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Trade liberalization gains under different trade theories: A case study for Ukraine*

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ABSTRACT

To analyze the Deep and Comprehensive Free Trade Area (DCFTA) between Ukraine and the EU we develop a multi-region general-equilibrium simulation model calibrated to GTAP 8.1 data. We implement three alternative trade structures for services and manufactured goods: a.) a standard specification of perfect competition based on the Armington [1969] assumption of regionally differentiated goods; b.) monopolistic competition among symmetric firms consistent with Krugman [1980]; and c.) a competitive selection model of heterogeneous firms consistent with Melitz [2003]. Across these structures the DCFTA indicates relatively large gains for Ukraine (and small gains for the EU). A novel result emerges, however, in that the gains for Ukraine are largest under an assumed Armington structure. This is attributed to a movement of resources into Ukraine's traditional export sectors which produce under constant returns. While there is little danger of deindustrialization dominating the overall welfare gains, we do observe substantially lower gains due to monopolistic competition.

JEL **classifications: F12, C68**
Keywords: DCFTA, Ukraine, EU, Armington, New trade theory, Krugman, Melitz.

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1 Introduction

Ukraine's recent revolution and Russia's annexation of Ukrainian territories have drawn the world community's attention. Being in a situation of continuing political and economic crises and with high external and public debt, Ukraine is now in receipt of urgent and necessary economic assistance from the EU, the US, as well as various international organizations such as the International Monetary Fund (IMF) and the World Bank. Looking forward, policies that hasten Ukraine's economic integration with western economies have a renewed importance.

The EU, for example, is accelerating its efforts to establish and ratify the Association Agreement (AA) with Ukraine, which is widely expected to bring long-term economic gains and therefore a way out of the existing crises. As a part of the AA, the Deep and Comprehensive Free Trade Area (DCFTA) constitutes a new type of agreement as it involves more than just bilateral import tariff elimination. It additionally envisages the harmonization of Ukraine's regulations on competition policy, state aid, public procurement, sanitary and phyto-sanitary measures, technical regulations and service trade liberalization. The political provisions of the AA between the EU and Ukraine were signed in March 2014 and the signature process of the remaining parts, including the DCFTA, was completed in June 2014. Moreover, since April 2014 the EU has temporarily removed customs duties on Ukrainian exports as an Autonomous Trade Measure (ATM). This unilateral transitional trade measure allows Ukraine to benefit substantially from the advantages offered by the DCFTA even before the implementation of the tariff-related section of the AA provisions.[1]

In this paper we conduct a comprehensive analysis of the DCFTA's potential effects on the Ukrainian economy. We look at both tariff and nontariff measures (trade facilitation and non-tariff barriers) to consider the full implications of the DCFTA. The analysis will likely be helpful in providing the parties with valuable information about the transitional impacts. As a central robust finding the DCFTA, with reductions in non-tariff barriers and trade facilitation improvements, indicate relatively large welfare gains for Ukraine of more than 3%. The impact of the DCFTA on the EU is small but positive. There is almost no measurable effect on the rest of the world region, but Russia and other Commonwealth of Independent States (CIS) countries suffer welfare losses as a result of the DCFTA.

Our analysis is innovative in its approach to trade structures. We implement three alternative trade structures for services and manufactured goods: a.) a standard specification of perfect competition based on the Armington [1969] assumption of regionally differentiated goods; b.) monopolistic competition among symmetric firms consistent with Krugman [1980]; and c.) a competitive selection model of heterogeneous firms consistent with Melitz [2003]. Across these structures a novel result emerges where the gains for

[1] See European Council [2014d], European Council [2014a], European Council [2014b], European Council [2014c] and European Council [2014e] available at `http://eeas.europa.eu/ukraine/news/`.

Ukraine are largest under the Armington structure. This is attributed to a policy induced movement of resources into Ukraine's traditional export sectors which produce under constant returns. While there is little danger of deindustrialization dominating the overall welfare gains, we do observe substantially lower gains under monopolistic competition. We caution, however, that our model does not include capital flows, so EU firms supply Ukraine's markets on a cross-border bases. Allowing for capital flows might change the story if EU firms were to engage in FDI, which would increase the number of EU varieties while increasing the demand for workers in Ukraine.

Our results are consistent with the recent theoretic analysis by Arkolakis *et al.* [2012]. In a multisector context the gains from trade are generally different across Armington and monopolistic competition models, but gains are not necessarily larger under monopolistic competition. If liberalization draws resources away from the increasing returns sectors the Armington model will indicate larger gains.[2] This is what we find for the EU-Ukraine DCFTA. Ukraine intensifies production and exports of agriculture and other sectors which it has a traditional comparative advantage in, while the increasing returns sectors shrink in the face of EU based import competition. Previous research on EU-Ukraine economic integration, by adopting the Armington structure, overlooks the important changes in industrial organization that follow from a reallocation of resources. Given our results these studies likely overstate the gains.

