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Final Report

Free Trade Agreements and their Impacts on CO_2 Emissions

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Free Trade Agreements and their impacts on CO_2 emissions
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List of Abbreviations

CHF	Swiss francs
CO_2	Carbon dioxide
EFTA	European Free Trade Association
EU	European Union
FAO	Food and Agriculture Organization
FTA	Free trade agreements
GDP	Gross domestic product
GHG	Greenhouse gas
LCA	Life cycle assessment
LW	Live weight
MFN	Most favored nation
NAFTA	North American Free Trade Agreement
OLS	Ordinary least squares
PPML	Poisson pseudo-maximum likelihood
PW	Packaged weight
UN	United Nations
USD	United States Dollars
WTO	World Trade Organization

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1. Introduction

As its domestic market size is limited, Switzerland is highly dependent on international trade. Therefore, Swiss foreign economic policy aims to improve access to foreign markets. Swiss trade policy rests upon the World Trade Organization [WTO] framework and the bilateral free trade agreements [FTAs] with partner countries. In addition to the European Free Trade Association [EFTA] convention and the FTA with the European Union [EU], Switzerland currently has a network of 31 FTAs with 41 parties (Bergstrand and Baier, 2010; SECO 2020a). In the last decades, international trade and climate change have become closely linked. In part due to the stalled negotiations within the WTO, the linkages between trade and the environment are currently best illustrated in recent bilateral and regional trade agreements, where sustainable development has become one of the main political mandates in modern trade (Jinnah and Morgera 2013: 324; Draper et al. 2017: 1). Although Switzerland's domestic environmental performance has achieved considerable improvement, its environmental impact abroad is still under-evaluated. Products for domestic consumption are increasingly substituted by imports from its trade partner countries, meaning that the environmental footprint related to their production cycle originates outside Switzerland (Frischknecht et al. 2018). Therefore, in a first step, this report focuses on the effects of Switzerland's bilateral free trade agreements on the volume of imported goods.

The main purpose of an FTA is to encourage trade between partner countries by reducing or eliminating trade barriers. Lowering tariffs for traded commodities is the central instrument of any free trade agreement. Despite this, countries have a vital interest in protecting their own sensitive areas. For instance, Swiss agriculture is protected by high domestic subsidies and import barriers (SECO 2020b, Economiesuisse, 2018). In Switzerland, industrial products have been mostly liberalized but tariffs on agricultural goods remain very high, with an average tariff of 36.1% of the import value (Economiesuisse, 2018). In this report, we first focus on the impact of free trade agreements on imports of agricultural commodities, including both animal- and plant-based products. As shown in Figure 1, the imports of agricultural products have seen a steadily increasing trend in recent years. This stresses the importance of studying the impact of policy on these imports. Moreover, agriculture is one of the four highest emission intensive import sectors. Hence, this report aims to answer the following first central question:

How do Swiss import patterns of agricultural commodities change following the introduction of a free trade agreement?

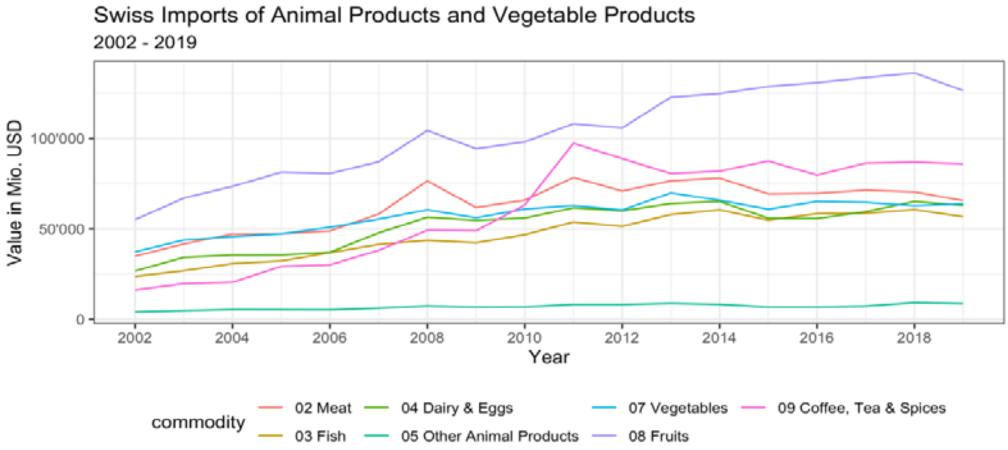

Figure 1: Swiss imports of animal products and vegetable products (TrendEconomy 2019)

Although fostering international trade is one of the central goals of Swiss economic policy, environmental concerns about the impact of free trade have garnered much attention in recent years. Besides improving access to foreign markets, sustainable development is an explicit goal of foreign economic policy (SECO 2020a). Whether these two objectives can be reconciled has been subject to widescale academic and public discussion. Hence, our aim is to contribute to this discussion by studying the direct effect of new free trade agreements on the imports of liberalized goods, especially emission-intensive agricultural goods.

Figure 2 provides an overview of the development of greenhouse gas [GHG] emissions of goods and services imported to Switzerland in millions of tons of carbon dioxide [CO_2] emissions. The main contributing sectors in terms of GHG emissions are energy sources, chemicals, other products, metals, as well as animal and vegetable products, listed in descending order. Following the trend of growing imports, GHG emissions for all import sectors are also increasing. Due to agricultural commodities being one of the most emission-intensive import sectors, this report will focus exclusively on agricultural products.

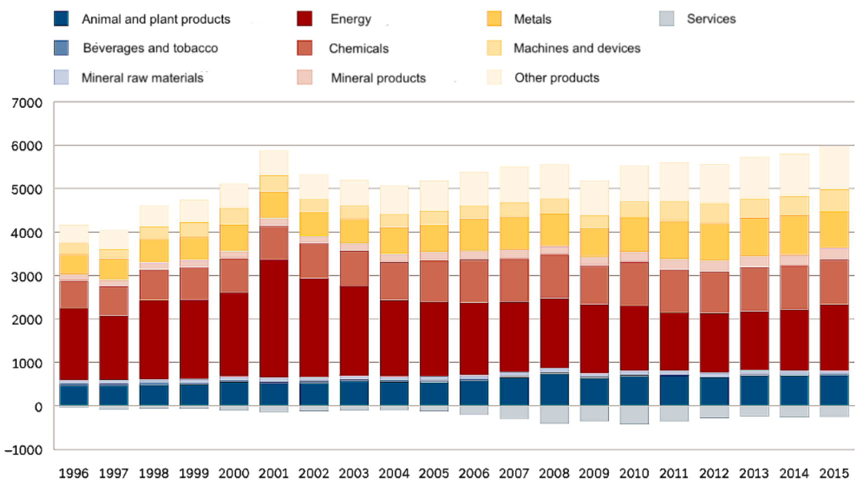

Figure 2: GHG emissions in millions of tons of CO2-eq (Frischknecht et al. 2018: 60)

Animal products, especially meat products, are on average more emission-intensive than plant-based products (Sonesson et al. 2010). Meat is a highly politicized agricultural product in Switzerland (Swiss Farmer's Union 2018), where the ongoing FTA negotiations between EFTA and Mercosur[1] are subject to widespread criticism. In order to contribute to this discussion, in a second step, this report aims to answer the following second central question:

How do the environmental impacts of meat production systems differ between Switzerland and Mercosur countries in terms of their greenhouse gas emissions?

In the following section, we review the existing literature on FTAs and trade. Subsequently, a chapter on theory introduces the theoretical framework of neoliberalism and presents the hypotheses. Next, we discuss data and methods. After the interpretation of the empirical results on an aggregate level, it follows a disaggregated analysis of selected product categories. Given the results, we conduct two case studies on the impact of meat imports from Mercosur on Switzerland's CO_2 emissions. We close with policy recommendations for Switzerland on the ongoing EFTA-Mercosur negotiation.

2. Literature Review

Over the last two decades, the global governance of trade has undergone a period of intense transformation. Many aspects of trade policy have been subject to change, although multilateral negotiations in the WTO seem to have stalled since the conclusion of the Uruguay round in 1994. Yet, while a comprehensive agreement remains out of sight, liberalization and the creation of rules for international trade have progressed apace with the proliferation of FTAs (Kim and Manger 2017: 467). Accordingly, much of the trade liberalization since the early 1990s has been due to the diffusion of FTAs rather than unilateral tariff liberalizations or multilateral agreements (Baccini 2019: 76).

With the primary aim of reducing or eliminating tariff barriers between two or more trading partners, FTAs have become a prominent instrument of foreign economic policy-making for many governments (Dür et al. 2014: 354). Increasingly, FTAs not only reduce conventional tariffs or non-tariff measures. They also serve as the main platform for negotiating regulatory changes to govern market access in investment, intellectual property rights, and many other related matters (Kim and Manger 2017: 467: Baccini 2019: 76). Therefore, FTAs not only reduce barriers at the border but also behind the border, leading to so-called deep integration between countries (Lawrence 1996: 60; Baccini 2019: 76).

With the increasing prevalence of FTAs, much of the academic literature has focused on the implications of FTAs for trade flows and whether FTAs increase trade between partner countries. The

[1] Mercosur is the abbreviation for "Mercado Común del Sur and is a regional integration project, consisting of the member states Argentina, Brazil, Paraguay and Uruguay (Mercosur 2020). Following the term Mercosur will be used when referring to the member countries of Mercosur.

ex-post effects of FTAs on bilateral trade flows have been widely analyzed with the use of the gravity model (Kepaptsoglou et al. 2010: 11). As described by Baier and Bergstrand "the gravity equation is typically used to explain cross-sectional variation in country pairs' trade flows in terms of the countries' incomes and bilateral distance" with the inclusion of dummy variables for the presence or absence of trade agreements (Baier and Bergstrand 2007: 73). Earlier *ex-post* assessment studies, which use gravity models to measure international trade flows, show no clear results about the effect of FTAs in expanding trade (Tinbergen 1962; Bergstrand 1985). Other evidence on the impact of FTAs have been mixed. For instance, Aitken (1973) and Brada and Mendez (1985) find that membership in the European Community has a statistically significant effect on trade flows between members, while Frankel, Stein and Wei (1995) observe insignificant effects. Gosh and Yamarik (2004) address the fragility of estimated FTA coefficients and find that for most of the FTAs, the estimated average treatment effects are not very robust.

Academic literature has subsequently proceeded to address problems of earlier studies, such as country-specific omitted variables or small and selected samples, and has used econometric techniques to approach endogeneity issues arising from selection bias (Hannan 2016: 7). For example, Magee (2003) uses instrumental variables with cross section data to address endogeneity issues. Other techniques include the use of country-pair fixed effects (Baier and Bergstrand 2007) or matching econometrics (Baier and Bergstrand 2009). In addition, an important alternation is the use of gravity estimation methods apart from ordinary least squares [OLS]. Silva and Tenreyro (2006) suggest using Poisson pseudo-maximum likelihood estimation [PPML] to address heteroskedasticity and potential biased estimates due to the correlation between the explanatory variable and the error term. While these studies show larger impact, results remain sensitive to the estimation techniques, the variables included as well as the years considered (Hannan 2016: 7).

Yet, the broad consensus from newer FTA literature is that more recent findings are to a greater extent consistently positive as well as more robust. For instance, in a widely cited paper, Baier and Bergstrand (2007) estimate a gravity equation with panel data and their findings indicate that on average, an FTA almost doubles parties' bilateral trade after ten years. In a meta-analysis from 159 papers that were published between 2006 and 2012, Head and Mayer (2014) find a positive mean effect of FTAs on trade of approximately 80 percent and a median effect of around 60 percent. Thus, while more recent studies observe positive and significant effects of FTAs on trade flows, a related question is whether FTAs lead to diversion in trade. The idea behind is that that parties of an FTA redirect trade among themselves to benefit from the preferential treatment and trade may be diverted from countries which are not part of the trade agreement (Hannan 2016: 7). While the literature has inconclusive findings on trade creation and diversion effects (Kepaptsoglou et al. 2010: 11), several authors suggest that trade diversion effects are smaller and relative to trade creation effects less important (Egger et al. 2011; Dai et al 2014; de Soyres et al. 2019).

With regard to sectoral impacts of FTAs, a few authors have analyzed the effects of FTAs on agricultural trade flows. Koo et al. (2006) use a gravity model to examine the effect of several regional trade agreements on agricultural trade. The authors find that the EU, North American Free Trade Agreement [NAFTA], or the Andean Pact did not significantly enhance agricultural trade between member countries, while the Association of Southeast Asian Nations free trade association did create statistically significant agricultural trade for its members. Lambert and McKoy (2009) study the impacts of several FTAs on both trade creation and diversion and conclude that FTAs generally lead to more agricultural trade among member countries. For example, agricultural trade increased by about 145 percent among NAFTA members and led to little diversion. In contrast, while Jayasinghe and Sarkar (2008) find a significant increase in certain agricultural commodities between NAFTA members, they also detect that NAFTA has led to considerable trade diversion. Grant and Lambert (2008) compare the increase in FTA members' trade between agricultural and non-agricultural products. The authors conclude that the effect is much larger in agriculture (72 percent) than for nonagricultural goods (27 percent), while positive effects may not occur immediately. In a recent study, Jean and Bureau (2016) apply a panel data approach at the detailed agricultural product level and find that on average FTAs increase parties' bilateral trade by 30 to 40 percent, with heterogeneity across the agreements.

In sum, In the more recent FTA literature in general and with particular emphasis on agricultural commodities, there appears to be more and more consistent positive evidence on the trade impact of tariff reductions. Yet, the effects vary widely between the studies and the agreements themselves. Results of FTA performances are still contradictory and firm empirical evidence for reliable estimates of the average effects of FTAs on bilateral trade are still comparatively limited (Kepaptsoglou et al. 2010: 12). Thus, the aim of the first part of this paper is to address this for the specific case of Switzerland by focusing on the question how Swiss trade patterns of agricultural commodities have changed following the introduction of its FTAs.

3. Theory

The key question related to signing an FTA is whether tariff reductions stimulate trade of the liberalized goods between the partner countries. As seen in the previous section, the available literature has not yet come to a widely supported conclusion regarding the effects of free trade agreements on trade. FTAs are typically used to encourage trade between partner countries by lowering tariffs on traded commodities. In addition to the EFTA Convention and the Free Trade Agreement with the European Union (EU) of 1972, Switzerland has reached a network of 31 FTAs with 41 parties. Most of them have been concluded through the membership in the European Free Trade Association [EFTA] (SECO 2020a). Compared to non-FTA partners who follow most-favored-nation (MFN) tariff rates under the framework of WTO agreements, Swiss FTAs grant their FTA partners greater tariff concession (WTO 2020b; SECO 2020b).

The theoretical framework that suggests trade liberalization leading to greater prosperity and wealth of the involved countries is neoliberalism, a resurgence of 19th-century classical liberalism in the 1960s. Compared to the Keynesian model, which encouraged government intervention to stabilize economies between 1945 and 1980, neoliberalist economists are against government intervention, arguing that intervention results in economic inefficiencies (Carlquist and Phelps, 2014). The 'economic rationalism' assumption believes that market forces unleash growth, innovation and efficiency, whereas governmental intervention impedes growth, stifles productivity, and generates inefficiencies in both the public and private sectors (Stokes 2014). In order to ensure economic prosperity, the role of the state is to safeguard an institutional framework that supports free markets and free trade (Harvey 2005). In the field of international trade, a typical practice of state intervention is setting tariff barriers in order to protect domestic industries from foreign competitors. Neoliberalism assumes that by reducing trade barriers, states enable free competition and better allocation of resources, building toward a free market. The reduction of trade costs is expected to encourage trade between partners. Based on this, our empirical analysis puts the following hypothesis to the test:

The higher the tariff reduction granted by Swiss FTAs, the higher the imports of agricultural commodities from partner countries.

In addition to the main variables tariff reduction and imports, as required by our hypothesis, two controlling variables are also necessary, namely the geographical distance to trade partner countries and economic size of trade partner countries. They are indispensable elements for the gravity model, which is considered as one of the best models to evaluate international trade (Sun and Reed 2006) because it is suitable for cross-country empirical analyses of international trade flows and the effects of free trade agreements (FTAs) on trade flows (Baier and Bergstrand, 2007). The concept of 'gravity' is borrowed from Newton's law of gravity, explaining trade flows between countries as a function of their economic sizes and distance. A decrease in distance between the two countries is expected to increase the trade between them. On the contrary, trade is proportional to economic size, the bigger the economic size of the trade partner countries, the higher the trade will be (Head and Mayer, 2014). Further details of the variables will be explained in the data section.

4. Data

Our analysis includes data on 13 agricultural products. These products were imported from 32 trading partners in the timespan from 1995 to 2018. Table 1 lists all 13 agricultural products with the corresponding 2-digit Swiss tariff heading (see Directorate General of Customs 2017). These agricultural commodities are selected because they have the highest import volume on average from 1995 to 2018. The calendar year 1995 marks the starting point, as it represents the starting year of the WTO data collection. This collection provides important data on tariff rates and bilateral reductions.

Agricultural Product Category	**2-digit Tariff Heading**	**Official Tariff Heading Labels**
Meat	02	Meat and edible offal
Milk	04	Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included
Living plants and flowers	06	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage
Edible vegetables	07	Edible vegetables and certain roots and tubers
Edible fruits	08	Edible fruit and nuts; peel of citrus fruit or melons
Coffee, tea, spices	09	Coffee, tea, maté and spices
Grains	10	Cereals
Oil seeds	12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder
Sugars	17	Sugars and sugar confectionery
Cereal preparations	19	Preparations of cereals, flour, starch or milk; pastrycooks' products
Vegetable preparations	20	Preparations of vegetables, fruit, nuts or other parts of plants
Beverages	22	Beverages, spirits and vinegar
Food waste	23	Residues and waste from the food industries; prepared animal fodder

Table 1: List of all 2-digit Agricultural Product Categories (Directorate General of Customs 2017)

The main explanatory variable of this analysis is the bilateral tariff reduction on product categories, as measured in the percentage point reduction from the WTO most favored nation [MFN] value after the introduction of a free trade agreement. The hypothesis to be tested is that the higher the tariff reductions introduced by an FTA, the stronger the increase of Swiss imports of the liberalized products in question. The WTO MFN tariffs are taken as the base values before bilateral liberalization from which the tariff reductions agreed upon in bilateral FTAs are computed. Since the WTO MFN tariffs are taken as the base values, tariff reductions before the enforcement of an FTA are set to zero. This data set has been published by the WTO (WTO TAO 2020). As a robustness test, the absolute reduction of tariffs in units of Swiss Francs from the standard WTO MFN value is used. Both these variables were mean-aggregated from the 6-digit level (as published by the WTO) to the 4-digit level and again to the 2-digit level.

The bilateral imports of goods serve as the independent variable and as a proxy of the Swiss demand for commodities. The data on the bilateral trade flows between Switzerland and each respective partner country are taken from the CEPII BACI database (Gaulier and Zignago 2010). BACI presents disaggregated data on bilateral, annual trade flows at the 4-digit level in tidy tabular form and is based on the United Nations [UN] ComTrade database. The bilateral trade flows are measured in units of 10'000 USD. Any trade flows that do not exceed an annual value of 10'000 United States Dollar [USD] are disregarded and thus assumed to be 0. In order to also cover bilateral trade flows at the 2-digit product level, the data have been transformed and aggregated at the 2-digit level. This simulates a category encompassing all 4-digit subcategories per 2-digit product category and has been added to the data set of the analysis. The data on bilateral imports are logged only for the OLS robustness checks, in order to nudge their skewed distribution closer to a normal distribution.

The data concerning the yearly gross domestic product [GDP] of the partner countries were taken from the World Bank DataBank (The World Bank DataBank 2020). The data were transformed into units of 1 billion USD in order to keep the numeric variables on similar scales. The World Bank DataBank reports this data for most countries starting in 1995. The only country in our analysis without the full time series of values on GDP, GDP per Capita and population is Montenegro, for whom the World Bank DataBank only reports data starting from the year 2000.

Finally, the data on the geographical distance between Switzerland and its trading partners were taken from the CEPII GeoDist database (Mayer and Zignago 2011). This data set describes the geographical distance between the capital cities of the selected countries in kilometers and was not transformed for the analysis.

After collecting all of the described data, the individual data sets were joined together, in order to create the unified data set used for the analysis. This data set displays one observation for each 4-digit level product subcategory for each of the analyzed trade partners of Switzerland, for each year between 1995 and 2018. For each year, trade partner and 4-digit product subcategory, the bilateral trade flows between Switzerland and the trade partner in question are reported. The data set also includes all the data on tariff reductions during the observed year, and whether an FTA with Switzerland was signed or enforced at the time and all of the control variables as described above (monetary measures of countries, distance from Switzerland and Swiss total trade flows of the product with the entire word). Table 2 displays the summary statistics of all the numeric variables.

Variable	Min	25. Pctl	Median	75. Pctl	Max	Mean	SD.
Bilateral Imports in $10'000 USD	0	0	4.50	200.80	120'89	1'084.5	4'835.34
Bilateral Tariff Reduction in CHF	0	0	0	7.00	100.00	5.67	10.70
Bilateral Tariff Reduction in %	0	0	0	70	100	0.27	40
GDP in $bln USD	1.87	20.61	90.25	291.75	13'894.82	509.83	1'418.71
log GDP	21.35	23.75	25.23	26.40	30.26	25.23	1.84
Distance to CH in km	924.47	2'631.15	4'490.38	9'132.99	11'866.25	5'487.6	3'534.31
log Distance to CH	6.83	7.87	8.41	9.12	9.38	8.34	0.80

Table 2: Summary Statistics of numeric variables

5. Methodology

5.1 PPML Gravity Regression

We test our research hypothesis with 13 gravity regression models. Each regression model is run for one of the 13 agricultural products. The gravity models are estimated via PPML. First, according to Shepherd et al., gravity modelling is the standard practice for empirical analyses on international trade (Shepherd et al. 2019: 4). Second, compared to OLS, PPML estimation has two main advantages (see Larson et al. 2018). Unlike OLS, it eliminates the bias caused by zero-values in bilateral agricultural imports (Larson et al. 2018: 312). This specific issue will be discussed in more detail in the later section on robustness tests. Moreover, again in contrast to OLS, PPML avoids biases introduced by heteroscedasticity of the cross-sectional intercepts (Larson et al. 2018: 312). Importantly, our data suffers from both these two issues.

The PPML gravity models base on panel data. In general, panel data consists of repeated observations on fixed units (Beck 2001: 111; Beck and Katz 1995: 634). The repetitions are time units. Conversely, the fixed units are cross sectional units (Beck 2001; Beck and Katz 1995). Starting with the former, our analysis includes 24-time units. These are all calendar years from 1995 to 2018.

Turning to the latter, our analysis comprises 32 cross sectional units. These are numerous partner countries in Swiss agricultural trade. In particular, these countries encompass Turkey, Israel, Palestinian Authority, Morocco, Mexico, Jordan, North Macedonia, Singapore, Chile, Tunisia, South Korea, Egypt, Canada, Japan, Albania, Serbia, Colombia, Peru, Ukraine, Hong Kong, China, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, the United Arab Emirates, Panama, Costa Rica, Bosnia-Herzegovina, Georgia and the Philippines. As mentioned in the previous part, Switzerland has reached 31 FTAs with 41 partners, therefore, not all countries or regions are included in the analysis. For example, Southern African Customs Union (SACU) is excluded because data are only available for SACU on the aggregated level, not for each country. As for EFTA and EU, data for control variables are not available before 1995, if included, it will result in a large number of zero-values in our trade data matrix. Additionally, in line with the posed research question, this analysis focuses on the effect of FTAs entering into force. The trade agreements with EFTA and the EU have entered into force long before the chosen timespan of the analysis.

The 13 gravity models estimated via PPML include one dependent variable, one independent variable and two controlling variables. First, the dependent variable is the bilateral imports to Switzerland for one of the 13 agricultural product categories. These imports are measured in 10'000 USD (see Gaulier and Zignago 2010). Second, the independent variable is the bilateral tariff rate reduction per 100 kilogram of gross agricultural product weight measured in percentage points (see WTO TAO 2020). Importantly, these tariff reductions result from the enforcement of Swiss bilateral FTAs. Finally, the two controlling variables are the economic strength of a partner country and the geographical distance between Switzerland and a trading partner. The economic strength, on the one hand, is measured as the partner country's GDP. These GDP values are measured in billion USD (see The World Bank DataBank 2020). The geographical distance, on the other hand, is the logarithm of the distance in kilometres between Switzerland and any trading partner country (see Mayer and Zignago 2011).

Equation 1 presents the specification of all 13 PPML gravity models. Each of these models regresses the bilateral imports to Switzerland on the bilateral agricultural tariff rate reduction, the economic strength of the partner country and the geographical distance between Switzerland and the partner country. Furthermore, each gravity model includes both time- and cross section specific fixed effects. These fixed effects control for unobserved heterogeneity of the time- and cross-sectional units (Shepherd et al. 2019: 28).

Equation 1: PPML Gravity Models with time- and partner country fixed effects (Shepherd et al. 2019)

$$\begin{aligned}\text{Bilateral Imports}_{it} &= \exp\{\beta_0 + \beta_1 * \text{Bilateral Tariff Rate Reduction}_{it} + \beta_2 * \text{GDP Partner Country}_{it} \\ &+ \beta_3 * \log(\text{Bilateral Distance})_{it} + \beta_4 * \text{Year}_{it} + \beta_5 * \text{Partner Country}_{it} + \varepsilon_{it}\}\end{aligned}$$

In this context, i denotes the cross-sectional units, t the time units, β_0 the intercept, $\beta_1 - \beta_5$ the beta coefficients and ε_{it} the error terms (Shepherd et al. 2019).

5.2 Robustness Tests

In order to test the stability of the estimated coefficients resulting from the PPML gravity model as shown in Equation 1, multiple alternative model specifications were fitted. The estimated direction and size of these coefficients from alternative models were then compared to the corresponding estimates from the PPML-model specification from Equation 1. One approach to such a robustness test was the estimation of a linear OLS-model with time- and cross-sectional fixed effects, as described in Equation 2:

Equation 2: Linear OLS-model with time and unit fixed effects as robustness checks

$$\log(\text{bilateral Imports}_{it}) = \exp\{\beta_0 + \beta_1 * \text{Bilateral Tariff Rate Reduction}_{it} + \beta_2 * \log(\text{GDP Partner Country}_{it}) + \beta_3 * \text{Year}_{it} + \beta_4 * \text{Partner Country}_{it} + \varepsilon_{it}\}$$

Again, i denotes the cross-sectional units and t denotes the time units. β_0 denotes the intercept again, $\beta_1 - \beta_4$ the beta coefficients and ε_{it} the error terms.

One striking difference from the PPML gravity model, as seen in Equation 1, is the logarithmic transformation of both the dependent variable as well as the GDP of the partner country. The reason for this transformation goes back to the original structure of the gravity model, which assumes that the predictor variables representing the economic size of the observed countries (GDP) are multiplied with each other (see Isard 1954). When expressing this with a linear model such as OLS-regression, we turn to a logarithmic transformation of the trade flows and the GDPs, as this turns the previous product of GDPs into a linear addition of the logged GDPs instead. This transformation also accounts for a major limitation of gravity models expressed through a linear estimator: the logarithmic transformation demands the removal of all observations evaluated as zero, since the log of zero does not exist. This results in a large number of observations being disregarded, due to the observed trade flow of a commodity being zero for the respective year and partner country. This means that the OLS-based models are estimated on a much smaller subsample of the data than the PPML-models, which is why PPML was chosen over OLS as the main model for this study.

Another approach to testing the robustness of the estimates was to retain the structures of both the PPML gravity model as seen in Equation 1 and the linear OLS model as seen in Equation 2 by using different operationalizations for trade liberalization than the bilateral tariff reductions measured in percentage points.

One way of using an alternative operationalization was the simple use of a dummy variable indicating whether a bilateral trade agreement had already entered into force during the year of any given observation in the data. Unlike the main operationalization used in this analysis, the bilateral tariff reduction in percentages of the WTO MFN, this operationalization via a simple dummy only estimates the effect of a free trade agreement being in place, instead of taking the amount of tariff reduction into account.

This results in another model for both the PPML specification and the OLS specification, with a dummy for an FTA being in force as the main predictor, as described in Equation 3 and 4.

