# Heterogeneous Firms, Non-tariff Measures, and US Beef Trade

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April 2016

**Abstract**

This paper examines the implications of reducing the NTMs associated with beef hormone ban imposed on US exports into the EU. We contribute to this line of literature by taking firm heterogeneity and extensive margin effects prevalent in the processed beef market into account. For this purpose, we use the newly developed firm heterogeneity module of GTAP where we explicitly model monopolistic competition with heterogeneous firms. An additional novelty in this work is to model NTMs as efficiency losses that occur on the supply-side. We treat the processed beef and manufacturing sectors as monopolistically competitive with heterogeneous firms, while we retain the perfectly competitive structure as well as the Armington assumption in the rest of the sectors. Simulation results show that the number of US beef producers that export into the EU increases significantly as a result of fixed cost reductions and average productivity in the US beef industry increases. Furthermore, we observe that welfare in the US increases mainly due to productivity and scale effects, while welfare gain in the EU is primarily due to the allocative efficiency effect. Our study indicates that incorporation of firm heterogeneity in the remainder of the economy, where there are no fixed cost reductions, has an important mitigating effect on the terms-of-trade component of welfare change. While the fixed cost reduction occurs only in processed beef sector, the fact that manufacturing sector is also characterized by heterogeneity leads to modest terms-of-trade effects on welfare both in the US and in the EU.

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# 1 Introduction

Regulatory measures and non-tariff barriers are among the key issues discussed in recent trade agreement negotiations between the United States (US) and the European Union (EU). Lowering of protection on several agricultural products has been on the agenda of the Transatlantic Trade and Investment Partnership (TTIP) Agreement where beef trade stands out among many others as it is heavily protected in the EU market. Non-tariff barriers in the EU beef market include sanitary and phystosanitary (SPS) measures such as the hormone ban on beef (Arita et al., 2014). In particular, the use of growth-promoting hormones in beef production was banned in the EU in 1989 which has put a significant restriction on US beef exports into the EU market (FAS, 2014). These measures have been subject to scrutiny by US beef exporters as well as industry stakeholders and are being discussed in recent TTIP negotiations.

In order to ensure that beef exports meet the EU standards, the Agricultural Marketing Service (AMS) of the United States Department of Agriculture (USDA) has been offering the Non-Hormone Treated Cattle (NHTC) Program (FSIS, 2014). Signing up for this program brings additional costs to the firms as it requires them to pay for on-site visits by AMS, prepare documents as well as adapt the production and packing processes to comply with the hormone-free beef production (Arita et al., 2014). These are significant fixed costs which may prevent US beef producers to export into the EU market. Removal of these barriers could yield significant economic gains by reducing fixed costs in export markets and by improving US market access to the EU.

There are a few CGE-based studies of the TTIP that quantify the economic implications of removing NTMs in general (ECOYRS, 2009; CEPR, 2013; EP, 2014) and the beef hormone ban in particular (Arita et al., 2015; Beckman and Arita, 2015). The established approach in this literature is to model trade based on the Armington assumption of national product differentiation. Even though computational policy analysis with Armington-based models shed light on the implications of NTM removal, it fails to capture important (i) demand-side mechanisms based on product differentiation and (ii) supply-side mechanisms based on productivity dispersion across firms.

Beef industry is assumed to have a perfectly competitive market structure in these studies (Arita et al., 2015; Beckman and Arita, 2015). However, a more appropriate treatment is to allow for monopolistic competition in the beef industry. Consumers in the EU market differentiate between hormone-free and hormone-treated beef such that they have a higher preference for the hormone-free varieties (Lusk et al., 2003). In fact, studies show that European consumers, on average, indicate a willingness to pay a premium for steaks with a

*USDA Choice No Hormones or GMOs* stamp (Tonsor and Shroeder, 2003). A monopolistically competitive industry structure fits better in this case as it captures the effect of availability of different varieties from different source regions.

On the supply-side, the interaction of fixed costs and productivity dispersion across firms provides significant insights into which exporters will sign up for the NHTC program and which will be given the license to export. One of the stylized facts in the empirical literature is that firms substantially vary in their efficiency levels and only the relatively productive ones are able to export (Bernard and Jensen, 1999; Bernard et al., 2003). This applies to the beef industry as well which implies that the same fixed costs imposed by the NHTC program are more detrimental to the activities of inefficient firms. Productivity dispersion in the beef market will impact which firms will export and which firms will supply the domestic market. Therefore, the costly compliance procedures may prevent inefficient US firms to export beef into the EU market. These mechanisms have significant welfare implications.