2 Literature review

Different steps in liberalizing Ukraine's trade are widely evaluated in the literature. After applying for the WTO membership in 1993, a detailed analysis of Ukraine's WTO accession was executed by Pavel *et al.* [2004], Jensen *et al.* [2005] and Kosse [2002]. Measuring the impact of an import tariff reduction in a standard static CGE model with perfect competition and constant returns to scale (CRTS), Kosse [2002] finds the WTO membership beneficial for Ukraine due to a positive impact on national welfare. In the same modeling framework Pavel *et al.* [2004] simulate the full WTO accession accounting for improved market access and adjustment of domestic taxation in addition to the tariff reduction. They identify a welfare gain of 3% and an increase of real GDP by 1.9%. Jensen *et al.* [2005] support these findings by prediction of an overall welfare gain of 5.2% and a rise of real GDP by 2.4% using an extended model concerning imperfect competition and increasing returns to scale (IRTS) for some manufacturing sectors and incorporating a reform of FDI barriers to service sectors.

After Ukraine's accession to the WTO in 2008, the negotiations on the AA including a DCFTA with the EU were launched and this issue became the first priority for economic research. Analyzing different potential FTAs between Ukraine and the EU, Emerson *et al.*

[2] A result demonstrated by Balistreri *et al.* [2010].

[2006] and Ecorys & CASE-Ukraine [2007] show that the DCFTA, which additionally incorporates a reduction of different non-tariff barriers (NTBs) and liberalization of trade in services, would have a stronger positive impact on Ukraine's welfare (up to 7%) compared to the simple one (incorporating tariff reductions only) where the effects are small or even slightly negative.[3] Maliszewska *et al.* [2009] support these findings by simulating different FTAs between the EU and five CIS countries: Armenia, Azerbaijan, Georgia, Ukraine and Russia. Their results show that Ukraine benefits the most among the CIS countries and the gains from the deeper integration (5.83%) are higher than from the simple tariff reduction (1.76%). The same question is studied by Francois & Manchin [2009] in a multi-regional model with a higher number of included CIS countries.[4] According to their results, a bilateral tariff reduction would lead to a decrease of real income for the CIS region as a whole and for Ukraine in particular (-0.83 and -2.12%, respectively). Modeling the DCFTA by adding services liberalization and reduction of barriers to efficient trade facilitation, they find a smaller real income decrease for Ukraine of -0.4%. von Cramon-Taubadel *et al.* [2010] focus mainly on the agricultural sectors of the GTAP7 dataset and find that a 50% reduction in all bilateral tariffs would only result in moderate gains for Ukraine and the EU. Thus, the greatest possible benefit is found in case of improved agricultural productivity modeled by a 5% exogenous boost in technical change.

The most recent study is done by Movchan & Giucci [2011] who investigate a broader range of Ukraine's integration strategies. They compare the effects of different FTAs with the EU on the one hand and Ukraine's accession to the customs union with Russia, Belarus and Kazakhstan on the other hand. Simulating the DCFTA with 2.5% reduction of boarder dead-wight costs on trade in addition to the tariff elimination, they find a long-run welfare effect of 11.8% which is significantly higher than the impact of a simple FTA (4.6%). Thus, an implementation of a joint external tariff in case of the customs union would lead to a welfare loss up to 3.7%.

Most of the cited studies implement standard static CGE models characterized by perfect competition and an Armington [1969] trade structure for all commodities. Kehoe [2005] criticizes the performance of this class of models (in the context of their predicted impact of NAFTA) based on the fact that they fail to capture trade growth in new varieties and trade-policy induced productivity impacts. Some recent studies (e.g. Jensen *et al.* [2005], Maliszewska *et al.* [2009], Ecorys & CASE-Ukraine [2007], Francois & Manchin [2009], Movchan & Giucci [2011]) do consider new varieties by applying model with imperfect competition and IRTS in manufacturing and services. These efforts rely on firm-level product differentiation of symmetric varieties (consistent with the theory suggested by Krugman [1980]). Thus, trade liberalization may allow consumers to enjoy new foreign varieties which, through the love-of-variety effect, create higher welfare gains.

[3] A slightly negative long-term welfare effect of -0.06% is found for Ukraine by Emerson *et al.* [2006].