Equation 3: PPML Gravity Model with FTA in force dummy for robustness test

$$\text{Bilateral Imports}_{\text{it}} = \exp\{\beta_0 + \beta_1 * \text{FTA in force}_{\text{it}} + \beta_2 * \text{GDP Partner Country}_{\text{it}} + \beta_3 * \log(\text{Bilateral Distance})_{\text{it}} + \beta_4 * \text{Year}_{\text{it}} + \beta_5 * \text{Partner Country}_{\text{it}} + \varepsilon_{\text{it}}\}$$

Equation 4: Linear OLS-model with FTA in force dummy for robustness test

$$\log(\text{bilateral Imports}_{\text{it}}) = \exp\{\beta_0 + \beta_1 * \text{FTA in force}_{\text{it}} + \beta_2 * \log(\text{GDP Partner Country}_{\text{it}}) + \beta_3 * \text{Year}_{\text{it}} + \beta_4 * \text{Partner Country}_{\text{it}} + \varepsilon_{\text{it}}\}$$

A secondary approach was the use of the absolute bilateral tariff reduction in Swiss francs instead of the variant measured in percentages. This variable was not used as the main explanatory variable due to concerns about the scaling of tariff reductions measured in absolute differences. The tariff rate pre-liberalization (the WTO MFN in the case of our study) is not being taken into account when only looking at the absolute difference in Swiss Francs. The transformation to percentages deals with this problem, leading to better comparability among individual tariff reductions. Due to this disadvantage, trade liberalization as the difference in absolute units of Swiss Francs is only used as a robustness test in the context of this study.

This results in another two models, one for both the PPML gravity model specification and the linear OLS specification, with the bilateral tariff reductions in percentage points as the main predictor, with the remaining model specification being identical to the previously introduced Equations 1 and 2. The resulting regression tables of these robustness tests can be found in the appendix, from Table 7 to 19.

6. Findings

6.1 PPML Gravity Regression

In this part of the analysis, we will first evaluate the effect of tariff reduction at the aggregated level before further analysis at the disaggregated level for product group meat. Figure 9 and 10 in the appendix visualize the Swiss meat imports by countries at the 2-digit level. As shown in Table 3 below, 13 agricultural product groups with the highest import quantities are included in the analysis. The dependent variable is the imports into Switzerland, measured in units of 10,000 USD, and the main explanatory variable is tariff reduction in ratio, between 0 and 1. The reduction is based on the absolute difference between the WTO MFN tariffs and tariffs granted by FTAs, and is further calculated in ratios points by dividing it by the WTO MFN values. Further details are explained in the data section. To explain the relationship between tariff rate reduction and import values under the PPML gravity model, as explained in the section of methodology, controls are logged-distance to Switzerland and GDP of partner countries in the unit of one billion USD. In the analysis, both time- and cross-section specific fixed effects are included.

In Table 3, the effect of tariff reduction on imports is positive and statistically significant for 7 out of the total observed 13 product categories. The positive effect is statistically significant at the 0.001 level for several product categories, including Meat (02), Dairy (04), Vegetable (07), Cereal (10) and Oil seed (12). Moreover, the positive effect is significant at the 0.01 level for the product category Plant (06) and at the 0.05 level for the product category Fruit (08). A positive effect can also be observed for the product category Prepared 2 (20), although not statistically significant.

For these 7 product categories, the interpretation of the size of coefficients requires conversion. The formula to calculate these sizes in PPML regression is (e^{bi} - 1) * 100% to convert to percentage changes. In this context, *bi* is the estimated coefficient (Silva and Tenreyro, 2006). Before the conversion, it should be taken into consideration that the independent variable is a ratio, ranging between 0 to 1. Table 4 shows the coefficient sizes and the values after the conversion. Among the seven categories, the size of the effect of tariff reduction on imports is the highest for Dairy (04). A 1% decrease in tariff rates compared to previous MFN rates is expected to increase the imports by 3.23%. Furthermore, an additional 1% reduction in tariffs for the product groups Meat (02) results in a 1.37%-increase in imports, and for Cereal (10) is a 1.42%-increase. The positive effect of tariff reduction on product group Oil seeds (12) is also strong. A 1% tariff reduction by Switzerland for this product group is expected to increase its imports by 0.76%. The positive effect of tariff reduction also applies to product groups Plants (06), Vegetables (07) and Fruits (08). For the product group Plants (06), a 1%-reduction in tariffs is estimated to increase imports by around 0.28%. Additionally, the imports of product group Vegetables (07) tends to increase by around 0.45%, the increase of imports for product group Fruit (08) is relatively lower, by around 0.13%.

Table 3: PPML Gravity Model Regression Results

Dependent variable: Imports to Switzerland (in 10'000 USD)

	Meat	**Dairy**	**Plant**	**Vegetable**	**Fruit**	**Coffee**	**Cereal**	**Oil seed**	**Sugar**	**Prep. 1**	**Prep. 2**	**Beverage**	**Residue**
Tariff reduction	1.36*** (0.22)	3.18*** (0.67)	0.28** (0.09)	0.45*** (0.06)	0.13* (0.06=	-0.12 (0.08)	1.41*** (0.21)	0.76*** (0.11)	-0.18 (0.19)	-0.21 (0.24)	0.10 (0.12)	-0.12 (0.10)	-0.23 (0.26)
Distance (logged)	8.41 (4.53)	47.36 (2538.65)	-7.49 (13.55)	3.65*** (1.00)	8.80* (3.60)	-1.54 (2.55)	29.41 (74.76)	8.71*** (0.70)	18.99 (15.56)	38.13 (3276.56)	8.01* (3.63)	5.68*** (1.43)	27.38 (56.64)
GDP (billion USD)	-0.00*** (0.00)	-0.00 (0.00)	0.00*** (0.00)	-0.00*** (0.00)	0.00 (0.00)	0.00*** (0.00)	0.00 (0.00)	0.00 (0.00)	-0.00* (0.00)	0.00 (0.00)	-0.00*** (0.00)	0.00* (0.00)	0.00*** (0.00)
Intercept	-58.80 (33.68)	-348.53 (18929.03)	54.37 (95.99)	-21.89** (7.35)	-59.70* (26.80)	15.13 (18.38)	-209.97 (557.41)	-57.08*** (5.19)	-135.74 (116.05)	-283.16 (24431.14)	-54.55* (26.99)	-37.15*** (10.63)	-196.64 (422.35)
Country Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Deviance	248063.58	48024.42	41799.76	154282.01	574925.66	298990.61	700069.31	345920.55	233460.78	62114.55	229771.71	160040.05	264471.41
Num. obs.	768	768	768	768	768	768	768	768	768	768	768	768	768

Notes: Standard Errors in Parentheses. *Significant at the 0.05 level ($p < 0.05$). **Significant at the 0.01 level ($p < 0.01$). ***Significant at the 0.001 level ($p < 0.001$).

Table 3: PPML Gravity Model Regression Results

For the remaining five product groups, we find a negative effect of tariff reduction for five product groups, although not statistically significant at the 0.05 level. This includes Coffee (09), Sugar (17), Prepared 1 (19), Beverage (22), Residue (23). The size effect of the coefficients is weak and some of them are very close to 0.

Product categories	**Sizes of coefficients**	**Converted values of the sizes**
Meat (02)	0.0136	1.37%
Dairy (04)	0.0318	3.23%
Plant (06)	0.0028	0.28%
Vegetable (07)	0.0045	0.45%
Fruit (08)	0.0013	0.13%
Cereal (10)	0.0141	1.42%
Oil seed (12)	0.0076	0.76%

Table 4: Coefficients sizes of the main explanatory variable after the conversion[2]

The controlling variables are logged-distance and GDP of partner countries. Contrary to expectations, the effect of distance on imports is positive and significant for the product groups Vegetables (07), Fruits (08), Oil seeds (12), Preparations 2 (20) and Beverages (22)[3]. Furthermore, the results are mixed for the GDP of partner countries. While five coefficients are negative, the others are positive. They are also significant in both directions. In addition, the magnitude of the coefficients is almost zero for all 13 product categories.

To summarize, the findings support our expectations derived from neoliberal theory. The null hypothesis can be rejected for the product categories Meat (02), Dairy (04), Plant (06), Vegetable (07), Fruit (08), Cereal (10) and Oil seed (12), at the 5 percent level. In other words, the higher the tariff reduction granted by bilateral free trade agreements, the higher the imports to Switzerland for these agricultural commodities.

In order to examine the drivers of this increase in imports, the data on meat imports has been disaggregated to the 4-digit level and visualized for each partner country. The resulting plots are in the appendix from Figure 11 to 44. From these visualizations it can be inferred that the increase in meat imports after tariff reduction seems to be largely driven by beef. This is particularly interesting, as beef is the most emission-intensive subcategory among all meat products (Poore and Nemecek 2019; Ritchie and Roser 2020).

[2] In table 4, only the significant coefficients are shown.

[3] Although this contradicts the general notion of gravity modelling, these results are not surprising. Fruits, vegetables and oil seeds tend to be imported from more distant and warmer countries, where products are produced at lower costs.

6.2 Robustness Tests

According to the PPML gravity model regression results as displayed in Table 3, the effect of tariff reduction is positive and statistically significant for product categories Meat (02), Dairy (04), Plant (06), Vegetable (07), Fruit (08), Cereal (10) and Oil seed (12). In order to gain confidence in these results, we estimated a variety of different models to test their robustness. These models use different operationalizations of trade liberalization such as tariff reduction in absolute Swiss francs [CHF] and a liberalization dummy as well as a linear OLS estimator. More detail on these models can be found in the methodology section.

As displayed in Tables 7 to 19 in the appendix, for product categories Meat (02), Dairy (04) and Vegetables (07) the effects of main explanatory variables in all models are positive and significant at least at the 0.05 level. For the category Fruit (08) the effect is not robust when estimating the models with the absolute tariff reduction in CHF as the main explanatory variable. As for product categories Cereal (10) and Oil seed (12), the effects are not fully consistent with the main model regarding the significance. The OLS coefficients are markedly smaller than their PPML counterparts. They also vary in their direction and none of them are significant. That being said, all the significant coefficients are in line with our findings for these two categories.

As for product category Plants (06), the estimates for the models with the liberalization dummies go against the findings of our main model. Their coefficients are both negative and significant, implying a questionable reverse effect of reducing tariffs on import volumes.

In sum, for product categories Meat (02), Dairy (04), Vegetable (07) and Fruit (08), the effects of main explanatory variables in all models are positive and significant at least at the 0.05 level, which are fully consistent with the main model and support our neoliberalist expectation. As for product categories Plant (06), Cereal (10), Oil seed (12), we can observe differences in the direction and significance of the effect of the main explanatory variables among different models, making our results for these categories less clear for the aforementioned ones.

7. Conclusion on Tariff Reductions and Agricultural Imports

Theory suggests an obvious and strong causal link between the liberalization of tariffs on the import of commodities and their import volume. The general effects of FTAs on trade flows between the signing parties has been well studied. The general consensus of the existing literature on FTAs suggests that trade agreements lead to an overall increased level of trade among the signing members of the agreement (Brandi et al. 2020: 2).

Our analysis has found confirmation for this hypothesis in the case of agricultural products, albeit not for all of the studied categories of goods. For commodities such as raw sugars, preparations of flour, cereals, and starch, preparations of nuts, fruits and vegetables as well as residue and waste of the food industry the hypothesis of lower trade barriers leading to higher imports cannot be confirmed. Further research may be needed to more closely determine the impact of reducing tariffs on these goods. More importantly, according to our analysis, the hypothesis holds for agricultural products that can be expected to see a relatively large daily demand among private consumers, such as meat, dairy, coffee, vegetables and cereals.

From this we draw the conclusion, that agricultural goods that make up a larger share of daily consumption among private consumers react stronger to the liberalization of trade. Hence, if policymakers do not aim to increase the import of GHG intensive agricultural goods such as meat, dairy, chocolate and coffee, it seems intuitive to discourage the institutional reduction of trade. Higher tariffs are associated with a reduction of the imports of the affected goods, making higher tariffs appear as a suitable instrument to reduce the demand and hence the production of GHG intensive goods.

Albeit intuitive, this conclusion does not take a persistent demand for meat products, especially beef, into account. Trade diversion is not being accounted for and higher tariffs may well lead to an increase in demand for domestically produced meat. It stands to reason that policymakers should take the local GHG efficiency of the production of agricultural products into account. Tariffs may well keep the imports of agricultural commodities at bay, but whether this actually reduces the global GHG footprint depends on whether these measures do not shift the demand elsewhere. Despite beef products and their production cycles getting most of the attention in the current public debate, for Switzerland poultry is becoming an increasingly sensitive product as its consumption as well as its imports and domestic production have steadily been on the rise in the past years (Agrarbericht 2020, Schweizer Bauer 2016). Poultry is the only meat product that has seen a steady rise in per capita consumption since 2002, whereas beef per capita consumption has been stagnating since 2013 (Agrarbericht 2020).

In terms of limitation, it is important to note that our results only offer insight into a relatively small and limited subset of Swiss trade relations. Many of Switzerland's most sizable trading partners are excluded from the analysis, due to the signing of their respective free trade agreements having taken place decades before most data bases allow for their empirical investigation. This is especially limiting, as the EU remains Switzerland's largest and most important trading partner to date (Federal Customs Administration, 2019). Another limiting factor is the exclusion of all other countries, that do not share a bilateral free trade agreement with Switzerland. Including these countries would have introduced more variance into the estimated models, as it could be argued that Switzerland's chosen trading partners might share latent attributes whose effects may be disregarded by excluding other countries that have not currently engaged in bilateral trade liberalization with Switzerland. This directly leads to the next concern, that our estimated coefficients might be subject to selection bias. Can it really be assumed that Switzerland chooses its partner countries in a random fashion? Or might there be a selection process at work that leads our estimates to be biased?

Finally, our analysis currently disregards the question whether the observed changes in trade flows due to tariff reductions are a result of trade diversion or trade creation. This also begs the question whether a decrease in imports results in an equivalent increase elsewhere, which could go unnoticed due to the limited number of observed countries. These limitations leave room for future research, as our analysis can be expanded upon in multiple ways by addressing these concerns and increasing the number of observed countries and their respective trade flows in future studies.

8. The Environmental Impact of Meat

The previous sections of this paper have illustrated how Swiss agricultural trade patterns have changed following the introduction of its FTAs. In particular, the analysis has shown that trade liberalisation has led to an increase in Swiss imports of several agricultural products, among them meat. While meat is of major economic importance for the Swiss farming sector and of high societal relevance, it is also a high emission-intensive agricultural commodity and its production has a significant impact on the environment (Djekic 2015: 63). Yet, how much GHG emissions are caused by the production of one kilogram of meat and to what extent does the resulting environmental impact depend on where and how this meat was produced? The following chapters will address these questions and compare the environmental impact of meat production systems in Switzerland and selected import countries.

Over the last years, the livestock production has received growing attention as it appears to have major impact on the environment. The increasing need of the livestock sector for natural resources, such as land, water and energy, and its resulting emissions have a severe impact on air, soil and water quality (de Vries and de Boer 2010: 2). According to the Food and Agriculture Organization [FAO], 18 percent of global GHG emissions are caused by livestock production. Meat is a food commodity which carries one of the greatest environmental burden (Steinfeld et al. 2006: 112; Weidema et al. 2008). Figure 3 shows the climate impact resulting from GHG emissions for the production of a range of food categories. Although the emission levels are averages for each product and may differ substantially depending on the production system, meat products have a high climate footprint. This is because of the animals' inefficiency in converting feed to meat. Roughly 75 to 90 percent of the animal's energy consumed is needed for body maintenance or lost in by-products such as skin and bone or manure (Röös et al. 2013: 573). Thus, as the global demand for meat products is expected to double by 2050, more attention needs to be paid to reducing the environmental impact of meat production (Steinfeld 2006: 15).

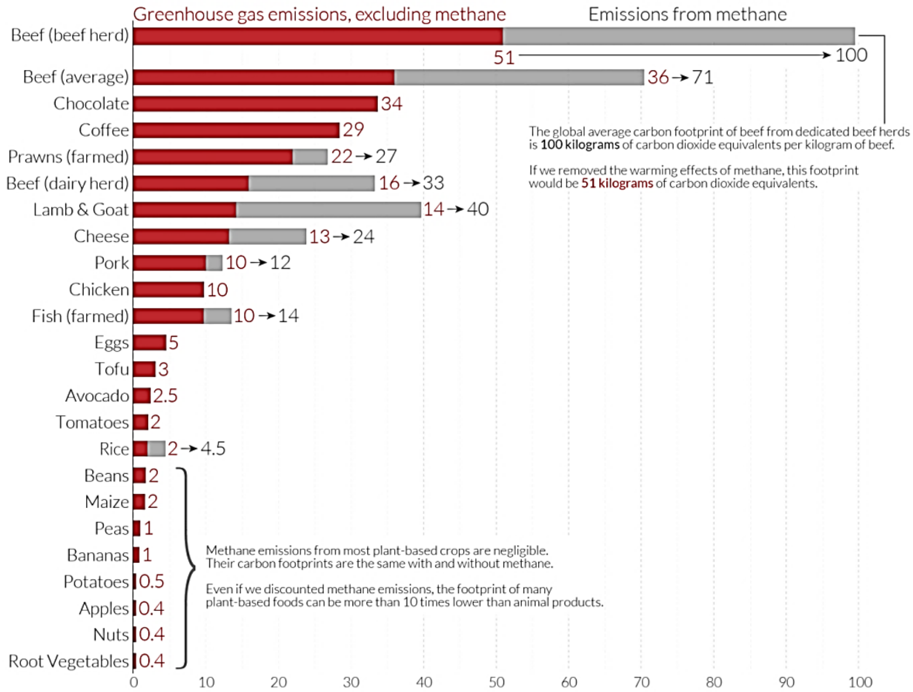

Figure 3: Greenhouse gas emissions per kilogram of food production, kg CO_2-equivalent per kg product (Ritchie 2020; Poore and Nemecek 2018)

In Switzerland, emissions caused by net imports of agricultural products have been slowly but steadily increasing since 1996. The agricultural sector is among the top sectors making up the Swiss GHG Footprint. In 2015, meat contributed around a third of net imported GHG emissions in the agricultural sector (Frischknecht et al. 2018: 60). Livestock products have dominated both the political and public discourse on trade agreements in Switzerland in recent years and are thus the most salient topic of the agricultural sectors. Regular referenda also highlight the public's interest in food and farm issues. Financial support for the farming sector is widely accepted despite its low share of 0.7% in GDP, which is linked to generally high trust in the quality of Swiss agricultural products (Sterly et al. 2018: 47).

Thus, local agriculture remains of high societal relevance, which is also reflected in the public debate on the upcoming EFTA-Mercosur[4] trade agreement and its implications for the Swiss farming sector. In general, Mercosur's relevance for Swiss trade is low, as the trading bloc accounts for about 1 percent of total foreign trade. Nevertheless, the four member states, have a highly industrialized and highly competitive agricultural sector. Accordingly, most imported products from Mercosur are agricultural commodities, including beef and poultry. Because of their competitiveness, Mercosur countries are pushing for an opening of the Swiss agricultural market, which is a cause of concern for Swiss farmers (Swiss Farmer's Union 2018: 1-6).

[4] Mercosur officially stands for Southern Common Market or «Mercado Común del Sur» and is a trade bloc consisting of the member states Argentina, Brazil, Paraguay and Uruguay (Mercosur 2020).

Therefore, the EFTA-Mercosur agreement is not without controversy. Concerns expressed by the Swiss civil society also relate to a number of issues involving both agricultural policy and sustainability (Swiss Farmer's Union 2018; NZZ 2019). Thus, the following parts of this paper focuses on the question of how environmental impacts of meat production systems differ between Switzerland and Mercosur countries in terms of their greenhouse gas emissions. To address this question, the paper first provides a general overview of different production systems and the main stages in meat production. Subsequently, two case studies compare the impact of red and white meat production on GHG emissions between Switzerland and Mercosur countries. The last part summarizes the findings, gives recommendations and addresses the limitations to provide pathways for future research.

9. Meat Production Systems and Life Cycle Assessment

Meat production systems can broadly be categorized into two farming methods: intensive or extensive. Intensive farming, also known as industrial agriculture, is a farming technique which needs larger amounts of capital, in comparison to the land area. It is also characterized by the use of fertilizers and pesticides which produces higher crop yields per unit area compared to extensive agriculture (Mózner et al. 2012: 59). Thus, intensive livestock farms rear animals indoors at high stocking densities, taking advantage of economies of scale, biotechnology and modern machinery (Ilea 2009: 154). Extensive farming, in contrast, refers to an agricultural system in which generally a larger land area and relatively fewer inputs of capital are used (Mózner et al. 2012: 59). Therefore, extensive livestock farming includes organic production systems as well as systems, where animals have access to outdoor range (Bahlo et al. 2019: 460). Both, intensive and extensive systems have different impacts on the environment.

The environmental impact of meat production is usually quantified by using a life cycle assessment [LCA]. LCA is a holistic method to systematically analyze the environmental impact of a product during its entire life cycle. Two kinds of environmental impacts are generally considered during the life cycle of a product: the use of resources such as land, water or fossil fuels and emissions of pollutants into the environment (de Vries and de Boer 2010: 2). These emissions contribute to a number of impact categories such as climate change, biodiversity, toxicity, and eutrophication and acidification of ecosystems (Röös et al. 2013: 573). As this paper seeks to compare the climate impact of various meat production systems from Switzerland and Mercosur countries, the primary focus lies on GHG emissions caused by meat production.

Figure 4 provides an overview of the LCA "cradle to gate approach", which includes the main production stages for packaged meat production. The LCAs for the systems under analysis considered three main life cycle stages: feed production, meat production, and slaughtering. The feed production stage begins with the production of crop inputs and passes through the stages of crop production, including grain drying, processing and feed manufacturing. Emissions from crop production are volatile as they depend on factors such as farming practices, soil type and climate. In addition, depending on the region, crop production may also be associated with deforestation-related emissions if deforestation in these regions has occurred in recent years. The meat production stage includes on farm emissions from cattle rearing and is followed by the slaughter stage, where the meat is eventually processed, cooled and packaged (da Silva et al. 2014: 223-226).

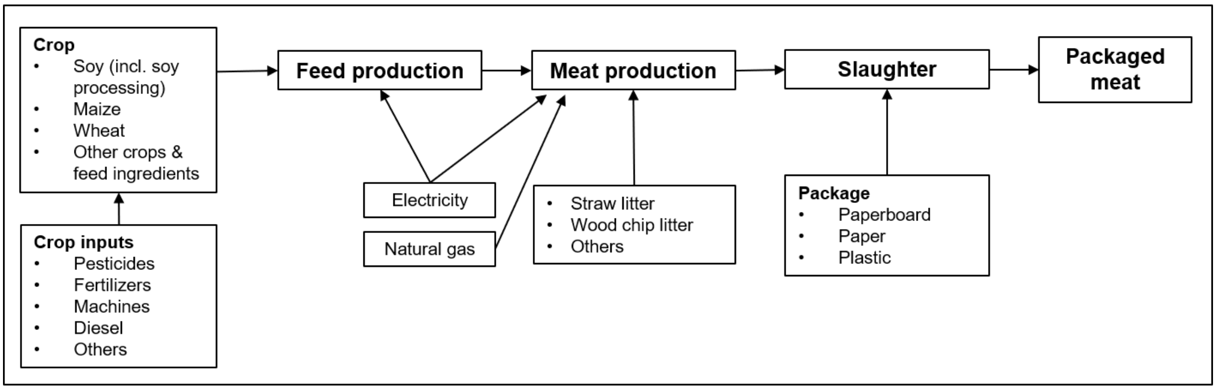

Figure 4: Flowchart of the main processes in packaged meat production (own illustration based on da Silva et al. 2014)

The environmental impact of meat production is typically measured at the farm gate and in some studies additionally at the slaughterhouse gate. To compare LCA results among selected studies, an identical functional unit is necessary. For instance, different meat commodities can be compared in terms of the environmental impact per kg of meat (de Vries and de Boer 2010: 3). In order to compare the meat production systems in Switzerland and Mercosur, the LCA results of the studies were recalculated and expressed in the functional unit of 1 1 kg of packaged weight [PW] at the retail level (Poore and Nemecek 2018: 1). Environmental impact is measured as CO_2-equivalent emission. This is a standard metric used to compare the emissions of different GHGs and provides a measure of CO_2 emissions that would have the same impact as an emitted amount of a mixture of GHG emissions (Metz et al. 2007: 3). The following subchapters address the environmental impact of red and white meat. After providing an overview of meat imports from Mercosur countries, the sections discuss the relevance of red, and respectively white, meat with regard to GHG emissions and their relevance for the Swiss farming sector. Subsequently, several Swiss and Mercosur meat production systems will be compared in terms of their GHG emissions at different production stages.

10. Case Studies on GHG Emissions of Meat Production Systems

10.1 Red Meat

Red meat is the most imported meat category from Mercosur to Switzerland. In 2017, red meat accounted for approximately 50 percent of all meat imports from Mercosur member states (Swiss Farmer's Union 2018: 17). The corresponding import volume is more than 54 million Swiss francs (Swiss Farmer's Union 2018: 17). Figure 5 visualises how the different red meat categories contribute to the overall red meat imports. Specifically, Figure 5 shows Swiss red meat imports from Mercosur in 2017 (Swiss Farmer's Union 2018: 18). Most importantly, the figure suggests that beef imports heavily dominate Swiss red meat imports. In 2017, beef imports amount to roughly 40 million Swiss francs. Clearly, the second most imported category of horsemeat falls far behind (Swiss Farmer's Union 2018: 18). In aggregate, beef imports account for 6.3 percent of all Mercosur imports to Switzerland (Swiss Farmer's Union 2018: 40). Given this high importance of beef within red meat, this case study focusses on beef only.

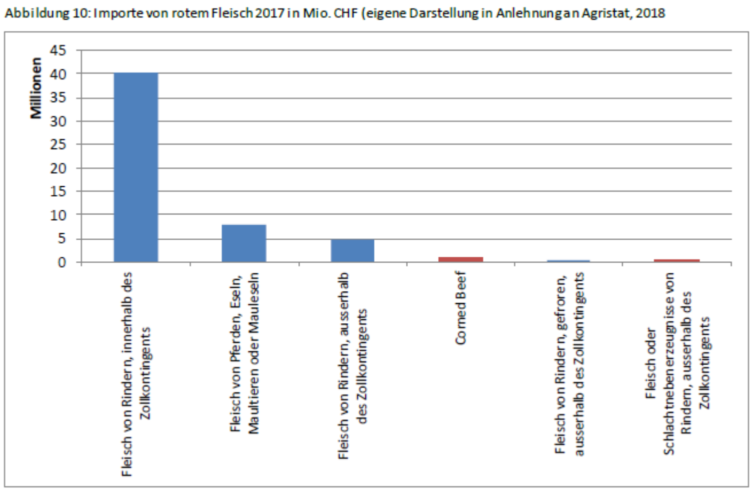

Figure 5: Imports of red meat from Mercosur in 2017 in million CHF (Swiss Farmer's Union 2018: 18)

Figure 6 disaggregates Swiss red meat imports to the single Mercosur member states. These states comprise Argentina, Brazil, Paraguay and Uruguay (Mercosur 2020). According to Figure 6, Uruguay is the largest exporter of beef in 2017 (Swiss Farmer's Union 2018: 19). Given this fact, Uruguay is the most relevant Mercosur nation for a cross-country environmental comparison with Switzerland.

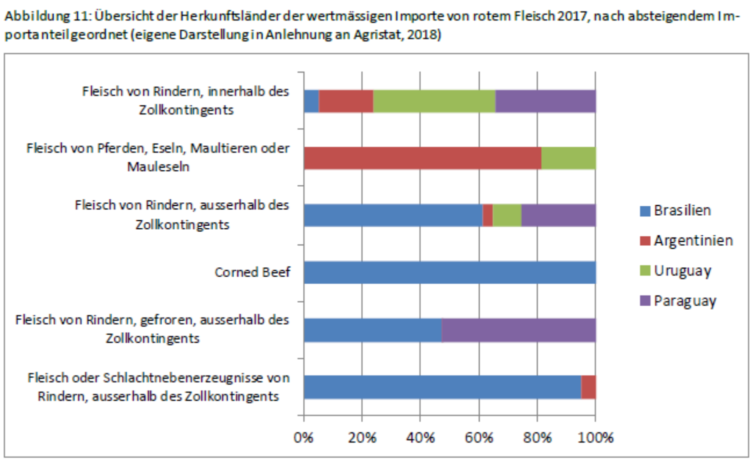

Figure 6: Overview of the countries of origin of red meat imports in 2017, sorted in descending order of import (Swiss Farmer's Union 2018: 19)

Turning from Mercosur imports to Swiss domestic production, the Swiss Farmer's Union claims that beef is one of the most sensitive domestic agricultural products (Swiss Farmer's Union 2018: 17). More importantly, however, the intensity of beef GHG emission is the highest for all livestock products (Food and Agriculture Organization of the United Nations 2020).

