Trade Liberalization and Growth: Plant-Level Evidence from Switzerland*

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Abstract

This paper estimates the effect of trade liberalization on growth, using plant-level data from Switzerland. We employ a natural experiment framework to quantify the effect of a bundle of treaties liberalizing trade between Switzerland and the EU enacted in June 2002 ("Bilateral Agreements I") on the growth of Swiss plants. Using both a semi-parametric difference-in-differences and a matching approach, we find that the liberalization of trade increased the growth of affected plants by 1-2 percent during the first six years after liberalization. Our results suggest that trade liberalization has a relevant effect on growth.

Keywords: Trade liberalization, growth, plant size, policy evaluation

JEL Classification: C31, F13, F43, L25, O47, O52

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1 Introduction

What is the effect of trade liberalization on economic growth? Great effort has been devoted to answering this question, yet there is arguably little persuasive empirical evidence. The key difficulty in providing persuasive evidence is to identify the direction of causation between trade and growth (Frankel and Romer, 1999; Irwin and Terviö, 2002). Other major difficulties include the measurement of a country's openness to trade, and the plausible isolation of the effects of trade liberalization from other events (Edwards, 1993; Rodríguez and Rodrik, 2000; Yanikkaya, 2003; Wacziarg and Welch, 2008). In view of these difficulties, Winters (2004, F4) finds that the most plausible conclusion from a survey of the literature is that trade liberalization "generally induces a temporary (but possibly long-lived) increase in growth". In another survey, López (2005, 623) offers a more gloomy view of the literature, stating that "neither the existing theoretical models nor previous empirical analyses seem to have produced a definitive and positive answer to this area of inquiry."

In this paper, we propose a policy evaluation approach towards estimating the effect of trade liberalization on growth.[1] This approach is designed to quantify the causal effect of an exogenous policy change on the relevant outcome variables of a population of subjects in a natural experiment (Meyer, 1995) framework, thereby circumventing the difficulties mentioned above. Specifically, we view the enactment of a bundle of treaties between Switzerland and the European Union in June 2002—the "Bilateral Agreements I"[2]—as a plausibly exogenous instance of trade liberalization and estimate its impact on the growth of business plants in Switzerland, using micro data on the universe of Swiss plants from 1995 to 2008.

To implement this approach, we carefully study the contents of the seven treaties and employ the Swiss equivalent of the Standard Industrial Classification (SIC) code at the two-digit level to assign individual plants to the groups of 'non-affected', 'affected', and 'strongly affected' plants, respectively. Based on this classification, we use a Difference-in-

[1] See Angrist and Pischke (2008), Blundell and Costa Dias (2009), and Imbens and Wooldridge (2009) for recent surveys of the policy evaluation literature.

[2] The Bilateral Agreements I prescribe a significant reciprocal market opening in seven areas: technical trade barriers, free movement of persons, agricultural products, public procurement, ground transportation, civil aviation, and scientific and technological cooperation. We provide further details on these agreements in Section 2 below.

Differences (DiD) approach[3] to estimate the effect of the Bilateral Agreements I on plant growth in Switzerland. The idea is that, if the non-affected and the affected plants were subject to the same time trends (i.e., similar plant growth) and if trade liberalization had no effect in the pre-liberalization period, we can use the mean change in the size of the non-affected plants and add it to the mean size of the affected plants prior to the liberalization to construct the mean counterfactual size the affected plants would have reached if they had not been subject to trade liberalization. Of course, we control for exogenous variables that would have led to differential time trends in the absence of trade liberalization.[4] To ensure a high robustness of our results against potential misspecification of the relation between outcome and control variables, we do this in a semi-parametric way based on the propensity score.

We also adopt a matching approach (Rubin, 1978) to check the robustness of our result to a slight, but potentially important, variation of the identifying assumptions.[5] The key difference between the matching and the DiD methodology concerns the role of the pre-liberalization outcomes for constructing the non-observable counterfactual outcome. With matching, these outcomes are used together with exogenous variables to find plants not subject to trade liberalization which are similar to plants subject to liberalization. They are then used to estimate the counterfactual outcomes. With DiD, in turn, plants are made identical with respect to the exogenous variables only, and the pre-liberalization outcomes are directly subtracted from the post-liberalization outcomes to estimate the missing counterfactual trends.[6]

The estimation results of the DiD approach are similar to those of the matching approach, even though the latter are somewhat less precise. Our results suggest that the liberalization of trade increased the growth of the affected plants by 1-2 percent during the first six years after liberalization. The extra growth of the strongly affected plants during the same time is estimated to be higher (up to around 4-5 percent). In addition, the estimates indicate that, just prior to their enactment, the Bilateral Agreements I transitionally reduced the average growth of the affected plants by up to 2 percent.

[3]See Lechner (2010) for a recent survey on the estimation of causal effects by DiD methods.

[4]We will detail our econometric approach in Section 4.

[5]See Imbens and Wooldridge (2009) for a recent survey on matching methods.

[6]That is, once pre-liberalization outcomes are used as conditioning variables in DiD, matching and DiD are identical.

The latter result is consistent with the notion that plants improve their productivity in anticipation of a market opening (cf. López (2005)).[7]

It is instructive to compare our microeconometric estimates with the macroeconomic evidence recently reported by Wacziarg and Welch (2008). Building on Rodríguez and Rodrik (2000), these authors provide an updated version of the classic cross-country study by Sachs and Warner (1995). Using data from 1950 to 1998, they find that countries which liberalized their trade regimes experienced average annual growth rates that were about 1.5 percentage points higher than before liberalization. In a related cross-country study, Mattoo et al. (2006) find that countries with fully open telecom and financial services sectors grow up to 1.5 percentage points faster than other countries. These results are fairly similar to our findings both in terms of the sign and the size of the estimated effect, even though the authors use very different data and econometric techniques.[8]

This paper contributes to three related strands of the literature. First, by exploiting a plausibly exogenous variation in trade policy and using micro data on the universe of an economy's plants to provide an estimate of the causal effect of trade liberalization on growth at the plant level, we introduce the policy evaluation approach into the literature on the effect of trade liberalization on growth surveyed by Rodríguez and Rodrik (2000), Winters (2004), and López (2005). To the best of our knowledge, this is the first microeconometric study of the effect of trade liberalization on growth. Our approach exploits the heterogeneity available in a large population of business plants and is well-suited to circumvent many of the difficulties plaguing previous empirical contributions to this strand of the literature. In contrast to previous work, which often focused on developing countries, this paper considers a small open economy in the middle of Europe with a well-developed service sector. In doing so, our analysis sheds new light on the subtle relation between trade policy and economic growth.

Second, our analysis provides further evidence on the new trade theory pioneered by Melitz (2003) and Bernard et al. (2003).[9] Assuming that firm productivity is fixed, the

[7]The result needs to be interpreted carefully, though, since we cannot directly observe plant productivity and must assume that plant output was not reduced.

[8]López (2005, 628) provides a list of other well-cited cross-country studies which find a positive and statistically significant correlation between some measure of openness to trade and economic (or productivity) growth.

[9]More recent work includes Melitz and Ottaviano (2008), Baldwin and Forslid (2010), Redding (2010),

new trade theory predicts that trade liberalization leads to the exit of the least productive firms and the reallocation of market shares towards more productive firms. That is, according to the new trade theory, trade liberalization should have a negative (positive) effect on the growth of the least (most) productive firms, whereas the average effect on the affected firms is generally ambiguous. Our finding of a significant and positive growth effect on the affected plants is consistent with the predictions of the new trade theory. Note, however, that we cannot directly test these predictions with our data, since we do not observe productivity.

Third, our analysis adds to related work by Pavcnik (2002), Trefler (2004), Ederington and McCalman (2008), and Bustos (2011). These papers emphasize that trade liberalization not only generates a reallocation of market shares towards more productive firms, but also increases the productivity within firms. In particular, trade liberalization may induce firms to purposefully increase their productivity in anticipation of trade liberalization (López, 2005), or to use the resulting revenue increase for technology upgrading after trade liberalization (Bustos, 2011). Our estimates are consistent with such productivity increases both before and after the opening of the Swiss economy towards the European markets.

We believe that the evaluation of changes in macroeconomic (e.g., trade) policy at the microeconomic (e.g., plant) level offers a promising avenue for future research. In particular, the increasing availability of comprehensive plant-level data sets provides interesting new opportunities for analyzing the impact of major policy changes on relevant outcome variables at the micro level (e.g., plant size, plant productivity, etc.). Regarding the impact of trade liberalization on growth, it would be interesting to compare the results of our analysis to similar microeconometric studies of other instances of trade liberalization.[10] A collection of such studies is likely to provide persuasive empirical evidence on the impact of trade liberalization on economic growth.

The remainder of the paper is structured as follows. Section 2 provides a survey of Switzerland's trade policy towards the European Union, and discusses the contents

Bernard et al. (2010), and Eaton et al. (forthcoming). Panagariya (2000) provides a useful survey of the theory of preferential trade liberalization.

