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Estimating ad valorem equivalents of non-tariff measures in Swiss agriculture

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Summary

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In Switzerland, non-tariff trade measures (NTMs) are playing an ever-increasing role in regulating agricultural imports. This report converts the trade effects of some of these NTMs into ad valorem tariff equivalents (AVEs). The empirical analysis is based on a combination of Swiss import data on agricultural products and NTMs introduced between 2004 and 2018 that target the agricultural sector. We conceptualize AVEs as the proportional increase in the import price of a product to which an NTM is applied and empirically estimate the AVEs using panel data models. Our main findings are two-fold. First, our baseline model estimations show that, across all agricultural products, Swiss NTMs are associated with an increase in import volumes but do not affect import prices. Hence, in aggregate the market-creating effects induced by Swiss NTMs appear to outweigh their associated costs of doing business. However, aggregate estimates can obscure important heterogeneities. Thus, in a second step, we use product-level linear regressions to estimate the AVEs of Swiss NTMs at the HS6 digit level. The sample median values of our estimated product-specific AVEs imply that, ceteris paribus, a one-unit increase in the number of SPS and TBT measures is associated with an increase in import prices by 11% and 35%, respectively. We also augment the AVEs with findings from product-level gravity models to offer qualitative evidence on the trade-creating or trade-disrupting effects of NTMs. For some agricultural products, Swiss SPS and TBT measures increase import quantities even if the NTMs lead to high AVEs.

Zusammenfassung

Abschätzung der ad valorem-Äquivalente von nicht-tarifären Massnahmen in der Schweizer Landwirtschaft

In der Schweiz spielen nicht-tarifäre Handelsmassnahmen (NTM) eine zunehmende Rolle bei der Regulierung von Agrarimporten. In diesem Bericht werden die Handelseffekte von ausgewählten NTMs in ad valorem-Äquivalente (AVEs) umgerechnet. Die empirische Analyse basiert auf einer Kombination von Schweizer Importdaten zu landwirtschaftlichen Produkten und NTMs, die zwischen 2004 und 2018 im Agrarsektor eingeführt wurden. Die Studie definiert AVEs als proportionale Erhöhung des Importpreises eines Produkts, auf das ein NTM angewendet wird, und schätzt die AVEs empirisch mit Hilfe von Paneldatenmodellen. Die Analyse zeigt zwei wichtige Ergebnisse: gemäss Schätzungen des Basismodells sind die Schweizer NTMs über alle landwirtschaftlichen Produkte hinweg mit einem Anstieg der Importmengen verbunden, wirken sich aber nicht auf die Importpreise aus. Die aggregierten marktfördernden Effekte der Schweizer NTMs scheinen daher die damit verbundenen Kosten zu übersteigen. Die Schätzungen über alle Produkte hinweg überdecken jedoch mögliche Unterschiede zwischen einzelnen Produkten. Daher werden in einem zweiten Schritt lineare Regressionen auf Produktebene durchgeführt, um die AVEs der Schweizer NTMs auf Produktebene (6-stellige HS-Codes) zu schätzen. Diese produktspezifischen AVEs implizieren, dass ceteris paribus eine zusätzliche sanitäre und phytosanitäre (SPS) Massnahme mit einem Anstieg der Importpreise um 11 % verbunden ist. Ein zusätzliches technisches Handelshemmnis (TBT-Massnahme) ist mit einem Anstieg der Importpreise um 35 % verbunden. Wir ergänzen die AVEs auch mit Ergebnissen aus Gravitationsmodellen auf Produktebene, um qualitative Hinweise auf die handelsfördernden oder handelshemmenden Auswirkungen von NTMs zu erhalten. Bei einigen landwirtschaftlichen Produkten erhöhen die schweizerischen SPS- und TBT-Massnahmen die Importmengen, selbst wenn die NTMs zu hohen AVEs führen.

Résumé

Estimation des équivalents ad valorem des mesures non tarifaires dans l'agriculture suisse

En Suisse, les mesures commerciales non tarifaires (MNT) jouent un rôle croissant dans la régulation des importations agricoles. Dans ce rapport, les effets commerciaux de certaines MNT sont convertis en équivalents ad valorem (AVE). L'analyse empirique se base sur une combinaison de données d'importations suisses relatives aux produits agricoles et de MNT introduites dans le secteur agricole entre 2004 et 2018. L'étude définit les AVE comme une augmentation proportionnelle du prix à l'importation d'un produit auquel une MNT est appliquée et estime les AVE de manière empirique à l'aide de modèles de données de panel. L'analyse aboutit à deux résultats importants: selon les estimations du modèle de base, les MNT suisses vont de pair avec une augmentation des quantités importées, tous produits agricoles confondus, mais n'affectent pas les prix à l'importation. Les effets agrégés de stimulation du marché des MNT suisses semblent donc dépasser les coûts qu'elles entraînent. Les estimations portant sur l'ensemble des produits masquent toutefois l'hétérogénéité de chacun d'eux. C'est pourquoi, dans un deuxième temps, des régressions linéaires sont effectuées à l'échelle des produits afin d'estimer les AVE des MNT suisses à cette échelle (codes HS à 6 chiffres). Ces AVE spécifiques aux produits impliquent que, ceteris paribus, une mesure sanitaire et phytosanitaire (SPS) supplémentaire est associée à une augmentation de 11 % du prix des importations. Un obstacle technique supplémentaire au commerce (OTC) est associé à une augmentation de 35 % du prix des importations. Nous complétons également les AVE par les résultats de modèles gravitationnels à l'échelle des produits afin d'obtenir des indications qualitatives sur les effets favorables ou défavorables au commerce des MNT. Pour certains produits agricoles, les mesures SPS et les OTC suisses augmentent les quantités importées, même si les MNT conduisent à des AVE élevés.

1 Introduction

While custom tariffs remain the most popular trade policy instrument, their use has become less popular over time.[1] Yet, potential gains from trade due to tariff liberalization are being offset by so-called non-tariff trade measures (NTMs). Formally, NTMs are policy measures, other than custom tariffs, that can affect international trade in goods, by affecting quantities traded, prices or both (UNCTAD, 2015). The proliferation and increasing relevance of NTMs are fueled particularly by sanitary and phytosanitary (SPS) and technical barriers to trade (TBT) measures.[2] These measures are imposed in the importing country (hence are also called "behind-the-border" NTMs) and have no direct trade objectives. They are *prima facie* introduced to correct market failures and negative externalities such as alleviating information asymmetry, mitigating food consumption risks and enhancing sustainability (Olper, 2016; Fernandes et al., 2019). Hence, SPS and TBT measures do not directly discriminate as they apply to domestic and foreign exporting firms equally.[3] Nevertheless, they can also be disguised instruments for protection when policymakers use them to protect their domestic producers from international competition. As a result, NTMs deserve the necessary academic and policy attention.

The increasing introduction of NTMs is particularly true for high-income countries such as Switzerland. Switzerland, especially, is a small market, highly dependent on agri-food imports, but also with a high demand and the necessary purchasing power to pay for high-quality products (Hillen & Cramon-Taubadel, 2019). Due to these quality requirements, exports to Switzerland have to pass different forms of quality control related to SPS and TBT measures. Even though the Codex Alimentarius Commission – i.e., the body responsible for all matters regarding the implementation of the Joint FAO/WHO Food Standards Program – establishes standards that are seen by many researchers as the social optimum (Li & Beghin, 2014), governments are allowed to define and introduce stricter minimum quality requirements based on scientific risk assessment. For instance, the Swiss Food Law[4] applies from farm to fork and affects all imports, exports and goods in transit. Thus, domestic food production and imports must meet the requirements of Swiss food legislation. Liabilities for food safety risks are also shifting from the state to firms. Article 26 of the Swiss Food Law requires retailers to enforce the statutory food safety requirements and ensure self-supervision. Traceability requirements enshrined in the Food Law require that companies must set up systems and procedures to trace their food products at all levels of production, processing and distribution. Retailers, e.g., Coop, Migros, risk damaging their reputation and losing out financially if the quality of their imports is compromised. As a result, retailers have also

[1] Between 1997 and 2015, average tariffs for non-agricultural products decreased from about 9% to 5%. In agricultural markets, where levels of protection are traditionally high, average tariffs over the same period decreased from 18% to 11% (Niu et al., 2018). In Switzerland, the MFN tariffs applied in the agricultural sector reduced from 44% in 2006 to 30% in 2020 (WTO Data).

[2] SPS measures aim to protect human, animal or plant health from risks, e.g., through additives, contaminants, toxins, pests, diseases, or disease-causing organisms. TBT measures cover all other technical regulations and related conformity assessment procedures, that are not dealing with human, animal or plant health. A technical regulation defines mandatory product characteristics (e.g., "chocolate" imports must contain a minimum of 30 per cent cocoa) or related processes and production methods – e.g., animal slaughtering requirements according to Islamic law (Irek, 2022).

[3] This is to ensure consistency with the WTO's national treatment principle (GATT Article III) which requires that once imported goods have crossed the border, they must be treated like locally produced goods. However, these measures tend to distort bilateral trade flows whether they are introduced for protectionist intents or not, e.g., introducing a stricter NTM will protect the health and safety of domestic consumers but will also increase trade costs for producers.

[4] SR 817.0 - Federal Act of 20 June 2014 on Foodstuffs and Utility Articles (Foodstuffs Act, FSA) (admin.ch)

introduced or adopted a variety of *de jure* private voluntary but often *de facto* mandatory standards that regulate their supply chains, e.g., GlobalGAP and SwissGAP standards. How these requirements influence Swiss import patterns is therefore a matter of high policy relevance.

An extensive literature studies the relationship between trade flows and NTMs, often summarized by a trade elasticity. Santeramo & Lamonaca (2019) offer a review of this literature. However, to facilitate the comparison of the trade effects of NTMs and to evaluate their policy impacts, we need to calculate their ad valorem tariff equivalents (AVE). This is because the AVEs supply policymakers with the level of ad valorem duty that would have the same effect as the NTM under consideration.[5] Thus, the AVEs allow us to assess quantitatively how NTMs affect economic outcomes and can also be integrated into simulation models for ex-ante assessments. Since the pioneering work of Loi Kee et al. (2009), many recent studies have inferred AVEs of NTMs at the HS6 product level for multiple importing countries (Cadot & Gourdon, 2016; Cadot et al., 2018; Tchakounte & Fiankor, 2021). However, this also means that importing country-specific findings are missing from the literature. This report contributes to this line of research with a focus on Swiss agricultural imports only. Working with country-specific estimates of a trade policy – instead of the usual average effect across all countries – will enhance evidence-based trade policy-making (Fiankor et al., 2021a).