In this paper we address these gaps by using the firm heterogeneity module of GTAP developed in Akgul et al. (in review) where we explicitly model monopolistic competition with firm heterogeneity based on the seminal work of Melitz (2003). A unique aspect of this model is its ability to capture the trade creation and diversion effects at the extensive margin and to tease out productivity changes due to within-industry factor movements. These new mechanisms available in the firm heterogeneity module of GTAP will help better understand the welfare implications of NTMs in general and the EU hormone ban in particular. In addition, we provide values for key parameters of the firm heterogeneity model consistent with the underlying theory based on the insights discussed in Akgul et al. (2015).

In this paper we explore the implications of reducing the hormone ban imposed by the EU on US beef imports by using two specific policy instruments: (i) increase in input efficiency used in fixed export costs, (ii) reduction in tariffs. There are three forms of modeling NTMs in the mainstream CGE literature. These are summarized by Andriamananjara et al. (2003) as tariff-equivalent, export tax equivalent, and as efficiency losses. Our treatment for (i) falls under the efficiency loss category, while that of (ii) falls under the tariff-equivalent category.

In the GTAP model NTMs are modeled as efficiency losses by considering their implications on the effective price and demand for imports from a particular exporter (Hertel et al., 2001). This is a demand-side treatment of NTMs which does not trace out the direct effect of fixed costs on firms. However, the fixed costs associated with beef hormone ban accrue directly to producers and exporters before they are reflected in consumer prices. Therefore, we lose important information on firm behavior when NTMs are modeled on the demand-side only. A novelty in our paper is to model NTMs on the supply-side. In particular, we map NTMs to country pair-specific fixed export cost shifters that capture efficiency losses on the use of inputs in fixed costs. These shifters are additional policy leverages introduced to the GTAP model in the context of firm heterogeneity. Finally, we explore the welfare implications of reducing the fixed export costs associated with beef hormone ban.

# 2 Data and Empirical Background

Our model is calibrated to GTAP Version 9 data base with 2011 as the base year. We aggregate the data base to include five regions, thirteen sectors and four primary factors of production as listed in Table 1.

In the GTAP sectoral definition beef includes *bovine meat products*. Therefore, the beef industry in this study is composed of firms that produce and sell bovine meat products. We assume a monopolistically competitive market structure in the beef industry with firm-level productivity heterogeneity. The motivation for this treatment is based on consumer preferences. Beef is not just one homogeneous product. There are many varieties within the industry. The most important distinction is between hormone-free and hormone-treated beef. Consumers in the EU have a higher preference for the hormone-free varieties of beef (Lusk et al., 2003) which are sold as premium products.

There is also variation across the varieties of different regions. For example, US beef imports in the EU are grain-fed and are considered as higher value products. In contrast, South American beef is categorized as prepared products such as corned beef and manufacturing-grade product used in ground beef production (Arita et al., 2014). This type of product differentiation is tracked by the endogenous number of firms exporting from that particular region in the firm heterogeneity framework.

Similar to beef, we treat the manufacturing sector as monopolistically competitive with heterogeneous firms. The rest of the sectors are assumed as perfectly competitive.

Key to our analysis is how we calibrate the parameters of our aggregation in the firm heterogeneity model. There are two parameters of particular importance in the firm hetero-

Table 1: Data Aggregation: GTAP Version 9

| Regions | Sectors | | Endowments |
|---|---|---|---|
| European Union (EU) | Feed | Processed Dairy | Land |
| United States (US) | Primary Food | Processed Ruminants (Beef) | Skilled Labor |
| Rest of TPP | Dairy | Processed Non-ruminants | Unskilled Labor |
| Rest of NAFTA | Cattle | Extraction | Capital |
| Rest of the World (ROW) | Wool | Manufactures | |
| | Non-ruminants | Services | |
| | Processed Food | | |

geneity model: (i) the elasticity of substitution across varieties which governs the demand-side heterogeneity and (ii) the shape parameter of productivity distribution (Pareto) which governs the supply-side heterogeneity. Pinning down the structural parameters is paramount for policy analysis, as quantitative results heavily depend on parameter values. Previous firm heterogeneity CGE models have often used Armington elasticities that are not appropriate in a firm heterogeneity model. The traditional gravity equation that delivers Armington elasticities do not control for the impact of firm self-selection into export markets which is the main micro mechanism for productivity and variety induced gains from trade. In the absence of firm behavior the resulting coefficient estimates confound the demand-side effects with the supply-side effects resulting in inaccurate elasticities (Akgul et al., 2015).