Out of 29 different food products[5], beef causes the highest GHG emissions per 1 kilogram of food packaged weight (Poore and Nemecek 2019; Ritchie and Roser 2020). According to Poore and Nemecek's meta-analysis of global food systems, beef has the highest GHG emissions in terms of aggregate food product supply chains (Poore and Nemecek 2019). The differences in these food GHG emissions are massive. While a kilogram of beef emits 60 kilograms of CO_2 equivalents, peas only emit 1 kilogram per 1 kilogram of packaged weight (Poore and Nemecek 2019; Ritchie and Roser 2020). Most of the beef GHG emissions originate from processes at the farm stage. The second highest share is caused by land use (Poore and Nemecek 2019; Ritchie and Roser 2020). On a global scale, in 2017, most Swiss beef imports originate from Germany, followed by Austria, Ireland and Uruguay (Agristat 2018: 117).

Table 5 compares the GHG emissions of intensive and extensive Swiss and Uruguayan beef production systems at the slaughterhouse gate. In particular, it compares GHG emissions for 1 kilogram of beef packaged weight. Most importantly, Table 5 has two implications. First, regardless of the production system, comparing Uruguayan with Swiss GHG emissions, Uruguayan beef production scores higher than its Swiss counterpart (Wolff et al. 2012: 36-48; Picasso et al. 2014: 347-351; Poore and Nemecek 2019). As a result, considering GHG emissions only, Swiss beef production outperforms its Mercosur counterpart.

Production System / Country	**Switzerland**	**Uruguay**
Intensive	57.3 kg CO2eq per 1 kg PW	65.4 kg CO2eq per 1 kg PW
Extensive	55.9 kg CO2eq per 1 kg PW	74.3 kg CO2eq per 1 kg PW

Table 5: Comparing GHG emissions of Swiss and Uruguayan beef production systems at the slaughterhouse gate for 1kg packaged weight (Wolff et al. 2012: 36-48; Picasso et al. 2014 347-351; Poore and Nemecek 2019)

The second implication concerns the comparison of intensive and extensive production systems. Comparing the two countries there are mixed results. In Switzerland, intensive beef production causes higher GHG emissions than its extensive counterpart. In Uruguay, conversely, intensive beef production comes with lower GHG emissions than extensive beef production.

So far, we neglected GHG emissions related to transport activities. However, these GHG emissions are a relevant aspect when considering trade and GHG emissions. More trade generates more transport, which results in increased GHG emissions. Yet, when considering agricultural products, GHG emissions resulting from transport activities tend to be negligible when comparing it to other factors of environmental impacts (Poore and Nemecek 218: 4). In general, transport accounts for less

[5] Excluding beef herd, the remaining 28 food products comprise the following: lamb and mutton, cheese, dairy beef herd, chocolate, coffee, farmed prawns, palm oil, pig meat, poultry meat, olive oil, farmed fish, eggs, rice, wild catch fish, milk, cane sugar, groundnuts, wheat and rye, tomatoes, corn maize, cassava, soymilk, peas, bananas, root vegetables, apples, citrus fruit, nuts (Poore and Nemecek 2019; Ritchie and Roser 2020).

than 1 percent of beef's GHG emissions. Therefore, the consumption of locally produced beef has minimal impact on the GHG footprint (Ritchie and Roser 2020). Table 5 does not include GHG emissions caused by transport activities between the trading partners. A brief example of beef imports from Uruguay to Switzerland shows that the results hold even when GHG emissions resulting from international trade are taken into account. Assuming that Uruguayan beef is exported to Switzerland as refrigerated cargo, GHG emissions would only increase by 0.18 kgCO_2 per kg PW beef.

10.2 White Meat

Besides red meat, white meat[6] is another agricultural commodity that is imported in large quantities from Mercosur. Approximately 49 percent of overall imported meat from Mercosur to Switzerland is white meat, which corresponds to almost 54 million Swiss francs of the import value. Figure 7 gives an overview of the imports of white meat. The graph shows in particular the dominance of poultry and turkey import, where poultry accounts for the largest share with an import value of more than 35 million Swiss francs. Moreover, compared to overall imports from Mercosur, poultry accounts for 5.9 percent. Pork, in contrast, is barely imported at all in recent years and falls behind imports of rabbit and hare (Swiss Farmer's Union 2018: 6-22). As poultry imports clearly dominate over other categories of white meat from Mercosur, the following comparison of meat production systems focuses on poultry production.

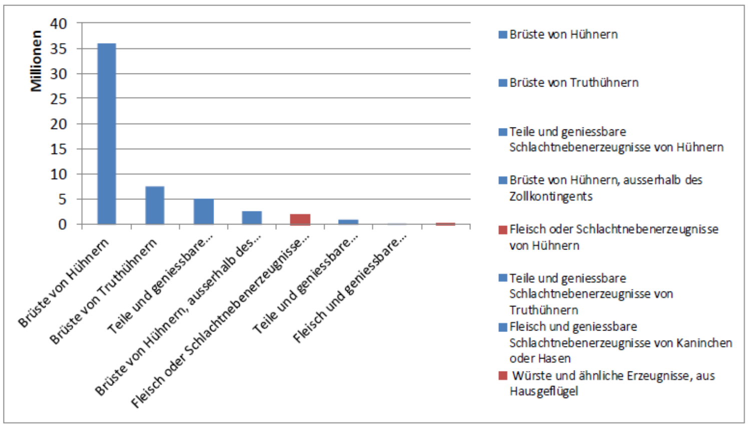

Figure 7: Imports of white meat from Mercosur in 2017 in million CHF (Swiss Farmer's Union 2018: 23)

When considering the origin of these imports from Mercosur, Figure 8 provides a distinct picture. Of the four Mercosur countries, Brazil is, apart from two exceptions, in fact the only exporter of poultry to Switzerland. The country also clearly dominates in exports of other white meat categories (Swiss Farmer's Union 2018: 23). These corresponds to general figures, according to which Brazil is the world's largest exporter of poultry (ITC 2019; OECD-FAO 2018). On a global scale, most poultry imports in 2017 came from Brazil, followed by Germany, France and Hungary (Agristat 2018: 117). Since Brazil is the main exporter of poultry to Switzerland, the GHG emissions of poultry production

[6] Here white meat is defined as meat of livestock which predominantly consumes concentrated feed. This includes in particular meat from chicken, turkey and pork, but also meat from rabbits and hare.

systems from Switzerland and Brazil will be compared in order to examine how the environmental impacts differ with respect to the countries of production.

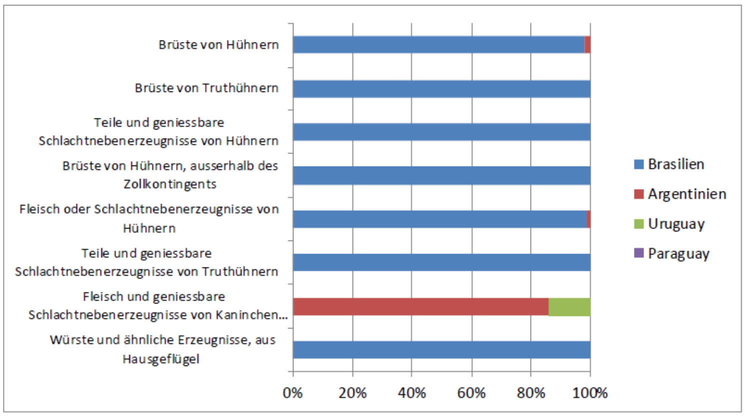

Figure 8: Overview of the countries of origin of white meat imports in 2017, sorted in descending order of import (Swiss Farmer's Union 2018: 24)

Regarding the GHG emission impact of individual livestock products, Figure 3 showed that poultry has a lower CO_2 footprint than for example beef or lamb. However, its impact is still higher than most plant-based products (Ritchie and Roser 2020). In addition, poultry is considered to be a sensitive product for the Swiss agriculture due to several reasons. Besides relatively high production costs, poultry production is hampered by restrictions such as land use constraints or maximum livestock numbers. Thus, Swiss price levels are considerably above the ones of neighboring countries, making competitive production at the international level challenging (Sterly et al. 2018: 47; Swiss Farmer's Union 2018: 22). Yet, in recent years, many farmers have chosen poultry production as a supporting pillar of their business due to an increasing demand, stable price developments, and the low domestic share. Consequently, the domestic share of poultry consumption has increased and amounted to 57.9 percent in 2017 (Swiss Farmer's Union 2018: 22). Thus, despite the relatively lower CO_2 impact of poultry compared to other food products, locally produced poultry is a relevant commodity for the Swiss farming sector.

Table 6 compares the GHG emissions of intensive and extensive Swiss and Brazilian poultry production systems at the retail level, referring to 1 kilogram of processed and packaged poultry. GHG emissions are measured as CO_2-equivalent. For Switzerland, three different production systems are being considered, an intensive system, an extensive system with high-animal-welfare husbandry, and an extensive organic variant, respectively (Wolff et al. 2016: 15; Alig et al. 2012: 2). For Brazil, the comparison includes two intensive production systems. While both use rapid-growth strains, one is associated with impacts deforestation due to crop production (da Silva et al. 2014: 223).

	Switzerland			Brazil	
	Intensive (Indoor)	Extensive (Outdoor Access)	Extensive (Organic)	Intensive (Deforestation)	Intensive (No deforestation)
GHG emissions at the retail level	5 kg CO2eq per 1 kg PW	6.6 kg CO2eq per 1 kg PW	6.8 kg CO2eq per 1 kg PW	5.3 kg CO2eq per 1 kg PW	4 kg CO2eq per 1 kg PW

Table 6: Comparing GHG emissions of Swiss and Brazilian poultry production systems at the retail level per kg packaged weight (Poore & Nemecek 2019).

Two main observations are observed. First, when comparing Swiss and Brazilian GHG emissions, Brazilian poultry production that is not associated with deforestation accounts for less emissions than the Swiss ones. The Brazilian intensive system, which is linked to prior deforestation for the production of soybeans and maize for animal feed, has higher GHG emission values than the Swiss intensive system (Wolff et al. 2016: 15-24; da Silva et al. 2014: 223-228). Thus, taking only GHG emissions into account, poultry production systems in Brazil are more environmentally friendly than those in Switzerland if they are not related to recent deforestation for crop production. Again, environmental impact related to transport activities play a minor role in the overall picture. If including GHG emissions resulting from the transportation of packaged poultry from Brazil to Switzerland, GHG emissions of Brazil poultry production would increase by 0.16 $kgCO_2$ per kg packaged poultry.

Second, there also appears to be a difference in GHG emissions between intensive and extensive poultry production systems. One the one hand, the environmental impacts of poultry production is largely determined by the crop production, which in all systems accounts for the largest share of total GHG emissions along the poultry production supply chain (da Silva et al. 2014: 226-227; Wolff et al. 2016 : 18-23). As the organic system has a lower productivity per unit in crop production, GHG emissions are higher compared to other systems (Wolff, et al. 2016: 19). On the other, closely related to the crop production, the most relevant factor in terms of GHG emissions at the poultry production stage is the feed conversion rate of each system. Intensive systems use rapid-growth strains which require less feed per unit of animal growth and therefore cause fewer GHG emissions. Extensive systems use slow-growing strains, and the greater physical activity of the animals required more energy, resulting in a slower weight gain (Wolff et al. 2018: 19-24). Thus, against the general notion, intensive systems have a lower environmental impact in terms of GHG emissions compared to extensive systems with high-animal-welfare husbandry and organic feed.

11. Conclusion on Environmental Impacts and Meat

Our analysis on how environmental impacts of meat production systems differ between Switzerland and Mercosur countries in terms of their greenhouse gas emissions yields several results. On the one hand, it shows that Swiss beef production outperforms Uruguayan beef production with regards to GHG emissions. On the other hand, Brazilian poultry production systems that do not involve deforestation for crop production cause lower GHG emissions than its Swiss counterpart (see Picasso et al. 2014 347-351; Poore and Nemecek 2019; da Silva et al. 2014: 226-228; Wolff et al. 2012: 36-48). Furthermore, considering intensive and extensive production systems, no clear conclusion can be drawn as to which of the production systems contributes less to GHG emissions. It follows a discussion on the implication of these findings. After this discussion, we address the most relevant limitations. Based on these limitations, we formulate fruitful pathways for future research.

The findings show that climate impacts resulting from meat production not only differs in terms of production systems but also depend to a certain extent in which country the meat is produced. While beef production causes less GHG emissions in Uruguay compared to Switzerland, Swiss poultry production has lower GHG emission levels than Brazil's production. Therefore, considering climate aspects in FTA negotiations, we recommend reducing agricultural trade barriers primarily for those products, whose GHG emission levels are lower than those in Switzerland. Consequently, when looking at the upcoming Mercosur trade agreement, tariff liberalizations for poultry should be prioritized over beef. This recommendation holds even when taking into account the GHG emissions caused by international transportation. Yet, as suggested by other studies the environmental impact resulting from transportation tends to be insignificant when looking at the whole life cycle of meat production (Poore and Nemecek 2018: 4; Ritchie and Roser 2020). Hence, it appears to be crucial to further incentivize sustainable consumption by increasing communication about climate impacts of agricultural products for consumers. For instance, eating local may not be key to a low carbon diet. Instead, eating less meat, or switching from red meat to white meat reduces the carbon footprint of a diet by much more. Therefore, we recommend policy makers to advocate and promote sustainable consumption by broadening education on the true costs of food and incentivizing the adoption of environmental labels.

Furthermore, GHG emissions are not the only aspect that defines environmental and societal wellbeing. There are significant trade-offs between GHG emissions and other environmental aspects in the life cycle assessment. These aspects include the land use impact on the biodiversity, soil erosion and the ecotoxicity of applied pesticides (Picasso et al. 2014; da Silva et al. 2014). Apart from these environmental factors, societal aspects like labour standards and animal-friendly husbandry need to be taken into account as well. For instance, compared to Switzerland, animal welfare laws in Mercosur are rather vaguely formulated with a tendency towards more general regulations for husbandry, transport and slaughter. Compared to Switzerland, requirements are often formulated as recommendations. Besides, the adherence to the animal protection laws is only scarcely controlled, which is why professionals in the field estimate the animal protection laws as underdeveloped (Huber 2018: 10). Overall, choosing between different meat products based on an environmental impact and animal welfare perspective is complex. To help consumers make informed choices, the scientific literature needs to be simplified and condensed to facilitate active decision-making and raise awareness about the different environmental aspects.

Our report has several limitations. The most relevant limitation is that it only targets red and white meat products. This limited focus is due to data availability. Specifically, the data on GHG emissions of agricultural products in different nations is relatively scarce and based on different allocation methods. The meta-analysis by Poore and Nemecek's on the life cycles of food and drink products combines many data sources (Poore and Nemecek 2019). However, as researcher gather different information for different countries, cross-country comparisons are rather complex (Poore and Nemecek 2019). Given our limitations, we suggest that future research should replicate this study as soon as better data is available. Moreover, future research should test if our findings hold for additional agricultural products as well as for other relevant import countries. In addition, trade-offs between various environmental aspects may also be taken into consideration in future research.

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Appendix

Meat Imports by Country at the 2-digit level

The following two figures display the Swiss meat imports at the 2-digit level by partner country

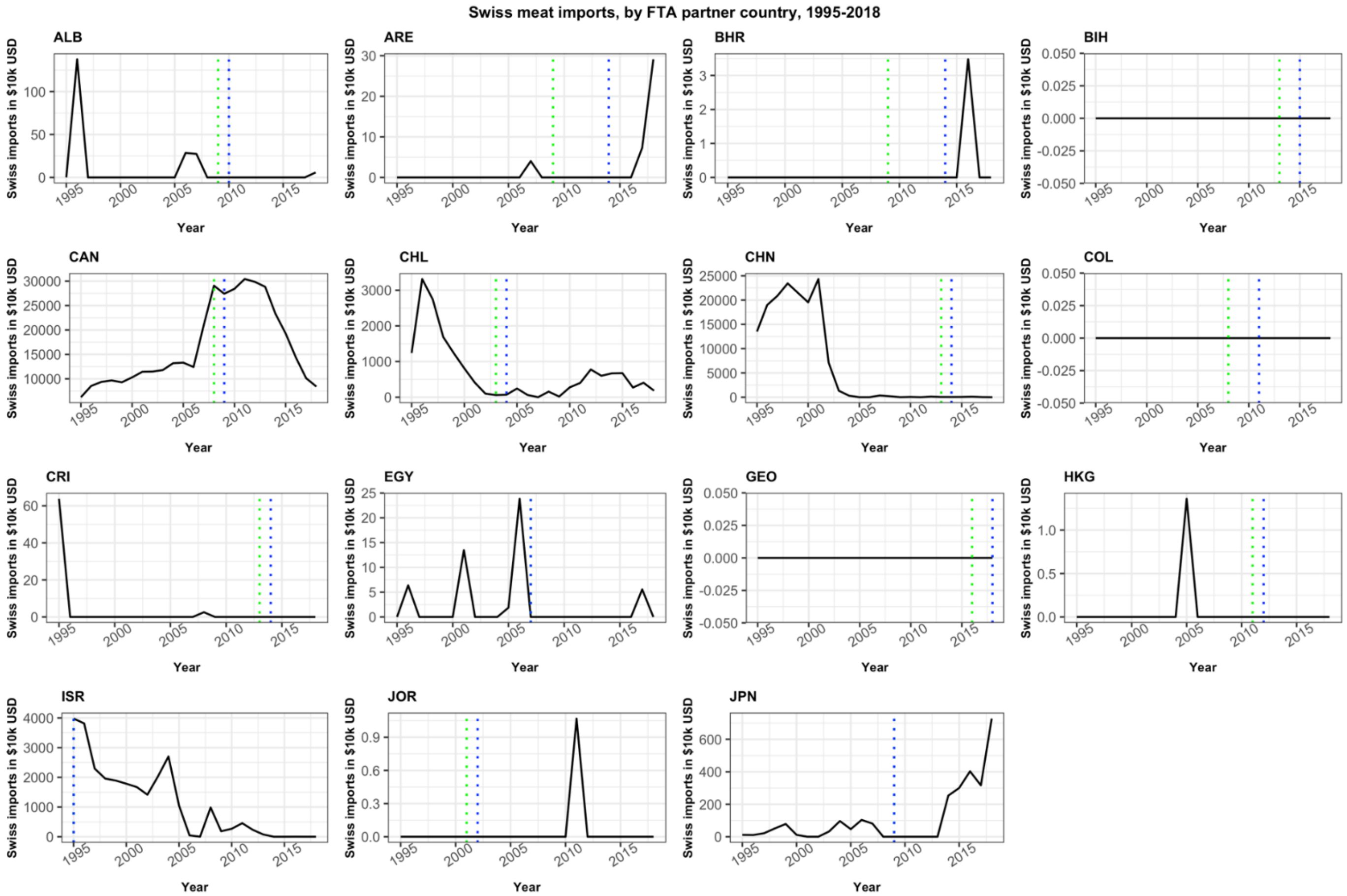

Figure 9: Swiss Meat Imports by Country, first half

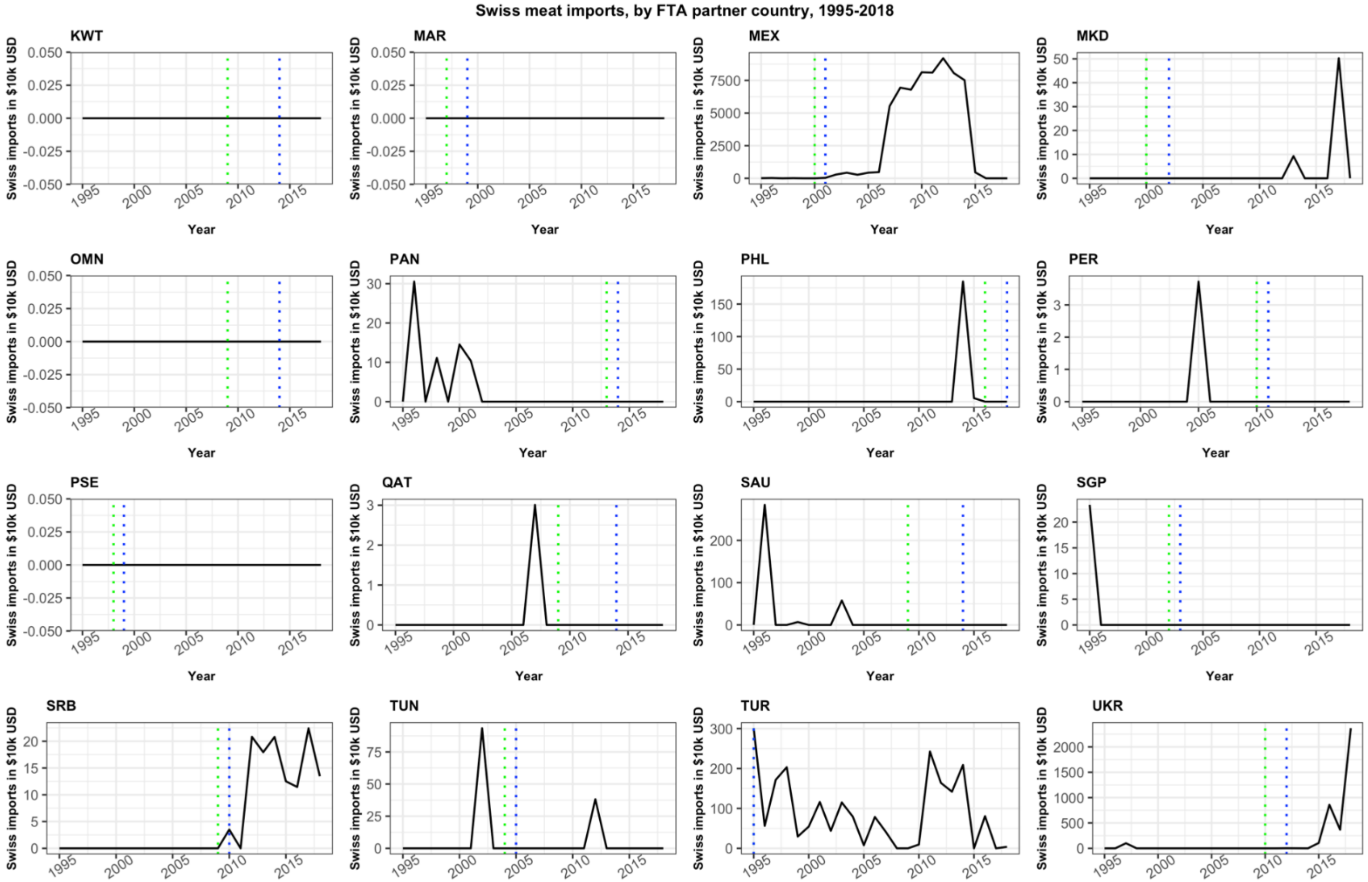

Figure 10: Swiss Meat Imports by Country, second half

Meat Imports by Country at the 4-digit level

According to our findings, there is a significant effect of tariff reductions on the imports of meat products. In order to more clearly determine the drivers of this effect, the following visualizations show the development of 4-digit meat products after the signing and entering into force of free trade agreements. These plots of yearly meat imports per country show that meat imports from only a selection of trade partners display an increase after an FTA has entered into force. Namely, these include the United Arab Emirates, Canada, Japan and Serbia. Out of these, only Japan and Canada account for an annual import value of meat products that exceeds $1 million USD. The other two report annual import values that are very close to $10,000 USD, the threshold under which the CEPII BACI database does not report trade flows anymore. The United Arab Emirates and Serbia are hence not included in this further analysis.

Disaggregating the meat imports for Canada and Japan shows that these increases are driven by single products, instead of meat imports as a whole. In the case of Canada, this increase is entirely driven by the imports of fresh beef (0201) and frozen beef (0201), although fresh beef had already seen a strong increase in imports before the signing of the FTA, starting in 2005. Additionally, frozen beef has seen a sharp decline in imports within the next 10 years. There appears to be no evidence pointing toward the tariff reduction for meat having a lasting, positive effect on meat imports, in the case of Canada. The Japanese case is similar, in that only beef imports (0201 and 0202) display an increase after the reduction in tariffs. The increase in imports of fresh beef does only start after the FTA has been put in force and these imports have seen steady growth since. This suggests that the reduction in tariffs has led to a stable increase in imports of fresh beef from Japan. The following section lists the same visualizations for all of the observed countries.