This report extends the Swiss agricultural trade literature. In the Swiss context, there are studies on non-technical NTMs, e.g., tariff-rate quotas (Hillen, 2019; Loginova et al., 2021), with no studies focusing on SPS and TBT measures. Recently, Irek (2022) characterized how different types of NTMs apply to Swiss imports, how they may influence trade patterns and how Switzerland applies NTMs compared to other countries. The analyses showed that in Switzerland, NTMs are playing an ever-increasing role in international trade. We extend the work of Irek (2022) by estimating and providing an analysis of the AVEs of Swiss NTMs. As a result, the goal of this report is to assess the product-level effects of NTMs on Swiss agricultural imports. We generate estimates of AVEs and their effect on trade volumes to assess the full NTM effects. By combining these two mechanisms (i.e., AVEs and quantity effects), we disentangle the trade costs and demand effects of NTMs using HS6 digit product-level import data for the period 2004 – 2018.[6] Closest to our work is Gourdon et al. (2020) and Tchakounte & Fiankor (2021) who investigate the trade-cost and trade-enhancing effects of SPS and TBT measures, along with other types of NTMs in agricultural trade. However, because they work with multiple importing countries, they provide average effects that are subject to vary across different countries. In this sense, ours is the first analysis that focuses on a single importing country.

The analysis combines HS6 digit level agricultural trade data and Swiss NTMs introduced between 2004 and 2018 that target the agricultural sector. Taking the ratio of import values in CHF and import volumes in kilograms, we calculate unit values as a proxy for import prices. Important for our analysis is how we define AVEs. We adopt a price-based approach and define AVEs as the proportional increase in the import price of a product to which an NTM is applied relative to a counterfactual where no NTM is applied (Cadot et al., 2018). Our main findings can be summarized in two parts. Our baseline model estimations show that on average, Swiss NTMs are associated with an increase in import volumes but do not affect import prices. Hence, in aggregate the market-creating effects induced by Swiss NTMs outweigh their associated costs of doing business. However, aggregate estimates can obscure important heterogeneities. Thus, in a second step, we use product-level linear regressions to estimate the AVEs of Swiss NTMs at the HS6 digit level. Our estimated product-specific AVEs are in line with multi-country average effects from previous studies, with a sample median of 0.11 for SPS measures and 0.35 for TBT measures. This implies that holding all other factors constant, a one-unit increase in the number of SPS and TBT measures is associated with an increase in import prices by 11% and 35%, respectively.

[6] The NTM data from UN TRAINS are only available at the HS6 digit level and are currently only available till 2018.

We also augment the AVEs with product-level quantity-based gravity equations that show that SPS and TBT measures imposed on Swiss imports can have positive, negative or no effects on trade volumes. In the end, while Swiss NTMs lead to higher AVEs, they can also leave import volumes unchanged or even enhance them. These AVEs can, thus, be seen as costs of ensuring consumer health and safety.

The rest of the report proceeds as follows. In Section 2, we define and measure ad valorem equivalents before introducing the conceptual framework in Section 3. Section 4 introduces our empirical model specifications. The data on which the analysis is based is described in Section 5. The empirical findings are presented in Section 6. Finally, Section 7 concludes.

2 Defining and measuring *ad valorem* equivalents

The AVE of an NTM is the level of ad valorem tariff that would induce the same proportionate change in the quantity imported as the presence of the NTM under consideration. Put differently, the AVEs allow us to find the ad-valorem tariff whose removal would have generated the same impact as the NTM in question. Alternatively, AVEs measure the proportional increase in the import price of a good to which an NTM is applied relative to a counterfactual where the same NTM is not applied (Cadot et al., 2018). Hence for a protectionist NTM, the AVE is equivalent to the tariff that reduces the imports of a product by the same proportions and increases its price on the domestic market.[7]

In this report, we adopt the price-based definition of AVEs (Cadot et al., 2018). Calculating the AVEs using data on import values requires information on import demand elasticities (Kee et al., 2009) or trade elasticities of substitution (Yotov et al., 2016) which are not always available at product levels for many countries, including Switzerland. The price-based approach has the advantage that it gets around this restrictive data requirement; we do not need to calculate or have data on demand elasticities. All that we need to implement the price-based approach is data on import prices at the product level. In this report, we follow a standard approach in the literature and measure import prices as unit values (Bojnec & Fertő, 2017; Cadot et al., 2018; Fiankor, 2023).

If we assume unit values as an appropriate proxy for import prices, we can isolate the AVE of NTMs as follows. Let us consider the case of a small open economy that introduces an NTM (Figure 1). The vertical axis measures cost-insurance-freight import prices and the horizontal axis measures total import quantities. P^w is the world market price in the absence of the importing country's NTM. The introduction of NTMs in the importing country raises the import competitive price to $P^{w+\mathrm{AVE}}$. The difference between $P^{w+\mathrm{AVE}}$ and P^w is the AVE of the NTM. This difference may reflect compliance costs (e.g., adaptation, information, and conformity assessment) which are assumed to be passed through completely to importers as higher prices, quality upgrading or a combination of the two effects. The difference between the two demand curves reflects the NTM's market-creating effects. In panel (a), the market-creating effects are weak, so the market equilibrium shifts from point A to point B and import volumes go down. In panel (b), the market-creating effects are strong, so the market equilibrium shifts from point A to point C and import volumes go up in spite of the demand-inhibiting effect of the AVE. Note that this decomposition is correct only under the small country assumption (i.e., if supply curves in Figure 1 are horizontal).[8]

Thus, variations in import prices can be used to retrieve AVEs, while variations in import volumes can be used to assess, qualitatively, the market-creating effects (although it does not yield a precise quantitative estimate for them). When the AVE is positive and import volumes go up, we can conclude that the NTM's market-creating effects outweigh its business costs. When the AVE is positive and import volumes go down, the business costs of the NTM outweigh its market-creating effects. When the AVE is zero and import volumes do not change, the NTM is ineffective. When the AVE is positive and import volumes do not change, then the compliance costs effects of the NTM are offset by its market-creating effects. Thus, this price gap approach disentangles a number of configurations that previous approaches could not (Cadot et al., 2018).

[7] As an illustration, assume that the price of a product without an NTM is equal to 100 CHF/kg and that the AVE of the NTM is 5%. Then, the product price with the NTM is 105 CHF/kg. Thus, for policymakers, the AVE of the NTM (and not the estimated beta coefficient on the NTM from a regression analysis) is more useful as it allows for a direct comparison with ad valorem tariffs.

[8] Fortunately, this is a reasonable assumption for Switzerland but should be taken cautiously for large agricultural importers like the US and the EU.

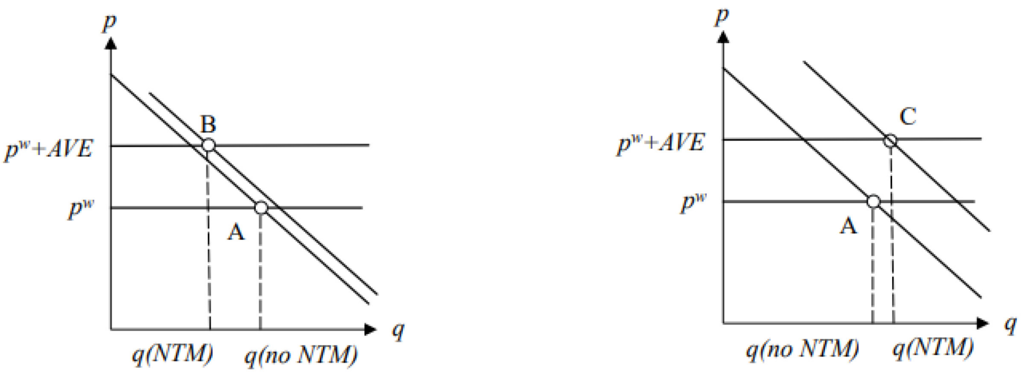


Figure 1: Compliance costs versus market-creating effects of non-tariff measures.

3 Conceptual framework

Now that we have settled on an approach to measure the AVEs, we need a framework that allows us to isolate them from the data. This section introduces a simplified conceptual framework following Xiong & Beghin (2014) to isolate the AVE and quantity effects of NTMs.

We begin by deriving an equation for the value of import demand in the importing country. How much country j imports from country i of good s (i.e., Q^d_{sij}) depends on how high the importer perceives the quality of the good (δ_{sj}), the price of the good (i.e., P_{sij}) and an elasticity of substitution parameter ($\in > 1$). For simplicity, we assume that the only determinant of the perceived quality of good s is NTM. Thus, $\delta_{sj} = \exp[\beta \text{NTM}_{sij}]$. Q^d_{sij} is, however, constrained by how much the importing country has to spend on imports. This budget constraint is the GDP of the importing country (Y_j).

The second step is deriving the export supply equation. We assume that for good s, exporting country i has a production capacity of Q_{si} and a production technology characterised by a constant elasticity of transformation ($\eta > 1$), which allows them to export to different destinations. The challenge for the exporting country is the decision as to which destination country to export to and how much to supply to the market (Q^s_{sij}) taking into account NTMs in the destination country j. The exporter also has to deal with other costs of doing business. These trade costs are the bilateral non-product or product-varying determinants of trade between i and j (such as distance, common border, common language, preferential trade agreements, and tariffs) and NTMs.

By combining the import demand equation and the export supply equations, we obtain under market clearing conditions[9], the equilibrium price (P_{sij}) and the equilibrium trade value (V_{sij}) in good s for trade between i and j. For a detailed derivation of the equations in this section, we refer the reader to Appendix A3.

[9] Market clearance implies that for good *s,* exports from i, expenditures in j, and the sum of sales to all destinations must be equal.

4 Empirical Analysis

4.1 Econometric Issues

Log-linearizing the equilibrium price (P_{sij}) and the equilibrium trade value (V_{sij}) derived in Section 3 and Appendix 3 yields the following generic estimation equation:

$$\ln(X_{sij}) = \alpha Y_j - \alpha \Pi_i + (1-\alpha)Q_{si} + \beta G_{ij} + \beta \mathrm{NTM}_{sij} \tag{3}$$

where the dependent variable is either V_{sij}(when we assess the demand effect) or P_{sij} (when we assess the AVE). All other variables here and in the appendix remain as defined above. Because the present work focuses on only Swiss NTMs and imports, we adapt the multi-country model of Section 4 to a single importing country case. Thus, to make our equation (3) fit our empirical analysis, a few empirical considerations are worth pointing out.

