{aligned} Integrated = \alpha \quad &+ \quad \beta_1 After + \beta_2 Treatment + \beta_3 (After \times Treatment) + \\ &+ \quad \gamma_1 y95 + \gamma_2 y05 + \gamma_3 y08 + X'\delta + u, \end{aligned} \tag{2}$$

where the dependent variable *Integrated* indicates whether a plant is vertically integrated, *Treatment* indicates whether a plant is treated by the MRA, *After* is a dummy variable

Table 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
Plant size	Large (250+ 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 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 illustrative example, while 18.48 percent of all treated plants are small plants, only 14.83 percent of all control plants are small plants. Also information on the services sector and the full sample is provided.

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 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 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 the plausibility of each of each of these assumptions 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 2, the MRA targeted a well-defined subset of plants (only those operating in the product sectors listed in Table 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.[15]

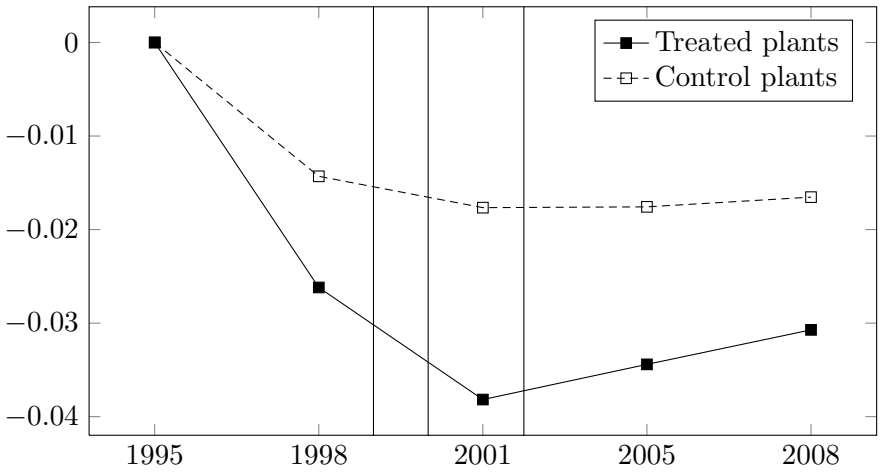
Second, the covariates X' need to be exogenous. In our specification, X' reflects the plant characteristics from 1995 until 2008. It seems safe to assume that the plant characteristics as of 1998 are exogenous, as they are measured well before the MRA became effective. Regarding the characteristics measured 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.

[15]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.

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 6 on robustness.

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 2.

Figure 2: Change in average vertical integration relative to 1995 (manufacturing)



Notes: Figure 2 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.

Figure 2 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 2), which enabled the Swiss government to negotiate international treaties such as the MRA to eliminate technical barriers to trade.[16] 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 2 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 explicit institutional foundation for anticipation effects.

5 Results

Table 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 6).

We find the following key results. First, and foremost, 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 2 suggest that the negative effect of the MRA on the average value of

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

Integrated tends to level out in the long run, our estimates do not pick up such a leveling out (see column (4) in Table 3).

Second, the effect of the MRA on vertical firm structure is economically significant 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 2).

Table 3: Effects of globalization on vertical integration (manufacturing)

	Dependent variable: *Integrated*			
	(1)	(2)	(3)	(4)
Independent variable	Limited controls	Baseline estimation	Industry controls	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.

6 Robustness

To check the robustness of our results, we perform two types of tests. First, we run two 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 two placebo experiments that we conducted are summarized in Table 4. In each of these experiments, we estimate a slightly adapted version of our baseline model, pretending that the MRA was approved after the actual approval (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. Note that we would ideally also run placebo experiments before the actual treatment. However, as between the two previous census years the THG was introduced, and we do not have earlier data available, such a placebo experiment is not feasible.

Table 4: Placebo experiment regression results (manufacturing)

	Dependent variable: *Integrated*	
	(1)	(2)
	Placebo	Placebo
Independent variable	2001–2005	2005–2008
After × *Treatment*	-0.0031	-0.0008
	(0.003)	(0.003)
Constant, *After*, *Treatment*	Yes	Yes
Year dummies	Yes	Yes
Plant characteristics (X')	Yes	Yes
Industry dummies	No	No
Observations	208,355	208,355
R-squared	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. All estimations are a modifications of the baseline model (see column (2) in Table 3) which pretend that the trade facilitation took place at another 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 composition of the treatment group remains unchanged. Table 5 provides the results.

Table 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 3 only considers manufacturing plants, Table 5 also includes services plants in the control group.