[10] A related study by Revenga (1997) on the impact of trade liberalization on Mexican manufacturing employs different econometric techniques and does not consider the impact on growth.

of the treaties forming the Bilateral Agreements I. Section 3 describes the data base, explains the classification of individual plants into groups of non-affected, affected, and strongly affected plants, and provides a first descriptive analysis. Section 4 discusses the empirical research design, the plausibility of the required identifying assumptions, and our estimation approach. Section 5 provides the results from estimating the causal effect of trade liberalization on plant growth. Section 6 concludes. The Appendix provides detailed information on the construction of our sample, the complete classification of plants, and further supporting material.

2 Swiss Trade Policy towards the European Union

Switzerland is a small open economy located in the middle of Europe. The country is a member of the European Free Trade Association (EFTA),[11] but belongs neither to the European Economic Area (EEA) nor to the European Union (EU).[12] Instead, Switzerland's relations to the EU are governed by a set of bilateral agreements surveyed below.

2.1 Survey of Bilateral Agreements

Over the last decades, the following agreements between Switzerland and the EU (or the European Community, respectively) were concluded (see Integration Office, 2009):[13]

(1) *Free Trade Agreement of 1972*: This agreement forms the basis of the close economic relations between Switzerland and the EU.[14] It prohibits tariffs and quotas on industrial products (e.g. watches and machines) between Switzerland and the EU, but falls short of a customs union.

(2) *Insurance Agreement of 1989*: This agreement guarantees insurance companies the mutual right to establish operations in the territories of the contracting parties.

[11] At the time of writing, the other EFTA members are Iceland, Liechtenstein, and Norway.

[12] The national currency is the Swiss Franc (CHF).

[13] Updated information is available at: `www.europa.admin.ch/themen/00500/index.html?lang=en`.

[14] The EU is Switzerland's most important trade partner. In 2008, bilateral trade per day passed 1 billion CHF. Roughly every third CHF was earned through trade with the EU, and roughly 80% of Swiss exports went to the EU. Conversely, Switzerland was the third-largest trading partner of the EU behind the U.S. and Russia, but ahead of China (Integration Office, 2009, 4).

(3) *Bilateral Agreements I*: This is a bundle of agreements which goes well beyond the Free Trade Agreement of 1972 and prescribes further market opening in seven areas: technical trade barriers, free movement of persons, agricultural products, public procurement, ground transportation, civil aviation, and scientific and technological cooperation.[15] The Bilateral Agreements I were approved by the Swiss electorate in May 2000 (approval rate: 67%) and are effective since June 1, 2002.

(4) *Bilateral Agreements II*: This bundle of agreements concerns further interests. In particular, it extends cooperation to the fields of internal security, asylum, the environment, and culture. These agreements were jointly approved in June 2005 (approval rate: 55%), but the time of enactment varies considerably across the individual agreements.

In our empirical analysis below, we will focus on the Bilateral Agreements I. These agreements are designed to liberalize (and safeguard) free trade between Switzerland and the EU. The 'Bilateral Agreements II', in turn, extend the mutual cooperation to asylum, security, and environmental policy and have little (if any) relevance for international trade. Our focus on the Bilateral Agreements I is further warranted by the fact that they have a single and well-defined date of enactment (June 1, 2002) which happens to be in the middle of our panel data set on the universe of Swiss plants ranging from 1995 to 2008.[16]

2.2 The Bilateral Agreements I

The Bilateral Agreements I implemented a mutual opening of Swiss and EU markets in seven areas. We briefly discuss the respective contractual agreements, based on information provided by the Integration Office (2009).

(A) *Technical trade barriers.* The so-called "Mutual Recognition Agreement" (MRA) stipulates the mutual recognition of conformity tests for most industrial products. Conformity tests certify that a product complies with the relevant regulations and may be offered on the market. The agreement covers diverse groups of industrial

[15] See Section 2.2 for further details.
[16] We will provide a more detailed description of our data in Section 3.

products, including machines, printers, medical products, motor vehicles, tractors, measuring instruments, telecommunications devices and (since March 2008) building materials (Integration Office, 2009, 14). The mutual recognition of conformity tests simplifies bilateral trade between Switzerland and the EU considerably. It implies, in particular, that any product approved in either Switzerland or the EU can be introduced in both markets, eliminating the need for double conformity testing.

(B) *Free movements of persons.* The agreement ensures equal treatment of Swiss and EU citizens in taking up residence and work. In particular, it improves the gradual mutual opening of labor markets, stipulates the recognition of professional diplomas, and coordinates the different social security systems.

(C) *Agricultural products.* The agreement liberalizes the cheese market (free trade since June 2007) and simplifies trade in other agricultural products by reducing customs duties and eliminating non-tariff barriers to trade.

(D) *Public procurement.* The agreement extends WTO rules and subjects larger tenders by municipalities and licensed firms (e.g., telecommunications and railway operators) to compulsory tendering.

(E) *Ground transportation.* The agreement increases the maximum weight limit for heavy trucks from 28 to 40 tonnes and prescribes the introduction of a Pigouvian tax on heavy vehicles, which provides incentives for moving transalpine freight from road to rail.

(F) *Civil aviation.* The agreement stipulates reciprocal access to aviation markets (including landing rights).

(G) *Scientific and technological cooperation.* The agreement improves the participation of Swiss research institutions and individuals in EU research programs.

3 Data

As mentioned in the introduction, the empirical analysis will exploit the cross-sectional variation in the extent to which plants were affected by the liberalization. Our panel data

set allows us to combine this variation with the longitudinal variation from the fact that even the (strongly) affected plants were unaffected by the liberalization years before the market opening. In this section, we begin with describing the data base and classifying the plants into groups of non-affected, affected, and strongly affected plants, respectively. Next, we characterize the sample actually used and provide some descriptive statistics for the various groups of plants.

3.1 Data Base

Our analysis is based on five waves (1995, 1998, 2001, 2005 and 2008) of the Swiss Business Census, which is a complete inventory count of all business establishments with more than 20 weekly aggregate working hours (excluding the agricultural sector). The Business Census is compiled by the Federal Statistical Office, and participation is mandatory. The Business Census provides detailed plant-level information on individual firms. In particular, it covers the number of employees (as well as their gender, nationality, etc.), the geographic location, and the industry classification, using the Swiss equivalent to the SIC code. Our database is unique in sample size, coverage of economic sectors and length of the observation period. In particular, it includes the service sector (e.g., wholesale and retail trade, banking, etc.), which is of crucial importance for the Swiss economy.

There are a two drawbacks of our data as well. First, we lack information about the productivity of individual plants or firms. Second, we cannot observe the outputs (or prices) of individual plants and therefore use the level of employment in full-time equivalents (FTEs) as a proxy for plant size. Nevertheless, if we accept the level of employment in FTEs as a reasonable measure of plant size, the database is well-suited to examine the effect of trade liberalization on plant growth.

3.2 Classification of Plants

We classify individual plants as non-affected, affected, or strongly affected, respectively, by the Bilateral Agreements I, based on an assessment of the extent to which a plant's (two-digit level) industry was affected by the seven agreements (A)-(G) discussed in

Section 2.2.[17] Let us illustrate this assessment, using industry 33 ("Medical Apparatus, Precision Instruments") as an example. For each individual agreement, we studied the official documentation and determined whether it affected industry 33. We found that this industry was affected by agreements (A), (B) and (D), but not by the other agreements. In light of our finding that industry 33 was affected by three out of seven agreements, we classified it as strongly affected and assigned it to group "2".[18] Industries affected by less than three agreements, in turn, were typically classified as affected (group "1") or "non-affected" (group "0"), respectively. Table A.1 in the Appendix provides the complete classification of all industries and further details on our assessment of individual industries.

Table 1 summarizes our classification of plants by industry. It shows each industry's classification into one of the three groups as well as the number of plants in that industry. Several comments are in order. First, the group of strongly affected plants is dominated by manufacturing industries 29 ("Machinery, Equipment") and 33 ("Medical Apparatus, Precision Instruments"). They jointly account for roughly 70% of the 8,602 plants. Agreement (A) lists these industries among those which particularly benefit from the elimination of technical trade barriers. Second, in the group of affected firms, the service industries 50 ("Trade Vehicle") and 51 ("Wholesale and Commission Trade") account for almost 65% of the 44,662 plants. These industries are affected, for instance, by the "packing conformity" stipulated by agreement (A). Third, a considerable number of industries, in particular in the service sector (e.g., 52 "Retail Trade", 55 "Lodging and Restaurants", etc.) is not affected by the Bilateral Agreements I. The 187,672 non-affected plants in these industries form the control group.[19]

3.3 Sample

Since we are interested in estimating the impact of trade liberalization on the growth of profit-oriented plants, we deleted cooperatives ("Genossenschaften"), associations and clubs ("Vereine"), foundations ("Stiftungen"), as well as churches, embassies and interna-

[17] We acknowledge that this assessment involves some judgement on our part.

[18] None of the industries was affected by more than three agreements.

[19] Potentially, all industries might have been affected by agreement (B). However, the inflow of workers from EU countries was, and continues to be, severely limited by quotas (see Section 4.2).