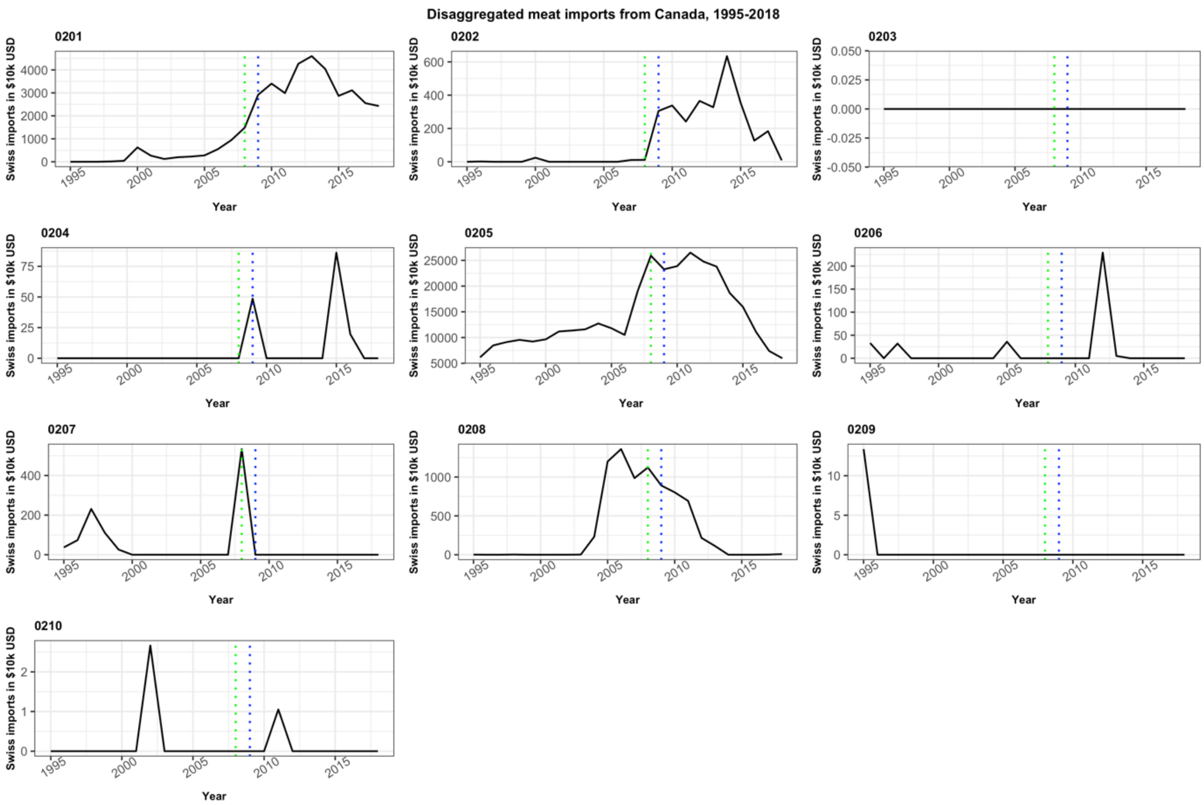

Figure 11: 4-digit level meat imports from Canada

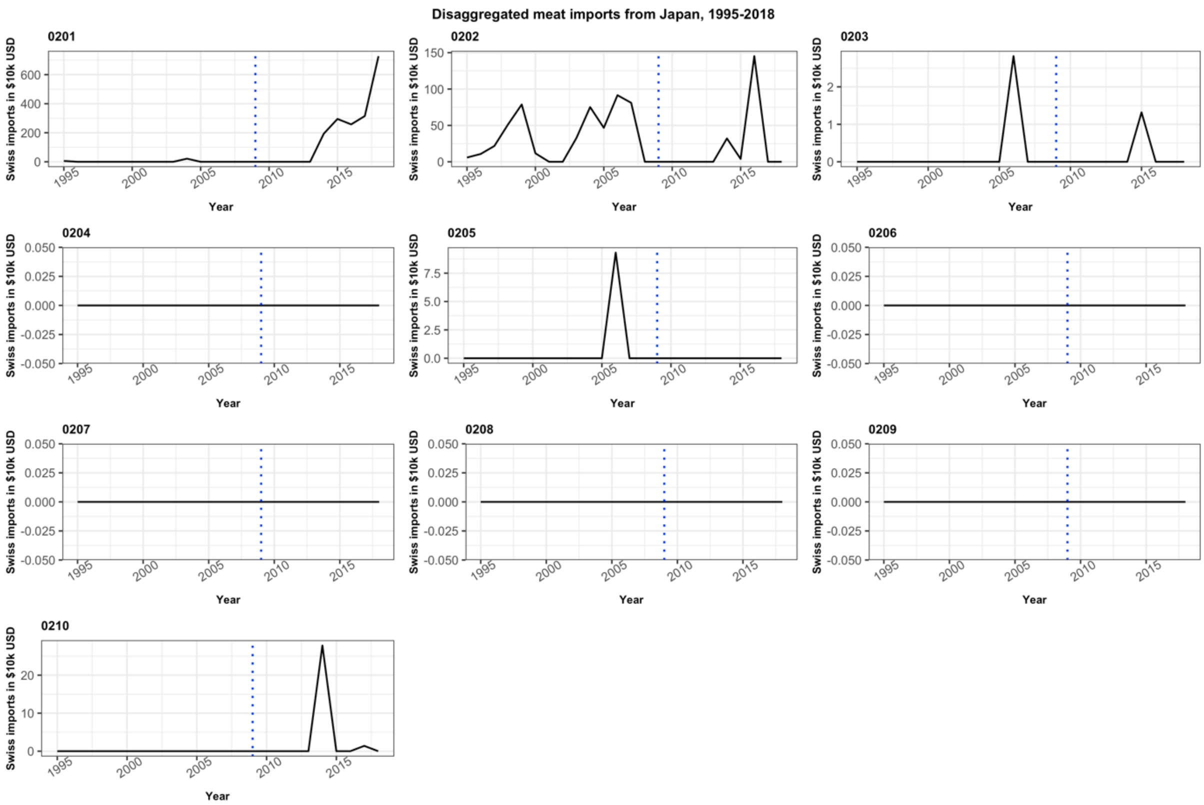

Figure 12: 4-digit level meat imports from Japan

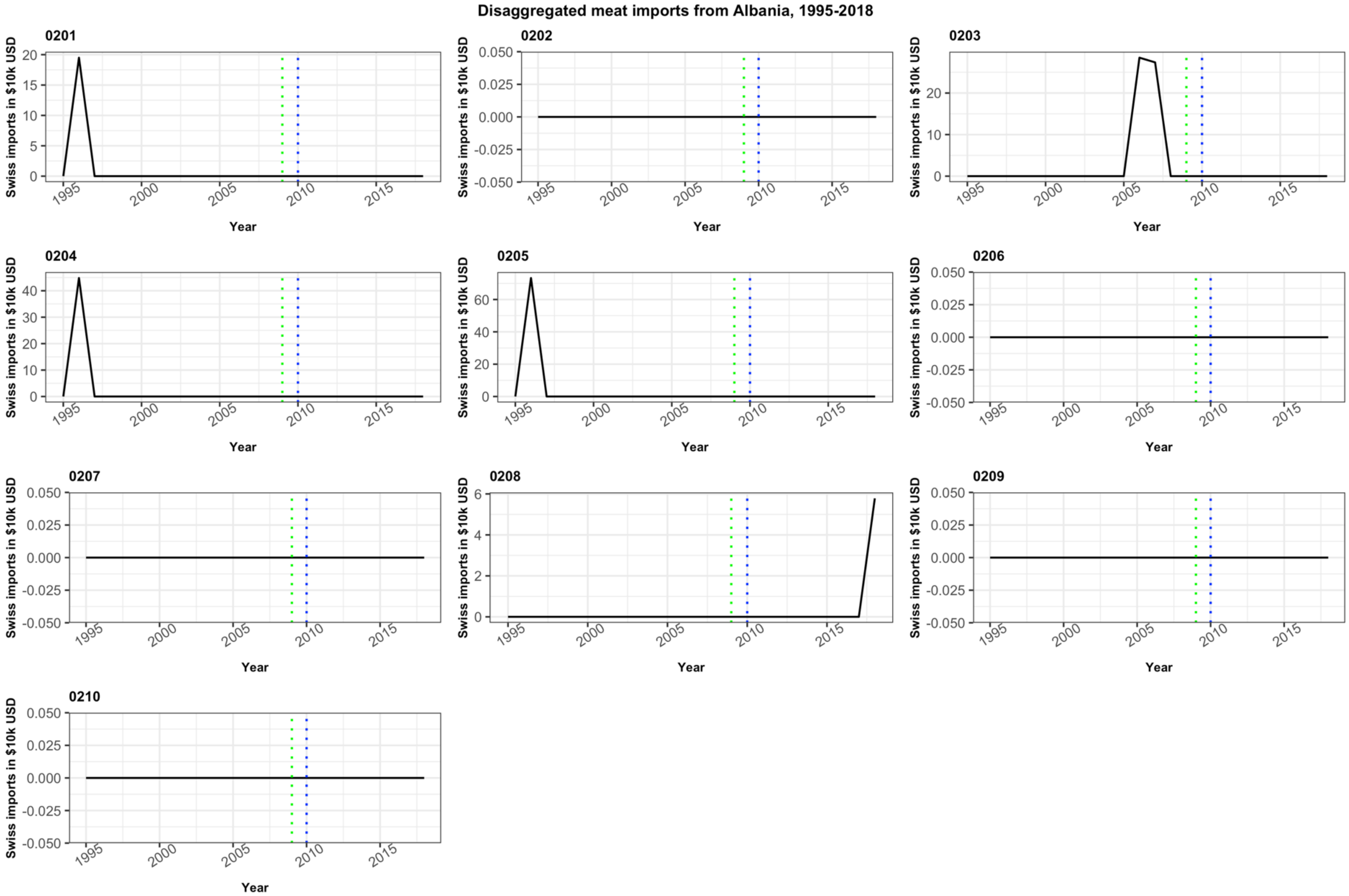

Figure 13: 4-digit level meat imports from Albania

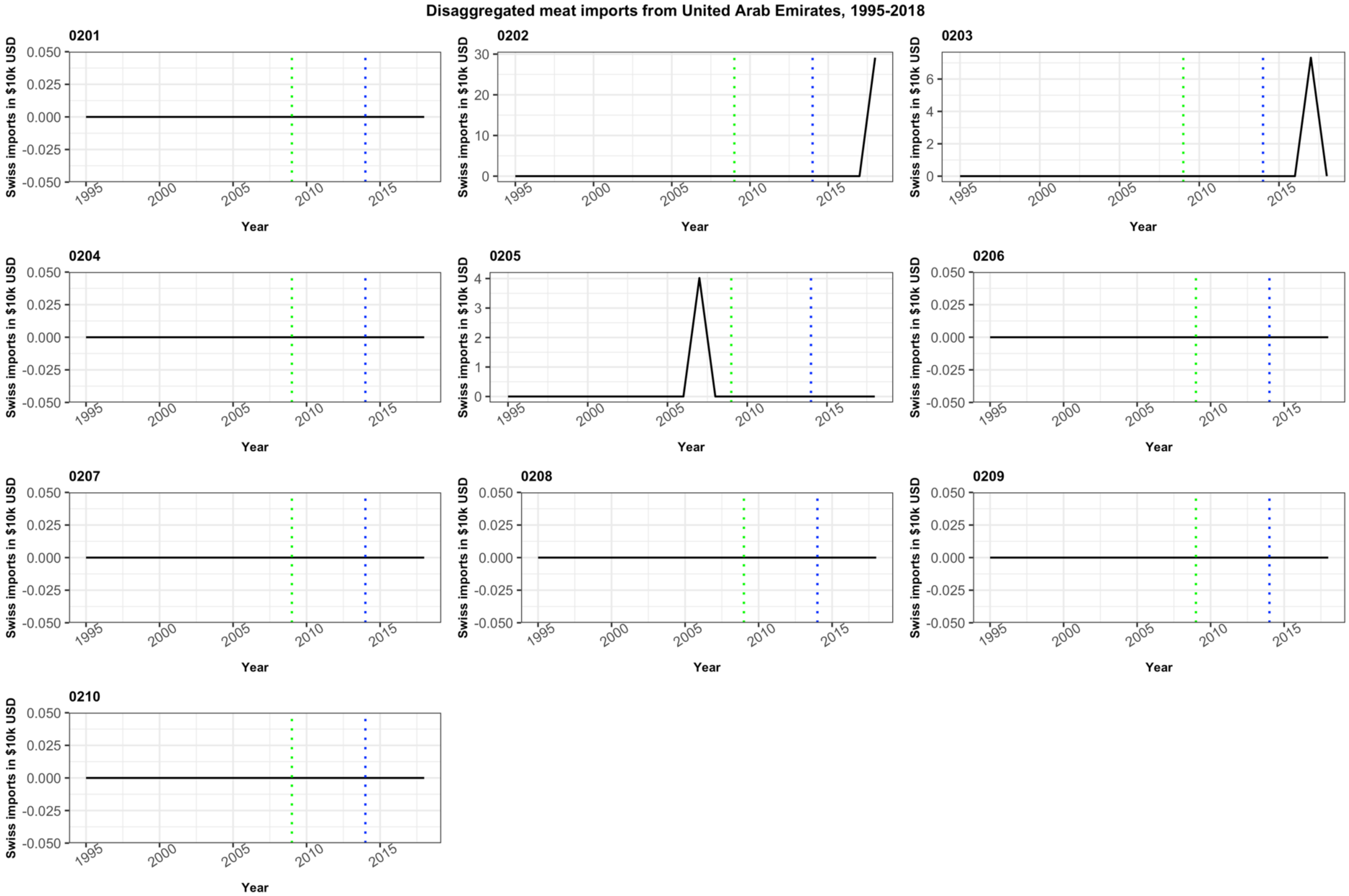

Figure 14: 4-digit level meat imports from the United Arab Emirates

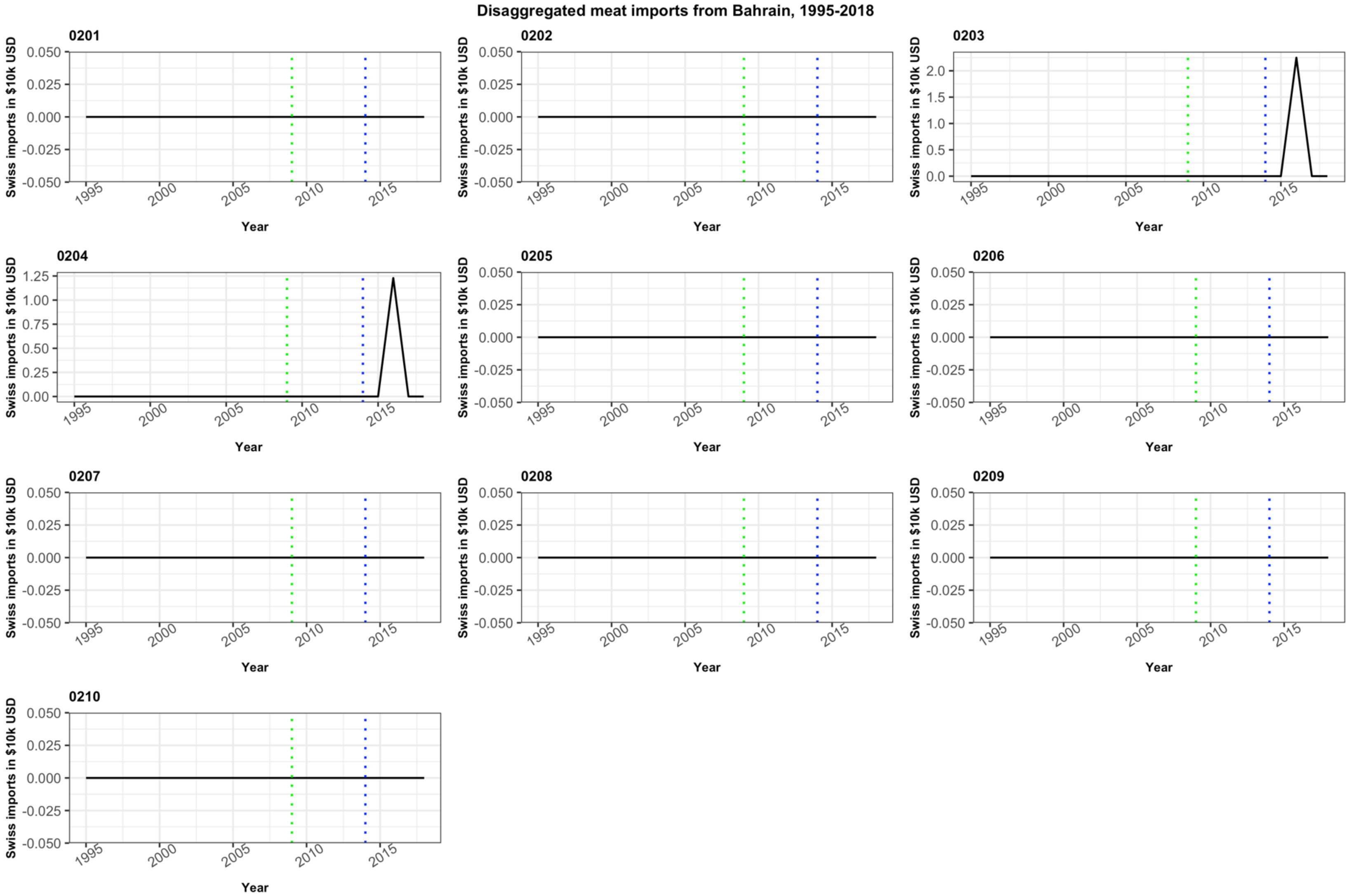

Figure 15: 4-digit level meat imports from Bahrain

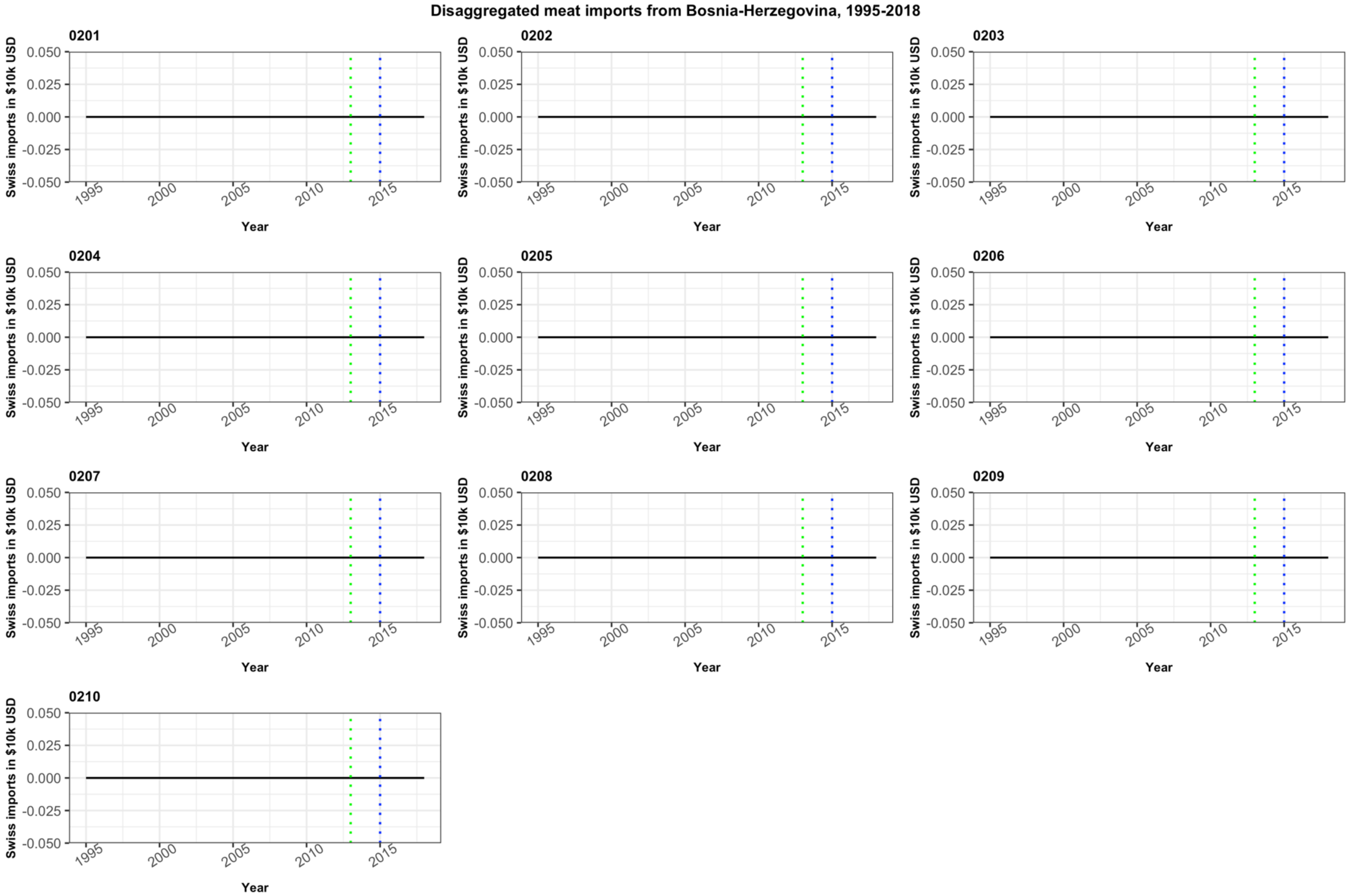

Figure 16: 4-digit level meat imports from Bosnia-Herzegovina

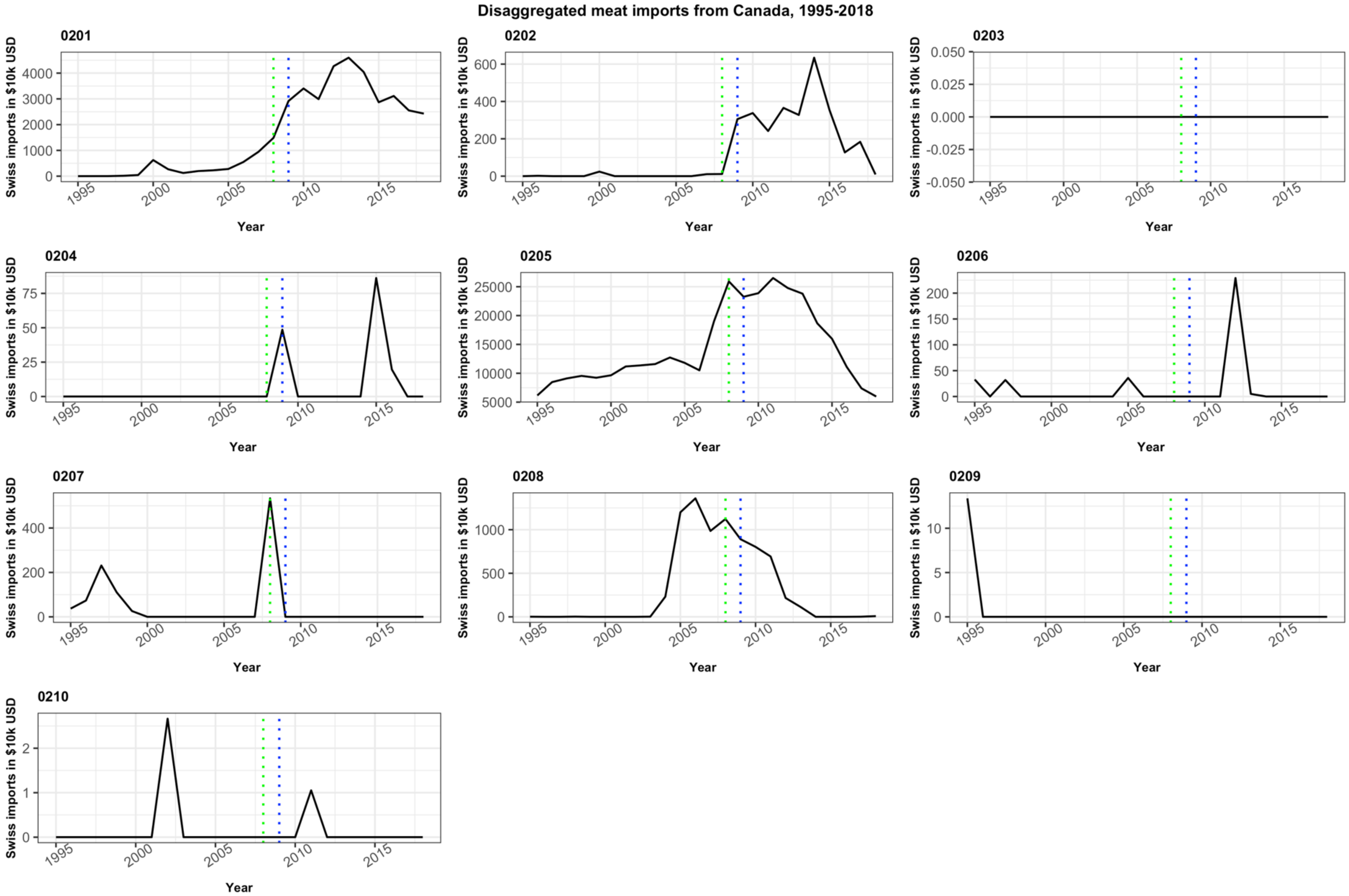

Figure 17: 4-digit level meat imports from Canada

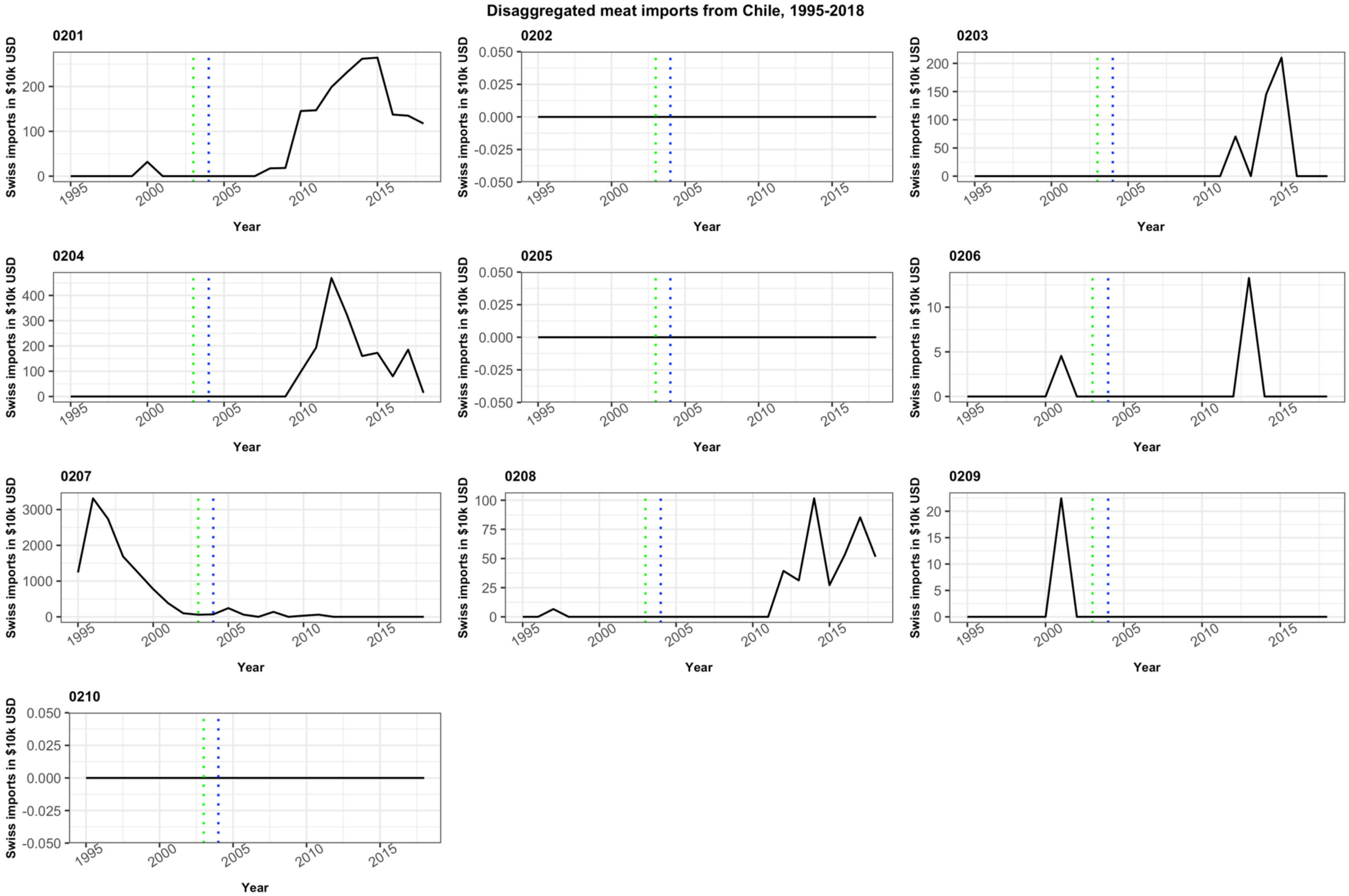

Figure 18: 4-digit level meat imports from Chile

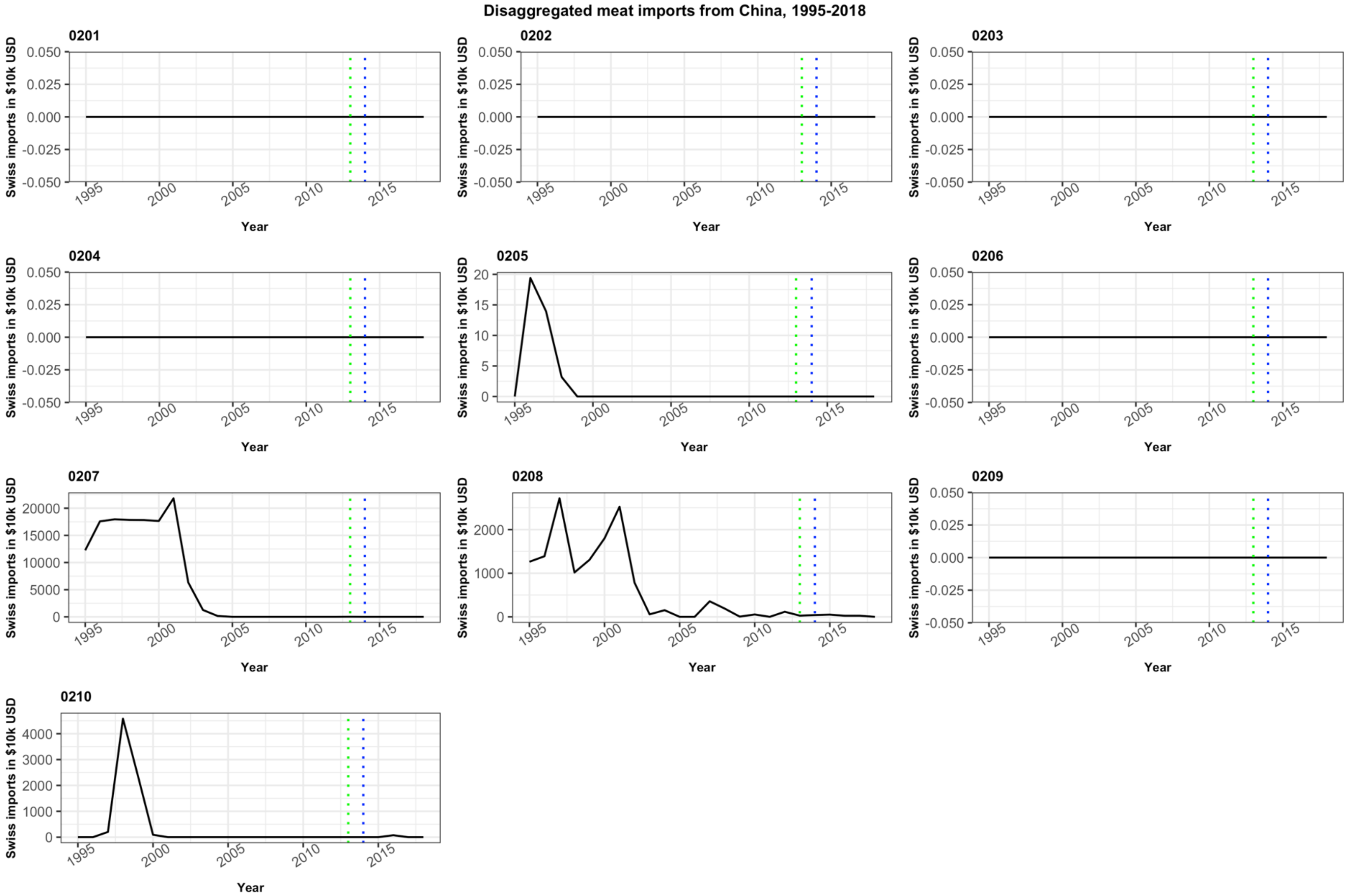

Figure 19: 4-digit level meat imports from China

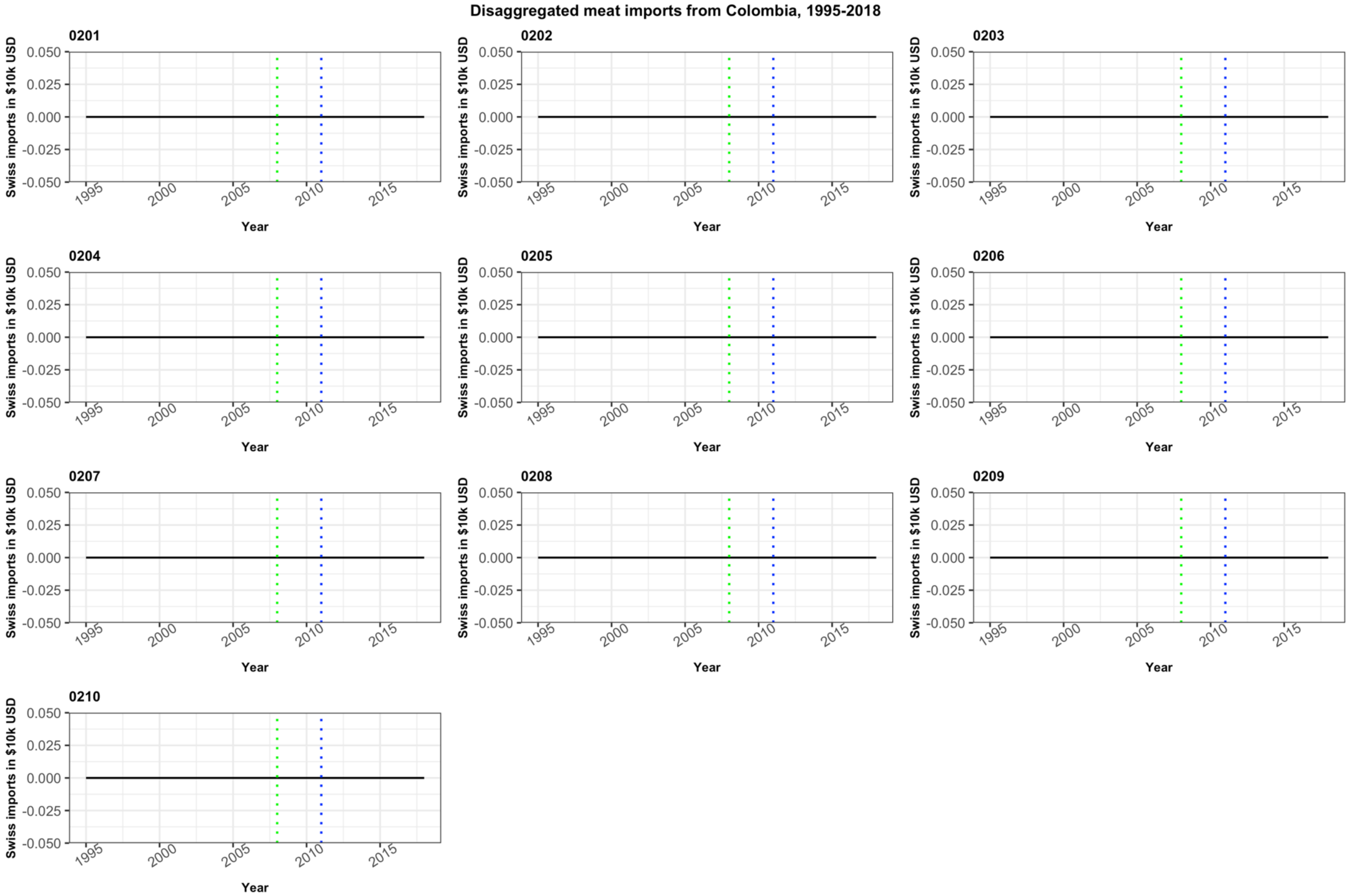

Figure 20: 4-digit level meat imports from Columbia

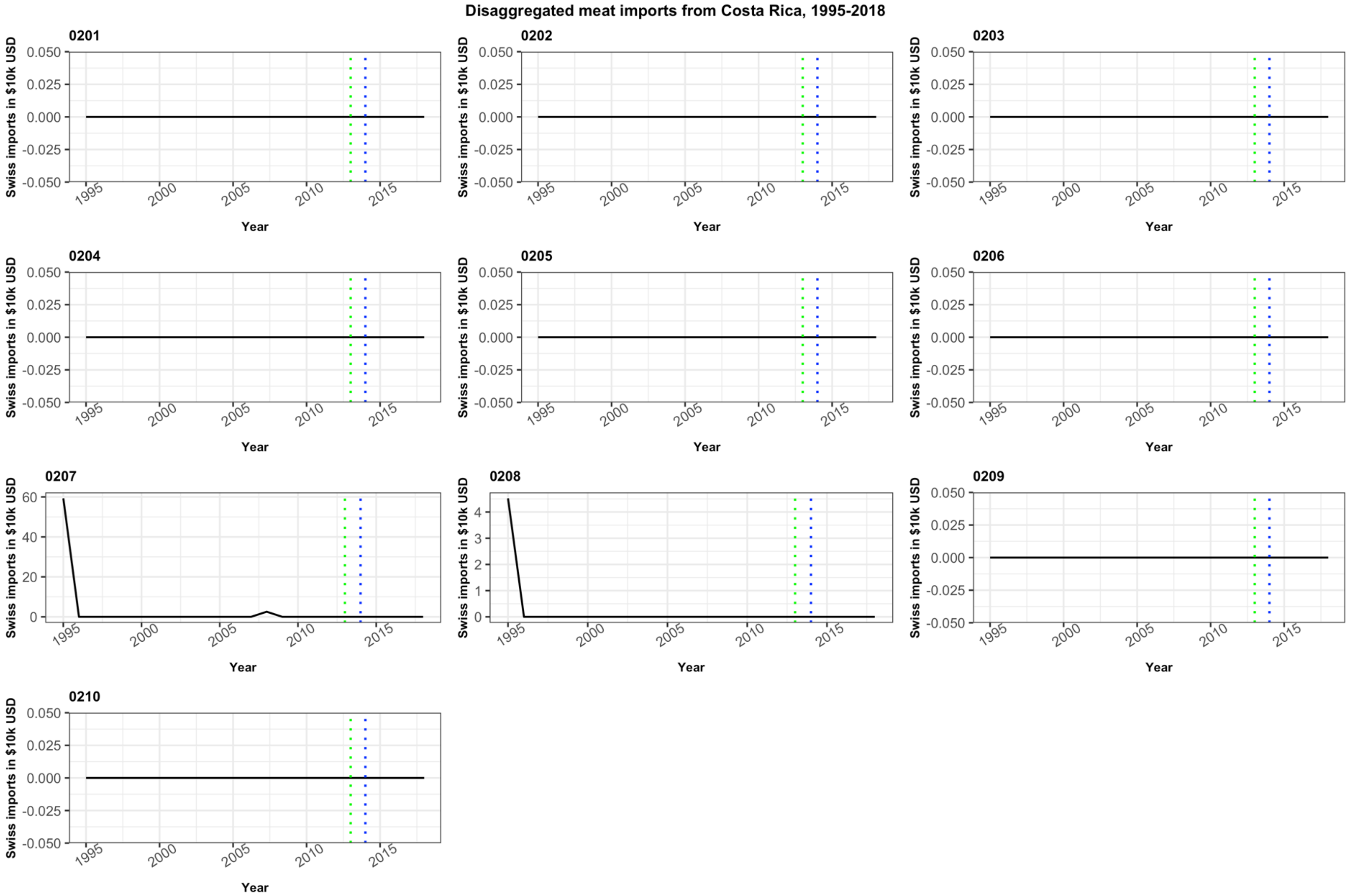

Figure 21: 4-digit level meat imports from Costa Rica

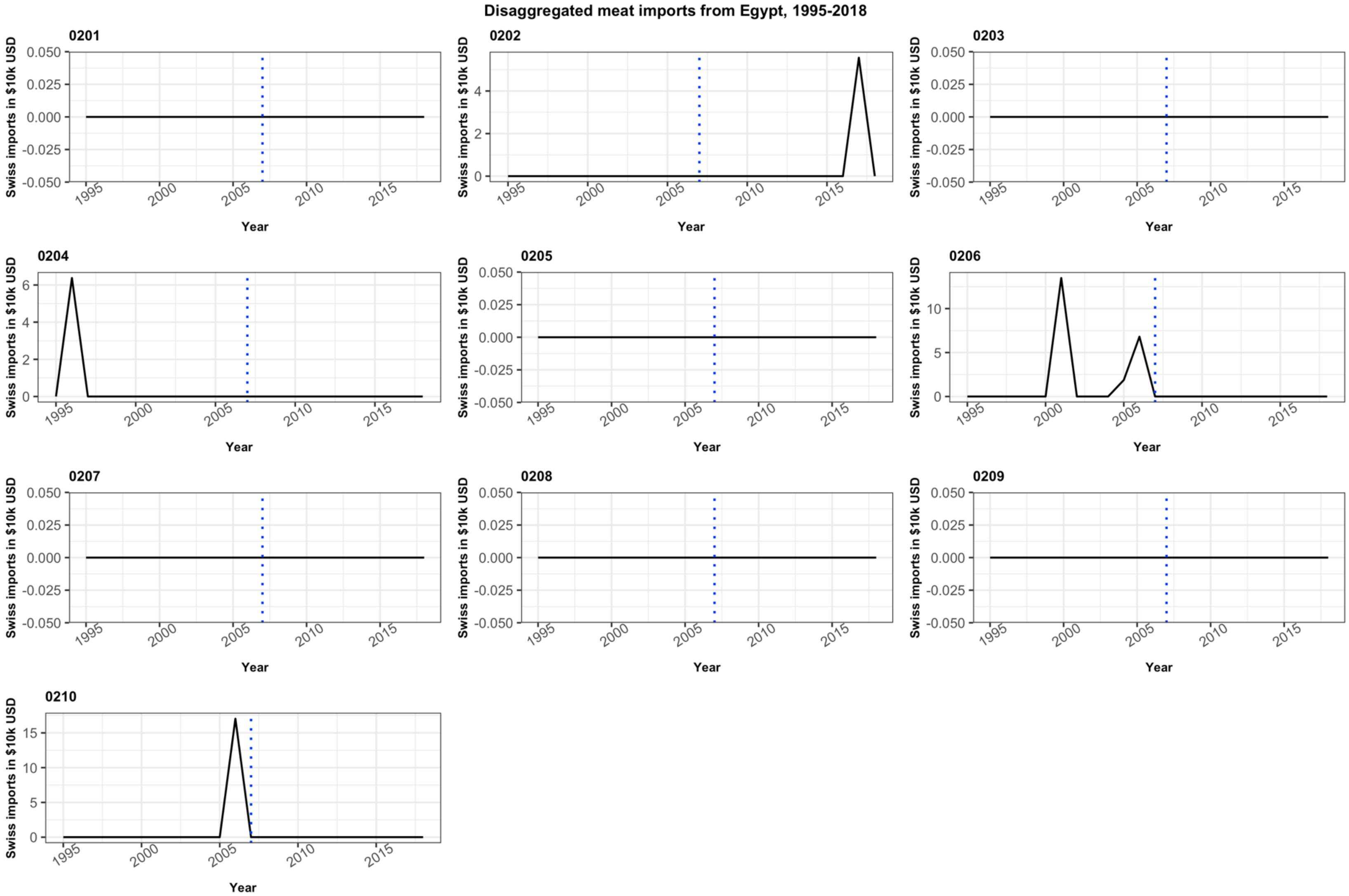

Figure 22: 4-digit level meat imports from Egypt

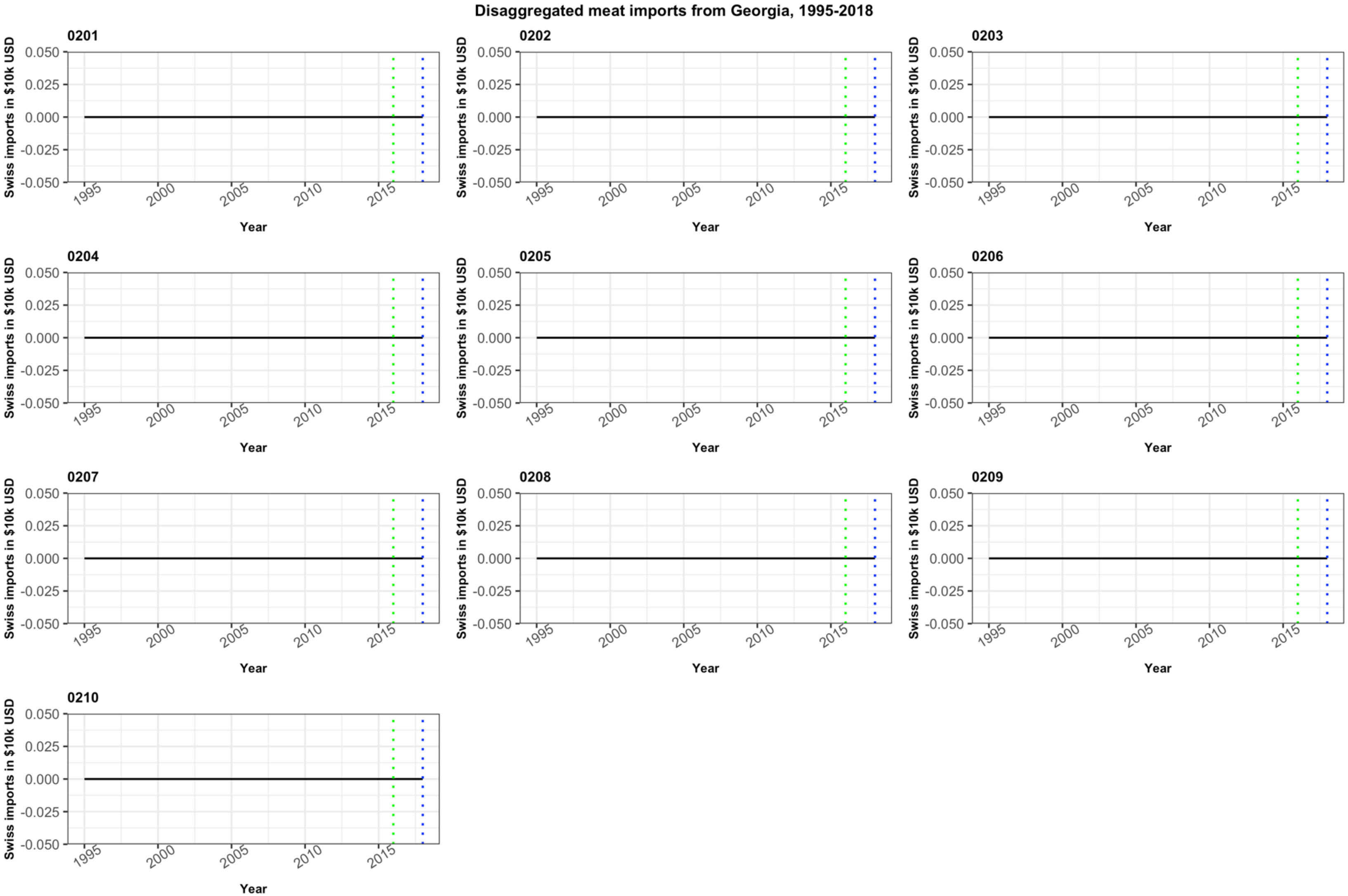

Figure 23: 4-digit level meat imports from Georgia

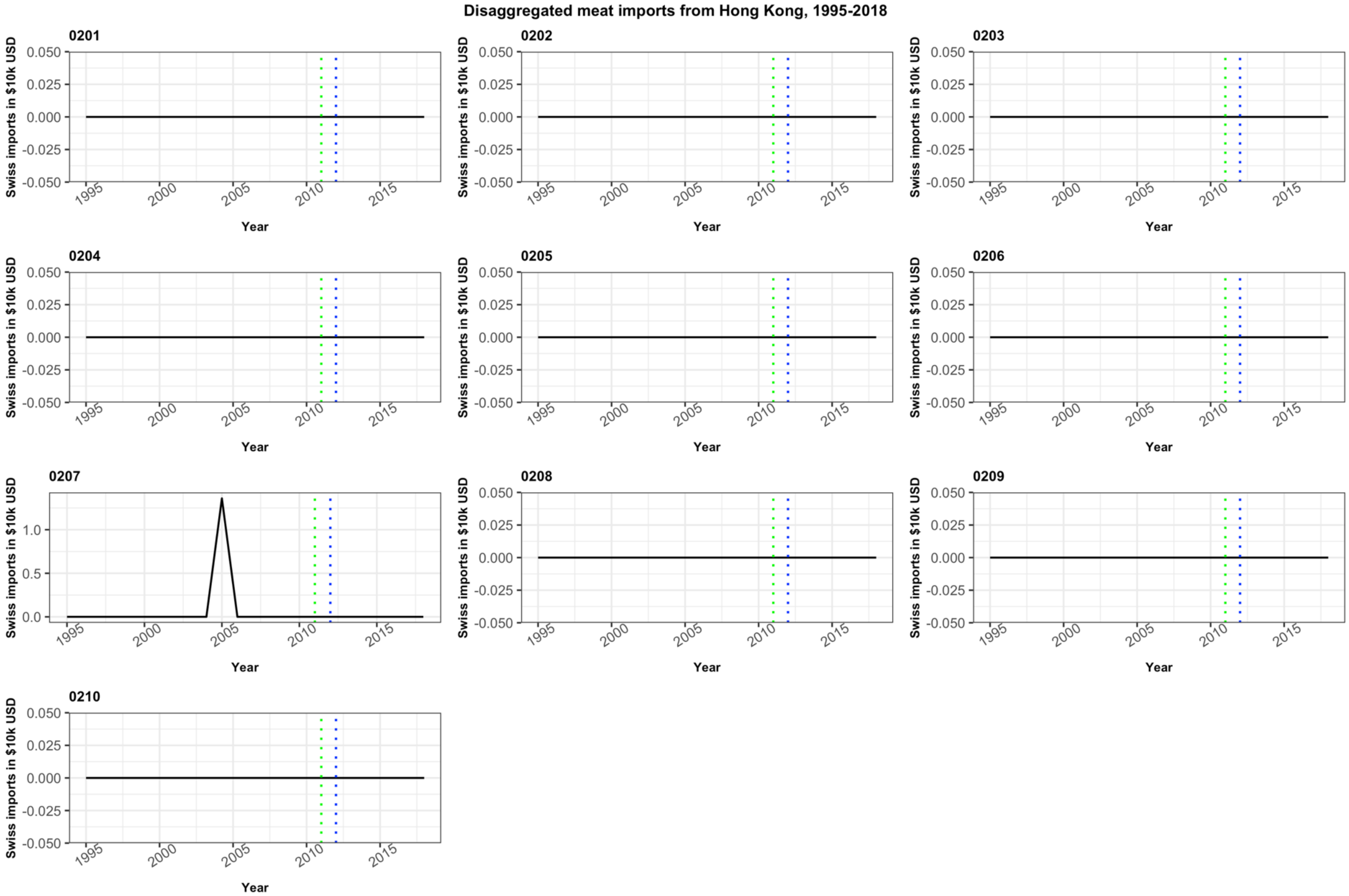

Figure 24: 4-digit level meat imports from Hong Kong

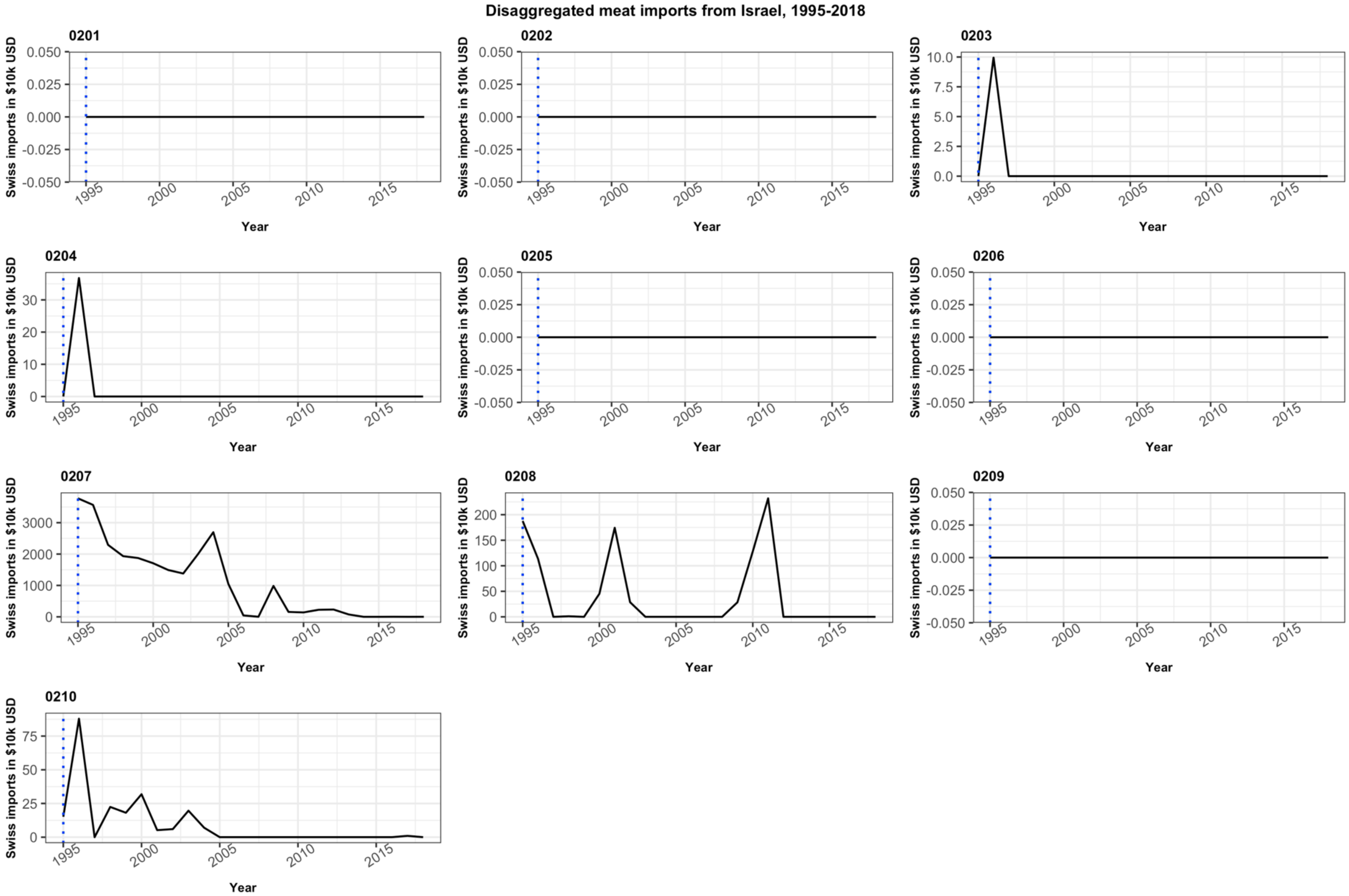

Figure 25: 4-digit level meat imports from Israel

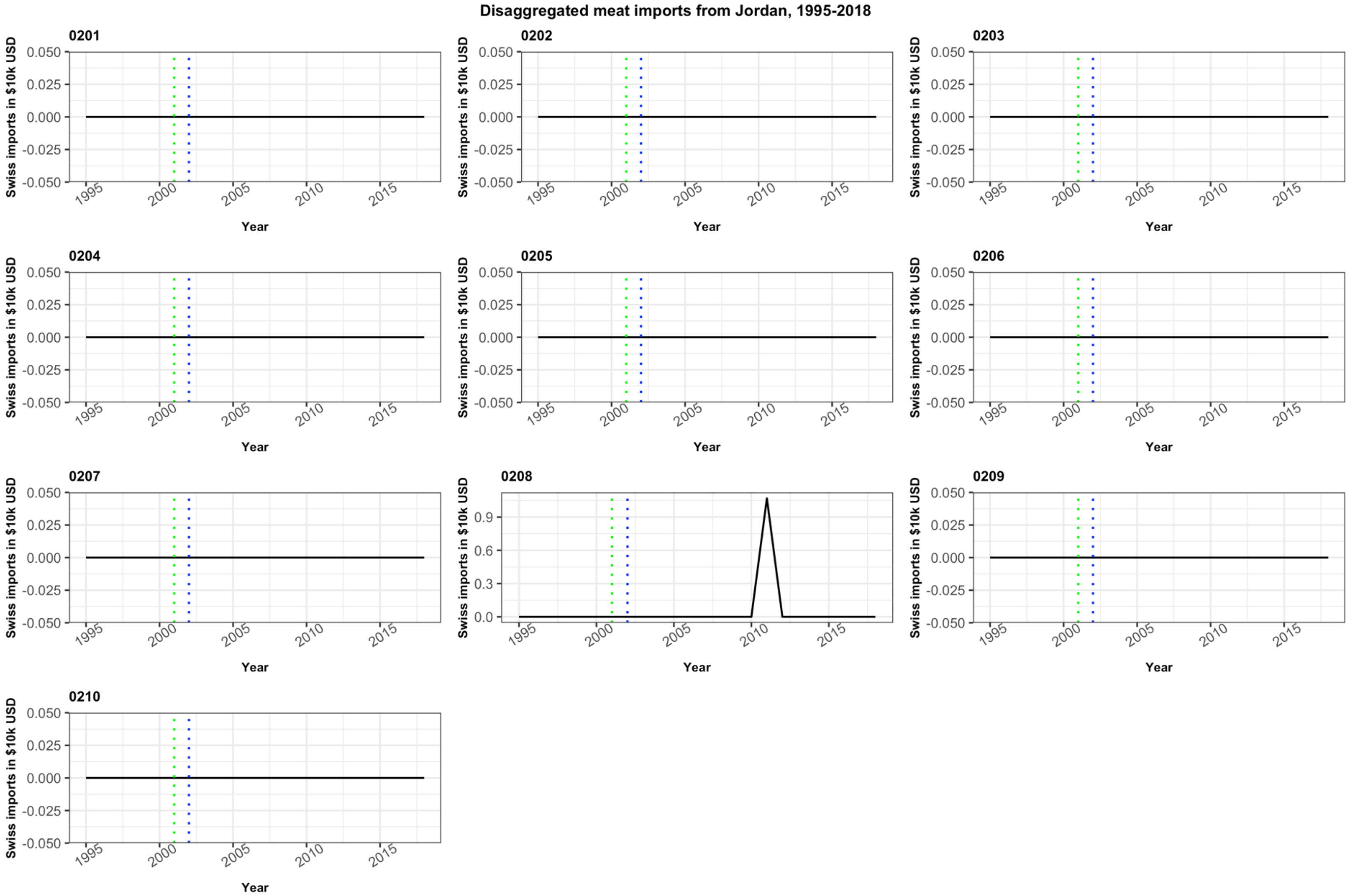

Figure 26: 4-digit level meat imports from Jordan

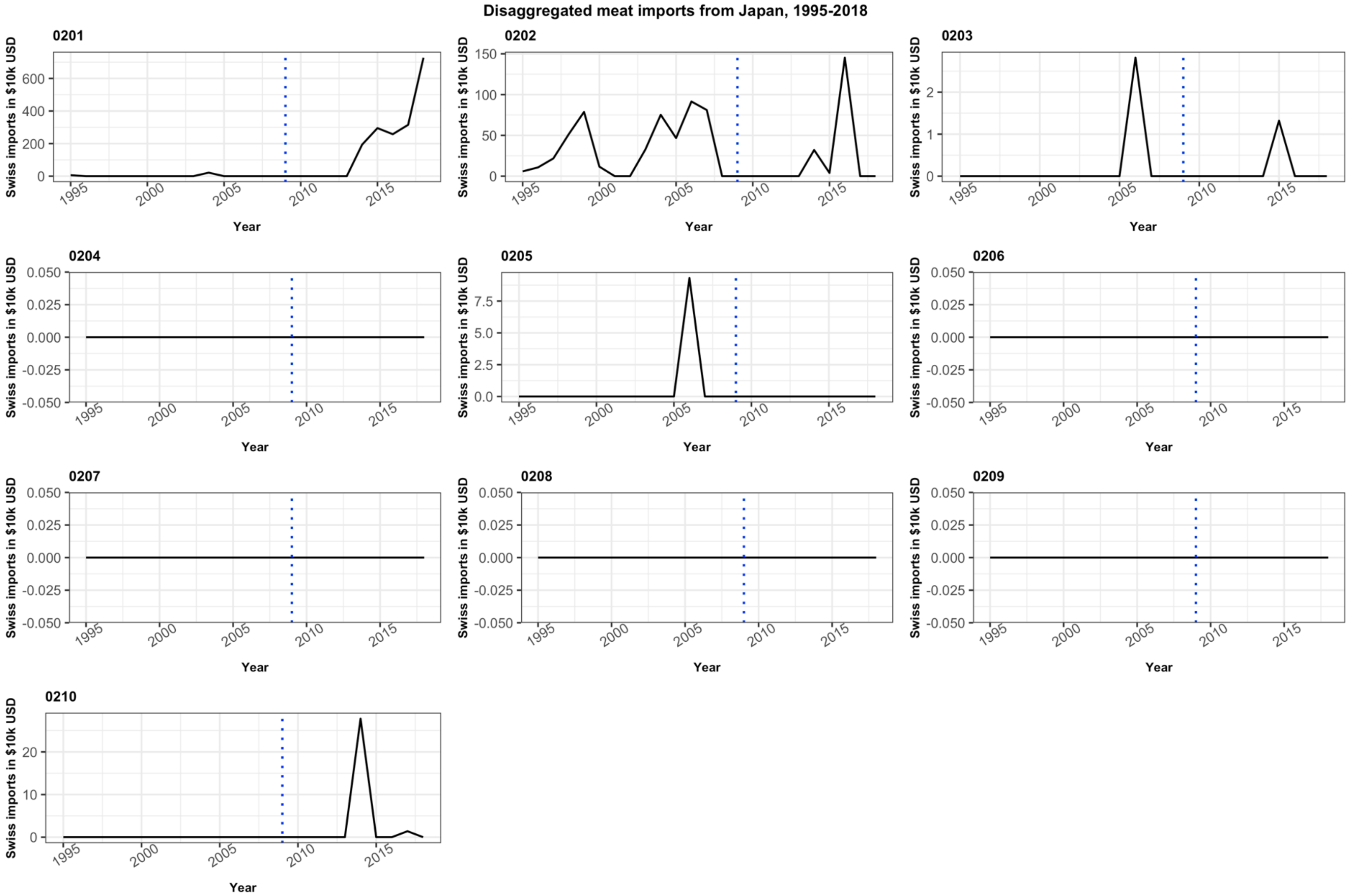

Figure 27: 4-digit level meat imports from Japan

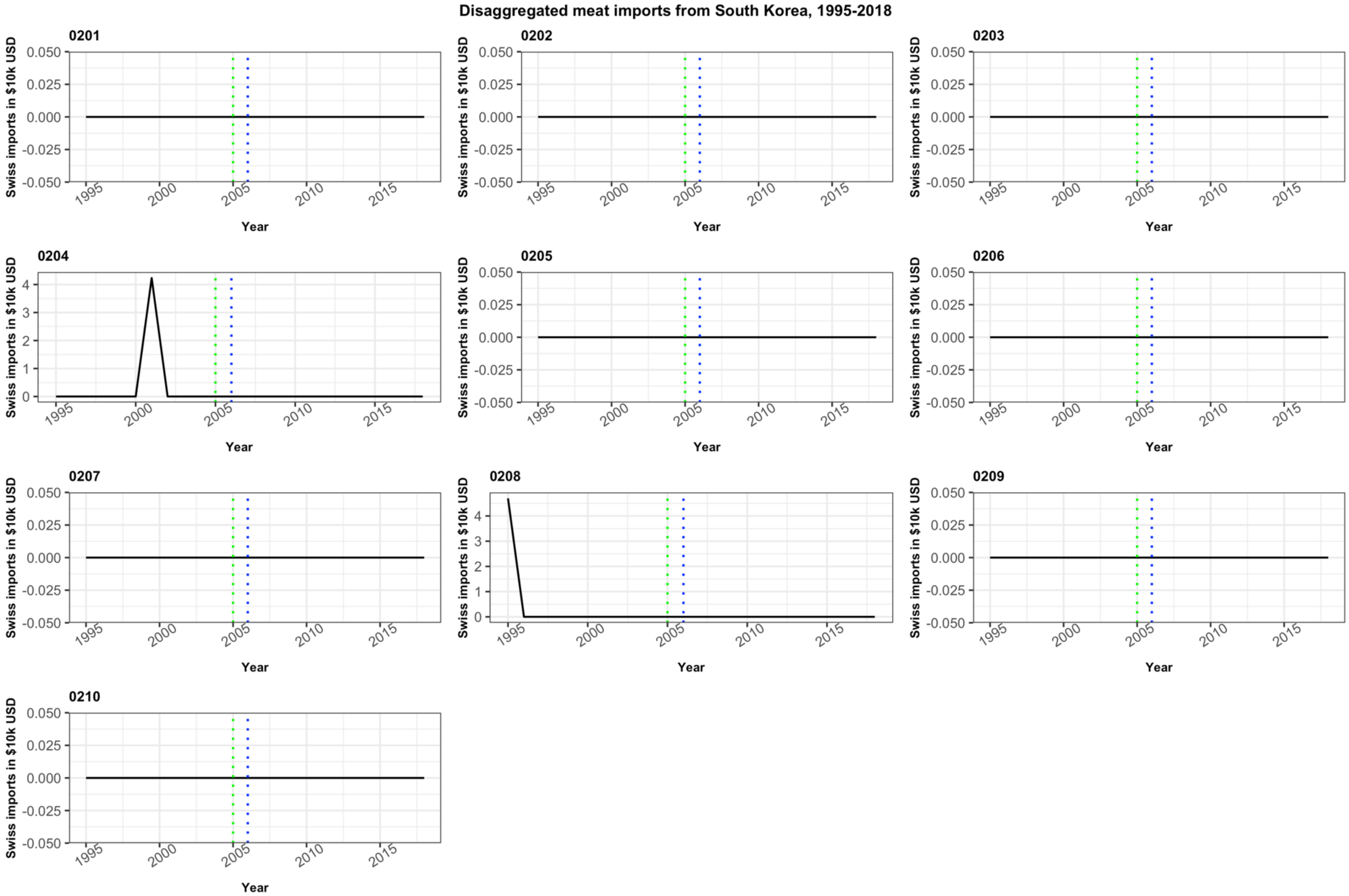

Figure 28: 4-digit level meat imports from South Korea

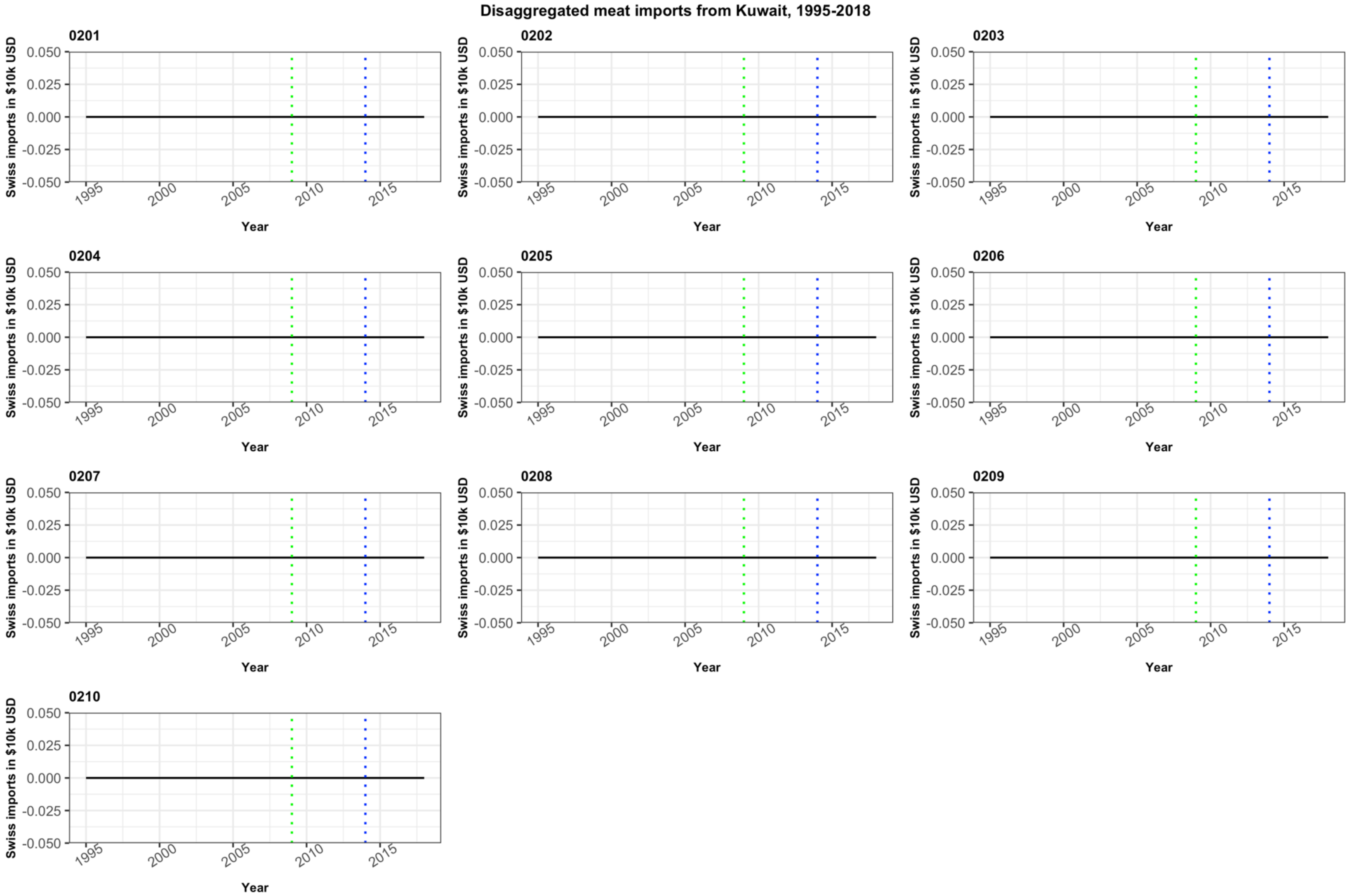

Figure 29: 4-digit level meat imports from Kuwait

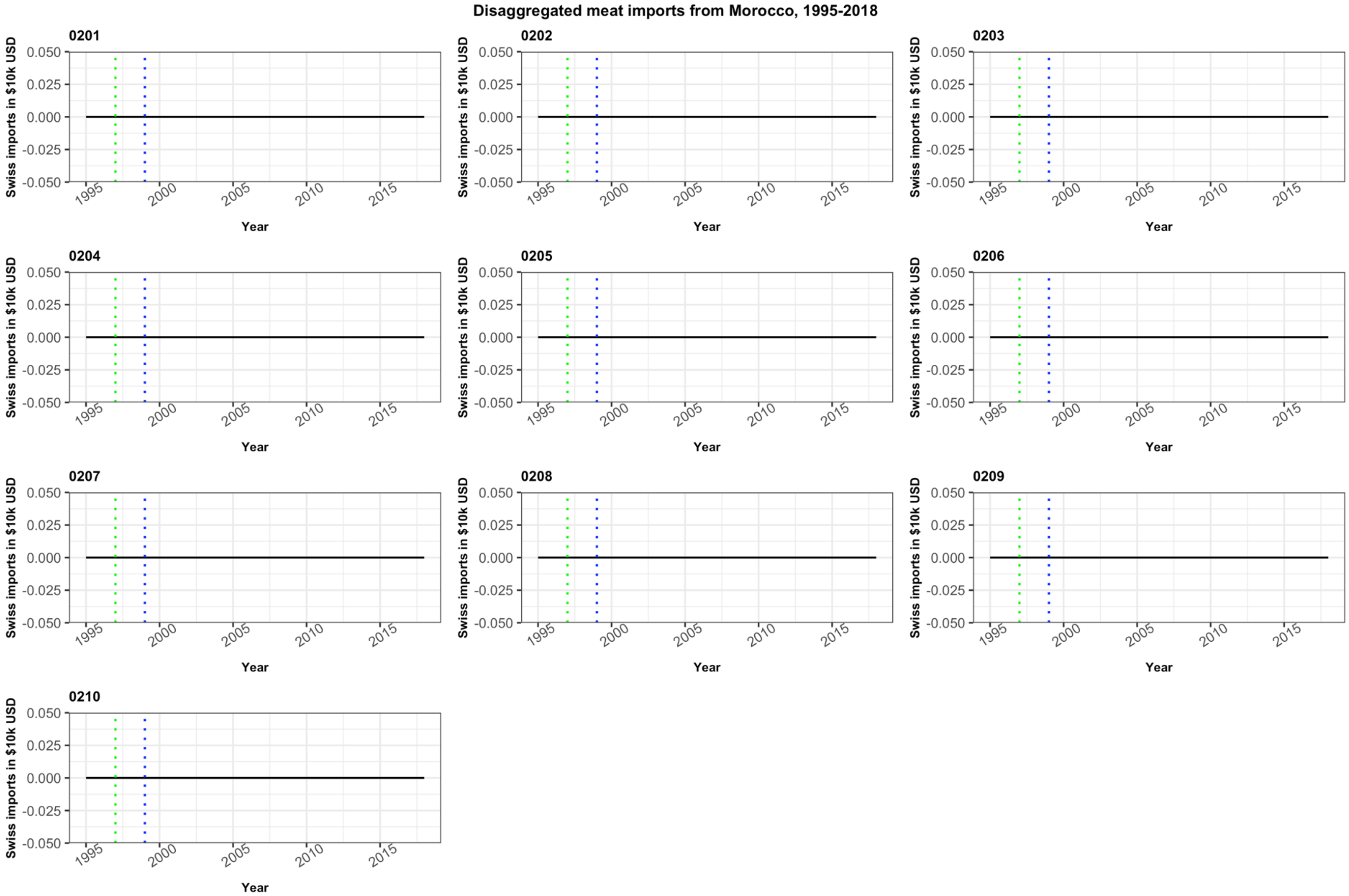

Figure 30: 4-digit level meat imports from Morocco

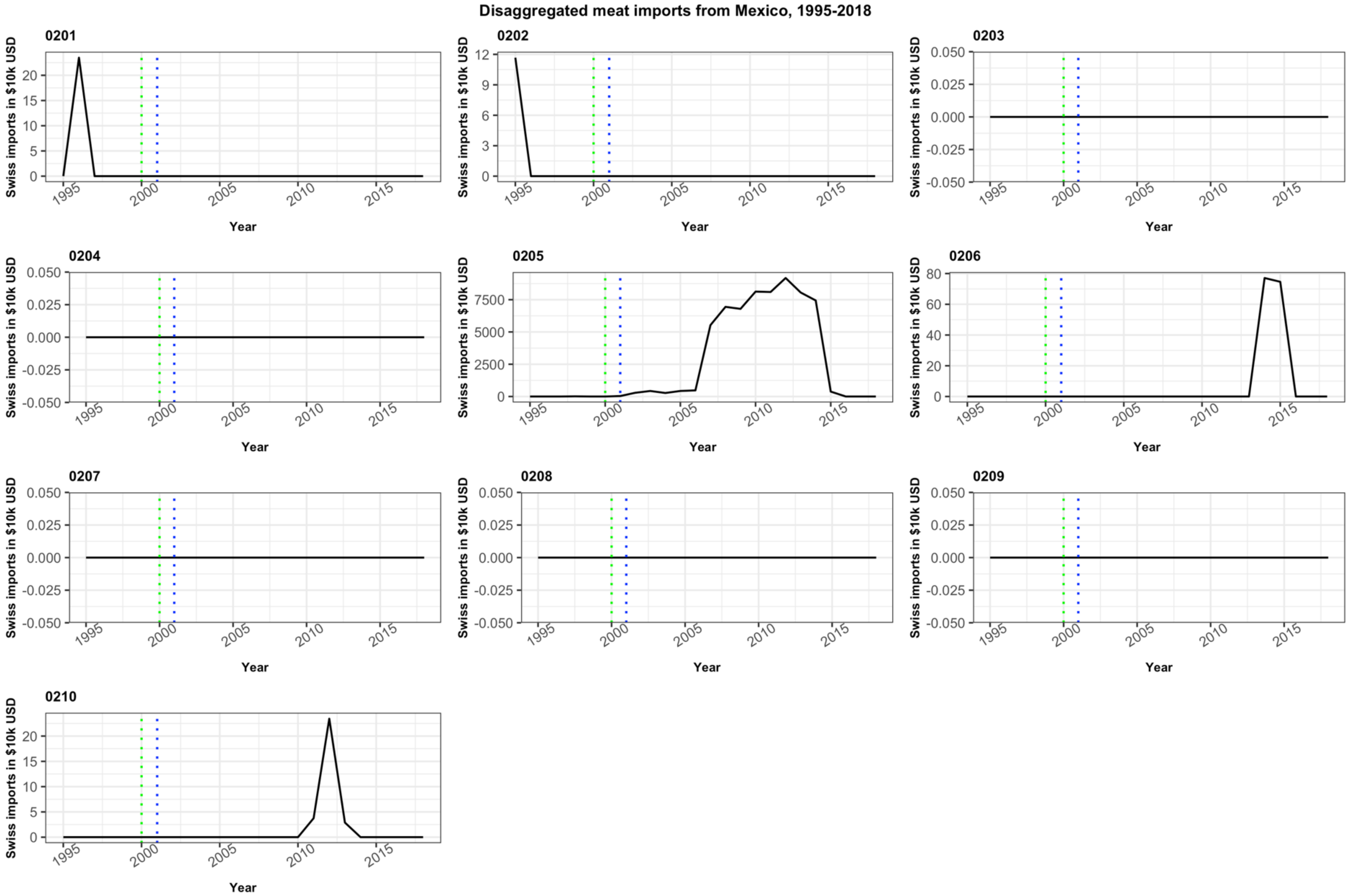

Figure 31: 4-digit level meat imports from Mexico

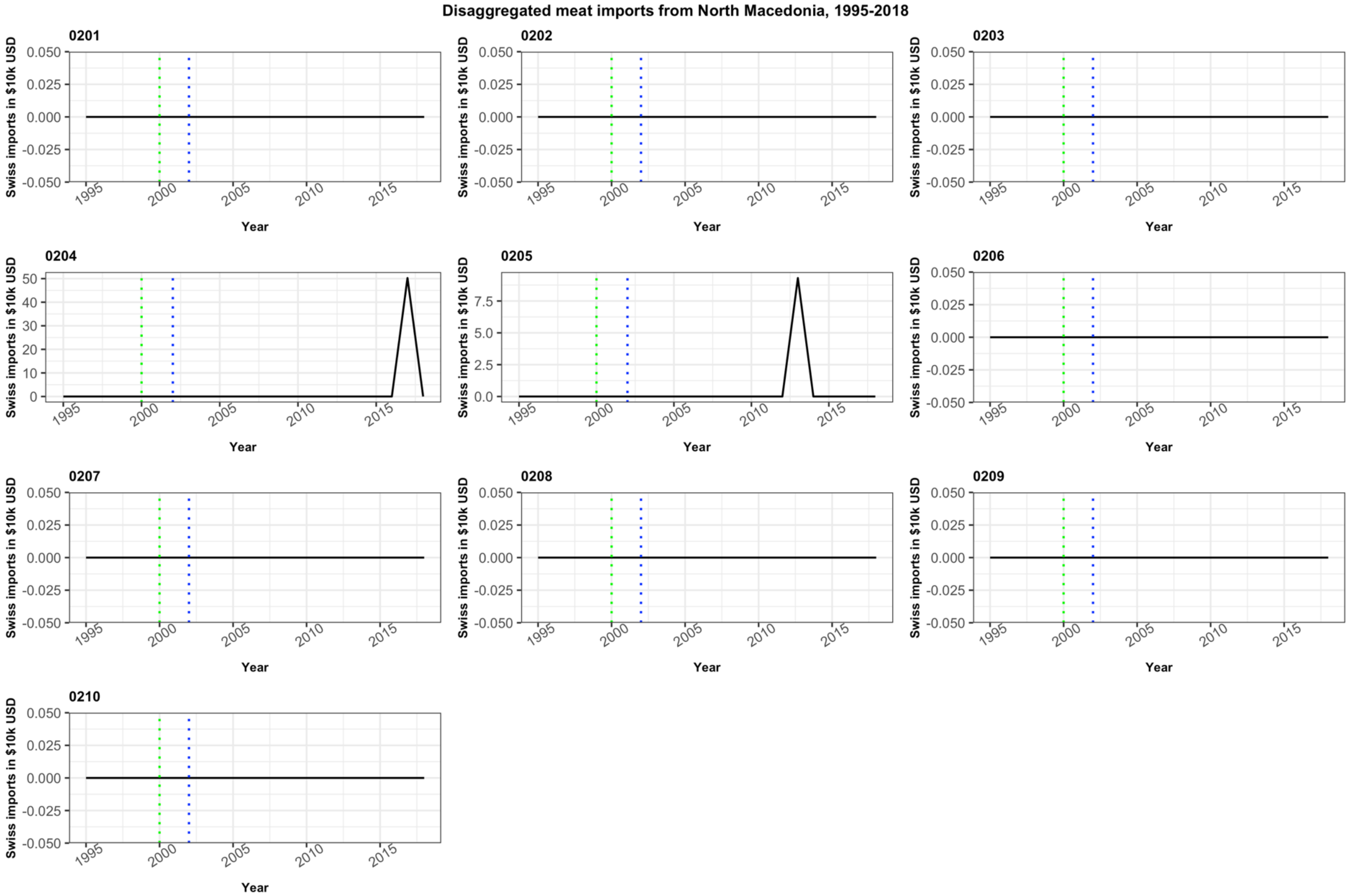

Figure 32: 4-digit level meat imports from North Macedonia

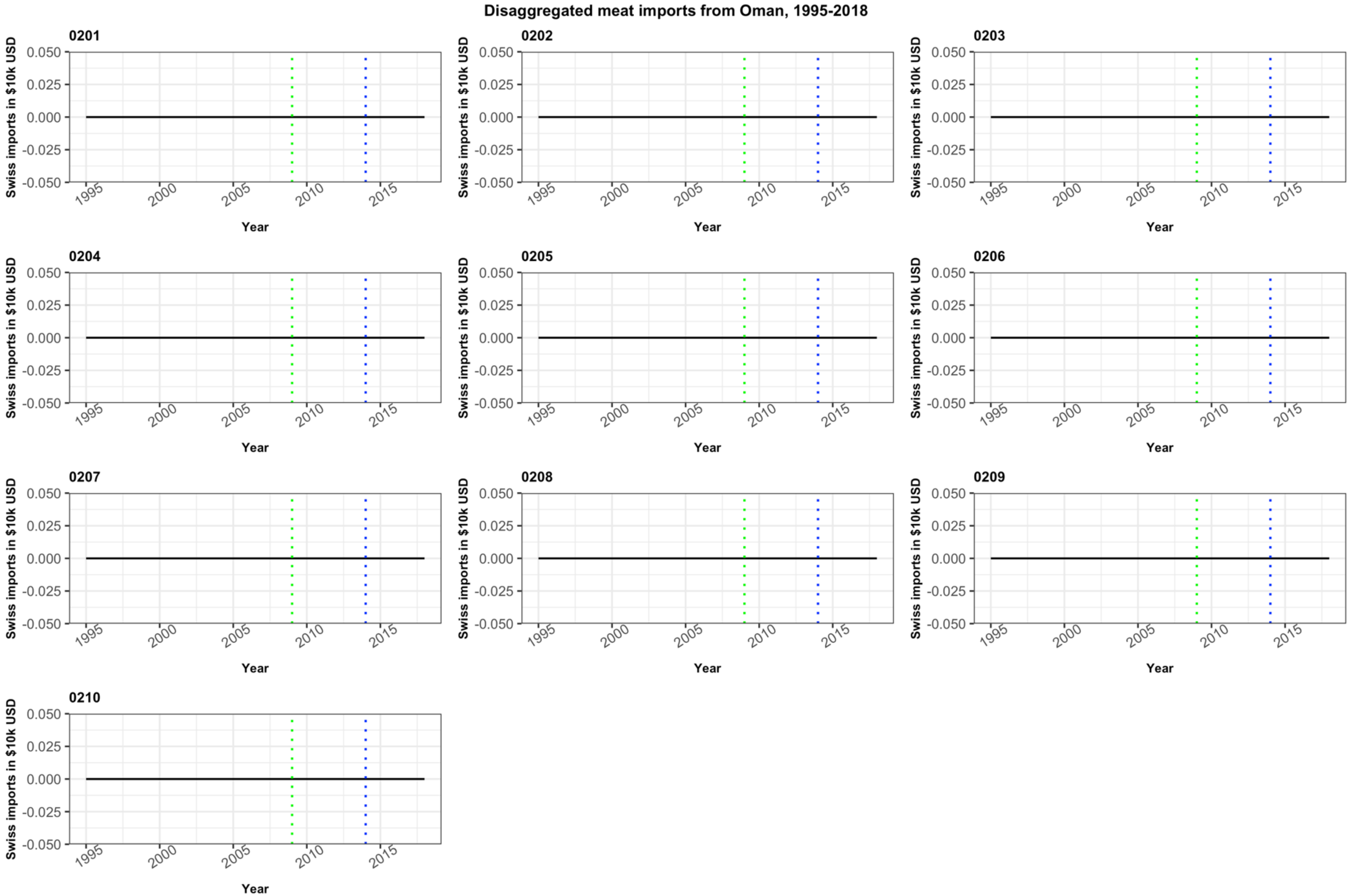

Figure 33: 4-digit level meat imports from Oman

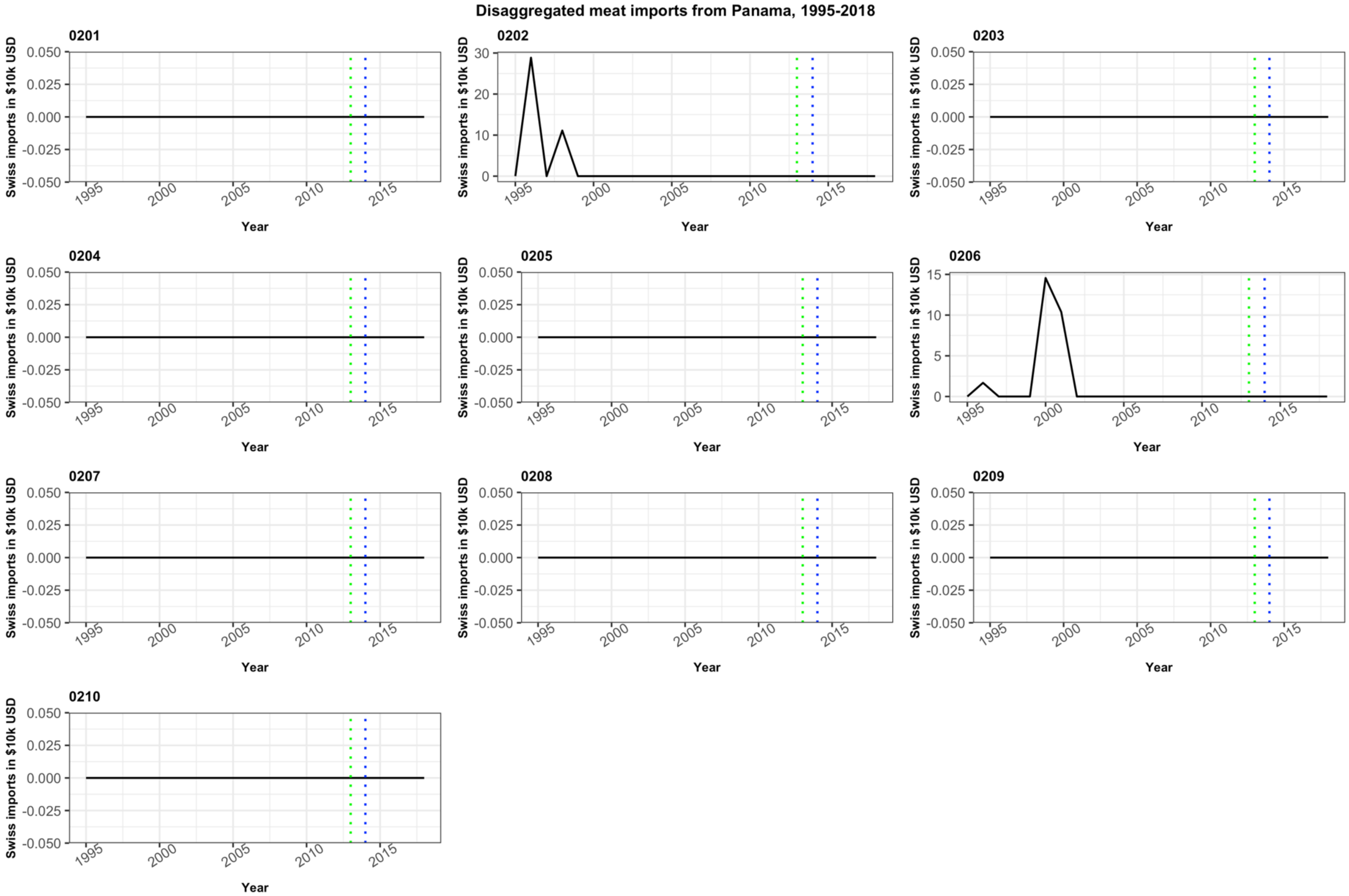

Figure 34: 4-digit level meat imports from Panama

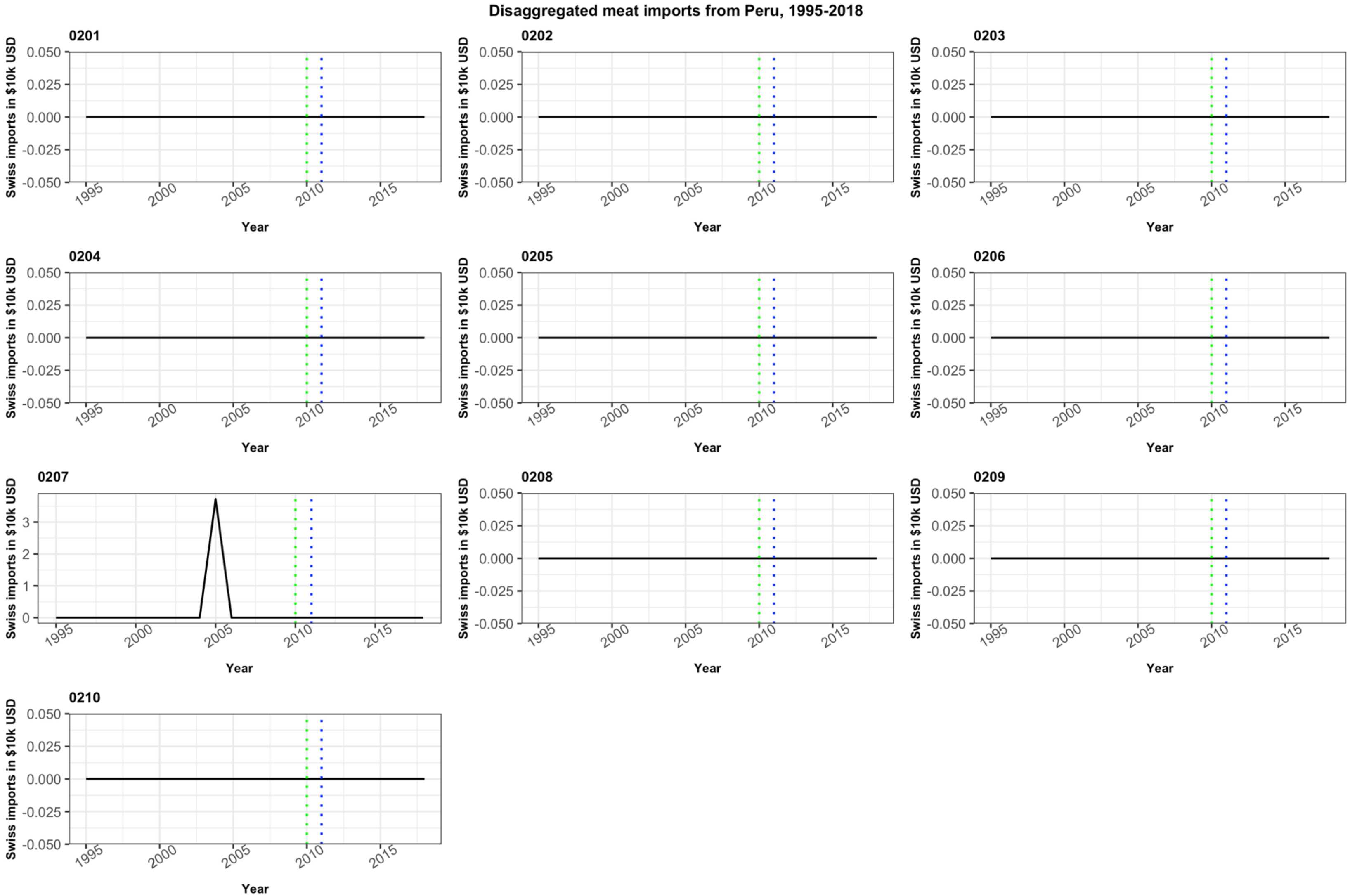

Figure 35: 4-digit level meat imports from Peru

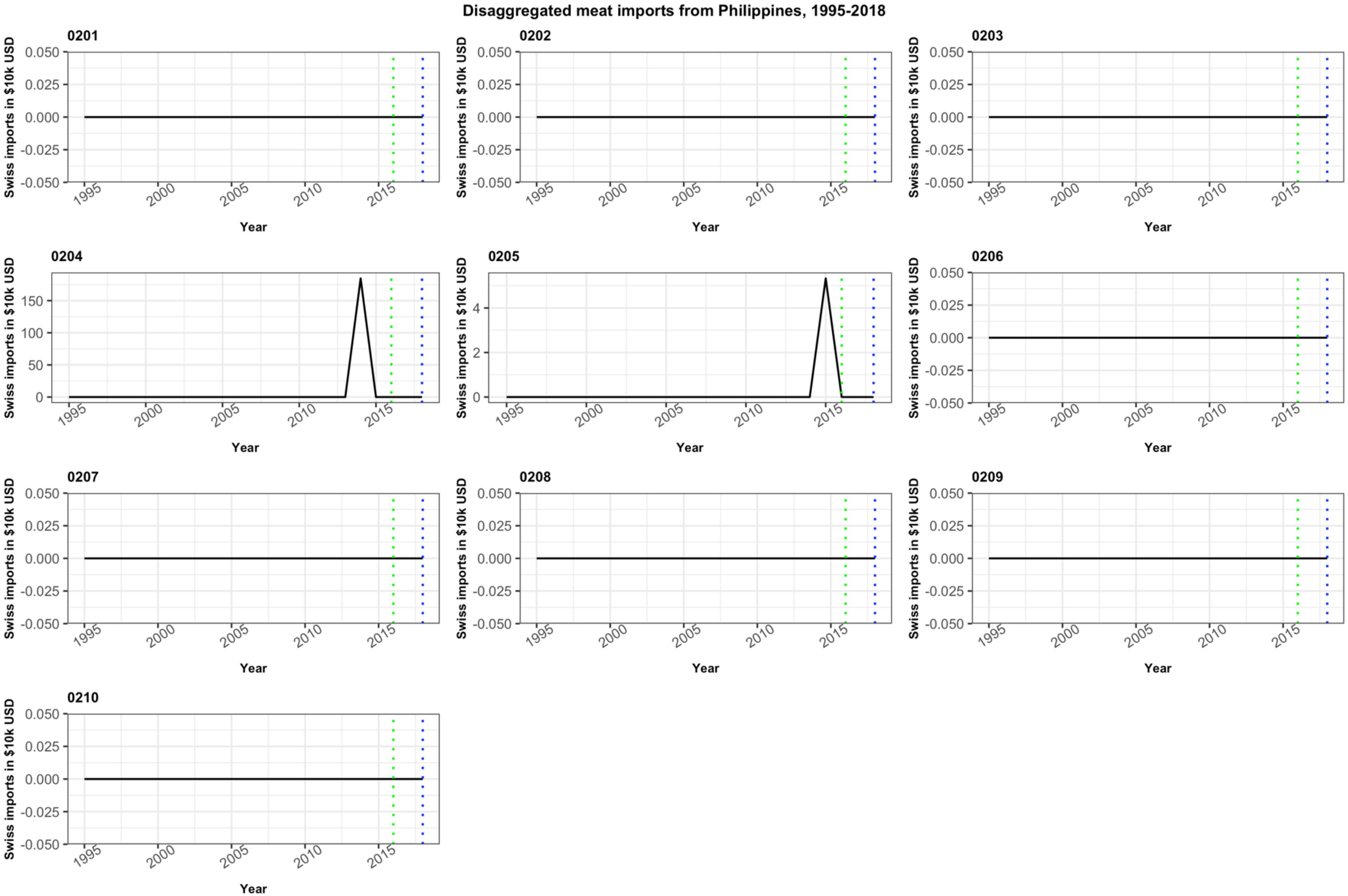

Figure 36: 4-digit level meat imports from the Philippines

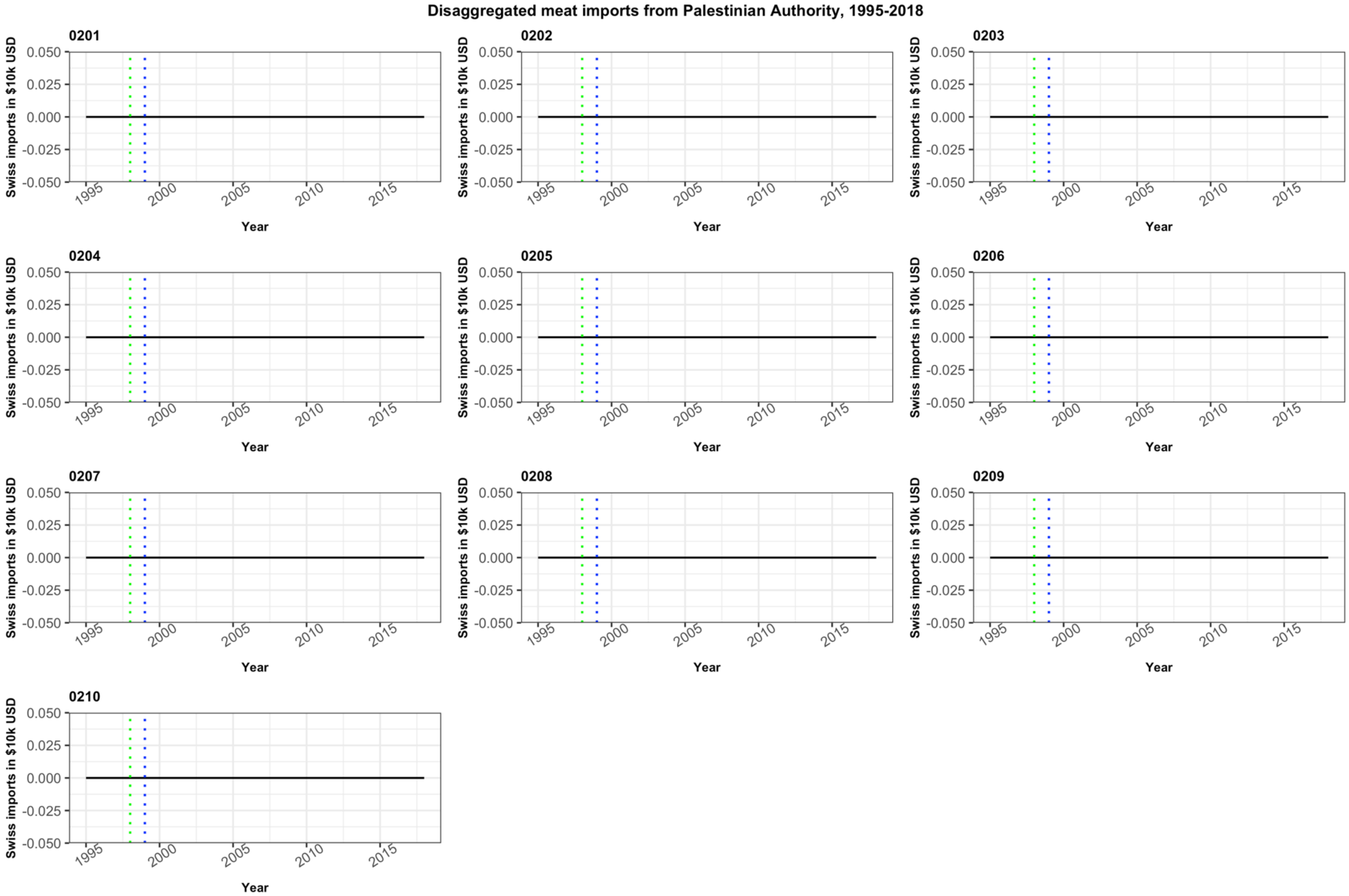

Figure 37: 4-digit level meat imports from Palestine

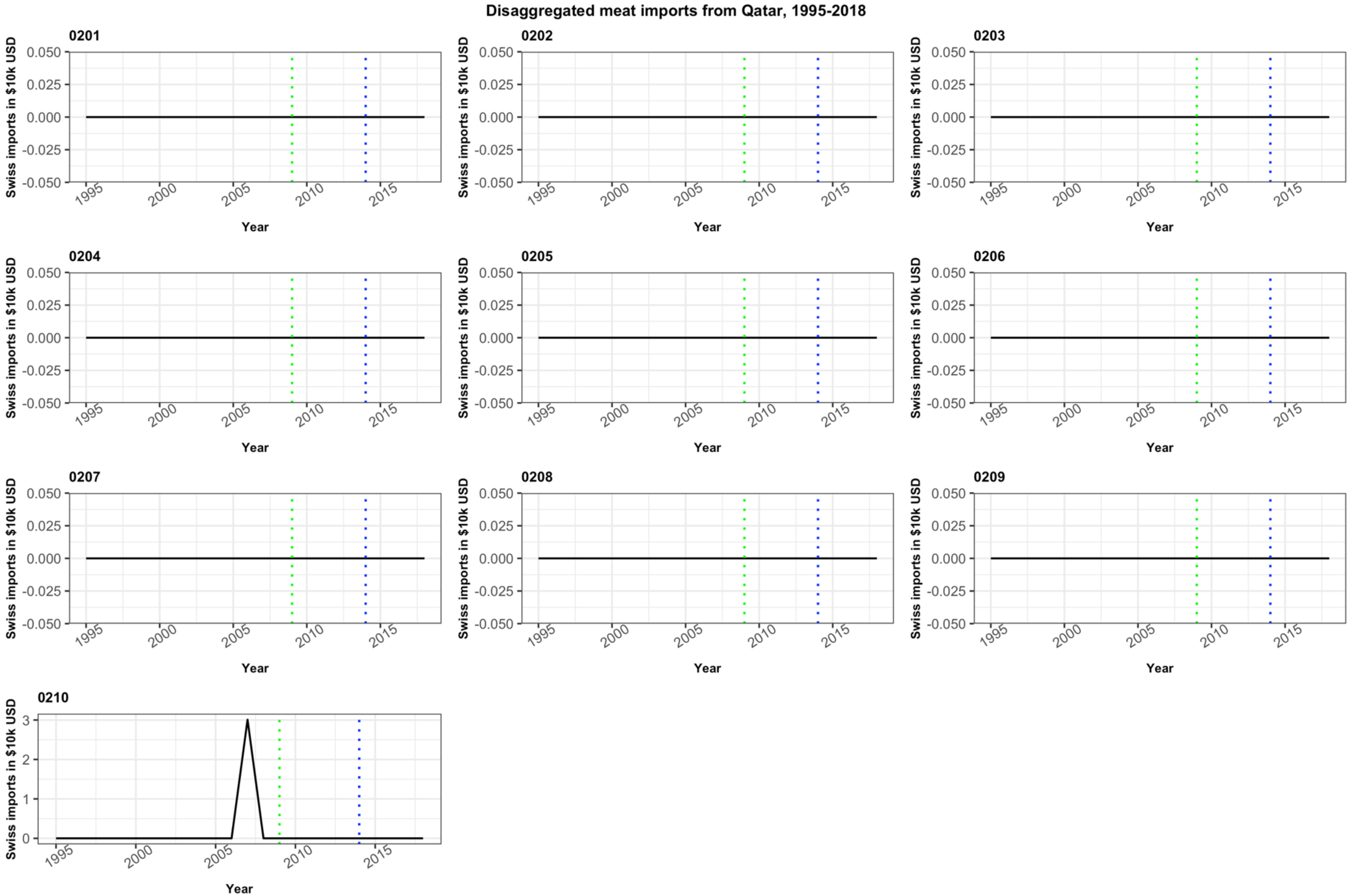

Figure 38: 4-digit level meat imports from Qatar

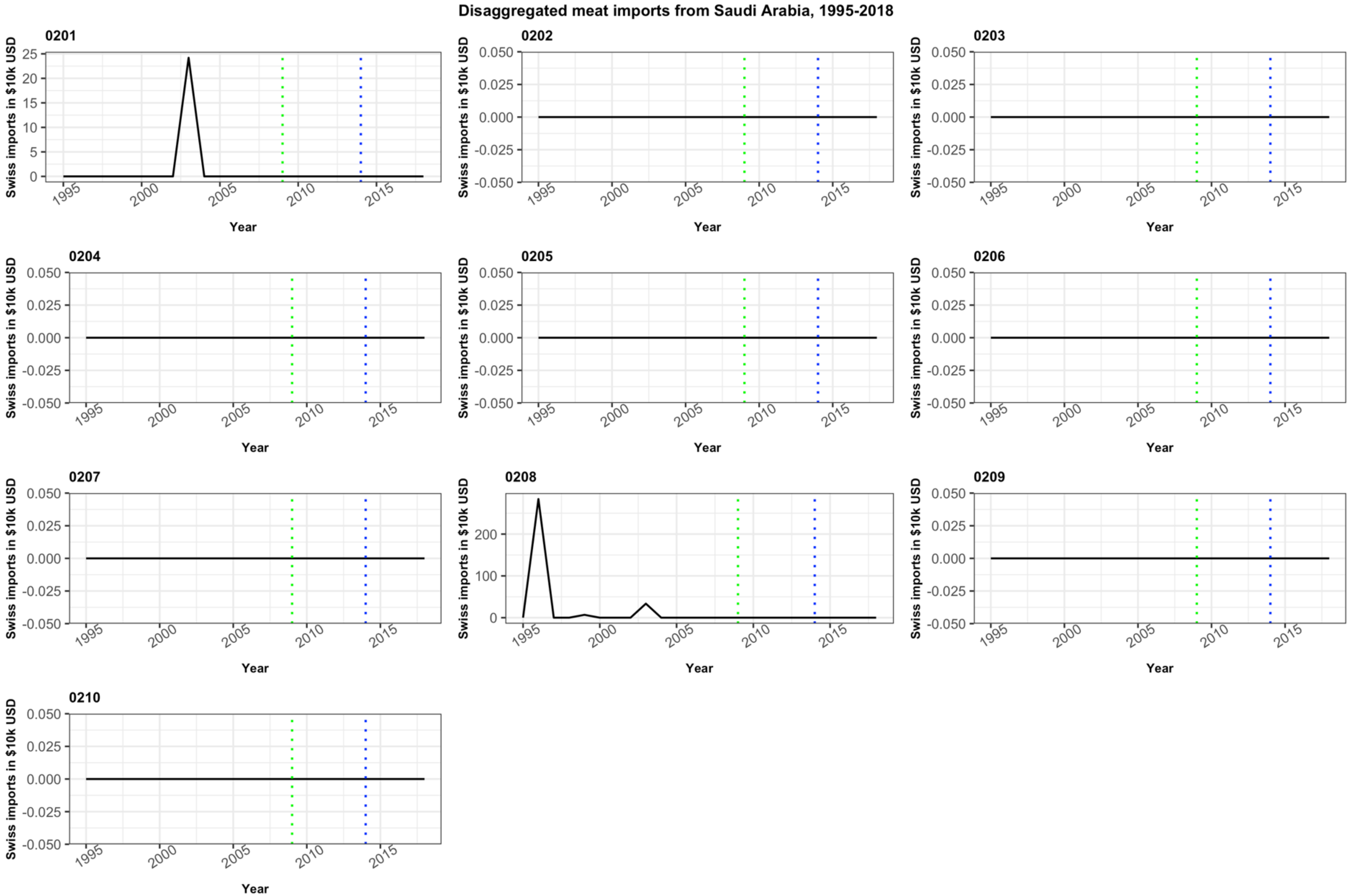

Figure 39: 4-digit level meat imports from Saudi Arabia

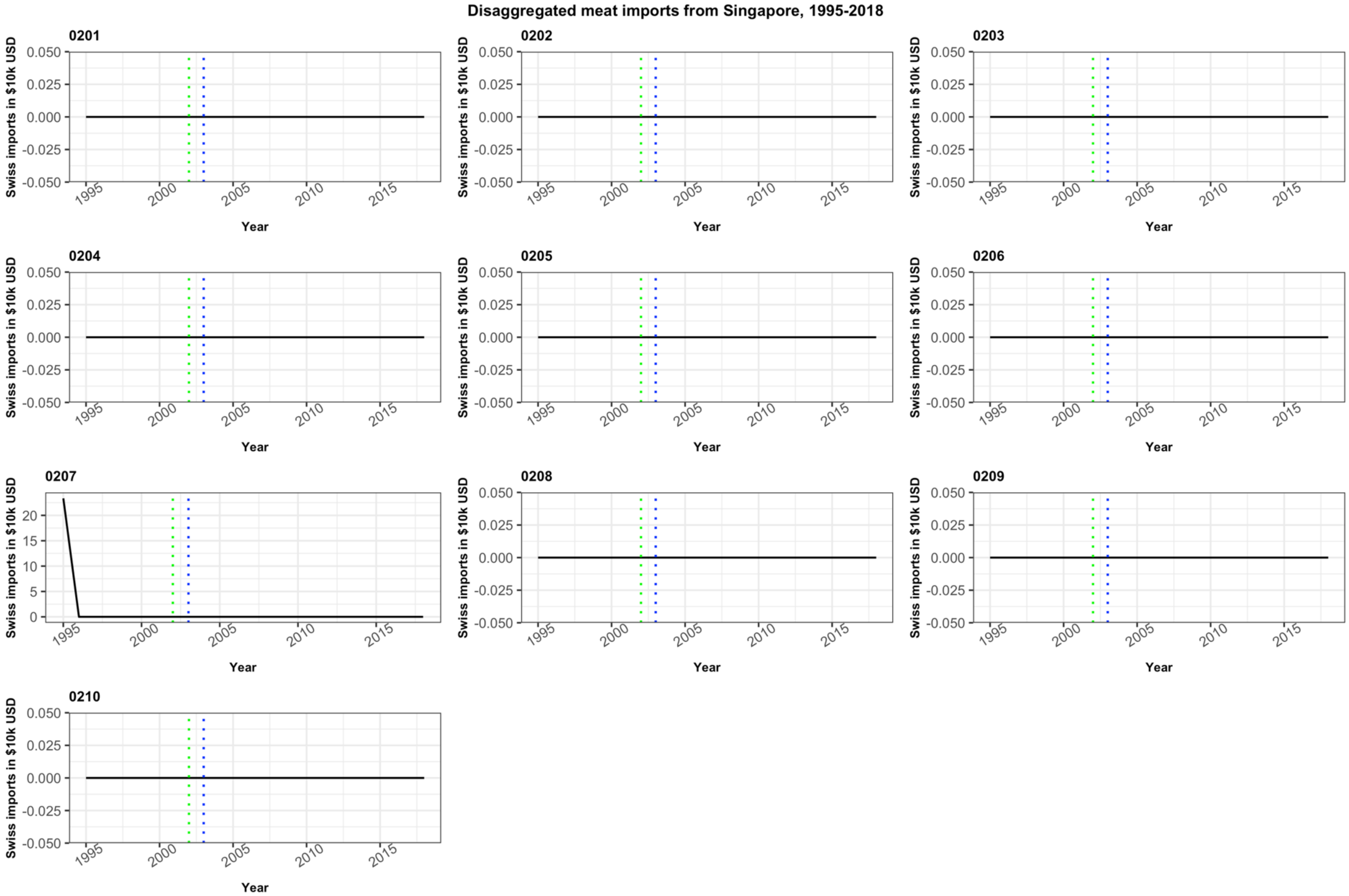

Figure 40: 4-digit level meat imports from Singapore

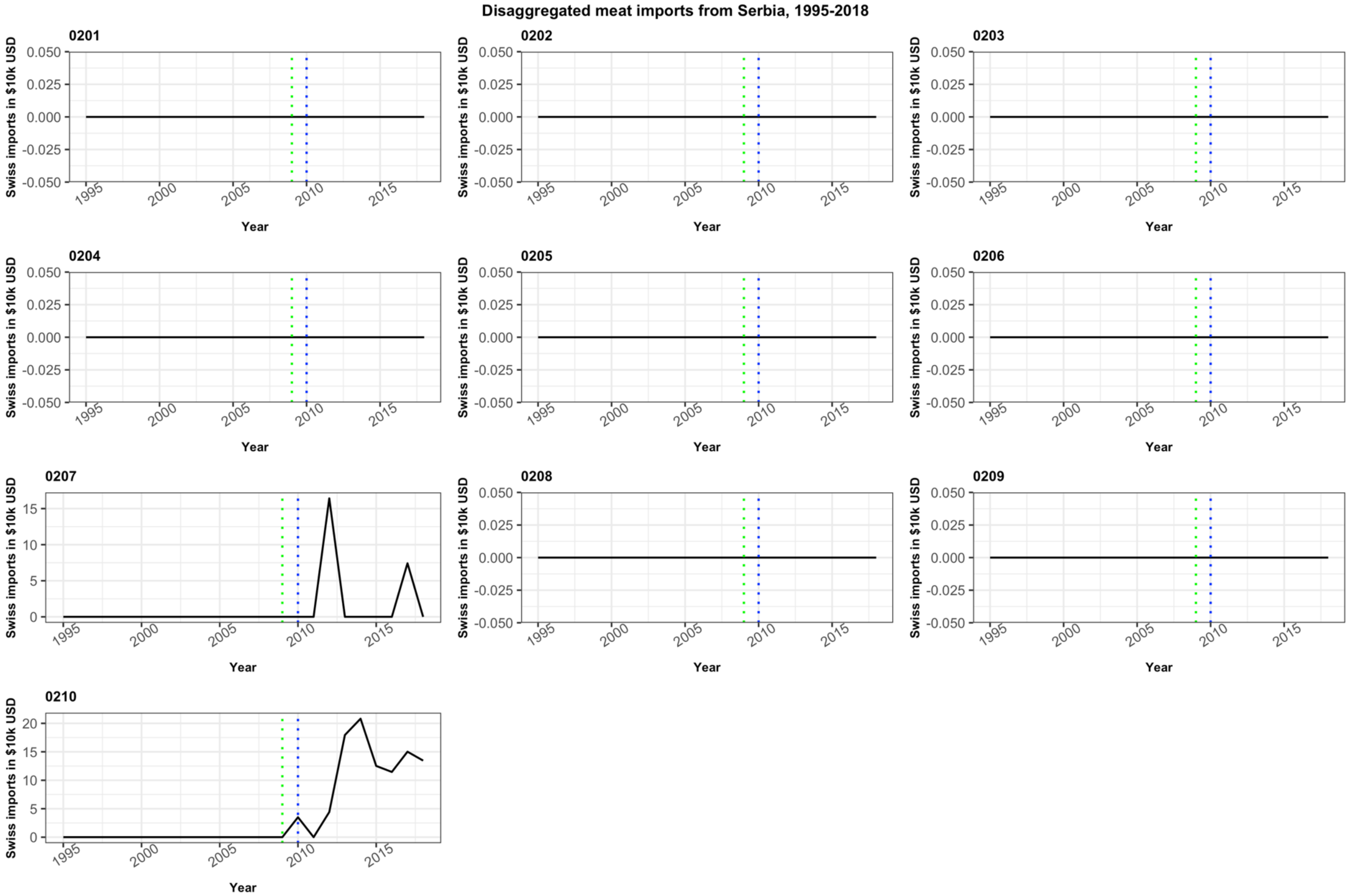

Figure 41: 4-digit level meat imports from Serbia

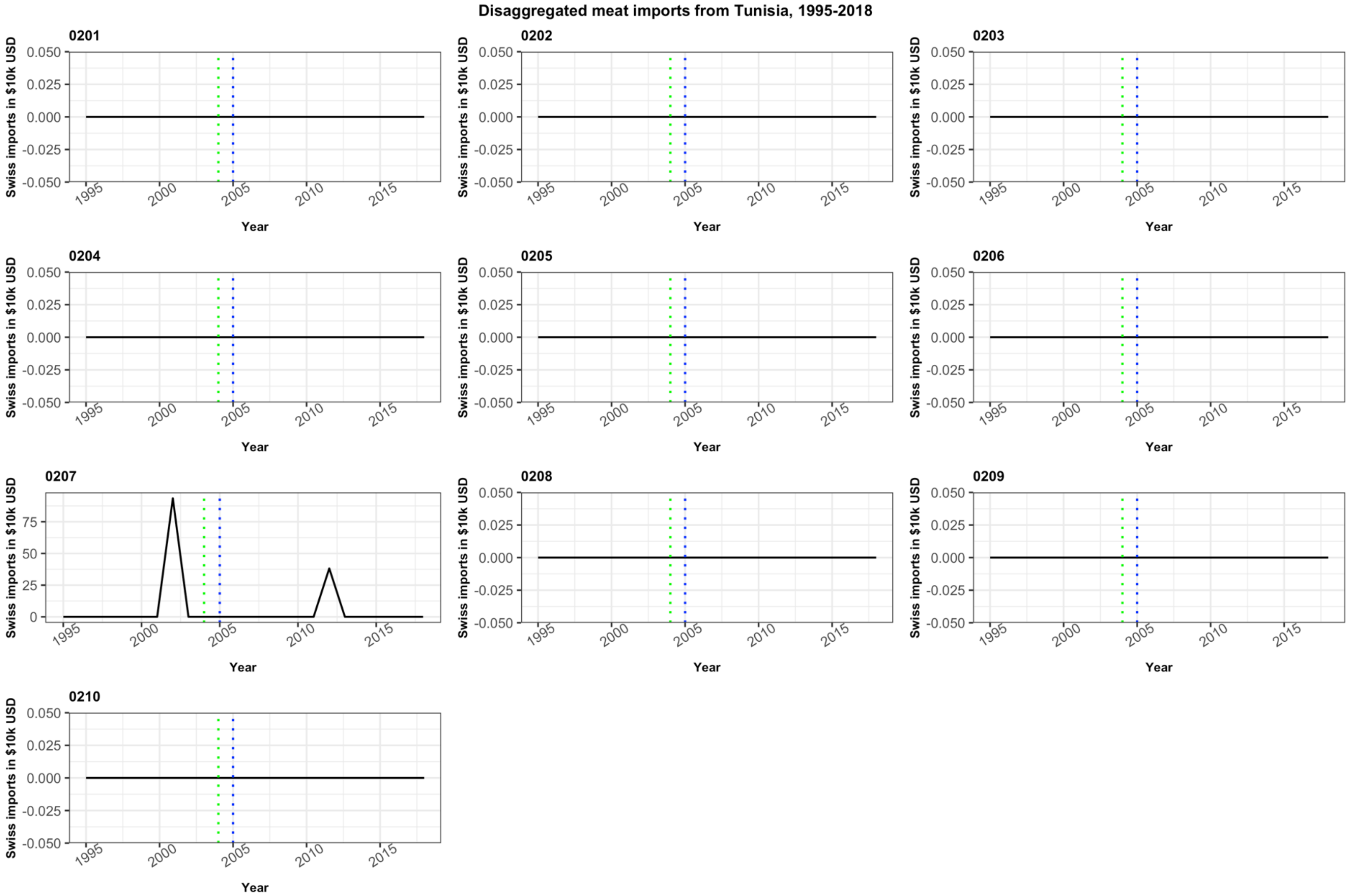

Figure 42: 4-digit level meat imports from Tunisia

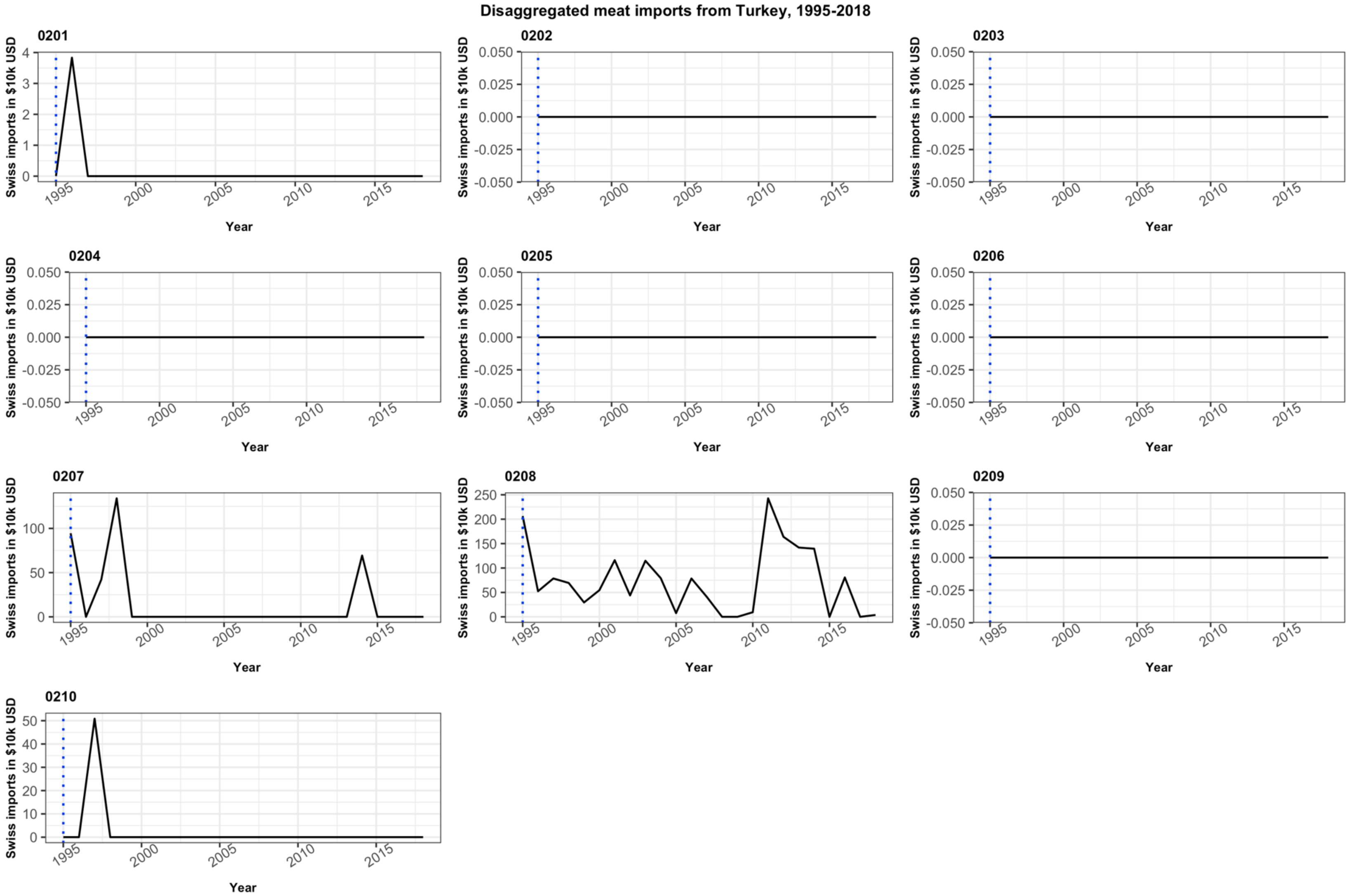

Figure 43: 4-digit level meat imports from Turkey

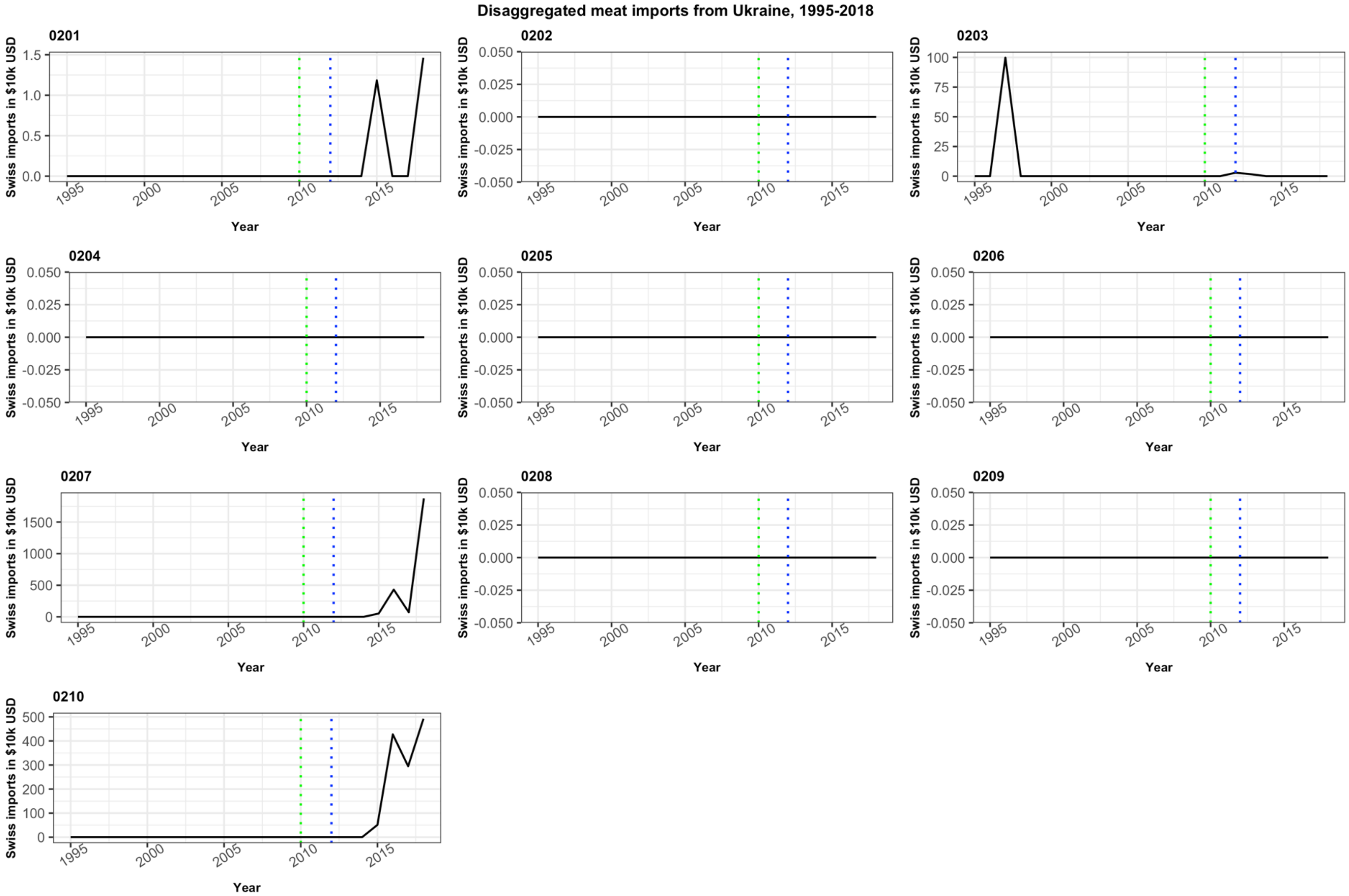

Figure 44: 4-digit level meat imports from Ukraine