In order to be consistent with the underlying firm heterogeneity theory, interpretation and estimation/calibration of key parameters of the model have to be tailored to the model specification. We cannot simply use the Armington elasticities in the GTAP data base in this study. Instead, we use the method proposed in Akgul et al. (2015) where the intensive and extensive margins of trade are distinguished in a multi-sector, multi-country firm heterogeneity model resulting in two estimating equations. The first equation estimates the probability of a bilateral trade taking place, while the second equation estimates the value of bilateral trade conditional on the choice to export. In the export participation equation the distance coefficient is a combination of the distance and substitution elasticities. On the other hand, in the gravity equation, the distance coefficient is a combination of the shape parameter of productivity distribution and substitution elasticity. This provides two equations in three unknown parameters, whereupon we use the productivity parameter estimates provided in Spearot (forthcoming) to solve for the theoretically consistent estimates of substitution elasticities. We, then, aggregate the new elasticities based on each product's respective share in world trade, while we aggregate the shape parameters based on each industry's respective share in total costs of production. The calculated parameter values are presented in Table 2.

Parameters in perfectly competitive industries are calibrated via the usual techniques where GTAP Armington elasticities are used for primary food, extraction and services products. For the monopolistically competitive industries with heterogeneous firms, we find that 'Melitz' elasticities are lower than the GTAP Armington elasticities. The 'Melitz' elasticity for the beef industry is found to be 4.21, while the elasticity is 7.70 if the industry was treated as perfectly competitive. This big difference indicates that the choice of market structure has important welfare implications.

Table 2: Key Parameters of the Model.

| Aggregate Sectors | Market Structure | Shape Parameter $\gamma$ | Melitz Elasticity $\sigma$ | GTAP Armington Elasticity ESUBM |
|---|---|---|---|---|
| Feed | PC | - | - | 4.96 |
| Primary Food | PC | - | - | 5.12 |
| Dairy | PC | - | - | 7.30 |
| Cattle | PC | - | - | 4.00 |
| Wool | PC | - | - | 12.90 |
| Non-ruminants | PC | - | - | 2.60 |
| Processed Food | PC | - | - | 4.19 |
| Processed Dairy | PC | - | - | 7.30 |
| Processed Ruminants (Beef) | FH | 4.21 | 3.78 | 7.70 |
| Processed Non-ruminants | PC | - | - | 8.80 |
| Extraction | PC | - | - | 11.35 |
| Manufactures | FH | 4.50 | 4.50 | 7.08 |
| Services | PC | - | - | 3.85 |

**Notes:** FH: Firm heterogeneity, PC: Perfect Competition (Armington).

# 3 Policy Application

In this section we analyze the implications of reducing EU's hormone ban imposed on US beef by using two specific policy instruments: (i) efficiency increase in factor usage for fixed export costs, (ii) reduction in tariff rates.

## 3.1 Treatment of Non-Tariff Measures

Treatment of NTMs in the firm heterogeneity model is quite different than the mainstream approach adopted in the standard GTAP model. To highligt the differences we briefly summarize each approach before detailing the specifics of the shock.

NTMs are modeled as efficiency losses in the standard GTAP model. They enter as technical coefficients, `AMS(i,r,s)`, and work through the demand-side (Hertel et al., 2001). `AMS(i,r,s)` is defined as the import augmenting technical change of product $i$ from source region $r$ to destination $s$. Changes in the value of `AMS(i,r,s)` are reflected in the import price as well as the import demand. Thus, non-tariff measures work their way through the prices. Moreover, since there are no NTM costs in the initial data base, the model needs to be calibrated to add those costs into the database.

Unlike the standard GTAP model, the impact of NTMs work through the supply-side in the firm heterogeneity model. In particular, we map NTMs to country pair-specific fixed export cost shifters that capture efficiency losses on the use of inputs in fixed costs. For this purpose, a new policy instrument `AVAFS(i,r,s)` is defined as the technical change in the fixed cost of exporting product $i$ from source region $r$ to destination $s$. An increase in

`AVAFS(i,r,s)` ensures a fall in the effective quantity of primary factors used in fixed export costs. Thus, each firm faces lower fixed export costs conditional on exporting. This has repercussions for the effective price of primary factors as well.

Initial fixed costs in the model are calibrated based on a gravity equation of trade flows. We assume that domestic suppliers face similar plant modification costs as exporters to segregate the production line for hormone-free and hormone-treated beef. Based on our parameter settings, we find that the average firm in the beef industry devotes 3.6 % of its net revenues from sales in a particular market on the fixed costs to operate in that market.