First, since Switzerland is the only import destination in this report, the importing country index j is redundant. For simplicity, we drop it. Second, we extend the definition of NTM in equation (3) to include behind-the-border measures (SPS and TBT) and border measures (OtherNTMs).[10] Third, to identify product-specific effects of NTMs, we estimate as many regressions as there are HS6 digit products, i.e., we estimate 733 different regressions.[11] This also means that we drop the product index s. Fourth, as in any analysis with multiple units of observations over time, we introduce time variation t and include year fixed effects to capture all (un-)observable year-specific effects. Ideally, we should also control for exporter fixed effects. However, many of the Swiss NTMs affect all countries equally (i.e., they are unilateral trade policy measures). In such cases, $\mathrm{NTM}_{it} = \mathrm{NTM}_t$, and including country-fixed effects means that we will lose all the variations in cases where the NTMs affect all countries similarly. Hence, we include the GDP of the exporting country as a country-specific control instead of country fixed effects. Finally, NTMs in general, are endogenous to trade. The more an agricultural product is imported, the higher the potential incidence of NTMs, as policymakers may need to safeguard the health of domestic consumers. Not accounting for endogeneity may underestimate the trade and AVE effects of NTMs. We use the year fixed effects – which should account for endogeneity induced by omitted variable biases – and lags of the NTM variables – which controls for endogeneity caused by reverse causality. Another reason to lag the NTM variables is that it may take some time for the price and/or trade effect of NTMs to occur, providing a further argument to lag the NTMs by at least one year.

4.2 Model specification

For each product s, addressing the economic issues raised in Section 4.1, the final estimation equation for the price regression is as follows:

$$\begin{aligned} \ln\ P_{it} = {} & \beta_0 + \beta_1^A \mathrm{SPS}_{it-1} + \beta_1^B \mathrm{TBT}_{it-1} + \beta_1^C\ \mathrm{OtherNTM}_{it-1} + \beta_2 \ln \mathrm{GDP}_{it} + \beta_3 \ln \mathrm{Distance}_i \\ & + \beta_4 \mathrm{Language_i} + \beta_5 \mathrm{Border}_i + \beta_6 \mathrm{FTA}_{it} + \beta_7 \mathrm{Tariff}_{is} + \alpha_t + u_{it} \end{aligned} \tag{4}$$

[10] In sensitivity analyses, we will treat the SPS and TBT measures as one component. See Table A5 in the appendix.

[11] The alternative is to interact the NTM variables with each product. However, this will result in too many estimates (733 products at HS6 digit level) in one regression. The process risks running out of degrees of freedom and becomes unmanageable. Instead, we split the sample across HS6 digit products.

where P_{it} is CIF import prices – defined as unit values – for good s imported from country i in year t.[12] SPS_{it} and TBT_{it} capture the number of SPS and TBT measures, respectively, applied on product s imported from i in year t.[13] $\mathrm{OtherNTM}_{it}$ designates all other remaining NTMs (see Figure 2b). u_{it} is the error term which we cluster at the exporting country level. Since product prices are never zero, the AVEs from equation (4) are estimated using ordinary least squares.

Once we have the coefficient estimates from equation (4), we proceed to convert them to AVEs. If β_1 is the coefficient on the number of NTMs per product, then the AVE is calculated as:

$$\mathrm{AVE} = \exp^{\widehat{\beta_1}} - 1. \tag{5}$$

Since the NTM variables are not logged transformed, the estimated β_1 coefficients are marginal effects and not elasticities. Thus, β_1^A and β_1^B capture the percent change in import prices when the count of SPS and TBT measures increases by one unit, i.e. $d \ln X_{it}/SPS_{it-1} = 100 \times \beta_1^A$. Following, the transformation in equation (5), both parameters represent the AVE effect of one additional SPS or TBT measure.

For the quantity-based regressions, the dependent variable is the quantity in kg of a product imported from country *i* in year *t*, (Q_{it}). Unlike prices, zero trade quantities are not statistical anomalies but reflect the absence of trade.[14] To understand why some countries do not trade, we need to consider these zero trade observations. As such we need an estimator that accounts for the presence of zeros in the dependent variable. We use the Poisson pseudo maximum likelihood estimator (Santos Silva and Tenreyro, 2006). The estimation equation becomes the following:

$$Q_{it} = \exp[\beta_0 + \beta_1^A \mathrm{SPS}_{it-1} + \beta_1^B \mathrm{TBT}_{it-1} + \beta_1^C\, \mathrm{OtherNTM}_{it-1} + \beta_2 \ln \mathrm{GDP}_{it} + \beta_3 \ln \mathrm{Distance}_i + \beta_4 \mathrm{Language_i} + \beta_5 \mathrm{Border}_i + \beta_6 \mathrm{FTA}_{it} + \beta_7 \mathrm{Tariff}_{is} + \alpha_t] + u_{it} \tag{6}$$

Note that this estimation step only provides qualitative evidence on the market-creating or market-disrupting effects of NTMs and does not offer direct inference on AVEs. Thus, the main interests here are in their signs and not their magnitudes.

Source: Cadot et al. (2018)

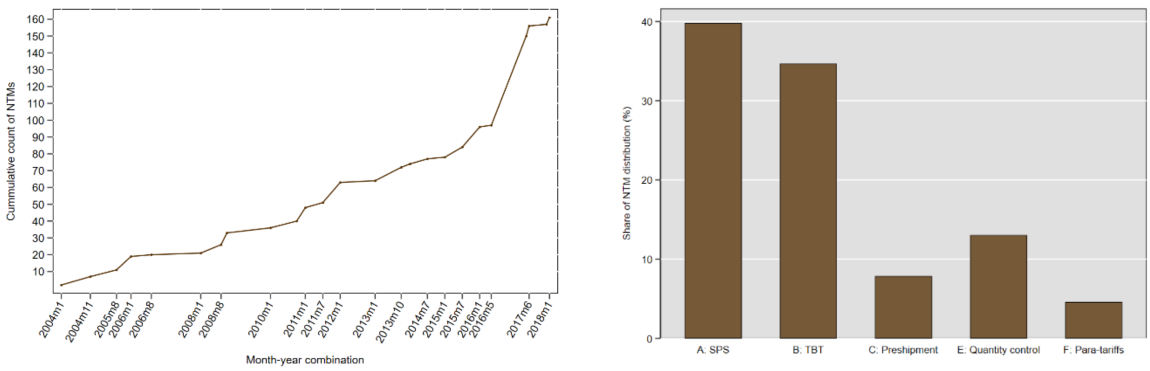
[12] For the analysis, trade unit values are used as a proxy for the price of good *s*. In an ideal situation, domestic prices should be used for this purpose. However, such prices are not always available systematically across products from all countries over time. Hence, we resort to unit values which are easy to observe. Second, we assume that firms in the exporting countries entirely pass-through the compliance cost of NTMs to trade unit values. That is if exporters from country A face higher standards in country B, they will pass on the extra cost they incurred in meeting the standard entirely to the consumer in country A. Third, import unit values can only be calculated in cases where import volumes and values are not zero. Lastly, Information on unit values can be particularly noisy because the trade data may contain measurement errors at the disaggregated product level. To deal with potential outliers in the price estimations, we screen the dataset and exclude extreme unit values within the 1st and 99th percentiles. We also drop annual growth rates within the 1st and 99th percentiles. This data-cleaning procedure eliminates 0.12% of our observations.

[13] We could also use a dummy variable to capture the presence or otherwise of NTMs. However, the dummy variable approach assumes that the effect of one NTM is not different from the effect of several NTMs. It is more reasonable to believe that the compliance cost increases with the number of NTMs.

[14] For each HS6 digit product, there is an excessive number of bilateral country pairs that do not trade. This feature is of even greater importance for the present work since the analysis is done at the HS6 digit level (the incidence of zero trade is higher, the higher the level of disaggregation).

5 Data

The analysis covers the period 2004 – 2018, 733 HS6 digit agricultural products[15] and 232 exporting countries. Over the study period, a total of 160 NTMs (Figure 2a) were introduced in Switzerland by different Swiss government agencies including the Federal Offices for Agriculture (FOAG), Public Health (FOPH), Food Safety and Veterinary (FSVO), Environment (FOEN), Swiss Customs amongst others. For a full list of NTMs, implementing Federal offices and regulation titles see Table A2 in the appendix. Consistent with the agricultural sector, the majority of the measures introduced were either SPS or TBT measures (see also Irek, 2022). These are measures applied behind-the-border and so affect domestic producers as well. On the other hand, few border measures (i.e., pre-shipment inspections, quota licensing, and para-tariffs[16]) were introduced (Figure 2b). Some of these measures are bilateral in nature, targeting specific products from specific partner countries. Others are unilateral in that they affect all countries equally (Table A3). For a more thorough review of how the NTM landscape has evolved in Switzerland, in particular for agri-food products, we refer the reader to Irek (2022).



(a) Evolution of Swiss NTMs

(b) Distribution of NTM chapters

Figure 2: Swiss NTMs targeting the agricultural sector (2004 - 2018)

The data we use for the empirical analysis comes from different sources. Trade data on import volumes and values – which are also then used to calculate import unit values – comes from Swiss customs (Swiss-Impex, 2022). The information on NTMs is accessed from WTO's comprehensive data on NTM notifications via the Trade Analysis and Information System (TRAINS).[17] It is an inventory-based dataset of official trade control measures/de jure mandatory measures, which are collected directly from the respective official legal sources of UNCTAD's partner countries. It is worth mentioning here that TRAINS data only provide information on whether a country has particular NTMs applied to specific products without providing more information on the actual requirements. Data on the gross domestic product (GDP) of the exporting countries comes from the World Bank. Data on free trade agreements (FTA) comes from Egger and Larch (2008) and data on bilateral distance, sharing a common border and a common language comes from the Centre d'Etudes Prospectives et d'Informations (Conte et al., 2021). Summary statistics on the variables used in the empirical analysis – across all years and products – are

[15] We follow the official definition of agricultural products adopted by the Federal Office for Agriculture. The product coverage includes HS01 – H24 (excluding fish and fish products, HS03), 290543, 290544, 3301, 3501 – 3505, 380910, 382360, 4101 – 4103, 4301, 5001 – 5003, 5101 – 5103, 5201 – 5203, 5301, 5302.

[16] These are additional taxes that act as a tariff but are not included in a country's tariff schedules.

[17] https://trainsonline.unctad.org/home

presented in Table 1. Consistent with Figure 1b, the average number of SPS measures is 5.87. This is higher than the average number of TBT measures (i.e., 3.74) and the average of all other NTMs (i.e., 1.94).

Table 1: Summary statistics

Variable	Mean	SD	Min	Max	N
SPS	5.866	5.25	0	27	439320
TBT	3.741	3.066	0	19	439320
Other NTMs	1.946	1.704	0	12	439320
Import value (mill. CHF)	0.016	0.149	0.000	15.494	439320
Import quantity (‘000 kg)	4.825	29.914	0.000	999.553	439320
GDP (trillion USD)	1.147	2.665	0.000	20.527	425543
Bilateral distance (‘000 km)	4.757	4.157	0.309	19.006	432645
Common language[d]	0.218	0.413	0	1	432645
Common border[d]	0.097	0.296	0	1	432645
Free trade agreements[d]	0.480	0.500	0	1	437175
Tariff	36.849	127.956	0	1445	429795
Unit values (CHF/kg)	17.400	41.083	0.366	452.256	166548

Notes: Variables designated with superscript *d* are dummy variables that take the value of 1 when the exporter shares that variable with Switzerland and 0 otherwise. The summary statistics presented here cover all agricultural products and all years. N is the number of observations, SD is the standard deviation, Min is the minimum value and max is the maximum value. SPS is Sanitary and phytosanitary measures, TBT is Technical Barriers to Trade.