Table 1: Classification of Plants by Industry

		Group Classification			Percentage within	
	Industry	"0"	"1"	"2"	Group	Total
	Manufacturing					
15	Food and Luxury Food	0	2,678	0	6.00	1.11
16	Tobacco Products	0	19	0	0.04	0.01
17	Textiles	0	802	0	1.80	0.33
18	Apparel	0	851	0	1.91	0.35
19	Leather Products	0	300	0	0.67	0.12
20	Wood, Cork, etc.	0	5,909	0	13.23	2.45
21	Paper	0	240	0	0.54	0.10
22	Publishing, Printing	3,872	0	0	2.06	1.61
23	Koke, Refined Petroleum	21	0	0	0.01	0.01
24	Chemicals	0	764	0	1.71	0.32
25	Syntheticals	0	750	0	1.68	0.31
26	Glass, Ceramic	1,291	0	0	0.69	0.54
27	Production of Metal	299	0	0	0.16	0.12
28	Metal Products	6,550	0	0	3.49	2.72
29	Machinery, Equipment	0	0	3,428	39.85	1.42
30	Business Machines	0	0	133	1.55	0.06
31	Electric Machinery	0	0	1,123	13.06	0.47
32	Radio, TV, Communication	0	0	582	6.77	0.24
33	Med. Appar., Precision Instr.	0	0	2,803	32.59	1.16
34	Automobiles and Parts of Cars	0	0	208	2.42	0.09
35	Other Vehicles	0	0	325	3.78	0.13
36	Furniture, Jewelry, etc.	0	3,476	0	7.78	1.44
37	Recycling	255	0	0	0.14	0.11
	All Manufacturing Industries	12,288	15,789	8,602		15.22
	Services					
40	Energy Supply	336	0	0	0.18	0.14
41	Water Supply	26	0	0	0.01	0.01
45	Construction	28,486	0	0	15.18	11.82
50	Trade Vehicles (also Parts)	0	12,659	0	28.34	5.25
51	Wholesale and Commission Trade	0	16,214	0	36.30	6.73
52	Retail Trade	44,136	0	0	23.52	18.32
55	Lodging and Restaurants	23,317	0	0	12.42	9.68
60	Land Transportation, Pipelines	6,090	0	0	3.25	2.53
61	Water Transportation	108	0	0	0.06	0.04
62	Air Transportation	221	0	0	0.12	0.09
63	Auxiliary Transport Activities	2,971	0	0	1.58	1.23
64	Post and Telecommunications	260	0	0	0.14	0.11
65	Banks, Funds	2,916	0	0	1.55	1.21
66	Insurance Companies	1,618	0	0	0.86	0.67
67	Banking Business Activities	1,490	0	0	0.79	0.62
70	Real Estate and Housing	2,469	0	0	1.32	1.02
71	Renting of Goods and Chattels	665	0	0	0.35	0.28
72	Data Processing and Data Bases	4,232	0	0	2.25	1.76
73	Research and Development	241	0	0	0.13	0.10
74	Other Business Activity	39,288	0	0	20.93	16.31
90	Sewage and Waste Treatment	325	0	0	0.17	0.13
91	Sp. Intr. Groups, Relig. Org.	424	0	0	0.23	0.18
92	Culture and Sports Activities	3865	0	0	2.06	1.60
93	Other Services	11,900	0	0	6.34	4.94
	All Services Industries	175,384	28,873	0		84.78
	All Industries	187,672	44,662	8,602		100.00

Notes: Shown is the number of plants by industry in 1995, classified into non-affected ("0"), affected ("1"), and strongly affected ("2") plants, as well as their shares in the respective group and the full sample. The total number of plants is 240,936 with 36,679 units in the manufacturing and 204,257 units in the service sector.

tional organizations from our sample. In addition, we dropped industries with a negligible number of plants (e.g., mining) and non-profit oriented industries dominated by public administration (e.g, education, and health care and welfare). Finally, since our identification strategy requires pre-liberalization outcomes and covariates, we restricted the sample to firms which were active both in 1995 and 1998. Table A.2 in the Appendix shows how deleting these groups of plants affects the sample size. To avoid any selection bias due to liberalization-induced exit, we kept non-surviving plants after 1998 in the sample, but set their employment levels to zero.[20] Table A.3 in the Appendix provides more detailed information on the number of plants and plant exit. It shows, not surprisingly, that the probability of closure is considerably higher for smaller plants than for larger plants. This finding holds for all three groups.

3.4 Descriptive Statistics

A relevant question for our analysis is whether the firms in the different groups are similar with respect to their characteristics. Next, we therefore provide descriptive statistics for the pre- and post-liberalization plant characteristics by group and year, respectively.

Inspection of Table 2 indicates that, pre-liberalization, the three-year growth rates of plant employment (from 1995 to 1998, and from 1998 to 2001, respectively) were around ten percent for all groups.[21] The average number of employees per plant, in turn, varied considerably across groups. The average size of non-affected plants (around seven FTEs) was slightly smaller than that of affected plants (around ten FTEs), and much smaller than that of strongly affected plants (above 25 FTEs) in all years. The share of manufacturing firms was highest in the group of strongly affected firms (more than 75 percent). This is as expected because the Bilateral Agreements I were meant to facilitate trade in industrial products. Similarly, for 1995, we find that the share of exporting and importing plants was highest in the group of strongly affected firms (around 45 and 52 percent, respectively).[22] The pattern is less clear for the other pre-liberalization plant characteristics.

[20]This is feasible because the only post-1998 information needed for the estimation is based on employment levels which are well defined even if a plant is closed.

[21]Note that the 1995-1998 comparison covers only firms with positive employment in both years.

[22]This information is available only for 1995 and 2005.

Table 2: Pre-Liberalization Plant Characteristics by Year and Group

	1995			1998			2001		
Variables	"0"	"1"	"2"	"0"	"1"	"2"	"0"	"1"	"2"
No. of Employees	7.09	9.94	26.20	6.87	9.62	25.23	7.65	10.87	28.61
Manufacturers	6.55	35.35	100.00	7.35	32.70	80.47	7.95	33.24	77.90
Foreign Assets	3.37	3.87	8.16	n/a	n/a	n/a	2.14	4.20	9.25
Foreign Owned	2.44	5.72	5.48	n/a	n/a	n/a	1.68	4.53	5.36
Exporters	11.15	22.75	45.77	n/a	n/a	n/a	n/a	n/a	n/a
Importers	20.00	42.77	52.26	n/a	n/a	n/a	n/a	n/a	n/a
Renewal Region	27.20	28.05	32.32	27.20	28.13	32.39	27.36	28.08	32.57
Municipality									
Center	39.82	28.93	31.62	39.46	28.51	31.14	38.96	27.40	29.82
Suburban	24.12	30.22	31.78	24.29	30.49	32.07	24.44	30.98	33.11
High-Income	3.53	3.53	2.70	3.57	3.55	2.71	3.56	3.60	2.61
Periurban	7.20	8.72	8.75	7.28	8.82	8.81	7.34	8.97	9.00
Touristic	5.47	2.93	1.26	5.48	2.93	1.28	5.62	2.98	1.30
Ind. Tertiary	9.78	10.51	11.89	9.79	10.58	11.94	9.89	10.69	12.12
Rural Commuter	4.37	6.28	5.84	4.38	6.24	5.92	4.36	6.41	5.74
Rural Mixed	4.89	7.58	5.63	4.92	7.61	5.55	4.99	7.69	5.70
Rural	0.82	1.30	0.53	0.83	1.27	0.58	0.85	1.29	0.60
Region									
Geneva Lake	19.00	16.71	12.86	18.99	16.71	12.90	18.85	16.37	12.46
Espace Midland	21.43	21.77	27.26	21.42	21.76	27.17	21.48	21.70	27.42
North-West	12.43	12.13	13.24	12.42	12.13	13.35	12.34	12.47	13.29
Zürich	18.05	18.40	18.40	18.00	18.29	18.40	17.93	18.02	18.27
East	14.69	15.21	15.66	14.71	15.23	15.65	14.79	15.58	15.93
Central	9.09	10.61	8.85	9.13	10.72	8.81	9.31	10.90	8.90
Tessin	5.31	5.17	3.73	5.31	5.17	3.72	5.30	4.97	3.72
	1995 to 1998			1998 to 2001					
	"0"	"1"	"2"	"0"	"1"	"2"			
Growth Rates	10.66	10.93	10.52	10.88	9.26	11.16			

Notes: Shown are the numbers of employees (in FTEs), the percentage shares, and the growth rates by year and group. "0", "1" and "2" label the groups of non-affected, affected, and strongly affected plants, respectively. The definitions of the variables are provided in Table A.4 in the Appendix.

Table 3 shows that, after liberalization, the growth rates were around seven percent from 2001 to 2005, and around eight to eleven percent from 2005 to 2008. That is, except for the group of strongly affected plants, growth rates were consistently lower than in the pre-liberalization period. The average number of employees per plant, in turn, increased slightly. Specifically, the average size of non-affected plants increased from around seven FTEs in the pre-treatment period to around eight (2005) and nine (2008) FTEs in the post-treatment period, whereas the size of affected plants increased from around ten FTEs to around twelve (2005) and thirteen (2008) FTEs.[23] The share of the manufacturing plants in the group of strongly affected plants stayed roughly constant above 75 percent. Also, the share of exporting and importing plants continued to be highest in the group of strongly affected firms (around 46 and 54 percent, respectively). Again, there is no clear pattern for the other plant characteristics.