## 3.2 Policy Instruments and Scenarios

The shock we impose on our policy instrument is based on the gravity estimations obtained in Arita et al. (2015). They use estimates of NTM costs as data in the standard GTAP model as well as in a supply-chain module of GTAP where detailed land-use competition among livestock markets are modeled. The removal of NTM costs is, then, broken out into changes in import taxes (`tms(i,r,s)`), changes in export taxes (`txs(i,r,s)`) and changes in efficiency (`ams(i,r,s)`). They find that if the removal of NTM costs is allocated entirely to the efficiency variable, US beef exports to the EU increases by 274%. If it is allocated entirely to import taxes, US beef exports to the EU increases by 274%, as well. If on the other hand, the removal of NTM costs are broken into three policy variables under a supply-chain model explored in Arita et al. (2015), US beef exports to the EU increases by 306%. These simulation results are in line with the gravity model predictions presented in Arita et al. (2015). According to their gravity model, if the hormone ban were removed, the estimated amount of US beef exports ranges between 210% - 314% across different specifications.

We calibrate the shocks used in our policy scenarios based on the trade volume changes obtained in Arita et al. (2015). We use the percentage change in exports found by using the tariff and efficiency variables only (274%) as opposed to the one found in the supply-chain case (306%). There are two reasons for this preference. First, in the firm heterogeneity model we do not allow for land-use competition among livestock markets as in the supply-chain module in Arita et al. (2015). Second, we explore the effects of policy instruments separately; therefore, isolating the shocks is more appropriate for our purposes.

We fix the percentage change in export sales of beef from the US to EU as 274% in our model and calibrate how much efficiency increase in fixed export costs is required to obtain this trade volume increase. This gives us the shock on the fixed export cost shifter, `avafsall(i,r,s) = 203.24`.We repeat the same procedure for the tariff rate with the same trade volume increase. This gives us the shock on the power of the tariff, `tms(i,r,s) = -13.28`.

A positive value for the fixed export cost shifter means that, fixed export cost per active firms will be reduced. As per firm fixed export costs are now lower, profitability in the export market increases which attracts new firms into the market. Therefore, the mass of exporters in the US-EU beef market expands. As a result of this firm entry, total fixed costs incurred in the post-shock economy is actually higher than initial fixed costs. This is purely an extensive margin effect. We should note that the fixed export cost shock of 203.24% does not eliminate all fixed costs. It is merely a reduction in fixed costs per firm conditional on observed trade patterns.

The -13.28 per cent reduction in the power of tariff brings about an ad-volarem tariff rate of 43.35 per cent. Therefore, it is not a complete removal of tariff, rather a reduction to facilitate imports from the US.

We analyze two scenarios that reduce NTMs on US beef imports in the EU:

* Efficiency increase in factor usage for fixed export costs of 203.24%

* Tariff reduction of 13.27%

## 3.3 Results under the Firm Heterogeneity Model

One of the major mechanisms captured by the Melitz (2003) model is the self-selection of firms into domestic and export markets. In this theory, firm participation in industries or in export markets is governed by the productivity threshold to enter that market. The productivity threshold is defined as the lowest productivity level for a firm to produce or export in that market. We first focus on the effect of fixed export cost reduction on these key firm heterogeneity mechanisms. Then we compare the results with that of the tariff cut scenario.

Table 3 presents the changes in the productivity threshold to enter the EU beef market as well as the changes in the number of exporters that supply this market under the efficiency scenario. Results show that while export productivity threshold decreases for the US firms, it increases for all other regions. The direct effect of lower fixed export costs is a fall in the demand for value-added inputs used by existing US beef exporters to fulfill the AMS/USDA export requirements. As fixed export cost per sale decreases, it becomes more profitable for existing US exporters to supply the EU market. This is especially good news for the marginal exporters of US beef who previously made zero profits in the pre-shock economy. As they start to make positive profits, the cutoff productivity level to export into the EU beef market decreases by 29%.

The profitability in the European beef market attracts new exporters which previously could not afford to sign up for the AMS/USDA program due to their relatively low productivity

Table 3: Efficiency Increase Scenario: Changes in the Export Threshold and Number of Exporters to the EU Beef Market (%).

| Regions | Productivity Threshold | Number of Exporters |
|---|---|---|
| European Union | 0.001 | −1.473 |
| United States | −29.173 | 271.059 |
| Rest of TPP | 0.028 | −0.378 |
| Rest of NAFTA | 0.027 | −0.354 |
| Rest of the World | 0.035 | −0.122 |

levels compared with the existing exporters. Consequently, the number of US exporters that supply the EU market increases by 271%. This rather large increase is partly because of the rate of productivity dispersion in the beef industry. There is a large pool of low-productivity producers in the beef industry around the margin that can now profitably export in the post-shock economy.