6 Results and discussion

Before we dive into the product-specific findings, Table 2 reports estimates of the average effects across all products. NTMs do not affect import prices (columns 1 and 2) but have positive and statistically significant effects on import volumes (columns 3 and 4). The imposition of an additional NTM increases Swiss imports by 2%. Specifically, an extra SPS measure is associated with an increase in import volumes of 1%. For TBT, an additional measure increases imports by 4%. For other measures, the effect of an additional measure on import volumes is 3%. The main finding here is that, on average Swiss NTMs increase import volumes without necessarily increasing import prices. This means that the market-creating effects induced by Swiss NTMs outweigh their associated costs of doing business. But as we will show in the next section this product aggregation hides a lot of interesting heterogeneities across individual products at the HS6 digit level.

The results from these initial analyses also allow us to test standard predictions from the gravity literature and check whether our models are correctly specified. The control variables have the expected signs with meaningful magnitudes across the various models in columns (1) – (4). GDP has a positive effect on import prices and trade volumes. Distance increases import prices but decreases trade volumes. Speaking a common language increases import prices but contrary to our a priori expectations decreases import volumes. Sharing a common border decreases import prices but increases import quantities. Free trade agreements increase import prices and import volumes. Tariffs, on the other hand, increase product prices but decrease import volumes.

Table 2: The effect of NTMs on Swiss import prices and import volumes across all agricultural products

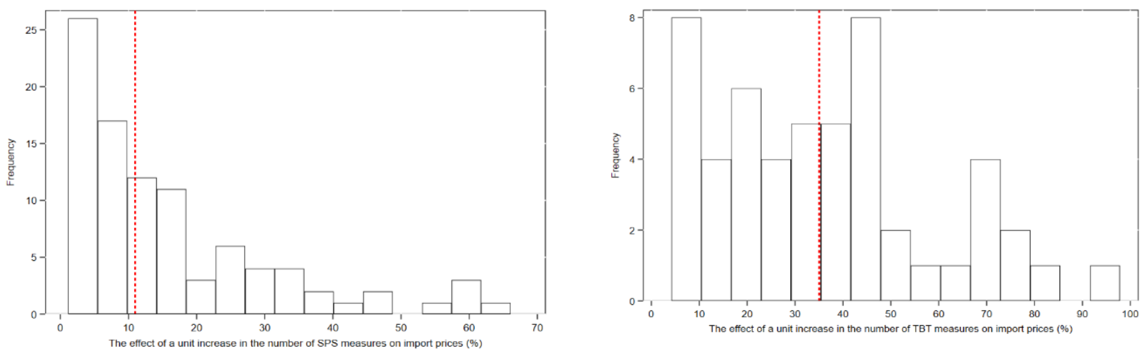
	Unit values (CHF/kg)		Import quantities (kg)	
	(1)	(2)	(3)	(4)
NTM_{ist-1}	-0.001		0.024***	
	(0.001)		(0.003)	
SPS_{ist-1}		0.001		0.013**
		(0.003)		(0.006)
TBT_{ist-1}		-0.007		0.035***
		(0.005)		(0.009)
Others_{ist-1}		0.004		0.031**
		(0.008)		(0.014)
Log GDP_{it}	0.034***	0.034***	0.264***	0.264***
	(0.004)	(0.004)	(0.006)	(0.006)
Log Distance_{i}	0.126***	0.126***	-0.104***	-0.104***
	(0.010)	(0.010)	(0.017)	(0.017)
Language_{i}	0.068***	0.068***	-0.229***	-0.229***
	(0.018)	(0.018)	(0.037)	(0.037)
Border_{i}	-0.102***	-0.102***	1.175***	1.176***
	(0.024)	(0.024)	(0.042)	(0.042)
FTA_{it}	0.074***	0.074***	0.342***	0.342***
	(0.020)	(0.020)	(0.035)	(0.035)
$\text{Log}\ (1 + \text{Tariff}_{is})$	0.035***	0.035***	-0.372***	-0.372***
	(0.011)	(0.011)	(0.017)	(0.017)
Product fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Observations	153784	153784	391444	391444
adj. R^2	0.516	0.516	0.96	0.96
Estimator	OLS	OLS	PPML	PPML

Notes: The dependent variable in columns (1) and (2) is the price (unit values) of good s imported from country i in year t. The dependent variable in columns (3) and (4) is the quantity of good s imported from country i in year t. ***, ** and * denote significance at 1%, 5% and 10%, respectively. Intercepts are included but not reported.

6.1 Product-level trade cost effects (ad valorem equivalents) of NTMs

To assess the *ad valorem* equivalents of NTMs on Swiss agricultural imports at the product level, we estimate a total of 733 linear regressions – one for each HS6 digit product within the agricultural sector. With such a high number of potential estimates, it becomes challenging to present the results in a classical results table. To facilitate the presentation of the AVEs, we plot the range of product-specific AVEs on a histogram (Figure 3). For technical non-tariff measures (i.e., SPS and TBT measures), negative AVEs are economically inconceivable. It is counter-intuitive to imagine that compliance with standards – which comes with production cost increases – will lead to price reductions (Cadot & Gourdon, 2016). As a result, we keep only estimated coefficients of the SPS and TBT measures that are positive and statistically significant at least at the 10% significance level.[18] For the SPS and TBT measures, we obtained 86 and 43 statistically significant AVE effects, respectively. The mean and median R^2 across the different product-level regressions is 67%. Thus, the overall fit of the unit value equation is good across the different HS6 digit products.

Figure 3 shows the distribution of all statistically significant AVEs for SPS and TBT measures. Overall, we obtain respectively 93 and 52 statistically significant AVE effects for SPS and TBT measures across all products. This limited number of statistically significant effects across products explains in part the statistically insignificant effects we find when we pool all products together in Table 2. Furthermore, where they are statistically significant, the AVEs vary widely across products. For the full range of AVE estimates, please see Figures A1 and A2 in the appendix. For SPS measures, a unit increase in the count of measures imposed is associated with an ad valorem equivalent estimate that ranges from a low of 1.15% to a high of 66.08.0%. For TBT measures, the AVEs range from 4.20% to 97.84%. The median value across the statistically significant estimates (see red dotted lines in Figure 3) is 10.96% for SPS measures and 35.05% for TBT measures.



SPS measures (b) TBT measures

Notes*:* This graph shows the distribution of statistically significant quantity estimates for all countries and products. To ease the presentation, I drop outliers, i.e., observations that are above the 95th percentile of the AVE distribution. The red dotted lines represent the median value across the statistically significant estimates.

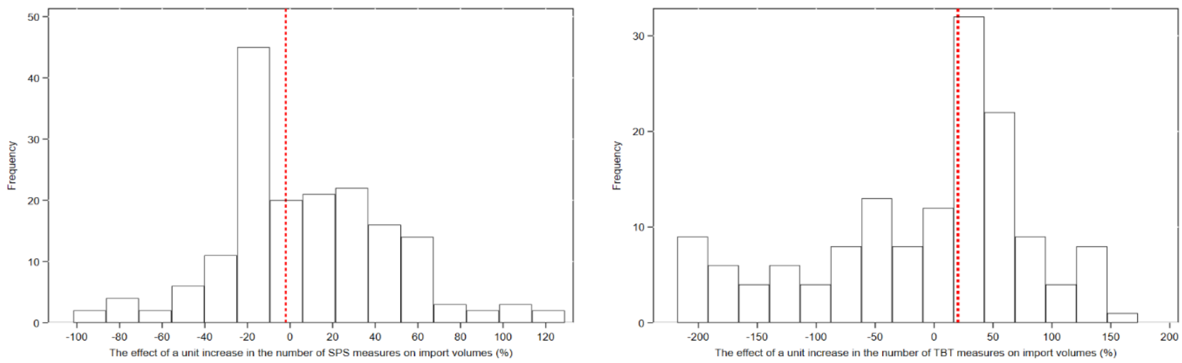
Figure 3: Distribution of AVE for Product-Level Regressions

[18] Yet, since NTMs can influence market structure—if unproductive firms exit the market—we can think of a situation where the NTM-induced price adjustments are not instantaneous. This means that for products where we observe negative or statistically insignificant price effects, we cannot rule out the price-increasing effect of standards. Rather it may take some more time for the effects to kick in.

6.2 Product-level trade volume effects of NTMs

Contrary to the price regressions, negative estimates in the quantity regressions are not odd. In fact, NTMs are expected to restrict trade because of their associated trade costs (Fiankor et al., 2021, 2021a), but if the price signalling effect of an NTM is strong enough, it may as well lead to an increase in import demand of the affected product (Fiankor et al., 2020). Moreover, statistically insignificant estimates from the quantity regressions provide us with important information as well: combined with a positive AVE from the corresponding price regression indicates that the price-raising effect of a given NTM and its market-creating effect compensate each other. Thus, we are left at the end with no change in trade flows for the affected product. We revisit this in more detail in the next subsection.

Here too, we plot the estimated coefficients in a histogram to ease the presentation (Figure 4) and relegate the full range of coefficients to the appendix (Figures A3 and A4). The general observation is that SPS and TBT measures do have both demand-enhancing and demand-impeding effects on agricultural trade. The introduction of an additional SPS measure decreases imports by as much as 100% but can also increase imports by as much as 100%. The pattern is similar for TBT measures but the effect sizes fall within a wider bound but with a smaller number of observations. The median value across the statistically significant estimates is -1.99% for SPS measures and 20.31% for TBT measures. In all cases, the majority of the marginal effects lie between -100% and 100%. This means that it is only in rare cases that the introduction of an NTM leads to the total collapse or doubling of existing import volumes. The extremes reported here should be seen as the exceptions and not the rule. However, this step of the analysis only offers qualitative evidence on the market-creating or market-disrupting effects of NTMs. Thus, the main interests here are in the signs and not the magnitudes.