Table 3: Post-Liberalization Plant Characteristics by Year and Group

	2005			2008		
Variables	"0"	"1"	"2"	"0"	"1"	"2"
Number of Employees	8.19	11.85	29.47	9.06	13.18	35.15
Manufacturers	7.97	32.71	78.33	8.15	32.24	77.45
Foreign Assets	1.96	3.88	8.91	n/a	n/a	n/a
Foreign Owned	2.13	5.54	6.60	n/a	n/a	n/a
Exporters	10.26	21.63	46.57	n/a	n/a	n/a
Importers	17.15	40.95	54.61	n/a	n/a	n/a
Renewal Region	27.51	28.45	32.86	27.81	28.93	33.08
	2001 to 2005			2005 to 2008		
	"0"	"1"	"2"	"0"	"1"	"2"
Growth Rates	6.64	6.76	6.61	9.40	8.00	11.12

Notes: Shown are the numbers of employees (in FTEs), the percentage shares, and the growth rates by year and group. "0", "1" and "2" label the groups of non-affected, affected, and strongly affected plants, respectively. The definitions of the variables are provided in Table A.4 in the Appendix.

The casual comparison of pre- and post-liberalization plant characteristics suggests that the liberalization of trade had a slightly negative (if any) effect on plant growth.

[23]The increase in plant size is partly due to exit, since smaller plants are more likely to exit than larger plants (see Table A.3 in the Appendix for further details).

Across all groups of plants, the growth rates first declined after liberalization, and then only partially recovered (except for the group of strongly affected firms). However, Tables 2 and 3 also highlight considerable differences across the groups of plants. When estimating the effect of the Bilateral Agreements I on plant growth based on the DiD and the matching approach, we will account for these differences.

As many of the characteristics shown in Table 2 are correlated, Table 4 provides the corresponding multivariate analysis based on a probit model comparing the unaffected group to the different affected groups.[24] It shows the key correlates of a plant's probability of being affected by the Bilateral Agreements I. Inspection of Table 4 indicates that manufacturing and importing plants with foreign owners have a particularly high probability of being (strongly) affected. Other plant characteristics are also relevant, but they appear to be less important.

[24]Later on, it will turn out that this estimation forms one of the 'propensity scores' we are using when estimating the effects corrected for the differences between the various plant groups (see Section 4.3).

Table 4: Binary Probit Estimates (Matching)

	Groups		
Variable	$\mathbf{0 \to 1}$	$\mathbf{0 \to 2}$	$\mathbf{0 \to (1, 2)}$
Headquarter	0.0503***	0.0003	0.0476***
Single-Plant Firm	0.0295***	0.0085***	0.0332***
Manufacturer	0.3073***	0.2538***	0.3837***
Exporter	0.0178***	0.0262***	0.0336***
Exporter-missing	0.0101**	-0.0009	0.0091*
Importer	0.1881***	0.0300***	0.1894***
Importer-missing	-0.0117**	0.0014	-0.0109**
Foreign Ownership/Assets (Ref.: "Not Owned" and "Not Owner")			
Owns	0.0097*	0.0083***	0.0127***
Owns-missing	-0.0009	0.0024	0.0001
Owned	0.1281***	0.0152***	0.1246***
Owned-missing	0.0055	0.0004	0.0051
Municipality (Reference: Center)			
Suburban	0.0691***	0.0075***	0.0685***
High-Income	0.0448***	0.0011	0.0416***
Periurban	0.0721***	0.0070***	0.0701***
Touristic	-0.0147***	-0.0124***	-0.0222***
Industrial Tertiary	0.0493***	0.0029**	0.0462***
Rural Commuter	0.0971***	0.0091***	0.0925***
Renewal Economic Region	0.0093***	0.0027***	0.0116***
Region (Reference: Zürich)			
Geneva Lake	-0.0051**	-0.0048***	-0.0073***
Espace Midland	-0.0093***	0.0006	-0.0081***
North-West	-0.0168***	-0.0017	-0.0170***
East	-0.0021	0.0014	-0.0024
Central	0.0093***	-0.0004	0.0073**
Tessin	0.0014	-0.0069***	-0.0026
Size (Non-linear)	YES	YES	YES
Observations:	232.334	196.274	240.936

Notes: Coefficients show the average marginal effects and for the dummy variables discrete changes in the quantities of interest. *, **, and *** estimates are significant at the 10%, 5%, and 1% level, respectively. "0", "1" and "2" label the groups of non-affected, affected, and strongly affected plants, respectively. The definitions of the variables and the complete results are presented in Tables A.4, A.5, and A.6, respectively, in the Appendix.

4 Econometrics

4.1 Empirical Research Design

It is useful to illustrate our approach using the potential-outcome notation which is now standard in the policy evaluation literature (Imbens and Wooldridge, 2009). Specifically, let D denote the binary indicator of trade liberalization (via the Bilateral Agreements I) with $d \in \{0, 1\}$.[25] We are interested in estimating the mean effect of trade liberalization (i.e., switching D from zero to one) on plant size in period t. To do so, let the outcome variable Y_t^d denote the 'potential' plant size that would be realized for some value d in period t (which may be unobservable). Y_t denotes the observed plant size in period t.

We want to answer the policy question whether the plants (strongly) affected by the Bilateral Agreements I benefited from the liberalization of trade. That is, we are interested in estimating the so-called 'average-treatment effect on the treated' (ATET) in period t,

$$\text{ATET}_t = \text{E}(Y_t^1 - Y_t^0 | D = 1). \tag{1}$$

It is important to note that, if t denotes a period prior to trade liberalization (e.g., the year 2001), ATET_t measures the anticipation effect of liberalization . If t denotes a period after trade liberalization (e.g., 2005 or 2008), ATET_t measures the medium to longer-run effect of trade liberalization.

The potential-outcome notation clarifies the estimation problem at hand and points to the key issue of causal inference: How can we infer what would have happened (in period t) to the plants affected by the trade liberalization, if the trade liberalization had not taken place? Unfortunately, this 'counterfactual outcome' is never observed. We therefore have to use credible assumptions to impute this outcome.

Our identification strategy exploits the two key advantages of our data base. First, we have data on a very large number of plants—the universe of Swiss plants. This feature allows us to avoid the behavioral restrictions implied (but seldom discussed) by tightly specified parametric models of the linear or non-linear regression type. Second, we have panel data over 13 years with measurements in five different periods (1995, 1998, 2001,

[25] Capital letters denote random variables, and small letters denote realizations of random variables.

2005, and 2008). Thus, we can use the pre-liberalization performance of the plants to find out what would have happened in the absence of trade liberalization.

The key assumption necessary for any partial-equilibrium analysis is that interactions between plants are not relevant for the effect of trade liberalization on plant growth (SUTVA, Rubin (1977)). This assumption implies that one of the potential outcomes Y_t^d is observable for each plant at time t, i.e., $Y_t = dY_t^1 + (1-d)Y_t^0$, with $d \in \{0,1\}$.[26]

In addition, we assume that the observable covariates X with value x are exogenous (EXOG) in the sense of not being influenced by the liberalization of trade. Similarly, we assume that the pre-liberalization outcomes for 1995 and 1998 were not affected by the liberalization of trade in 2002 (NEPT). We do allow, though, for the possibility that plants anticipated the change in 2001 and already reacted to it.

Finally, since our empirical strategy relies on the use of non-affected plants to impute what would have happened to affected plants in the absence of trade liberalization (for all values of X for which we observe affected or strongly affected plants), we also need to observe plants which are not affected by the liberalization of trade. This assumption is called the common support condition (COSU).

If these assumptions are satisfied, there are two major approaches towards exploiting the panel dimension for non- or semi-parametric identification, namely the matching approach (see the excellent survey by Imbens (2004)) and the differences-in-differences (DiD) approach (see Lechner (2010) for a recent survey).

With the matching approach, we can use the pre-liberalization outcomes as additional control variables. That is, we infer what would have happened to the plants affected by the trade liberalization by using the weighted mean of the outcomes of the non-affected plants. The weights are chosen such that the reweighted distribution of characteristics of the non-affected plants is identical to that observed for the affected plants, with the characteristics including functions of the 1995 and 1998 outcomes. The estimates based on this approach have a causal interpretation if the so-called conditional independence assumption (CIA) holds, that is, if we are able to control for all factors that jointly influence the outcomes and the fact that a plant is affected.[27] This assumption (in

[26] See Lechner (2010) for a formal definition of this and the following identifying assumptions.