While this cost reduction benefits US firms, it diverts trade from other beef exporters. US firms meet almost all the demand in the EU beef market such that they replace sales from all other regions. As potential sales to the EU market drop significantly for the rest of the regions, exporters no longer benefit from scale economies. Therefore, their export productivity thresholds increase as shown in Table 3. Marginal exporters lose their market sales and start making negative profits which force them out of the EU market. As a result, the number of exporters to the EU beef market diminish other regions.

Table 4 presents the results in the tariff cut scenario on productivity threshold and number of exporters into the EU beef market. The tariff cut scenario predicts smaller changes for the thresholds and number of exporters.

Table 4: Tariff Cut Scenario: Changes in the Export Threshold and Number of Exporters to the EU Beef Market (%).

| Regions | Productivity Threshold | Number of Exporters |
|---|---|---|
| European Union | 0.001 | −1.206 |
| United States | −17.017 | 103.824 |
| Rest of TPP | 0.023 | −0.327 |
| Rest of NAFTA | 0.022 | −0.308 |
| Rest of the World | 0.029 | −0.101 |

It is important to note the difference in the nature of tariffs and efficiency shifter as policy instruments. By using tariffs as a policy instrument we are allowing for money transfers between exporters and importers. On the other hand by using the efficiency shifter, we are actually improving the efficiency of value-added devoted to cover fixed costs and reduce the factor demand of firms for entering a new market. As a result, the underlying general equilibrium mechanisms are markedly different in each scenario.

Table 5 presents the changes in the number of exporters, domestic suppliers, and potential firms in the beef industry of each region under both scenarios. The number of beef exporters increases in the US by 0.564%, while it decreases in the EU by 0.064 %. Beef sector contracts in the EU as the domestic demand is mostly met by the cheaper US imports. As a result, factors of production released from the beef industry are devoted to production in other industries in the EU. Table 6 presents changes in the output of each industry in the EU and US under the two policy scenarios.

Table 5: Changes in Varieties in the Beef Market under Efficiency Increase and Tariff Cut Scenarios (%).

| **Regions** | **Exporters** | | **Domestic Suppliers** | | **Potential Firms** | |
|---|---|---|---|---|---|---|
| | Efficiency Scenario | Tariff Scenario | Efficiency Scenario | Tariff Scenario | Efficiency Scneario | Tariff Scenario |
| European Union | −0.064 | −0.053 | −1.473 | −1.206 | −1.468 | −1.201 |
| United States | 0.564 | 0.320 | −0.052 | −0.013 | 0.741 | 0.701 |
| Rest of TPP | −0.107 | −0.095 | −0.077 | −0.069 | −0.272 | −0.242 |
| Rest of NAFTA | −0.059 | −0.052 | −0.153 | −0.138 | −0.252 | −0.226 |
| Rest of the World | −0.001 | −0.001 | 0.014 | 0.011 | 0.012 | 0.009 |

Although the number of beef exporters increases in the US, there are now fewer beef producers in the industry (-0.052 %). This is due to the rising productivity threshold in the domestic market. As the threshold increases, firms with productivity levels lower than the new threshold cannot survive in the industry and exit.

The pool of potential firms is determined endogenously by the zero profits condition in the model. A potential firm decides to enter the industry if the potential profits from all sales are high enough to cover both domestic and export fixed costs. The US beef industry becomes highly profitable following the fixed export cut as a result of increased sales to the EU market. This attracts many potential firms to make the productivity draw and survive in the beef industry.

These compositional changes in domestic and export markets have significant implications for the industry productivity. Table 7 presents the changes of average productivity of domestic suppliers, exporters, and the whole industry under the two trade policy simulations.

For most regions, average productivity in the domestic market is affected only modestly by these policies. Comparatively, the US experiences a more sizable change. Average productivity

Table 6: Change in the Production of Each Sector under Efficiency Increase and Tariff Cut Scenarios (%).

| **Sectors** | **Efficiency Scenario** | | **Tariff Scenario** | |
|---|---|---|---|---|
| | US | EU | US | EU |
| Feed | 0.095 | −0.037 | 0.094 | −0.030 |
| Primary Food | −0.008 | −0.004 | −0.007 | −0.003 |
| Dairy | 0.005 | −0.011 | 0.005 | −0.009 |
| Cattle | 0.582 | −0.778 | 0.576 | −0.637 |
| Wool | −0.039 | 0.011 | −0.039 | 0.009 |
| Non-ruminants | 0.032 | 0.001 | 0.029 | 0.000 |
| Processed Food | 0.008 | −0.015 | 0.008 | −0.012 |
| Processed Dairy | −0.003 | 0.001 | −0.003 | 0.000 |
| Processed Ruminants (Beef) | 0.875 | −1.452 | 0.835 | −1.189 |
| Processed Non-ruminants | 0.041 | 0.002 | 0.037 | 0.001 |
| Extraction | −0.026 | 0.021 | −0.026 | 0.018 |
| Manufactures | −0.014 | 0.009 | −0.014 | 0.009 |
| Services | 0.000 | 0.002 | 0.000 | 0.002 |