Robustness Tests

The following section displays the regression tables from all the estimated models and puts them side-by-side with the robustness tests. Each model was estimated for a 2-digit tariff code category.
Note that the coefficients of cross-sectional and time-fixed effects were omitted for better readability of the tables.

Table 7: Model Comparison for Tariff Code 0200

	Tariff Reduction (%)		**Tariff Reduction (absolute CHF)**		**FTA in force Dummy**	
	PPML	**OLS**	**PPML**	**OLS**	**PPML**	**OLS**
Tariff reduction in %	1.36***	2.91***				
	(0.22)	(0.69)				
Tariff reduction in absolute CHF			0.05***	0.06*		
			(0.01)	(0.02)		
FTA in force					1.07***	1.89***
					(0.09)	(0.41)
log distance	8.41		11.89*		7.91	
	(4.53)		(4.86)		(4.46)	
GDP billions CHF	-0.00***		-0.00***		-0.00***	
	(0.00)		(0.00)		(0.00)	
log GDP		-3.35***		-3.52***		-2.10***
		(0.47)		(0.49)		(0.29)
Intercept	-58.80		-85.12*		-54.25	
	(33.69)		(36.20)		(33.16)	
Deviance	248063.58		259888.90		383396.26	
Num. obs.	768	193	768	193	768	193
R^2		0.33		0.28		0.25
Adj. R^2		0.10		0.03		0.13

Notes: Standard Errors in Parenthesis. *Significant at the 0.05 level (p < 0.05). ** Significant at the 0.01 level (p < 0.01). ***Significant at the 0.001 level (p < 0.001).

Table 7: Model Comparison for Tariff Code 0200

Table 8: Model Comparison for Tariff Code 0400						
	Tariff Reduction (%)		**Tariff Reduction (absolute CHF)**		**FTA in force Dummy**	
	PPML	**OLS**	**PPML**	**OLS**	**PPML**	**OLS**
Tariff reduction in %	3.18***	3.67***				
	(0.67)	(1.01)				
Tariff reduction in absolute CHF			0.04***	0.02**		
			(0.01)	(0.01)		
FTA in force					0.62***	0.50*
					(0.08)	(0.24)
log distance	47.36		46.94		46.87	
	(2538.65)		(2661.29)		(2851.29)	
GDP billions CHF	-0.00		-0.00		0.00	
	(0.00)		(0.00)		(0.00)	
log GDP		0.14		0.17		-0.21
		(0.33)		(0.33)		(0.17)
Intercept	-348.53		-345.52		-344.55	
	(18929.03)		(19843.45)		(21260.12)	
Deviance	48024.42		48291.13		59403.52	
Num. obs.	768	240	768	240	768	240
R^2		0.07		0.05		0.02
Adj. R^2		-0.20		-0.21		-0.12
Notes: Standard Errors in Parenthesis. *Significant at the 0.05 level (p < 0.05). ** Significant at the 0.01 level (p < 0.01). ***Significant at the 0.001 level (p < 0.001).						

Table 8: Model Comparison for Tariff Code 0400

Table 9: Model Comparison for Tariff Code 0600						
	Tariff Reduction (%)		**Tariff Reduction (absolute CHF)**		**FTA in force Dummy**	
	PPML	**OLS**	**PPML**	**OLS**	**PPML**	**OLS**
Tariff reduction in %	0.28**	-0.34				
	(0.09)	(0.19)				
Tariff reduction in absolute CHF			0.01	-0.01		
			(0.00)	(0.01)		
FTA in force					-0.40***	-0.42**
					(0.08)	(0.14)
log distance	-7.49		-7.55		-7.63	
	(13.55)		(13.60)		(16.79)	
GDP billions CHF	0.00***		0.00***		0.00***	
	(0.00)		(0.00)		(0.00)	
log GDP		0.81***		0.79***		0.13
		(0.22)		(0.22)		(0.12)
Intercept	54.37		54.79		54.63	
	(95.99)		(96.30)		(118.92)	
Deviance	41799.76		42145.69		61922.41	
Num. obs.	768	440	768	440	768	440
R^2		0.04		0.04		0.02
Adj. R^2		-0.08		-0.09		-0.05
Notes: Standard Errors in Parenthesis. *Significant at the 0.05 level (p < 0.05). ** Significant at the 0.01 level (p < 0.01). ***Significant at the 0.001 level (p < 0.001).						

Table 9: Model Comparison for Tariff Code 0600