[27] We discuss below whether we think this assumption is credible in our setting.

addition to those already mentioned) implies

$$\begin{aligned}
&\mathrm{E}(Y_t^0|X=x, Y_{98}=y_{98}, Y_{95}=y_{95}, D=1) \\
&= \mathrm{E}(Y_t^0|X=x, Y_{98}=y_{98}, Y_{95}=y_{95}, D=0) \\
&= \mathrm{E}(Y_t|X=x, Y_{98}=y_{98}, Y_{95}=y_{95}, D=0).
\end{aligned}$$

Since SUTVA also implies $\mathrm{E}(Y_t^1|D=1) = \mathrm{E}(Y_t|D=1)$, the ATET_t is identified in all periods t because, as can be seen by applying the law of iterated expectations to the second term in the ATET_t in (1),

$$\begin{aligned}
&\mathrm{E}(Y_t^0|D=1) \\
&= \mathrm{E}[\mathrm{E}(Y_t^0|X=x, Y_{98}=y_{98}, Y_{95}=y_{95}, D=1)|D=1] \\
&= \mathrm{E}[\mathrm{E}(Y_t|X=x, Y_{98}=y_{98}, Y_{95}=y_{95}, D=0)|D=1].
\end{aligned}$$

The alternative is to adopt a DiD approach and use the pre-liberalization outcomes in a differencing framework, where the key assumption is that the group of non-affected plants is facing the same time trend as the group of (strongly) affected plants would face in the absence of trade liberalization, given specific values of the covariates. This is called the 'common trend' assumption, which can be formalized as follows

$$\begin{aligned}
&\mathrm{E}(Y_t^0 - Y_{98}^0|X=x, Y_{95}=y_{95}, D=1) \\
&= \mathrm{E}(Y_t^0 - Y_{98}^0|X=x, Y_{95}=y_{95}, D=0), \qquad \forall t \in \{2001, 2005, 2008\}.
\end{aligned}$$

Note, in particular, that the outcomes of the year 1998 do not appear as conditioning variables, because otherwise the matching and the DiD approach would be identical.

Furthermore, due the exogeneity assumption applied to the outcomes (NEPT), we have

$$\begin{aligned}
&\mathrm{E}(Y_{98}^{\tilde{d}}|X=x, Y_{95}=y_{95}, D=d) \\
&= \mathrm{E}(Y_{98}|X=x, Y_{95}=y_{95}, D=d), \qquad \forall d, \tilde{d} \in \{0,1\}.
\end{aligned}$$

This assumption requires that we have access to all exogenous variables which could lead to a differential trend for the potential outcome of the non-affected and the (strongly) affected plants in the absence of trade liberalization. We will discuss in Section 4.2 below whether this is plausible in our context.

It is easy to show that the common trend assumption together with the assumptions made above (other than CIA), in particular NEPT, is sufficient to identify the missing counterfactual,

$$\begin{aligned}
&\mathrm{E}(Y_t^0|X=x, Y_{95}=y_{95}, D=1)\\
&\quad = \mathrm{E}(Y_t^0|X=x, Y_{95}=y_{95}, D=0) - \mathrm{E}(Y_{98}^0|X=x, Y_{95}=y_{95}, D=0)\\
&\qquad +\mathrm{E}(Y_{98}^0|X=x, Y_{95}=y_{95}, D=1)\\
&\quad = \mathrm{E}(Y_t|X=x, Y_{95}=y_{95}, D=0) - \mathrm{E}(Y_{98}|X=x, Y_{95}=y_{95}, D=0)\\
&\qquad +\mathrm{E}(Y_{98}|X=x, Y_{95}=y_{95}, D=1).
\end{aligned}$$

Applying the law of iterated expectations in the same way as for matching gives the expression for the ATET_t in terms of observable quantities and thus proves identification.

Comparing the assumptions of the matching and the DiD approach, it becomes clear that the common-trend assumption is in fact a CIA applied to a difference of the outcome variables over time. The advantage of this transformation is that any unobservable variable which affects the counterfactual outcome in all periods in the same way and is additively separable (e.g., an individual fixed effect in a fixed-effects panel regression), is no threat to validity because it is differenced out. This flexibility comes at the cost of a functional-form dependence: A common-trend assumption which is valid for the level of the outcome variable (and thus removes the fixed effect) is not necessarily valid for a monotone but nonlinear transformation (see Lechner (2010), for example). In this sense, identification is functional-form dependent.

The matching approach, on the other hand, uses the outcome variable of 1998 to make the plants comparable on that dimension as well, rather than to take a difference. Although this comparison does not formally remove a fixed effect (even if it is additively separable), it holds for all transformations of the outcome variable. Furthermore, one may argue that conditioning on the outcome 1998 implicitly conditions on the impact of

the fixed effect on the future outcome and thus removes (most of) that problem as well.[28]

4.2 Plausibility of Assumptions

The identification of the causal effect of trade liberalization on plant growth crucially relies on the identifying assumptions. We consider the plausibility of each of them in turn.

First, consider the SUTVA assumption, which requires that one of the potential outcomes Y_t^d is observable for each plant at time t. In our setting, the outcome variable Y_t is plant size in year t, measured by the log of the number of employees in FTEs plus one.[29] In our setting, SUTVA is violated if the liberalization of trade was important enough to affect the outcome for all (i.e., even the non-affected) plants. Our plant classification suggests that the Bilateral Agreements I did not affect all plants. Recall that the impact of agreement (B) on the free movements of persons, which might have affected all industries, was severely limited by so-called 'accompanying measures' ("flankierende Massnahmen"), which prevented major changes in the labor markets of non-affected industries. A crucial element of these measures are quotas which limited the inflow of workers from EU-15 countries until May 31, 2007, and continue to be in place for other EU countries. Given the existence of these quotas and other efforts against the undercutting of wages, we are confident that the remaining interactions between non-affected and other plants (if any) in our sample are negligible.

Next, consider the assumptions that both the covariates X (EXOG) and the outcomes for the years 1995 and 1998 (NEPT) are exogenous. We feel pretty safe in making these assumptions, since the negotiations between the EU (or the EC, respectively) and Switzerland were still well under way in 1998, and the Swiss electorate approved the Bilateral Agreements I only in May 2000 (see Section 2.1). It seems quite likely, though, that variables measured in 2001 were affected by the anticipated liberalization of trade. We therefore allow for an anticipation effect in the period from 1998 to 2001.

The common-support assumption (COSU), which requires that there is valid com-

[28] See Imbens and Wooldridge (2009) for further discussion.

[29] We add one to the number of employees in FTEs to deal with inactive plants (where the the number of FTEs is zero by definition).

parison group of non-treated plants for the characteristics x, is not problematic, because there is a very large control group of more than 185,000 plants with considerable variation of x. It is worth noting that this assumption is testable, and our tests suggest no problems.

Proceeding under the notion that these four basic assumptions are satisfied, we now discuss the different additional assumptions needed for the matching and the DiD approach, respectively. Recall that the matching approach additionally imposes the conditional independence assumption (CIA), which requires the control of all factors that jointly determine the outcomes and whether a plant is affected. We are convinced that, thanks to the large set of covariates X available at the plant level (including lagged outcomes from 1995 and 1998), we effectively control for the key factors discussed in the relevant literature. For instance, in addition to a plant's size, which is often viewed as a measure of productivity in the new trade literature, we are able to control for its export and import activity, whether it owns foreign assets or is owned by foreign firms, its geographic location, etc.[30] Nevertheless, we may imperfectly control for some relevant unobservable factors, such as a plant's pre-liberalization integration into European markets. With this in mind, one may argue that the common trend assumption (from 1998 onwards) necessary for the DiD approach is more plausibly satisfied, because by including the growth rate from 1995 to 1998 in the set of control variables, we have already enforced a common trend from 1995 to 1998 by construction.

On balance, it seems difficult to definitely determine which of the two non-nested approaches is more suitable for identifying the causal effect of trade liberalization on plant growth. We will therefore provide the results of both approaches in Section 5 below.

4.3 Estimation

Having established identification, the next issue is how to perform estimation. The simplest approach, which is still fairly common in some fields, is to specify a parametric model for the relation of the outcome variable with the policy variable and the condition-

[30] See Table A.4 in the Appendix for a list of the available plant characteristics.

ing variables. For the log of plant size, a linear regression would be a natural choice. For the DiD estimation, one would choose a specification with X and the 1995-1998 growth rate, a time trend, a group indicator, and the interaction of time and group capturing the effect of the liberalization. For the matching estimation, the outcome would be regressed on X and the log of plant size in 1995 and 1998. However, the disadvantage of these simple approaches is that they lead to inconsistent results if these regressions are misspecified. The latter is the case, for instance, if the effect of the liberalization is heterogeneous across plants, and this heterogeneity relates to the characteristics X or plant size in 1995 or 1998.

The alternative is to use semi-parametric matching-type procedures involving the propensity score. The idea is to specify the relation between the membership in a particular group (non-affected, affected, or strongly affected) and the respective control variables using a parametric model, but leaving the relation of the outcome to the control variables free. This approach is common in the program evaluation literature and now spreading to many other fields. It is justified by the additional robustness of not having to specify the relation of the outcomes to the policy variable and the conditioning variables. Clearly, such semi-parametric approaches require large data sets, because giving up functional-form assumptions leads to additional uncertainty in estimation. Yet, the requirement of a large data set is not a problem in our case.

The key insight for deriving practical estimators is that creating 'comparable observations' with respect to the conditioning variables is not necessary, provided that there is comparability with respect to a particular function of those variables called the propensity score

$$p(X) \equiv \Pr(D = 1|X) = \mathrm{E}(D|X). \tag{2}$$

Rosenbaum and Rubin (1983) used this property to develop the propensity-score matching estimators. Lechner (2010), among others, shows that the same idea can be used to develop semi-parametric DiD estimators based on propensity-score matching.