Table 7: Productivity Growth in the Beef Industry: Domestic, Export and Industry-Wide Averages under Efficiency Increase and Tariff Cut Scenarios (%).

| **Regions** | **Domestic Suppliers** | | **Exporters** | | **All Producers** | |
|---|---|---|---|---|---|---|
| | Efficiency Scenario | Tariff Scenario | Efficiency Scenario | Tariff Scenario | Efficiency Scenario | Tariff Scenario |
| European Union | 0.001 | 0.001 | −0.001 | 0.000 | 0.002 | 0.001 |
| United States | 0.209 | 0.188 | −0.055 | −0.032 | 0.236 | 0.203 |
| Rest of TPP | −0.052 | −0.046 | 0.012 | 0.011 | −0.056 | −0.049 |
| Rest of NAFTA | −0.026 | −0.023 | 0.010 | 0.009 | −0.028 | −0.025 |
| Rest of the World | −0.001 | −0.001 | 0.000 | 0.000 | −0.001 | −0.001 |

**Notes:** Domestic suppliers report the average productivity growth of firms that only sell in the domestic market. Exporters report the productivity growth of exporters in all export markets weighted by the respective share of each export market in total sales of beef. All producers report the average productivity growth in the industry weighted by the respective share of each market in total sales of beef.

of domestic suppliers increases by 0.209% under the efficiency scenario while it increases by 0.188% under the tariff cut scenario.

In comparison, average productivity of exporters decreases in the EU and the US as a result of the expansion of low-productivity firms into export markets. As export thresholds decrease, beef producers expand into new markets. Since new exporters are less efficient than the incumbents, their entry into reduces the overall efficiency in export markets on average.

Even though the average productivity of exporters is negative, the industry-wide average productivity increases both in the EU and the US. The magnitude is much higher in the US. The domestic average (0.209%) more than compensates for the reduced export market average (-0.055%) since domestic sales constitute a larger portion of the market. As a result, fixed cost reduction reallocates market share by shifting resources towards more productive firms in the industry which improves the aggregate productivity in the US beef sector by 0.236% under the efficiency scenario. The same mechanism is observed under the tariff cut scenario, as well.

## 3.4 Welfare Implications across Model Specifications

Implications of these TTIP scenarios are better understood by exploring the resulting welfare effects in each region. In this section we provide a detailed analysis on the components of welfare change in firm heterogeneity. There are four new sources of economic gains from trade that can be captured in firm heterogeneity models: (i) productivity effect, (ii) love-of-variety effect, (iii) scale effect, and (iv) fixed cost effect. These components are additional to the allocative efficiency and terms of trade effects which are the traditional channels of gains from trade in perfect competition models with Armington assumption.

Productivity effect is the result of within-industry compositional change of firms in favor of the high-productivity firms. As factors of production are reallocated towards more productive firms, overall efficiency in the industry rises which has a positive contribution to overall welfare. The productivity channel is unique to the firm heterogeneity model. The second channel is the Dixit-Stiglitz love-of-variety effect which is due to trade growth along the extensive margin. Trade contributes to overall welfare by allowing new varieties to become available to consumers who gain utility from the uniqueness of products. The third channel is the scale effect which is the result of increasing returns to scale technology available in the monopolistically competitive industries. As firms expand into export markets average variable costs decrease and firms operate at a higher scale generating additional gains from trade. Finally, the fourth channel is the fixed cost effect on welfare. Fixed cost payments of inactive firms reduces welfare.

Aggregate welfare effects of the fixed export cost reduction in the firm heterogeneity model are presented in Table 8.