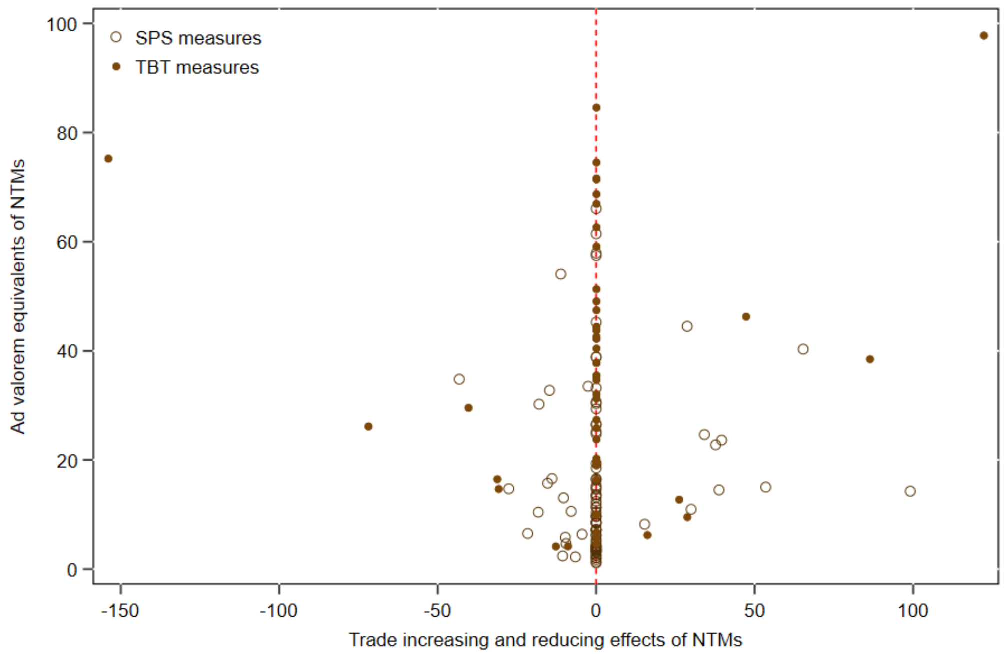
(a) SPS measures (b) TBT measures

Notes: These graphs show the distribution of statistically significant quantity estimates for all exporting countries and products. For the SPS and TBT measures, we obtain 173 and 146 statistically significant trade-volume effects, respectively. The general observation is that standards have both trade-enhancing (positive marginal effects) and trade-impeding (negative marginal effects) effects. To ease the presentation, we drop outliers, i.e., observations that are above the 95th percentile and below the 5th percentile of the AVE distribution. The red dotted lines represent the median value across the statistically significant estimates. The histograms only offer qualitative evidence on the market-creating or market-disrupting effects of NTMs. The main interests here are in the signs of the effects and not the magnitudes of the effect.

Figure 3: Distribution of trade effects for product-level regressions

6.3 Combining product-level AVEs and trade effects of NTMs

By combining the AVEs with the quantity estimates, we depict graphically the average equilibrium changes resulting from the imposition of Swiss NTMs. We focus on products for which the SPS and TBT measures have a cost-raising effect – i.e., products for which the price regression produced a positive and statistically significant estimate.[19] This allows us to investigate what the ultimate equilibrium changes are when the AVEs are combined with the corresponding demand effects. Figure 5 shows the combination of price and quantity estimates in one graph. For both SPS and TBT measures, a subset of statistically significant trade effects lies in the positive area of the distribution, i.e., above zero. This hints at the fact that for many products in the dataset with positive AVEs, the demand-enhancing effect of Swiss NTMs can indeed be substantial enough to still increase the volume of imports despite the price-raising effect. The reverse is also true, as many observations also lie in the negative region of the distribution. About 44% of the quantity-AVE combinations also lie on the vertical zero line. This implies that for these products, the quantity demanded remains unchanged despite the higher AVEs.



Notes: This figure depicts equilibrium changes in import volumes and import prices for Swiss agricultural imports. It shows combinations of price and quantity estimates obtained from equations (4) and (6). We focus on products for which the SPS and TBT measures have a cost-raising effect, i.e., products for which price regressions produced a positive and statistically significant SPS and TBT effect. We, note however, that the x-axis only offers qualitative evidence on the trade volume effects of NTMs. Thus, the main interests here are in the signs and not the magnitudes.

Figure 4: Equilibrium changes: combining trade volume and AVE effects of Swiss NTMs

[19] For example, if the estimated SPS coefficient for product 101105 in the price equation is either non-significant or negative, then the product is not reported in the equilibrium graph. However, if the coefficient in question is positive and significant, then the AVE of product 101105 will be reported in the graph (on the vertical axis) and match with its corresponding quantity estimate (on the horizontal axis).

6.4 Discussion

How do these findings compare to existing works? Since this is the first paper to assess the AVEs of NTMs for Switzerland, the findings are not directly comparable to existing estimates which are usually based on multiple importing country samples. However, we can still check the plausibility of the estimates by comparing them with existing studies (Cadot et al., 2018; Tchakounte & Fiankor, 2021). To ease the comparison, we calculate the average effects across HS sections and GTAP sectors. The HS sections are defined as follows: Section 1 (live animals and animal products, HS01, HS02, HS05), Section 2 (fruits, vegetables and nuts, HS06 – HS14), Section 3 (animal or vegetable fats and oils, HS15), and Section 4 (processed food, HS16 – HS24). The results are presented in Table 3. To facilitate the comparison of the AVEs across products, note that higher AVEs imply the need for producers of such products to improve the design or quality of their products substantially. For SPS measures, the AVEs are highest for fats and oils and lowest for live animals (i.e., column 1). For TBT measures, the AVEs are highest for fruits, vegetables and nuts and lowest for live animals (column 2). If we now compare our findings to existing works (i.e., columns 3 – 6), we see similarities but also differences. This is to be expected given our country-specific focus vis-à-vis the global focus in existing works. Nevertheless, our estimates are comparable to those reported in the existing literature.

Table 3: Average ad valorem equivalent of SPS and TBT measures by HS section

	Switzerland		**Global analysis** Cadot et al. (2018)		**Global analysis** Tchakounte & Fiankor (2021)	
	(1)	(2)	(3)	(4)	(5)	(6)
HS sections	SPS	TBT	SPS	TBT	SPS	TBT
1: Live animals	11%	12%	4.6%	16.5%	5.6%	19.1%
2: Fruits, vegetables, nuts	21%	40%	5.5%	17.1%	12.0%	14.3%
3: Fats and oils	25%	22%	17.7%	9.1%	11.3%	24.6%
4: Processed food	14%	37%	13.5%	12.1%	5.1%	8.6%

Notes: Estimations are carried out using OLS, product by product at the HS6 level and summarized across HS sections. The sections are defined according to the UNCOMTRADE’s Classification by Sections as follows: Section 1 (live animals and animal products, HS01–HS05, excluding HS03), Section 2 (HS06–HS14), Section 3 (animal or vegetable fats and oils, HS15), and Section 4 (HS16–HS24). Cadot et al. (2018) and Tchakounte & Fiankor (2021) focus their study on global agricultural trade flows.

To allow our AVE estimates to be also compared with estimates used in general equilibrium models for ex-ante evaluations, we also report section averages using GTAP sector codes in Table 4. THE GTAP sectors are defined at more disaggregate levels than those in the HS sections. However, the findings in Table 4 generally confirm the patterns in Table 3. For SPS measures, the AVEs are highest or sugar canes and beets, but are then followed by vegetable oils and fats and animal products, but lowest for animal products. For TBT measures, the AVES are highest for crops and vegetables and lowest for bovine meat products.

Table 4: Average ad valorem equivalent of SPS and TBT measures by GTAP sectors

GTAP sector	Sector code	SPS	TBT
Vegetables, fruit, nuts	V_F	13%	40%
Oil seeds	OSD		20%
Sugar cane, sugar beet	C_B	39%	
Crops n.e.c.	OCR	15%	46%
Animal products n.e.c.	OAP	24%	0%
Bovine meat prods	CMT	10%	7%
Meat products n.e.c.	OMT	4%	12%
Vegetable oils and fats	VOL	28%	22%
Dairy products	MIL	13%	
Processed rice	MIL	10%	
Food products n.e.c.	OFD	17%	34%
Beverages and tobacco products	B_T	10%	25%

The finding that, in many instances, at the product-specific level Swiss TBT measures have higher AVEs compared to SPS measures deserves some more attention. The finding implies that while SPS measures are more common in Swiss NTMs compared to TBT measures (Figure 2b), it appears that the potential price-raising effects of SPS measures are less pronounced. However, since we use counts of NTMs to estimate the AVEs, the implicit assumption here is that a unit increase in the count of NTMs is the same regardless of the number of measures already in force (i.e., the AVE effect of an increase from 2 to 3 measures is the same as the AVE effect from an increase from 30 to 31 measures). Ideally, the importance of the effect of one additional SPS or TBT measure should depend on the average number of the respective measures already in place. Thus, if a product had two NTMs imposed on it, then the marginal effect of increasing the number of NTMs on this particular product by one more unit is expected to be higher compared to a product where 30 NTMs are already applied. Since SPS measures are more common, it appears that the introduction of additional measures has limited AVE effects compared to TBT where the number of measures, to begin with, is limited. We also need to consider the specific stringency levels of the different NTMs to fully access their effects. For instance, though the number of TBT measures may be few, their requirements may be stringent compared. These caveats should be kept in mind when interpreting the higher AVEs of TBT measures vis-à-vis SPS measures as proof that TBTs are more disruptive.

6.5 Sensitivity Analyses

In this section, we conduct some robustness checks to confirm our main findings. First, the NTM-trade effect is heterogeneous along different dimensions. They may affect smaller exporters more than larger ones (Anders & Caswell, 2009; Fiankor, 2021a), have different short- and long-run effects (Maertens & Swinnen, 2009) or favour developed country producers more than those in developing countries (Xiong & Beghin, 2014). Given this background, we also assess how the effects in Table 2 differ across the development level of the exporting country. This is important given that developing countries are mostly standard-takers and not usually standard-makers. We use the high-income status of the exporting country – as defined by the World Bank in 2018 – as a proxy for developed countries. The results presented in Table A4 of the appendix show that being a developed country is associated with lower import volumes but developed countries charge higher prices for their products or export higher quality products. We then interact the variable for being a high-income country with the NTM variables to assess heterogeneous effects across income classification. For both export volumes and prices, we observe no statistically significant difference in the effects of SPS and TBT measures across country groups. We also estimate a model where we combine SPS and TBT measures into one measure and assess their joint effects on import volumes and prices. The results presented in Table A5 reaffirm those in Table 2: Swiss NTMs increase import volumes with no change in import prices.

7 Conclusion

In Switzerland, NTMs are playing an ever-increasing role in international trade. The goal of this report is to assess their product-level trade effects on Swiss agricultural imports. After calculating the effects of NTMs on Swiss product-level import prices, we transform the estimates into ad-valorem tariff equivalents. Our estimated AVEs are reasonable and in line with previous studies, with a sample median of 11% for SPS measures and 35% for TBT measures. However, there are also differences among products. For instance, the estimated AVEs of SPS and TBT measures are the smallest for live animals and animal products. We see much more pronounced effects for fats and oils, fruits, vegetables, nuts and processed foods. Since higher AVEs imply the need for producers of such products to improve the design or quality of their products substantially, our results show that in relative terms, products that are closer to the final consumer (e.g., processed foods, fruits, nuts and vegetables) impose stricter standards. Furthermore, we also estimate product-level quantity-based gravity equations that show that SPS and TBT measures imposed on Swiss imports can have positive, negative or no effects on import volumes. Combining the AVEs with the quantity estimate, we show that for a number of HS6 digit agricultural products, Swiss SPS and TBT measures can increase import quantities even if the NTMs lead to high AVEs.