In this paper, we estimate the propensity score with a probit model (see Table 4 in Section 3.4).[31] Then, for the matching estimates, we use a bias-adjusted radius matching

[31] The complete results are presented in Tables A.5 and A.6 in the Appendix.

procedure as in Lechner et al. (forthcoming), which has superior small-sample properties (Huber et al., 2010). For the DiD matching, an inverse probability estimator is used (Huber et al., 2010; Lechner, 2010).

Due to the particular structure of the plant data, observations for plants which belong to the same company are probably correlated. We approach this problem by devising a bootstrap procedure that independently draws firms (with all their plants in all periods) and basing the inference on the resulting bootstrap distribution of the estimates.

5 Results

Table 5 reports the results from estimating the ATET_t with the DiD and the matching methodology. The columns indicate the relevant comparison of plant groups. Specifically, we focus on non-affected vs. affected plants ($0 \to 1$), non-affected vs. strongly affected plants ($0 \to 2$), and non-affected vs. the pool of affected and strongly affected plants ($0 \to (1,2)$). The rows indicate the years for which the comparison is made (2001, 2005, and 2008, respectively).[32] The table entries report the estimated extra growth rates caused by trade liberalization measured in percentage changes.

Let us first consider the pre-liberalization year 2001. The DiD estimates suggest that the affected plants ($0 \to 1$) experienced a significant reduction in growth by 2 percent in anticipation of the trade liberalization (from 1998 to 2001). The pool of affected and strongly affected plants ($0 \to (1,2)$) also experienced a significant reduction in growth by 1.9 percent, whereas the group of strongly affected plants ($0 \to 2$) alone did not suffer from a significant reduction in growth. The matching estimates are less precise than the DiD estimates, but they suggest a reduction in growth of a similar order of magnitude. These findings are consistent with the notion that, in anticipation of the trade liberalization, the affected plants increased their productivity with the intention of becoming (larger) exporters (López, 2005).[33]

Next, consider the post-liberalization years 2005 and 2008. Both the DiD and the

[32] Recall that our identifying assumptions require the outcomes for 1995 and 1998 to be unaffected by the liberalization of trade.

[33] Note, though, that we do not observe productivity at the plant level, so that the anticipation effect needs to be interpreted carefully. Implicitly, this view of the anticipation effect presumes that (non-observable) outputs were non-decreasing during the anticipation phase.

Table 5: Estimates of the ATET

	Difference-in-Differences			Matching		
Year	$\mathbf{0 \to 1}$	$\mathbf{0 \to 2}$	$\mathbf{0 \to (1,2)}$	$\mathbf{0 \to 1}$	$\mathbf{0 \to 2}$	$\mathbf{0 \to (1,2)}$
2001	-2.00***	-0.60	-1.90***	-0.90	-0.10	-1.30
	(0.50)	(1.30)	(0.60)	(1.10)	(3.90)	(1.30)
2005	1.30*	1.30	1.20*	1.80*	2.20	1.60
	(0.70)	(1.90)	(0.80)	(1.10)	(3.70)	(1.30)
2008	1.30*	4.00**	1.60**	1.80*	5.30	2.20*
	(0.80)	(2.00)	(0.90)	(1.10)	(3.70)	(1.30)

Notes: Outcome variable is log(size+1) in the respective year, with size measured by the number of employees in FTEs. Results are shown in percentage points, which follow from the differences in the average outcomes across groups. Plants which exit in 2005 or 2008 are coded to have size zero.
*, **, and *** estimates are significant at the 10%, 5%, and 1% level, respectively.
Standard errors are in parentheses. Standard errors and inference has been obtained by clustered bootstrap at the firm level using the bootstrap distribution of the effects based on 499 replications.
"0", "1" and "2" label the groups of non-affected, affected, and strongly affected plants, respectively.

matching estimates suggest that the liberalization of trade increased the growth of the affected plants by 1-2 percent during the first six years after liberalization. The extra growth of the strongly affected plants during the same time is estimated to be around 4-5 percent. That is, the negative anticipation effect of trade liberalization on plant growth was transitory in nature and turned into a positive effect by 2005.

Summing up, our results suggest that, after a transitory anticipation phase in which plant growth was reduced by up to 2 percent, the Bilateral Agreements I increased the growth of affected plants by 1-2 percent during the first six years after liberalization. The growth of strongly affected plants, in turn, increased by 4-5 percent.

6 Conclusion

This paper has proposed a policy evaluation approach towards estimating the effect of trade liberalization on growth. This approach is designed to avoid the well-known econometric difficulties plaguing previous work in this field. In particular, it allows us to identify the direction of causation from trade liberalization on growth.

Viewing a bundle of bilateral agreements between Switzerland and the EU (Bilateral

Agreements I) enacted in June 2002 as a plausibly exogenous instance of trade liberalization, we have used data on the universe of Swiss plants from 1995 to 2008 to estimate the effect of trade liberalization on plant growth. Employing both a semi-parametric DiD and a matching approach, we have found the following results:

First, there is evidence for a negative anticipation effect. According to our estimates, the average growth of the affected plants was reduced by up to 2 percent in anticipation of the trade liberalization. This finding is consistent with the notion that firms improve their productivity in anticipation of a market opening.

Second, the negative anticipation effect was turned into a positive effect after liberalization, increasing the average growth of the affected plants by about 1-2 percent during the first six years after enactment. That is, the trade liberalization caused a significant and persistent extra growth of the affected plants.

Our results support the view that trade liberalization has a relevant effect on economic growth. It should be clear, though, that the effect is likely to vary across different instances of trade liberalization and industries affected. It would therefore be interesting to compare our results to similar policy evaluation studies of trade liberalization. A collection of such studies is likely to provide persuasive empirical evidence on the impact of trade liberalization on economic growth.

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A Appendix

Table A.1: Industry Classification into Groups

		Agreement							Group	Comment(s)
		A	B	C	D	E	F	G		
Mining of Coal and Minerals, Extraction of Oil and Peat										
10	Mining of Coal and Extraction of Peat	0	1	0	0	0	0	0	9	B1
11	Extraction of Crude Oil and Gas	0	1	0	0	0	0	0	9	B1
12	Mining of Uranium and Thorium Ores	0	1	0	0	0	0	0	9	B1
Mining of Iron Ores and Quarrying										
13	Mining of Iron Ores	0	1	0	0	0	0	0	9	B1
14	Other Mining and Quarrying	0	1	0	0	0	0	0	9	B1
Manufacturing of Food										
15	Food and Beverage	1	1	1	0	0	0	0	1	A2, B1,C1,C2
16	Tobacco Products	1	1	1	0	0	0	0	1	A2, B1,C1,C2
Manufacturing of Textiles and Textile Products										
17	Textiles	1	1	0	0	0	0	0	1	A1,A2,B1,X17
18	Apparel	1	1	0	0	0	0	0	1	A1,A2,B1
Leather and Leather Products										
19	Leather Products	1	1	0	0	0	0	0	1	A1,A2,B1
Manufacturing of Wood and Wood Products										
20	Wood, Cork, ...	1	1	0	0	0	0	0	1	A1,A2,B1
Manufacturing of Pulp, Paper and Paper Products										
21	Paper	1	1	0	0	0	0	0	1	A2,B1
22	Publishing, Printing	0	1	0	0	0	0	0	0	A2,B1
Manufacturing of Koke and Refined Petroleum										
23	Koke, Refined Petroleum	0	1	0	0	0	0	0	0	B1
Manufacturing of Chemicals and Chemical Products										
24	Chemicals	1	1	1	0	0	0	0	1	A1,B1,C2
Manufacturing of Syntheticals and Synthetical Products										
25	Syntheticals	1	1	0	0	0	0	0	1	A1,B1
Manufacture of Non-Metalic Mineral Products										
26	Glass, Ceramic, etc.	1	1	0	1	0	0	0	0	A2,B1,X26
Production, Manufacturing of Metal and Metal Products										
27	Production of Metal	1	1	0	1	0	0	0	0	A2,B1,X26
28	Metal Products	1	1	0	1	0	0	0	0	A2,B1,X26
Manufacturing Systems Engeneering										
29	Machinery, Equipment	1	1	0	1	0	0	0	2	A1,A2,D1
Manufacturing of Business Machines										
30	Business Machines	1	1	0	1	0	0	0	2	A1,A2,B1,D1
31	Electric Machinery	1	1	0	1	0	0	0	2	A1,A2,B1,D1
32	Radio, TV, Communication Apparatus	1	1	0	0	0	0	0	2	A1,A2,B1
33	Med. Apparatus, Precision Instruments	1	1	0	1	0	0	0	2	A1,A2,B1
Vehicle Manufacturing										
34	Automobiles and Parts of Cars	1	1	0	1	0	0	0	2	A1,B1,D1
35	Other Vehicles	1	1	0	1	0	0	0	2	A1,B1,D1

Table A.1: Industry Classification into Groups (continued)