Table 8: Welfare Effects of Two Scenarios under Firm Heterogeneity: Equivalent Variation in millions of $US.

| **Regions** | **Aggregate Welfare Effect** | **Allocative Efficiency Effects** | **Terms of Trade Effects** | **IS Effects** | **Productivity Effects** | **Scale Effects** | **Variety Effects** | **Fixed Cost Effects** |
|---|---|---|---|---|---|---|---|---|
| Efficiency Scenario | | | | | | | | |
| US | 87 | -26 | 18 | 6 | 180 | 170 | -103 | -158 |
| EU | 594 | 458 | -34 | -1 | 48 | 115 | 56 | -48 |
| Rest of TPP | 16 | 17 | 1 | -1 | -11 | -7 | 5 | 11 |
| Rest of NAFTA | 1 | 2 | 5 | -1 | -4 | -3 | -2 | 4 |
| ROW | -20 | -9 | 10 | -4 | 8 | 5 | -22 | -9 |
| World Total | 677 | 443 | 0 | 0 | 221 | 279 | -66 | -199 |
| Tariff Scenario | | | | | | | | |
| US | 67 | -27 | 21 | 5 | 141 | 148 | -85 | -137 |
| EU | 381 | 377 | -35 | -1 | 50 | 112 | -71 | -49 |
| Rest of TPP | 13 | 15 | 1 | -1 | -10 | -7 | 5 | 10 |
| Rest of NAFTA | 0 | 2 | 4 | -1 | -4 | -4 | -2 | 4 |
| ROW | -20 | -7 | 10 | -3 | 7 | 0 | -19 | -7 |
| World Total | 442 | 360 | 0 | 0 | 184 | 249 | -171 | -179 |

The firm heterogeneity model predicts a global welfare gain of $677 million under the efficiency scenario. This is much higher than the $442 million global welfare gain prediction of the tariff scenario. The higher welfare gain predicted by the efficiency scenario is not simply a result of the bigger shock imposed on fixed costs. In fact, since trade responses are equalized between the two scenarios, welfare differences are attributed to the differential effects of each policy instrument on the responses of productivity, firm scale, and product variety.

The global welfare gain under both scenarios is primarily due to the welfare gain in the EU, $594 million under the efficiency scenario and $381 million under the tariff scenario. The main driving force of these economic gains is due to the traditional allocative efficiency effect. As the EU welcomes increasing levels of beef imports from the US, a considerable amount of tariff rents are collected which contributes positively to European welfare ($458 million). Even in the case of the tariff scenario, the EU benefits from rents ($377 million) because tariffs are not completely eliminated and beef imports from the US increases by the same rate as in the efficiency scenario. As expected, terms of trade contribution is negative (-$34 and -$35 million respectively) due to terms of trade deterioration in the EU (-0.001% in both scenarios).

There is a large scale effect under both scenarios ($115 million and $112 million) due to increasing output per firm in the manufacturing industry. The industry-wide productivity increase in the EU contributes to welfare by $48 million in the case of the efficiency scenario and $50 million in the case of the tariff scenario. While productivity increases in all heterogeneous industries, the welfare contribution is primarily driven by the productivity increase in the manufacturing industry.

The variety effect is different across policy scenarios. While the variety effect raises welfare under the efficiency scenario ($56 million), it reduces welfare under the tariff scenario (-$71 million). The firms in the manufacturing industry benefit from the increase in the number of domestic varieties under the efficiency scenario. This welfare gain due to increasing number of domestic manufacturing varieties more than offsets the welfare loss due to fewer domestic beef varieties in the EU. Hence the variety effect is positive under the efficiency scenario. On the other hand, under the tariff scenario, the welfare loss due to fewer domestic beef varieties dominates the variety effect.Finally, fixed cost payments reduce the welfare in the EU by $48 and $49 million, respectively.

The firm heterogeneity model predicts a welfare gain in the US ($87 million and $67 million under the respective scenarios). In the efficiency scenario, the welfare gain in the US is driven by the average productivity gains ($180 million) and larger firm scale ($170 million). The productivity is primarily due to within-industry compositional change in favor of the high-productivity firms in the beef industry. Trade growth leads to welfare gain by forcing inefficient firms out of the industry and allowing efficient firms to expand into export markets. Firm scale also contributes to the welfare gain. Since there are fewer beef producers in the US, they operate at a larger scale.

While productivity and scale effects have positive contributions to US welfare, variety has a large negative effect (-$103 million and -$85 million respectively). US consumers suffer from the loss of domestic varieties in the beef industry as well as the manufacturing industry. In particular, the impact of domestic variety loss of beef is most severe on private households, while the impact of domestic variety loss of manufactures is most severe on firms that use manufacturing products as inputs. While there are many new entrants into the beef industry, they turn out to be quite inefficient such that they are not competitive enough to produce. Nonetheless, the setup costs they have paid for market entry contributes to the negative welfare effect of varieties (-$158 million and -$137 million respectively).