What are the policy implications of our findings? For SPS and TBT measures, interpreting AVEs as compliance costs is straightforward. Yet, higher AVEs do not necessarily reflect more severe distortions to economic welfare. The opposite interpretation is also plausible. Since high AVEs imply that producers must undertake substantial product quality upgrading, it suggests that the unregulated market equilibrium – i.e., the case of no NTMs – might be very far from a social optimum. This is especially the case in agriculture where food safety hazards are prominent. Furthermore, for many products with high AVEs, import volumes still increase. Thus, we should see these high AVEs as a cost of ensuring consumer health and safety. For exporters targeting Swiss markets, our findings imply that meeting Swiss NTMs may increase their production costs but will be rewarded with increased sales volumes and prices. We also see that at the aggregate level, NTMs do not lead to higher AVEs but enhance trade. However, such a one-size-fits-all approach to NTM policy making should be avoided as we see significant differences in effects once we consider individual products.

The study is not without limitations. Since we use counts of NTMs to estimate the AVEs, the implicit assumption here is that a unit increase is the same regardless of the number of measures already in force. This is a rather strict assumption that can be improved with higher quality data. Second, there are several limitations in the NTM dataset provided by TRAINS (de Melo & Nicita, 2018). Little or no information is provided on the actual stringency of each measure. Interpreting higher counts of NTMs on a particular good as higher stringency is not straightforward, since one measure can be more stringent than several measures combined. The assumption that a cumulative burden is equivalent to higher compliance costs may not always be true. Going forward, what is important for policymaking is how we measure NTMs. We need to “measure trade barriers before we estimate trade impacts” (Goldberg & Pavcnik, 2016). The findings in this report are only as accurate as the information provided on NTMs. What is important is maintaining at the national level a database on NTMs that is as comprehensive as those on trade flows and Most-Favoured-Nation tariffs.

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Appendix

Table A1: List of exporting countries

Algeria, Aruba, Afghanistan, Angola, Anguilla, Antarctica, Albania, Andorra, United Arab Emirates, Argentina, Armenia, American Samoa, Antigua and Barbuda, Australia, Austria, Azerbaijan, Burundi, Belgium, Benin, Burkina Faso, Bangladesh, Bulgaria, Bahrain, Bahamas, Bosnia and Herzegovina, Belarus, Belize, Bermuda, Bonaire, Bouvet Island, Bolivia, Brazil, Barbados, Brunei Darussalam, Bhutan, Botswana, Cambodia, Central African Republic, Canada, Chile, China, Côte d'Ivoire, Croatia, Cameroon, Congo, Cook Islands, Colombia, Comoros, Cape Verde, Costa Rica, Cuba, Curaçao, Cayman Islands, Cyprus, Czech Republic, Cook Islands, Christmas Island, Germany, Djibouti, Dominica, Denmark, Dominican Republic, Ecuador, Egypt, Eritrea, Western Sahara, Spain, Estonia, Ethiopia, Finland, Fiji, Falkland Islands, France, French Southern Territories, Faroe Islands, Micronesia, Gabon, United Kingdom, Georgia, Ghana, Gibraltar, Guinea, Guadeloupe, Gambia, Equatorial Guinea, Greece, Grenada, Greenland, Guatemala, French Guiana, Guam, Guyana, Hong Kong, Holy See, Heard Island and McDonald Islands, Honduras, Haiti, Hungary, Indonesia, India, Ireland, Iran, Iraq, Iceland, Israel, Italy, Jamaica, Jordan, Japan, Kazakhstan, Kenya, Kyrgyzstan, Saint Kitts and Nevis, South Korea, Kuwait, Laos, Lebanon, Liberia, Libya, Saint Lucia, Sri Lanka, Lesotho, Lithuania, Luxembourg, Latvia, Macau, Morocco, Moldova, Madagascar, Maldives, Mexico, Marshall Islands, Macedonia, Mali, Malta, Myanmar, Montenegro, Mongolia, Northern Mariana Islands, Mozambique, Mauritania, Montserrat, Martinique, Mauritius, Malawi, Malaysia, Namibia, New Caledonia, Niger, Norfolk Island, Nigeria, Nicaragua, Niue, Netherlands, Netherland Antilles, Norway, Nepal, Nauru New Zealand, Oman, Pakistan, Panama, Peru, Philippines, Palau, Papua New Guinea, Palestine, Pitcairn, Poland, Puerto Rico, Democratic People's Republic of Korea, Portugal, Paraguay, French Polynesia, Qatar, Reunion, Romania, Russia, Rwanda, Saudi Arabia, Sudan, South Sudan, Senegal, Singapore, Saint Helena, Solomon Islands, Sierra Leone, El Salvador, San Marino, Somalia, South Georgia and the South Sandwich Islands, Saint Pierre and Miquelon, Serbia, Sao Tome and Principe, Suriname, Slovakia, Slovenia, Svalbard and Jan Mayen, Sweden, Swaziland, Seychelles, Syria, Turks and Caicos Islands, Chad, Togo, Thailand, Tajikistan, Turkmenistan, East Timor, Tonga, Trinidad and Tobago, Tunisia, Turkey, Tuvalu, Taiwan, Tanzania, Uganda, Ukraine, Uruguay, USA, United States Minor Outlying Islands, Uzbekistan, Saint Vincent and the Grenadines, Venezuela, British Virgin Islands, United States Virgin Islands, Vietnam, Vanuatu, Samoa, Kosovo, Yemen, South Africa, Zambia, Zimbabwe, Zaire

Table A2: Timeline of the introduction of Swiss NTMs between 2004 and 2018

Date	Issuing agency	Regulation title
01. Jan 04	FOAG	Ordinance of 26 November 2003 concerning the labelling of agricultural products obtained on the basis of production methods forbidden in Switzerland (RS 916.51)
01. Jan 04	FOAG	Ordinance of 26 November 2003 on the egg market (RS 916.371)
01. Nov 04	FOPH	Ordinance of 27 October 2004 on tobacco products and products containing tobacco substitutes intended to be smoked (RS 817.06)
01. Aug 05	FOPH, FOAG, OEN	Ordinance of 18 May 2005 on the reduction of risks relating to the use of certain particularly dangerous substances, preparations and articles (RS 814.81)
01. Aug 05	FOEN	Ordinance of 3 June 2005 on the fees levied by the Federal Office for the Environment (RS 814.014)
01. Jan 06	FDHA	Ordinance of the FDHA of 23 November 2005 on genetically modified foods (RS 817.022.51)
01. Jan 06	FOEN	Ordinance of 22 June 2005 on the movement of waste (RS 814.610)
01. Jan 06	FOAG	Ordinance of 23 November 2005 on the labelling of poultry according to the production method (RS 916.342)
01. Aug 06	FOAG	Ordinance of 16 June 2006 on the fees levied by the Federal Office for Agriculture (RS 910.11)
01. Jan 08	FOAG	Ordinance of 14 November 2007 on viticulture and the importation of wine (RS 916.140)
01. Aug 08	FSVO	Federal Act of 16 December 2005 on the protection of animals (RS 455)
01. Aug 08	FSVO	Ordinance of 23 April 2008 on the protection of animals (RS 455.1)
01. Oct 08	FOEN	Ordinance of 10 September 2008 on the handling of organisms in the environment (RS 814.911)
01. Jan 10	Swiss customs	Ordinance on tobacco taxation of 14 October 2019 (RS 641.311)
01. Oct 10	FSVO	Ordinance of the FSVO of 13 September 2010 on measures against equine infectious anemia in horses originating from Romania (RS 916.443.105)
01. Jan 11	FOAG, FOEN	Ordinance of 27 October 2010 on the protection of plants (RS 916.20)
01. Jul 11	Swissmedic	Ordinance of 25 May 2011 on the control of narcotic drugs (RS 812.121.1)
01. Jan 12	FOAG	Ordinance of the EAER of 26 October 2011 on the production and circulation of animal feed, additives for animal feed and dietary animal feed (RS 916.307.1)
01. Jan 12	FOAG	Ordinance of 26 October 2011 on the production and marketing of animal feed (RS 916.307)
01. Jan 12	FOAG	Ordinance of 26 October 2011 on imports of agricultural commodities (RS 916.01)
01. Jan 13	FOAG	Ordinance of 31 October 2012 on livestock (RS 916.310)
01. Oct 13	FSVO	Ordinance of 4 September 2013 on the circulation of protected species of wild fauna and flora (RS 453.0)
01. Oct 13	FSVO	Ordinance of the FDHA of 4 September 2013 on the controls to be performed under the Convention on the Conservation of Species (RS 453.1)

01. Jan 14	FDHA	Ordinance of the FDHA of 25 November 2013 on additives permitted in foodstuffs (RS 817.022.31)
01. Jul 14	FSVO	Ordinance of the FSVO of July 8, 2014 establishing measures to prevent the introduction of classical swine fever present in certain Member States of the European Union (RS 916.443.108)
01. Jan 15	FSVO	Ordinance of the FSVO of 15 January 2015 establishing measures to prevent the introduction in Switzerland of the small hive beetle from Italy (RS 916.443.105.3)
01. Jul 15	FOPH	Ordinance of 5 June 2015 on the protection against dangerous substances and preparations (RS 813.11)
01. Jan 16	Swiss customs	Ordinance of the FDHA of 18 November 2015 on the control of the import and transit of animals and animal products (RS 916.443.106)
01. Jan 16	FSVO	Ordinance of 18 November 2018 on the import, transit and export of animals and animal products with third countries (RS 916.443.10)
01. May 16	SECO	Ordinance of 18 May 2016 establishing measures against the Democratic People's Republic of Korea (946.231.127.6)
01. May 17	FDHA	Ordinance of the FDHA of 16 December 2016 on foodstuffs for person with special nutritional needs (RS 817.022.104)
01. May 17	FDHA	Ordinance of the FDHA of 19 December 2016 on food of plant origin, mushrooms and edible salt (RS 817.022.17)
01. May 17	FSVO	Ordinance of the FDHA of 16 December 2016 concerning information on foodstuffs (RS 817.022.16)
01. May 17	FDHA	Ordinance of the FDHA of 16 December 2016 on food of animal origin (RS 817.022.108)
01. May 17	FDHA	Ordinance of the FDHA of 16 December 2016 on foreign substances and toxic components in food (RS 817.021.23)
01. May 17	FDHA	Ordinance of the FDHA of 16 December 2016 on the addition of vitamins and minerals and certain other substances to foodstuffs (RS 817.022.32)
01. May 17	FDHA	Ordinance of the FDHA of 16 December 2016 on beverages (RS 817.022.12)
01. May 17	FDHA	Ordinance of the FDHA of 16 December 2016 on hygiene in food-related activities (RS 817.024.1)
01. May 17	FSVO	Ordinance of 16 December 2016 on foodstuffs and basic commodities (RS 817.02)
01. Jun 17	EAER, FDF	Ordinance of 10 May 2017 concerning the compulsory storage of food and fodder (RS 531.215.11)
01. Dec 17	FSVO	Ordinance of the FSVO of 18 December 2017 establishing measures to prevent the spread of African swine fever diffused in certain Member States of the European Union, Iceland and Norway (RS 916.443.107)
01. Jan 18	SAB	Ordinance of 15 September 2017 on alcohol (RS 680.11)
01. Jan 18	FOAG	Ordinance of the FOAG of 29 November 2017 on phytosanitary measures for agriculture and productive horticulture (RS 916.202.1)