		Agreement							Group	Comment(s)
		A	B	C	D	E	F	G		
Manufacturing of Furniture, Jewellery, Musical Instruments										
36	Furniture, Jewellery, etc.	1	1	0	0	0	0	0	1	A1,B1
37	Recyling	0	1	0	0	0	0	0	0	B1
Electricity, Gas and Water Supply										
40	Energy Supply	0	1	0	1	0	0	0	0	B1,D2
41	Water Supply	0	1	0	1	0	0	0	0	B1,D2
Construction Industry										
45	Construction	0	1	0	1	0	0	0	0	B1,D2
Retail and Wholesale Trade, Repair of Automobiles										
50	Trade of parts and complete Vehicles Repair and Maintenance	1	1	0	0	0	0	0	1	A1,B1
51	Wholesale and Commission Trade	1	1	0	0	0	0	0	1	B1,X51
52	Retail Trade	0	1	1	0	0	0	0	0	B1,C1,X52
Lodging and Restaurants										
55	Lodging and Restaurants	0	1	0	0	0	0	0	0	B1
Transportation and Communication										
60	Land Transportation and Pipelines	0	1	0	0	1	0	0	0	B1,E1
61	Water Transportation	0	1	0	0	0	0	0	0	B1
62	Air Transportation	0	1	0	0	0	1	0	0	B1,F1
63	Auxiliary Transport Activities	0	1	0	0	1	1	0	0	B1,E1,F1
64	Post and Telecommunications	0	1	0	0	0	0	0	0	B1
Credit Institutions and Insurances										
65	Commercial and Central Banks, Fonds	0	1	0	0	0	0	0	0	B1
66	Insurance Companies	0	1	0	0	0	0	0	0	B1
67	Banking Business Activities	0	1	0	0	0	0	0	0	B1
Real Estate and Housing, Renting of Good and Chattels										
70	Real Estate and Housing	0	1	0	0	0	0	0	0	B1
71	Renting of Goods and Chattels	0	1	0	0	0	0	0	0	B1
72	Data Processing and Data Bases	0	1	0	1	0	0	0	0	B1,D1
73	Research and Development	0	1	0	0	0	0	1	0	B1,G
74	Other Business Activity	0	1	0	0	0	0	0	0	B1
Public Administration, Social Insurance										
75	Public Administration, Social Insurance	0	0	0	0	0	0	0	9	
Education										
80	Education	0	0	0	0	0	0	0	9	
Health Care, Welfare										
85	Health Care, Welfare	0	0	0	0	0	0	0	9	
Other Public or Private Services										
90	Sewage and Waste Treatment	0	1	0	1	0	0	0	0	B1,D1
91	Lobby, Religious Organizations	0	1	0	0	0	0	0	0	B1
92	Culture and Sports Activities	0	1	0	0	0	0	0	0	B1
93	Other Services	0	1	0	0	0	0	0	0	B1
Private Households Goods and Services										
95	Households with Employees	0	1	0	0	0	0	0	0	B1
96	Manufacturing for own use	0	1	0	0	0	0	0	0	B1
97	Services for own use	0	1	0	0	0	0	0	0	B1

Notes: "0", "1", "2" and "9" label the groups of non-affected, affected, strongly affected and excluded plants, respectively. You can find the "comments" below this table.

Comments:

(A1) The MRA explicitly covers the following industries: (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 plants and equipment; (11) Measuring instruments and prepackages; (12) Motor vehicles; (13) Agricultural and forestry tractors; (14) Good laboratory practice (GLP); (15) Medical products GMP Inspection and Batch Certification.

(A2) The MRA does not cover all "packing" from either country. Since the MRA allows to ask for conformity in a single inspection authority, it substantially eases the proof of conformity.

(B1) The *agreement on the free movement of persons* ensures equal treatment of Swiss and EU citizens in taking up residence and work. However, the inflow of workers from EU-15 countries continued to be limited by quotas until May 31, 2007, and it is still limited for other EU countries. It is thus reasonable to assume that, at least until summer 2007, this agreement had virtually no impact on Swiss industries.

(C1) The *agreement on agricultural products* liberalizes the cheese market (free trade since June 2007) and simplifies trade in other agricultural products. The treaty should be expected to influence all industries dealing with agricultural products.

(C2) The *agreement on agricultural products* removes technical trade barriers in the following fields: (1) Crop protection; (2) Animal feed; (3) Viniculture; (4) Spirits and flavored drinks containing wine; (5) Organic products and foodstuff; (6) Recognition of conformity checks for fruit and vegetables subject to marketing standards; (7) Veterinary and breeding measures applicable to trade in living animals and animal products.

(D1) The first chapter of the *agreement on public procurement* extends the WTO rules and subjects public authorities and bodies at the district and municipality level to compulsory tendering.

(D2) The second chapter of the *agreement on public procurement* subjects licensed firms (e.g., telecommunications and railway operators) to compulsory tendering.

(E1) The *agreement on ground transportation* increases the maximum weight limit for heavy trucks from 28 to 40 tonnes and prescribes the introduction of a Pigouvian tax on heavy vehicles, which provides incentives for moving transalpine freight from road to rail.

(F1) The *agreement on civil aviation* stipulates reciprocal access to aviation markets (including landing rights).

(G) The *agreement on scientific and technological cooperation* regulates the participation of Swiss research institutions and individual in EU programs.

(X17) Not affected by agreement D (no evidence for tendering).

(X26) Affected by agreement D (public tendering is observed).

(X51) Affected by agreement A (cf. A1 and A2 above).

(X52) Affected by agreement C, because agricultural products are imported more easily (cf. C1 above).

Table A.2: Sample Size

	Year				
	1995	1998	2001	2005	2008
Complete Data Base	372,782	379,330	385,074	375,167	389,165
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
Eliminated Plants					
Non-Private	37,892	35,361	34,073	33,050	32,747
	(10.16)	(9.32)	(8.85)	(8.81)	(8.41)
Mining Industries etc.	34,672	34,560	36,283	35,462	37,156
	(9.30)	(9.11)	(9.42)	(9.45)	(9.55)
Not Active in 1995 and 1998	59,282	68,473	119,107	147,172	175,998
	(15.90)	(18.05)	(30.93)	(39.23)	(45.22)
Final Sample	240,936	240,936	195,611	159,483	143,264
	(64.63)	(63.52)	(50.80)	(42.51)	(36.81)

Notes: Shown is the number and share of plants by year. The final sample consists of 240,936 plants. In the final sample all plants observed in 2001 and later are already observed in 1995 and 1998. Estimation is based on 240,936 plants with employment levels for plants which were closed after 1998 set to zero.

Table A.3: Number of Plants by Group, Size, and Year

		Year				
Group	Size	1995	1998	2001	2005	2008
not affected ("0")	Micro (0-9)	160,107	160,998	127,559	101,476	88,715
		(100.00)	(100.56)	(79.67)	(63.38)	(55.41)
	Small (9-49)	24,161	23,424	21,363	19,051	18,862
		(100.00)	(96.95)	(88.42)	(78.85)	(78.07)
	Medium (49-249)	3139	2,991	2,911	2,649	2,755
		(100.00)	(95.29)	(92.74)	(84.39)	(87.77)
	Large (249+)	265	259	277	230	253
		(100.00)	(97.74)	(104.53)	(86.79)	(95.47)
	Total (group "0")	187,672	187,672	152,110	123,406	110,585
		(100.00)	(100.00)	(81.05)	(65.76)	(58.92)
affected ("1")	Micro (0-9)	36,317	36,477	28,975	23,248	20,457
		(100.00)	(100.44)	(79.78)	(64.01)	(56.33)
	Small (9-49)	6,850	6,726	5,982	5,545	5,412
		(100.00)	(98.19)	(87.33)	(80.95)	(79.01)
	Medium (49-249)	1,350	1,316	1,214	1,079	1,096
		(100.00)	(97.48)	(89.93)	(79.93)	(81.19)
	Large (249+)	145	143	154	136	148
		(100.00)	(98.62)	(106.21)	(93.79)	(102.07)
	Total (group "1")	44,662	44,662	36,325	30,008	27,113
		(100.00)	(100.00)	(81.33)	(67.19)	(60.71)
strongly affected ("2")	Micro (0-9)	5,960	5,994	4,748	3,933	3,433
		(100.00)	(100.57)	(79.66)	(65.99)	(57.60)
	Small (9-49)	1,778	1,748	1,585	1,413	1,366
		(100.00)	(98.31)	(89.15)	(79.47)	(76.83)
	Medium (49-249)	691	688	686	580	602
		(100.00)	(99.57)	(99.28)	(83.94)	(87.12)
	Large (249+)	173	172	157	143	165
		(100.00)	(99.42)	(90.75)	(82.66)	(95.38)
	Total (group "2")	8,602	8,602	7,176	6,069	5,566
		(100.00)	(100.00)	(83.42)	(70.55)	(64.71)
	Total (all groups)	240,936	240,936	195,611	159,483	143,264
		(100.00)	(100.00)	(81.19)	(66.19)	(59.46)

Notes: The number in brackets shows the percentage relative to the reference year 1995. The classification of plants into groups is based on Table A.1.