Table 10: Model Comparison for Tariff Code 0700						
	Tariff Reduction (%)		**Tariff Reduction (absolute CHF)**		**FTA in force Dummy**	
	PPML	**OLS**	**PPML**	**OLS**	**PPML**	**OLS**
Tariff reduction in %	0.45***	0.40*				
	(0.06)	(0.19)				
Tariff reduction in absolute CHF			0.06***	0.09**		
			(0.01)	(0.03)		
FTA in force					0.78***	0.47**
					(0.06)	(0.14)
log distance	3.65***		3.72***		3.77**	
	(1.00)		(0.99)		(1.27)	
GDP billions CHF	-0.00***		-0.00***		0.00	
	(0.00)		(0.00)		(0.00)	
log GDP		-0.26		-0.27		0.55***
		(0.21)		(0.21)		(0.11)
Intercept	-21.89**		-22.41**		-22.55*	
	(7.35)		(7.32)		(9.40)	
Deviance	154282.01		154770.89		274655.25	
Num. obs.	768	566	768	566	768	566
R^2		0.01		0.02		0.14
Adj. R^2		-0.09		-0.08		0.09
Notes: Standard Errors in Parenthesis. *Significant at the 0.05 level ($p < 0.05$). ** Significant at the 0.01 level ($p < 0.01$). ***Significant at the 0.001 level ($p < 0.001$).						

Table 10: Model Comparison for Tariff Code 0700

Table 11: Model Comparison for Tariff Code 0800						
	Tariff Reduction (%)		**Tariff Reduction (absolute CHF)**		**FTA in force Dummy**	
	PPML	**OLS**	**PPML**	**OLS**	**PPML**	**OLS**
Tariff reduction in %	0.13*	0.36*				
	(0.06)	(0.14)				
Tariff reduction in absolute CHF			0.01	0.04		
			(0.01)	(0.02)		
FTA in force					0.70***	0.35**
					(0.06)	(0.12)
log distance	8.80*		8.79*		8.90*	
	(3.60)		(3.61)		(4.52)	
GDP billions CHF	0.00		0.00		0.00***	
	(0.00)		(0.00)		(0.00)	
log GDP		0.68***		0.66***		0.88***
		(0.19)		(0.19)		(0.09)
Intercept	-59.70*		-59.61*		-60.29	
	(26.80)		(26.89)		(33.65)	
Deviance	574925.66		577607.93		889345.11	
Num. obs.	768	589	768	589	768	589
R^2		0.03		0.03		0.29
Adj. R^2		-0.07		-0.07		0.25
Notes: Standard Errors in Parenthesis. *Significant at the 0.05 level ($p < 0.05$). ** Significant at the 0.01 level ($p < 0.01$). ***Significant at the 0.001 level ($p < 0.001$).						

Table 11: Model Comparison for Tariff Code 0800

Table 12: Model Comparison for Tariff Code 0900						
	Tariff Reduction (%)		**Tariff Reduction (absolute CHF)**		**FTA in force Dummy**	
	PPML	**OLS**	**PPML**	**OLS**	**PPML**	**OLS**
Tariff reduction in %	-0.12	-0.52**				
	(0.08)	(0.16)				
Tariff reduction in absolute CHF			0.01**	-0.03**		
			(0.00)	(0.01)		
FTA in force					0.30***	0.06
					(0.07)	(0.14)
log distance	-1.54		-1.44		-1.45	
	(2.55)		(2.51)		(3.13)	
GDP billions CHF	0.00***		0.00***		0.00***	
	(0.00)		(0.00)		(0.00)	
log GDP		0.09		0.09		0.70***
		(0.22)		(0.22)		(0.12)
Intercept	15.13		14.35		14.14	
	(18.38)		(18.06)		(22.58)	
Deviance	298990.61		296079.24		438610.53	
Num. obs.	768	549	768	549	768	549
R^2		0.02		0.02		0.11
Adj. R^2		-0.09		-0.09		0.05
Notes: Standard Errors in Parenthesis. *Significant at the 0.05 level (p < 0.05). ** Significant at the 0.01 level (p < 0.01). ***Significant at the 0.001 level (p < 0.001).						

Table 12: Model Comparison for Tariff Code 0900

Table 13: Model Comparison for Tariff Code 1000						
	Tariff Reduction (%)		**Tariff Reduction (absolute CHF)**		**FTA in force Dummy**	
	PPML	**OLS**	**PPML**	**OLS**	**PPML**	**OLS**
Tariff reduction in %	1.41^{***}	0.78				
	(0.21)	(0.47)				
Tariff reduction in absolute CHF			0.96^{***}	0.15		
			(0.22)	(0.12)		