Source: UNCTAD TRAINS

Table A3: Number of products and countries affected by NTMs

Date	HS6 digit products affected	Countries affected
01. 2004	48	73
11. 2004	11	156
08. 2005	64	154
01. 2006	368	234
08. 2006	42	132
01. 2008	5	136
08. 2008	13	62
10. 2008	43	111
01. 2010	8	141
10. 2010	7	1
01. 2011	76	162
11. 2011	14	116
01. 2012	63	115
01. 2013	6	15
10. 2013	86	184
01. 2014	220	172
07. 2014	13	4
01. 2015	2	1
07. 2015	8	44
01. 2016	457	208
05. 2016	507	1
05. 2017	824	227
06. 2017	185	199
10. 2017	14	5
01. 2018	6	60

Source: UNCTAD TRAINS

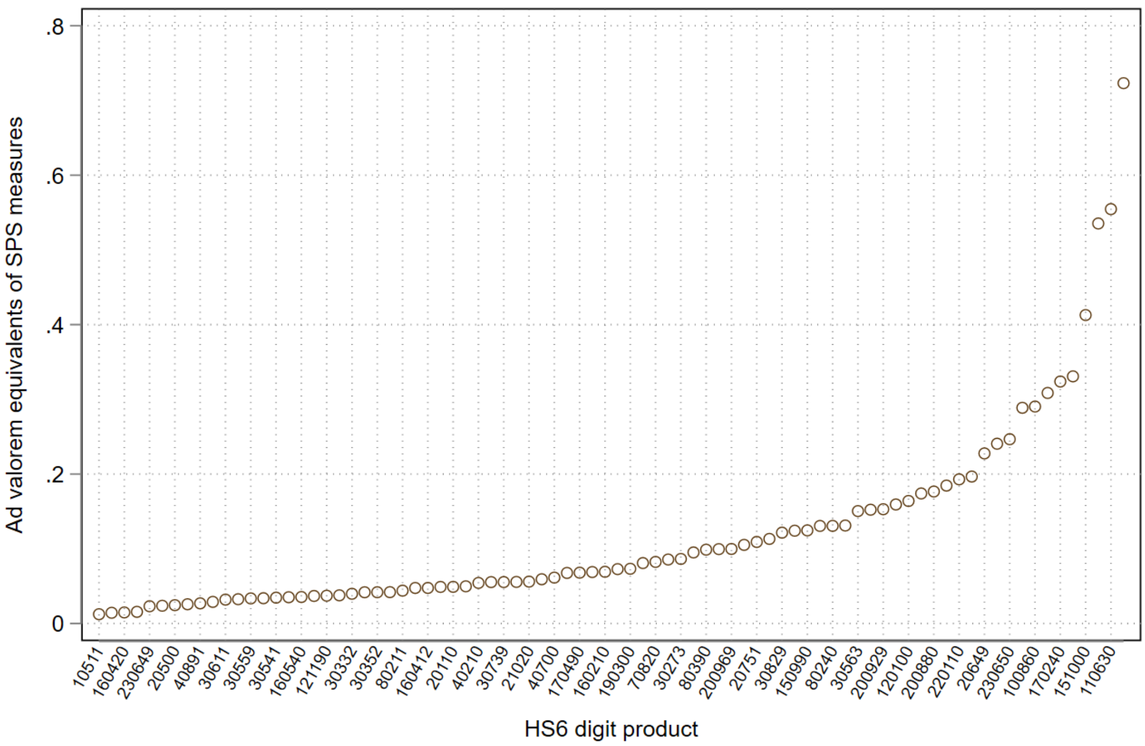

Figure A1: Product-specific ad valorem equivalents of Swiss SPS measures

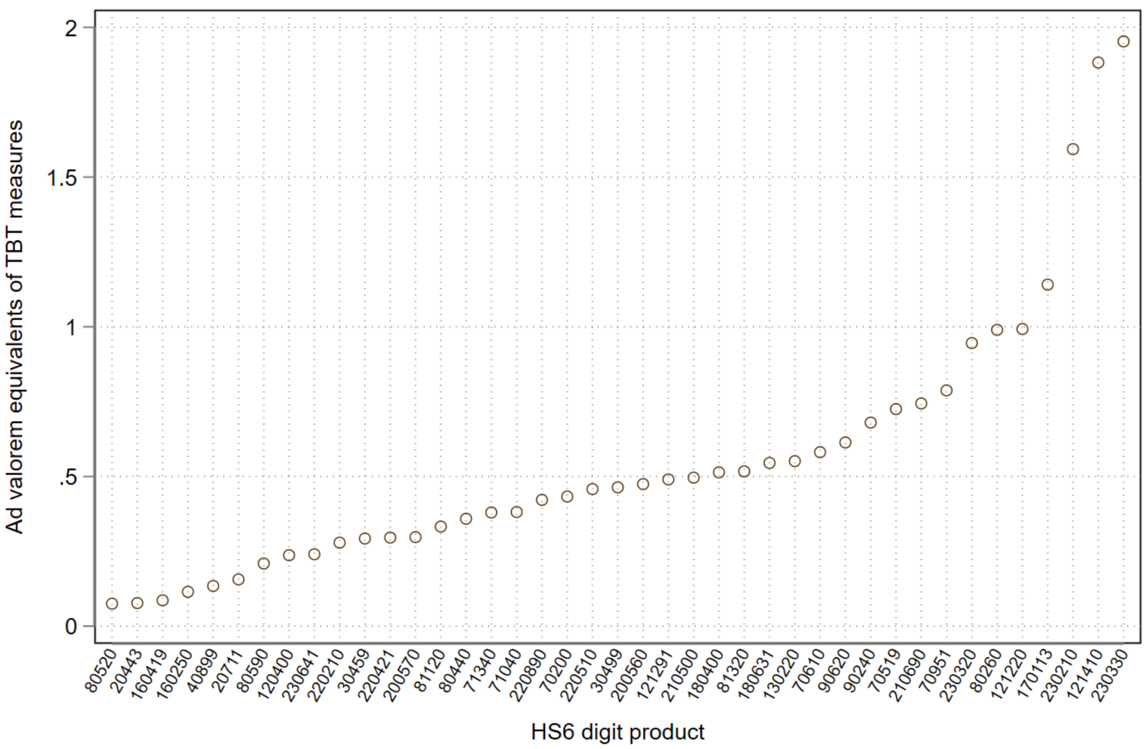

Figure A2: Product-specific ad valorem equivalents of Swiss TBT measures

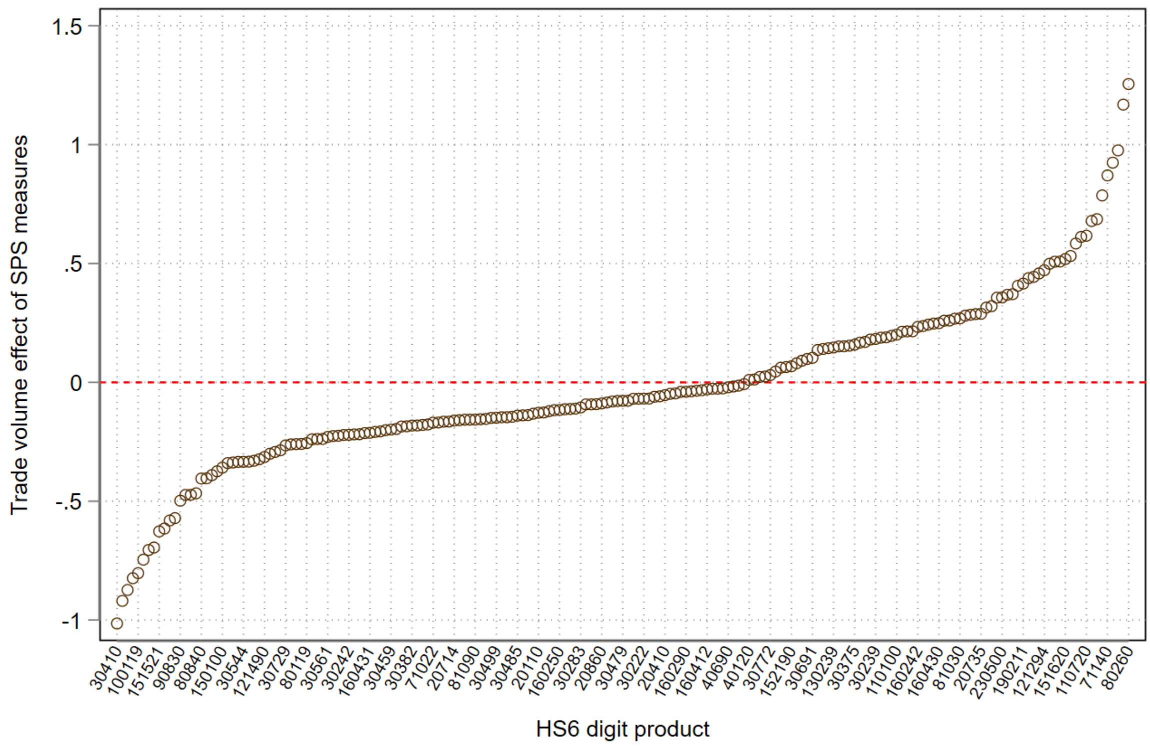

Figure A3: Product-specific trade cost effects of Swiss SPS measures

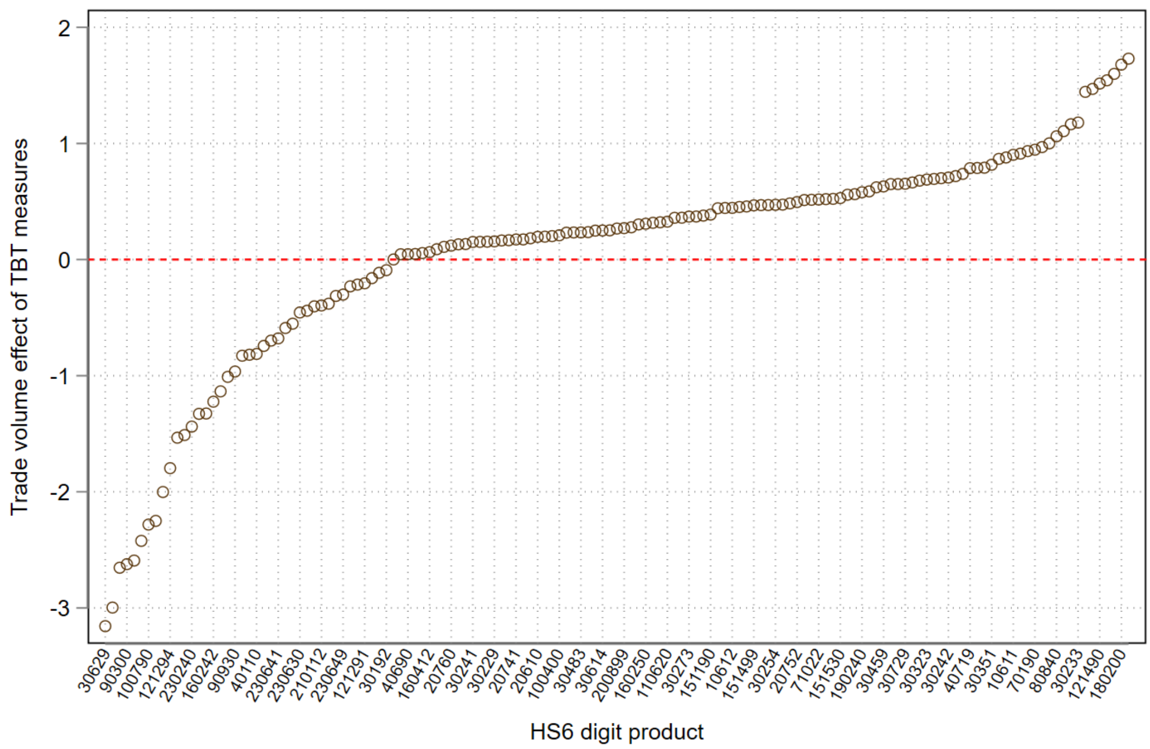

Figure A4: Product-specific trade cost effects of Swiss TBT measures

Table A4: The effect of NTMs on Swiss import prices and import volumes across all agricultural products: heterogeneities across development status of the exporting country

	Unit values (CHF/kg)		Import quantities (kg)	
	(1)	(2)	(3)	(4)
SPS$_{ist-1}$	0.000	-0.001	0.014**	0.021***
	(0.002)	(0.002)	(0.006)	(0.007)
TBT$_{ist-1}$	-0.006*	-0.006	0.034***	0.060***
	(0.003)	(0.004)	(0.009)	(0.011)
Others$_{ist-1}$	0.001	0.020***	0.033**	-0.028
	(0.005)	(0.005)	(0.014)	(0.018)
High income_i	0.328***	0.376***	-0.203***	-0.178***
	(0.007)	(0.011)	(0.030)	(0.042)
SPS$_{ist-1}$ $\times$ High income_i		0.003*		-0.010
		(0.002)		(0.006)
TBT$_{ist-1}$ $\times$ High income_i		0.000		0.000
		(0.003)		(0.009)
Others$_{ist-1}$ $\times$ High income_i		-0.031***		0.087***
		(0.004)		(0.014)
Log GDP$_{it}$	0.013***	0.012***	0.276***	0.275***
	(0.002)	(0.002)	(0.007)	(0.007)
Log Distance$_i$	0.187***	0.186***	-0.140***	-0.141***
	(0.005)	(0.005)	(0.018)	(0.018)
Language$_i$	0.096***	0.095***	-0.240***	-0.238***
	(0.008)	(0.008)	(0.037)	(0.037)
Border$_i$	-0.116***	-0.116***	1.180***	1.178***
	(0.010)	(0.010)	(0.043)	(0.043)
FTA$_{it}$	0.025***	0.023**	0.380***	0.381***
	(0.009)	(0.009)	(0.035)	(0.035)
Log Tariff$_{kt}$	0.013***	0.014***	-0.359***	-0.360***
	(0.004)	(0.004)	(0.018)	(0.018)
Product fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
N	153784	153784	391444	391444
adj. R^2	0.524	0.524		

Notes: ***, ** and * denote significance at 1%, 5% and 10%, respectively. Intercepts are included but not reported. High income includes all countries with a per capita GDP of > 12055 USD in 2018 (i.e., all countries classified as high-income).

Table A5: The effect of NTMs on Swiss import prices and import volumes across all agricultural products: combing SPS and TBT measures

	Unit values (CHF/kg)	Import quantities (kg)
	(1)	(2)
SPS-TBT$_{ist-1}$	-0.002	0.013***
	(0.002)	(0.004)
Others$_{ist-1}$	0.001	0.079***
	(0.007)	(0.012)
Log GDP$_{it}$	0.034***	0.264***
	(0.004)	(0.006)
Log Distance$_{i}$	0.126***	-0.105***
	(0.010)	(0.017)
Language$_{i}$	0.068***	-0.229***
	(0.018)	(0.037)
Border$_{i}$	-0.102***	1.177***
	(0.024)	(0.042)
FTA$_{it}$	0.074***	0.344***
	(0.020)	(0.035)
Tariffs$_{i}$	0.035***	-0.372***
	(0.011)	(0.017)
Product fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
N	153784	391444
Estimator	OLS	PPML

Notes: ***, ** and * denote significance at 1%, 5% and 10%, respectively. Intercepts are included but not reported. SPS-TBT denotes a combination of both SPS and TBT measures.

Appendix A3: Extended conceptual framework

This section introduces a conceptual framework following Xiong & Beghin (2014) to disentangle the two mechanisms – i.e., the AVE and quantity effects of NTMs – in Figure 1.

We begin by deriving an equation for the value of import demand in the importing country. Assuming a constant elasticity of substitution (CES) demand for goods *s* produced at home and abroad, consumer *C* in the importing country *j* maximises their consumption utility subject to a budget constraint as follows:

$$\max_{Q_{sij}^{d}} U_j = [\sum_i \sum_s (\delta_{sj} Q_{sij}^{d})^{\frac{\epsilon-1}{\epsilon}}]^{\frac{\epsilon-1}{\epsilon}}, \text{ s.t. } \sum_s \sum_i P_{sij} \times Q_{sij}^{d} = Y_j \quad (1)$$