Table A.4: Definitions of the Variables

Variable	Description
Headquarter	Plant is a headquarter of a Multi-Plant Company.
Single-Plant Firm	Plant is a Single-Plant Company.
Companion	Plant is a companion plant of a Multi-Plant Company.
Manufacturer	Plant is in the manufacturing sector.
Exporter	Plant belongs to a firm which exports to foreign markets.
Exporter-missing	Survey question is not asked (1998, 2001 and 2008) or not answered.
Importer	Plant belongs to a firm which imports from abroad.
Importer-missing	Survey question is not asked (1998, 2001 and 2008) or not answered.
Renewal Economic Region	Region is eligible for public funds supporting regional development.
Size	Plant's employment is measured in FTEs.
Foreign Ownership/Assets	
Owns	Plant belongs to a firm which (partly) owns foreign assets.
Owns-missing	Survey question is not asked (1998 and 2008) or not answered.
Owned	Plant belongs to a firm which is (partly) owned by foreign capital.
Owned-missing	Survey question is not asked (1998 and 2008) or not answered.
Municipality	
Center	Central municipality of a large agglomeration in a metropolitan region.
Suburban	Suburban or job-rich (non-central) municipality in a metropolitan region.
High-Income	Real income per resident exceeds some specific threshold in the region.
Periurban	Municipality in an agglomeration (neither suburban nor high-income).
Touristic	Municipality featuring a high number of touristic overnight stays.
Industrial Tertiary	Municipality with a high production of industrial goods and services.
Rural Commuter	Municipality located outside an agglomeration with a high share of commuters.
Rural Mixed	Municipality with a relatively high share of agrarian production.
Rural Municipality	Municipality with high share of agrarian production.
Geographic Region	*Canton*
Zürich	Zürich
Geneva Lake	Geneva, Vaud, Valais
Espace Midland	Bern, Fribourg, Jura, Neuchâtel, Solothurn
North-West	Aargau, Basel-Country, Basel-City
East	Appenzell Inner-Rhodes, Appenzell Outer-Rhodes, Glarus, Graubünden, St. Gallen, Schaffhausen, Thurgau
Central	Lucerne, Nidwalden, Obwalden, Schwyz, Uri, Zug
Tessin	Ticino

Notes: Municipalities and geographic regions are classified by the Swiss Federal Statistical Office and documented in Schuler et al. (2005).

Table A.5: Binary Probit Estimates (Matching)

	Coefficients			Average Marginal Effects		
Variable	$\mathbf{0 \to 1}$	$\mathbf{0 \to 2}$	$\mathbf{0 \to (1,2)}$	$\mathbf{0 \to 1}$	$\mathbf{0 \to 2}$	$\mathbf{0 \to (1,2)}$
Headquarter	0.2325***	0.0057	0.2102***	0.0503***	0.0003	0.0476***
Single-Plant Firm	0.1311***	0.1579***	0.1433***	0.0295***	0.0085***	0.0332***
Manufacturer	0.9930***	1.7734***	1.1850***	0.3073***	0.2538***	0.3837***
Exporter	0.0744***	0.3900***	0.1342***	0.0178***	0.0262***	0.0336***
Exporter-missing	0.0428**	-0.0160	0.0375*	0.0101**	-0.0009	0.0091*
Importer	0.6846***	0.4520***	0.6785***	0.1881***	0.0300***	0.1894***
Importer-missing	-0.0510**	0.0243	-0.0459**	-0.0117**	0.0014	-0.0109**
Foreign Ownership/Assets (Reference: "Not Owned" and "Not Owner", respectively)						
Owns	0.0409*	0.1347***	0.0521***	0.0097*	0.0083***	0.0127***
Owns-missing	-0.0038	0.0404	0.0004	-0.0009	0.0024	0.0001
Owned	0.4685***	0.2350***	0.4527***	0.1281***	0.0152***	0.1246***
Owned-missing	0.0235	0.0073	0.0210	0.0055	0.0004	0.0051
Municipality (Reference: Center)						
Suburban	0.2809***	0.1268***	0.2723***	0.0691***	0.0075***	0.0685***
High-Income	0.1804***	0.0186	0.1647***	0.0448***	0.0011	0.0416***
Periurban	0.2830***	0.1156***	0.2708***	0.0721***	0.0070***	0.0701***
Touristic	-0.0646***	-0.2452***	-0.0951***	-0.0147***	-0.0124***	-0.0222***
Industrial Tertiary	0.1990***	0.0498**	0.1829***	0.0493***	0.0029**	0.0462***
Rural Commuter	0.3688***	0.1471***	0.3478***	0.0971***	0.0091***	0.0925***
Rural Mixed	0.4021***	0.0871***	0.3647***	0.1067***	0.0052***	0.0973***
Rural Municipality	0.4207***	-0.0005	0.3661***	0.1136***	0.0000	0.0985***
Renewal Region	0.0396***	0.0467***	0.0480***	0.0093***	0.0027***	0.0116***
Region (Reference: Zürich)						
Geneva Lake	-0.0219*	-0.0873***	-0.0308***	-0.0051**	-0.0048***	-0.0073***
Espace Midland	-0.0402***	0.0103	-0.0342***	-0.0093***	0.0006	-0.0081***
North-West	-0.0738***	-0.0298	-0.0720***	-0.0168***	-0.0017	-0.0170***
East	-0.0092	0.0240	-0.0102	-0.0021	0.0014	-0.0024
Central	0.0395***	-0.0076	0.0301**	0.0093***	-0.0004	0.0073**
Tessin	0.0058	-0.1280***	-0.0108	0.0014	-0.0069***	-0.0026
Size (Non-linear)	YES	YES	YES	YES	YES	YES
Constant	-1.8170***	-2.7948***	-1.7785***	—	—	—
Observations:	232.334	196.274	240.936	232.334	196.274	240.936

Notes: The dependent variable is binary; it is 0 for non-treated plants and 1 for the treated plants in groups "1" or "2", respectively. *, **, and *** estimates are significant at the 10%, 5%, and 1% level, respectively. The sizes of firms and plants are measured in full time employment units and the coefficients are left out here for the purpose of clarity.

Table A.6: Binary Probit Estimates (Difference-in-Differences)

	Coefficients			Average Marginal Effects		
Variable	$\mathbf{0 \to 1}$	$\mathbf{0 \to 2}$	$\mathbf{0 \to (1,2)}$	$\mathbf{0 \to 1}$	$\mathbf{0 \to 2}$	$\mathbf{0 \to (1,2)}$
Growth (1995/1998)	-0.0007	-0.0072	-0.0011	-0.0002	-0.0004	-0.0003
Headquarter	0.3841***	0.1306***	0.3701***	0.0796***	0.0071***	0.0805***
Single-Plant Firm	0.1271***	0.1299***	0.1319***	0.0288***	0.0071***	0.0308***
Manufacturer	0.9975***	1.7783***	1.1923***	0.3109***	0.2570***	0.3888***
Exporter	0.0883***	0.3955***	0.1498***	0.0213***	0.0268***	0.0379***
Exporter-missing	0.0494**	-0.0077	0.0441**	0.0118**	-0.0004	0.0108**
Importer	0.6730***	0.4421***	0.6676***	0.1849***	0.0293***	0.1865***
Importer-missing	-0.0605***	0.0222	-0.0547***	-0.0139***	0.0013	-0.0130***
Foreign Ownership/Assets (Reference: "Not Owned" and "Not Owner", respectively)						
Owns	-0.0991***	0.1109***	-0.0754***	-0.0224***	0.0067***	-0.0177***
Owns-missing	-0.0092	0.0429	-0.0051	-0.0021	0.0025	-0.0012
Owned	0.4458***	0.1941***	0.4278***	0.1217***	0.0123***	0.1176***
Owned-missing	0.0270	0.0078	0.0245	0.0064	0.0004	0.0059
Municipality (Reference: Center)						
Suburban	0.2784***	0.1254***	0.2705***	0.0688***	0.0074***	0.0684***
High-Income	0.1750***	0.0191	0.1593***	0.0436***	0.0011	0.0404***
Periurban	0.2802***	0.1158***	0.2686***	0.0718***	0.0070***	0.0699***
Touristic	-0.0651***	-0.2513***	-0.0963***	-0.0149***	-0.0127***	-0.0225***
Industrial Tertiary	0.1932***	0.0459*	0.1773***	0.0480***	0.0027*	0.0449***
Rural Commuter	0.3663***	0.1454***	0.3454***	0.0969***	0.0090***	0.0923***
Rural Mixed	0.3985***	0.0835***	0.3612***	0.1063***	0.0050**	0.0968***
Rural Municipality	0.4179***	0.0020	0.3633***	0.1134***	0.0001	0.0983***
Renewal Region	0.0392***	0.0445***	0.0472***	0.0092***	0.0026***	0.0115***
Region (Reference: Zürich)						
Geneva Lake	-0.0156	-0.0824***	-0.0245**	-0.0037	-0.0046***	-0.0059**
Espace Midland	-0.0413***	0.0061	-0.0355***	-0.0096***	0.0004	-0.0085***
North-West	-0.0732***	-0.0309	-0.0713***	-0.0168***	-0.0018	-0.0169***
East	-0.0097	0.0182	-0.0111	-0.0023	0.0011	-0.0027
Central	0.0418***	-0.0122	0.0319***	0.0099***	-0.0007	0.0078**
Tessin	0.0105	-0.1283***	-0.0064	0.0025	-0.0069***	-0.0015
Constant	-1.8573***	-2.8151***	-1.8170***	—	—	—
Observations:	232.334	196.274	240.936	232.334	196.274	240.936

Notes: The dependent variable is binary; it is 0 for non-treated plants and 1 for the treated plants in groups "1" or "2", respectively. *, **, and *** estimates are significant at the 10%, 5%, and 1% level, respectively.