FTA in force					0.11	-0.13
					(0.12)	(0.34)
log distance	29.41		29.72		29.23	
	(74.76)		(79.39)		(85.92)	
GDP billions CHF	0.00		-0.00^{*}		-0.00	
	(0.00)		(0.00)		(0.00)	
log GDP		-0.62		-0.95		-0.10
		(0.48)		(0.50)		(0.27)
Intercept	-209.97		-212.27		-209.19	
	(557.41)		(591.97)		(640.67)	
Deviance	700069.31		740223.85		944281.87	
Num. obs.	768	252	768	252	768	252
R^2		0.03		0.02		0.00
Adj. R^2		-0.23		-0.24		-0.13
Notes: Standard Errors in Parenthesis. *Significant at the 0.05 level (p < 0.05). ** Significant at the 0.01 level (p < 0.01). ***Significant at the 0.001 level (p < 0.001).						

Table 13: Model Comparison for Tariff Code 1000

Table 14: Model Comparison for Tariff Code 1200						
	Tariff Reduction (%)		**Tariff Reduction (absolute CHF)**		**FTA in force Dummy**	
	PPML	**OLS**	**PPML**	**OLS**	**PPML**	**OLS**
Tariff reduction in %	0.76***	-0.11				
	(0.11)	(0.18)				
Tariff reduction in absolute CHF			0.42***	-0.06		
			(0.09)	(0.18)		
FTA in force					0.97***	0.06
					(0.11)	(0.15)
log distance	8.71***		8.89***		8.80***	
	(0.70)		(0.71)		(1.08)	
GDP billions CHF	0.00		-0.00**		0.00	
	(0.00)		(0.00)		(0.00)	
log GDP		-0.17		-0.13		0.52***
		(0.23)		(0.23)		(0.12)
Intercept	-57.08***		-58.33***		-57.04***	
	(5.19)		(5.31)		(8.06)	
Deviance	345920.55		357377.25		545477.12	
Num. obs.	768	495	768	495	768	495
R^2		0.00		0.00		0.07
Adj. R^2		-0.12		-0.12		0.01
Notes: Standard Errors in Parenthesis. *Significant at the 0.05 level (p < 0.05). ** Significant at the 0.01 level (p < 0.01). ***Significant at the 0.001 level (p < 0.001).						

Table 14: Model Comparison for Tariff Code 1200

Table 15: Model Comparison for Tariff Code 1700						
	Tariff Reduction (%)		Tariff Reduction (absolute CHF)		FTA in force Dummy	
	PPML	OLS	PPML	OLS	PPML	OLS
Tariff reduction in %	-0.18	-0.83**				
	(0.19)	(0.30)				
Tariff reduction in absolute CHF			-0.01	-0.02**		
			(0.01)	(0.01)		
FTA in force					0.68***	-0.19
					(0.14)	(0.21)
log distance	18.99		18.98		19.16	
	(15.56)		(15.55)		(19.93)	
GDP billions CHF	-0.00*		-0.00*		0.00	
	(0.00)		(0.00)		(0.00)	
log GDP		0.22		0.15		0.90***
		(0.32)		(0.33)		(0.17)
Intercept	-135.74		-135.66		-136.37	
	(116.05)		(115.94)		(148.63)	
Deviance	233460.78		233194.37		328270.38	
Num. obs.	768	420	768	420	768	420
R^2		0.02		0.03		0.08
Adj. R^2		-0.12		-0.12		0.00
Notes: Standard Errors in Parenthesis. *Significant at the 0.05 level (p < 0.05). ** Significant at the 0.01 level (p < 0.01). ***Significant at the 0.001 level (p < 0.001).						

Table 15: Model Comparison for Tariff Code 1700

Table 16: Model Comparison for Tariff Code 1900						
	Tariff Reduction (%)		**Tariff Reduction (absolute CHF)**		**FTA in force Dummy**	
	PPML	**OLS**	**PPML**	**OLS**	**PPML**	**OLS**
Tariff reduction in %	-0.21	-0.51				
	(0.24)	(0.32)				
Tariff reduction in absolute CHF			-0.01	-0.01		
			(0.01)	(0.01)		
FTA in force					0.47***	0.20
					(0.11)	(0.14)
log distance	38.13		38.13		35.92	
	(3276.56)		(3278.43)		(2325.83)	
GDP billions CHF	0.00		0.00		0.00***	
	(0.00)		(0.00)		(0.00)	
log GDP		0.32		0.32		1.07***
		(0.22)		(0.22)		(0.12)
Intercept	-283.16		-283.13		-266.19	
	(24431.14)		(24445.04)		(17342.15)	
Deviance	62114.55		62084.23		94476.79	