where δ_{sj} is *C*'s perceived quality of good *s*, Q_{sij}^{d} is *C*'s demand for good s originating from exporting country i, $\in > 1$ is the elasticity of substitution parameter, P_{sij} is the price of good *s* imported from i and Y_j is the national income (i.e. the GDP) of country j. Put simply, the value of total import demand from other countries can only be as high as the national income of the importing country. Thus, the budget constraint in this maximising problem is the GDP of the importer. Solving the maximisation problem from equation (1) yields the following equation:

$$V_{sij}^{d} \equiv P_{sij} \times Q_{sij}^{d} = \frac{\delta_{sj}^{\epsilon-1} P_{sij}^{1-\epsilon}}{\pi_j Y_j} \quad (2)$$

where V_{sij}^{d} is the value of the import demand of country j originating from country i. π_j is *C*'s price index in country j.[20] For simplicity, we assume that the only determinant of the perceived quality of good s is NTM. Thus, $\delta_{sj} = \exp[\beta \text{NTM}_{sij}]$. The dual effect of NTMs on the value of import demand can already be identified from equation (2). NTMs affect V_{sij}^{d} positively through $\delta_{sj}^{\epsilon-1}$ and negatively through Π_j.

The second step is deriving the export supply equation. We assume that a given producer *M* in sector *s*[21] in origin country i has a production capacity of Q_{si} and a technology characterised by a constant elasticity of transformation (CET), which allows them to export to different destinations. The challenge for producer M is the decision as to which market to export to and how much to supply taking into account NTMs in the destination country j. The producer's maximisation problem is expressed as follows:

$$\max_{\{Q_{sij}^{s}\}_{j \in \Omega_{si}}} \sum_{j \in \Omega_{si}} P_{sij} \times Q_{sij}^{s}, \text{ s.t. } [\sum_{j \in \Omega_{si}} (\tau_{sij} Q_{sij}^{s})^{\frac{\eta-1}{\eta}}]^{\frac{\eta-1}{\eta}} = Q_{si} \quad (3)$$

Where Ω_{si} is the set of destination countries where M decides to export to. Q_{sij}^{s} is the quantity of good *s* exported from country *i* to *j*; $\eta > 1$ is the CET parameter; τ_{sij} is the bilateral iceberg trade cost. Solving the maximization problem for producer *M* yields the following export supply equation:

$$V_{sij}^{s} \equiv P_{sij} \times Q_{sij}^{s} = \frac{Q_{si} \tau_{sij}^{\eta-1}}{\Psi_{si} P_{sij}^{\eta-1}} \quad (4)$$

where Ψ_{si} is *M*'s price index (i.e., the cost of exporting to all possible destinations).[22] The bilateral trade cost term (τ) encompasses all bilateral determinants of trade. Following a standard procedure in the trade literature we define τ as the following log-linear function of observed trade costs including NTMs:

$$\tau_{sij} = \exp(\beta_1 . \text{NTM}_{sij} + \beta_2 . \text{G}_{ij}) \quad (5)$$

where NTM_{sij} is the presence of an NTM, and G_{ij} is a vector of bilateral non-product varying determinants of trade between *i* and *j* such as distance, common border, common language, colonial ties and preferential trade agreements.

By combining the import demand equation (2) and the export supply equation (4), we obtain under market clearing conditions, the equilibrium price in sector *s* for trade between i and *j*;

[20] $\pi_j = \sum_s \sum_i \delta_{sj}^{\epsilon-1} P_{sij}^{1-\epsilon}$

[21] We use the index *s* interchangeably for goods (consumer side) and sectors (producer side)

[22] $\Psi_{si} = [\sum_{j \in \Omega_{si}} \tau_{sij}^{\eta-1} P_{sij}^{1-\eta}]^{\frac{\eta}{\eta-1}}$

$$P_{sij} = \left(\frac{Y_j}{\Pi_j}\right)^{\frac{1}{\epsilon-\eta}} \left(\frac{\Psi_{si}}{Q_{si}}\right)^{\frac{1}{\epsilon-\eta}} \delta_{sij}^{\frac{\epsilon-1}{\epsilon-\eta}} \tau_{sij}^{\frac{1-\eta}{\epsilon-\eta}} \tag{6}$$

and the equilibrium trade value in sector *s* for trade between i and j;

$$V_{sij} = \left(\frac{Y_j}{\Pi_j}\right)^{\frac{1-\eta}{\epsilon-\eta}} \left(\frac{Q_{si}}{\Psi_{si}}\right)^{\frac{\epsilon-1}{\epsilon-\eta}} \left(\frac{\delta_{sij}}{\tau_{sij}}\right)^{\frac{(\epsilon-1)(1-\eta)}{\epsilon-\eta}}, \tag{7}$$

where Y_j is the importing country's income level and Q_{si} is the exporting country's total supply. Equation (6) is used to estimate the AVE effect of NTMs and equation (7) is used to investigate their trade effects.