An important finding in this study is that incorporation of firm heterogeneity in the remainder of the economy, where there are no fixed cost reductions, has an important mitigating effect on the terms-of-trade component of welfare change. While the fixed cost reduction occurs only in processed beef, the fact that manufacturing sector is also characterized with heterogeneity leads to modest terms-of-trade effects on welfare both in the US ($18 million) and in the EU (-$34 million). On the other hand, if only processed beef is considered as heterogeneous and the heterogeneity in the manufacturing industry is ignored by assuming the traditional Armington and perfect competition structure in manufacturing, model predictions on terms-of-trade effects will be different. In such a case, we observe that the welfare gain in the US is much higher ($444 million) with a more pronounced terms-of-trade effect ($147 million). Welfare gain in the EU, on the hand, is lower ($244 million) due to a more pronounced terms-of-trade effect (-$154 million). This difference in model predictions highlights the importance of new mechanisms captured under firm heterogeneity.

Overall, the firm heterogeneity model predicts large welfare gains for the world as well as for the EU and US. Including firm-level heterogeneity in the model allows for tracing out the welfare implications of NTM reductions due to new channels which are unexplored in Armington-based perfect competition models. By ignoring the significant variation across firms, NTM removal scenarios miss the effect of productivity change and the extensive margin on global welfare. This leaves out important economic information which can be paramount for policy recommendation.

# 4 Limitations

The policy analysis in this study relies on the assumptions made in model calibration and parameterization to determine the values of substitution elasticities between varieties, shape parameters, and the associated fixed costs in the domestic and export markets. This parametric restriction is an outstanding issue in this study. As initial values for fixed costs and variable value-added depend on the parametric choice, we are restricted to the parameter combinations which provide positive values for fixed and variable value-added costs.

In order to improve the model, alternative methods of parameterization should be considered. Expansion of the parametric space can relax the dependency of the model on parameters which requires an alternative method to calibrate or estimate initial fixed costs. Estimation of fixed costs is difficult as their identification depends on their nonlinear effects on market participation patterns. Das et al. (2007) develops a structurally dynamic framework which allows for the estimation of fixed export costs based on plant-level data. In particular, Das et al. (2007) identify fixed costs by using the differences in the exporting frequency of plants with similar profit streams but different export participation history. We do not attempt to solve this issue in this study. However, using empirical information for initial fixed costs may improve the flexibility of the model for alternative parameters.

# 5 Concluding Remarks

Reducing NTMs as a means to increase market access and harmonizing the standards in trade between the US and the EU has been the main target of recent TTIP negotiations. EU's hormone ban on US beef is one of the frequently discussed issues in these negotiations. Removal of the fixed costs associated with US beef imports into the EU is expected to generate significant economic gains.

This study focuses on the implications of reducing beef hormone ban imposed on US imports. We contribute to this line of literature by taking firm-level heterogeneity and extensive margin effects prevalent in the monopolistically competitive beef market into account. For this purpose we use the newly developed firm heterogeneity module of GTAP which (i) accounts for fixed costs in domestic and export markets; (ii) traces out self-selection of firms into domestic and export markets based on productivity differences, and (iii) captures trade growth along the extensive margin. We compare the effects of using different policy instruments to capture NTM reductions. Moreover, we provide insights into welfare implications of the firm heterogeneity model and compare them with that of the perfect competition model.

Our findings show that the mass of US exporters into the EU beef market increases significantly under both scenarios. The compositional change in US beef export market is such that low-productivity firms expand their market shares as a result of lower productivity thresholds. We find that reducing fixed export costs cause aggregate productivity in the US beef industry to increase since it allows more efficient firms to expand into export markets, while forces inefficient firms to drop out of the industry. This has significant welfare implications. Higher average productivity in the beef industry contributes markedly to the US welfare gain. We find that the choice of policy instrument alters the magnitude of the welfare gain, while the underlying mechanisms at play are similar. When NTMs are captured as tariff equivalents in the firm heterogeneity model, we see that both the EU and the US experiences a lower welfare gain. Overall, we find important productivity and variety impacts of NTM reductions consistent with the firm heterogeneity literature on trade integration.

It should be noted that the EU has a restrictive TRQ policy on US beef imports that further restricts US exports. There may be interactive effects between the TRQ policy and the hormone ban which deserves further analysis. In fact, Beckman and Arita (2015) show that the binding TRQ is the limiting constraint and has significant implications for trade flows. So far we focus only on the impact of reducing beef hormone ban while we have in quota TRQs. In future work, we will incorporate the effect of TRQs on US-EU beef trade in addition to fixed export costs. We will examine the interactive effect of fixed cost reductions and TRQs on trade flows and welfare in the US and the EU.

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