Num. obs.	768	462	768	462	768	462
R^2		0.01		0.01		0.25
Adj. R^2		-0.12		-0.12		0.20
Notes: Standard Errors in Parenthesis. *Significant at the 0.05 level (p < 0.05). ** Significant at the 0.01 level (p < 0.01). ***Significant at the 0.001 level (p < 0.001).						

Table 16: Model Comparison for Tariff Code 1900

Table 17: Model Comparison for Tariff Code 2000						
	Tariff Reduction (%)		**Tariff Reduction (absolute CHF)**		**FTA in force Dummy**	
	PPML	**OLS**	**PPML**	**OLS**	**PPML**	**OLS**
Tariff reduction in %	0.10	0.36				
	(0.12)	(0.21)				
Tariff reduction in absolute CHF			0.00	0.02		
			(0.00)	(0.01)		
FTA in force					0.34***	0.84***
					(0.09)	(0.15)
log distance	8.01*		8.01*		8.05	
	(3.63)		(3.63)		(4.19)	
GDP billions CHF	-0.00***		-0.00***		0.00	
	(0.00)		(0.00)		(0.00)	
log GDP		-0.84***		-0.85***		0.33**
		(0.23)		(0.23)		(0.12)
Intercept	-54.55*		-54.54*		-54.88	
	(26.99)		(26.98)		(31.16)	
Deviance	229771.71		229818.88		348990.58	
Num. obs.	768	538	768	538	768	538
R^2		0.03		0.04		0.16
Adj. R^2		-0.08		-0.07		0.11
Notes: Standard Errors in Parenthesis. *Significant at the 0.05 level (p < 0.05). ** Significant at the 0.01 level (p < 0.01). ***Significant at the 0.001 level (p < 0.001).						

Table 17: Model Comparison for Tariff Code 2000

Table 18: Model Comparison for Tariff Code 2200						
	Tariff Reduction (%)		**Tariff Reduction (absolute CHF)**		**FTA in force Dummy**	
	PPML	**OLS**	**PPML**	**OLS**	**PPML**	**OLS**
Tariff reduction in %	-0.12	0.47**				
	(0.10)	(0.17)				
Tariff reduction in absolute CHF			-0.01	0.02*		
			(0.00)	(0.01)		
FTA in force					0.59***	0.65***
					(0.06)	(0.14)
log distance	5.68***		5.68***		5.84***	
	(1.43)		(1.43)		(1.58)	
GDP billions CHF	0.00*		0.00*		0.00***	
	(0.00)		(0.00)		(0.00)	
log GDP		-0.19		-0.19		0.65***
		(0.22)		(0.22)		(0.11)
Intercept	-37.15***		-37.16***		-37.80**	
	(10.63)		(10.63)		(11.72)	
Deviance	160040.05		160209.87		201841.10	
Num. obs.	768	576	768	576	768	576
R^2		0.02		0.01		0.20
Adj. R^2		-0.09		-0.09		0.16
Notes: Standard Errors in Parenthesis. *Significant at the 0.05 level (p < 0.05). ** Significant at the 0.01 level (p < 0.01). ***Significant at the 0.001 level (p < 0.001).						

Table 18: Model Comparison for Tariff Code 2200

Table 19: Model Comparison for Tariff Code 2300						
	Tariff Reduction (%)		**Tariff Reduction (absolute CHF)**		**FTA in force Dummy**	
	PPML	**OLS**	**PPML**	**OLS**	**PPML**	**OLS**
Tariff reduction in %	-0.23	0.26				
	(0.26)	(0.53)				
Tariff reduction in absolute CHF			-0.07***	0.06		
			(0.01)	(0.03)		
FTA in force					-0.39***	0.68*
					(0.10)	(0.33)
log distance	27.38		27.35		27.31	
	(56.64)		(53.08)		(58.32)	
GDP billions CHF	0.00***		0.00***		0.00***	
	(0.00)		(0.00)		(0.00)	
log GDP		-0.26		-0.76		-0.16
		(0.44)		(0.48)		(0.25)
Intercept	-196.64		-196.26		-195.86	
	(422.35)		(395.78)		(434.88)	
Deviance	264471.41		245548.80		310791.12	
Num. obs.	768	226	768	226	768	226
R^2		0.00		0.02		0.02
Adj. R^2		-0.27		-0.24		-0.10
Notes: Standard Errors in Parenthesis. *Significant at the 0.05 level (p < 0.05). ** Significant at the 0.01 level (p < 0.01). ***Significant at the 0.001 level (p < 0.001).						

Table 19: Model Comparison for Tariff Code 2300