Inspection of Table 5 suggests that the qualitative results are similar to those for the manufacturing sample, even though the numerical estimates are fairly different.[17] 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.

[17]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.

7 Effects on Trade

Our main interest in this paper lies in quantifying the effect of the MRA 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.[18] 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

$$Exporting_{it} = \begin{cases} 1, & \text{if plant } i\text{'s parent firm in census year } t \text{ is exporting} \\ 0, & \text{otherwise} \end{cases} \tag{3}$$

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 this information is only available at the firm level. We then estimate the linear probability model

$$Exporting = \alpha + \beta_1 After + \beta_2 Treatment + \beta_3 (After \times Treatment) + X'\delta + u, \tag{4}$$

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.[19] We estimate a similar regression with the dependent variable $Importing_{it}$ indicating whether a

[18] 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.

[19] 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.

plant belongs to an importing parent firm.

Before discussing the results, we want to point out the limitations of this approach. 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 EU. 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 6: Effects on export and import status (manufacturing)

	Dependent variable: *Exporting*		Dependent variable: *Importing*	
	(1)	(2)	(3)	(4)
Independent variable	Limited controls	Baseline estimation	Limited controls	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 (i.e. the firm didn't answer the question).

Table 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.[20] The 1.28 percentage point increase predicted by baseline estimation (2) thus 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.[21] Therefore, this type of analysis is beyond the scope of the present paper.

8 Conclusion

This paper has estimated the effect of trade facilitation on vertical firm structure. Based on the Swiss Business Census and the I-O Use Table, we have a constructed a binary measure of vertical integration for the universe of Swiss plants from 1995 to 2008. Viewing the MRA with the EU as an 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

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

[21] 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.

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 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 these issues in future research.

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Appendix

Table 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 8.

Table 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 agrochemical 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 7 and 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 which are listed in the agreement text, as well as more detailed descriptions of the NOGA industries as provided by the Swiss Federal Statistical Office. In cases where industry codes are listed at a general level, all subcategories are meant to be included.

Table 9: Vertically integrated plants in Switzerland by industry and year (percentages)

		1995	1998	2001	2005	2008
15	Manufacture of food products and beverages	13.77	12.69	10.84	10.77	11.49
16	Manufacture of tobacco products	22.73	11.11	7.14	0.00	7.14
17	Manufacture of textiles and textile products	6.38	4.50	4.11	3.20	2.73
18	Manufacture of wearing apparel	4.12	1.63	1.86	1.77	2.73
19	Manufacture of luggage, handbags, saddlery	0.00	0.00	0.00	0.00	0.00
20	Manufacture of wood and of products of wood	2.22	1.40	1.26	1.11	1.07
21	Manufacture of pulp, paper and paper products	6.41	5.53	3.61	1.70	2.80
22	Publishing, printing; reprod. of recorded media	4.68	2.77	2.91	2.45	2.81
23	Manufacture of coke, refined petroleum products	28.00	36.36	21.43	20.00	12.50
24	Manufacture of chemicals and chemical products	13.31	10.36	6.47	7.65	9.57
25	Manufacture of rubber and plastic products	8.60	6.12	5.49	4.92	5.34
26	Manufacture of other non-metallic mineral prod.	9.14	7.18	5.57	7.84	7.81
27	Manufacture of basic metals	6.36	2.32	2.70	2.86	2.10
28	Manufacture of fabricated metal products	3.10	1.74	1.63	2.29	1.43
29	Manufacture of machinery and equipment n.e.c.	7.96	4.75	4.11	4.13	4.86
30	Manufacture of office machinery	10.99	11.03	5.56	8.09	15.70
31	Manufacture of electrical machinery	9.59	6.33	4.73	4.65	7.00
32	Manufacture of radio, television	7.95	4.62	2.62	4.17	5.15
33	Manufacture of medical and optical instruments	4.66	2.46	2.35	2.66	2.73
34	Manufacture of motor vehicles, trailers	5.06	1.04	1.65	1.09	1.69
35	Manufacture of other transport equipment	3.74	7.42	3.42	3.80	4.43
36	Manufacture of furniture, jewellery, toys	4.63	3.21	2.64	2.47	2.42
37	Recycling	2.41	1.22	2.12	0.97	3.28
All manufacturing industries		5.66	3.82	3.24	3.39	3.55

Notes: Table 9 shows the percentage of plants in Switzerland that are vertically integrated, by industry and year. Industries are classified at the 2-digit level according to the Swiss NOGA 2002 industry classification.