[4] Francois & Manchin [2009] present detailed results for Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Russia and Ukraine.

Trade-policy induced changes in aggregate productivity still remain out of scope of most studies on Ukraine. At best some researchers proxy for policy induced impacts through exogenous productivity "kickers." Strong evidence over the past decade identifies endogenous productivity responses, and heterogeneous-firms theories rationalize these observations. The evidence starts with an observation of different productivity levels among coexisting firms.[5] Furthermore, trade policy induces a within industry reallocation of factors from less- to more productive plants (including exit of the lowest productivity plants), which links trade policy to aggregate productivity.[6] The popular theory proposed by Melitz [2003] rationalizes the observation of productivity changes in a model that includes endogenous changes in the number of varieties consumed (the extensive margin). The particulars of the Melitz theory are covered more extensively in the following section of this paper.

While a recent branch of the theoretic literature (most notably Arkolakis *et al.* [2012]) has focused on a set of equivalence results where, under a set of highly restrictive assumptions, each of the competing trade theories (Armington, Krugman, and Melitz) generate the same simple gravity equation, these efforts are largely irrelevant to an empirical study like ours. The DCFTA between the EU and Ukraine forces us to consider economies with multiple sectors and policy induced reallocations, as well as variety impacts through intermediate use. Balistreri *et al.* [2010] show the fragility of the equivalence results to intersectoral resource reallocations by adding a simple labor-leisure choice in the standard model. In general, the results across structures diverge substantially once multiple sectors are considered. For instance, Balistreri *et al.* [2011] demonstrate that a global reduction of tariffs under Melitz structure (applied to manufactured goods) indicates welfare gains on the order of four times larger than a standard Armington model. As another example, Corcos *et al.* [2011] apply a partial equilibrium model for the EU and find much larger gains from trade in the presence of selection effects with substantial variability across countries and sectors. A more complete discussion of divergence in results across structures and their empirical relevance are offered in Balistreri & Rutherford [2012] and Costinot & Rodríguez-Clare [2014].

While the direct equivalence results have little relevance in our context, one key lesson from this literature is that there is no purely theoretic reason to expect larger gains from liberalization under monopolistic competition (relative to Armington). This is directly stated by Arkolakis *et al.* [2012]. Clearly, a policy induced movement of resources away from the monopolistic competitive sectors and into Armington sectors could generate smaller effects relative to the predictions in a model that only considers Armington sec-

[5] See for example Bartelsman & Doms [2000] for differences in firm level productivity within an industry and Bernard *et al.* [2003] for differences in productivity of exporters and non-exporters .

[6] Aw *et al.* [2001] illustrate an overall productivity growth for Taiwanese manufacturing caused by reallocation of market share from less productive to more productive firms. In the context of NAFTA, Trefler [2004] shows the empirical link between trade policy and labor productivity growth. An extended review of the literature on heterogeneous firms and international trade can be found in Balistreri *et al.* [2011].

tors. In short, if expansion of the increasing returns sectors generates larger gains then a contraction of these sectors will generate smaller gains. In general, given the perception that manufactured goods are among the most trade intensive goods and are produced under monopolistic competition we would expect liberalization to generate larger gains relative to an assessment under purely Armington trade. To this point, the empirical studies (e.g., Balistreri *et al.* [2011]) support this prediction. In this paper, however, we find considerable evidence that this prediction is incorrect for Ukraine's integration with the EU. The key empirical feature which generates the unexpected result is Ukraine's observed intensity of exports in agricultural goods produced under perfect competition. Liberalization with the EU draws resources into these sectors and away from the increasing returns manufacturing and services sectors. The DCFTA with the EU has a deindustrialization effect, and although this effect does not dominate the overall gains from liberalization, we do find it to be important. To our knowledge this is the first study to confirm the theoretic prediction by Arkolakis *et al.* [2012] that trade models with monopolistic competition may predict smaller gains than a purely perfect competition model.

3 Theoretical background

Standard CGE models with perfect competition and constant returns to scale usually use the Armington assumption of differentiated regional products to model foreign trade.[7] In this formulation firm-level products and technologies are assumed to be identical within a region, whereas product varieties from different places of production are imperfect substitutes. Thus, consumers do consume home as well as foreign varieties of the same good which are aggregated to a composite commodity in a Constant Elasticity of Substitution (CES) function using the so-called Armington elasticity of substitution. Given the use of a high level of aggregation in a CGE model, the assumption of homogenous firm-level goods within one region is arguably unrealistic. Nonetheless, the Armington formulation as a model of intra-industry foreign trade which accounts for over 80% for some Ukrainian sectors such as textiles, chemicals, manufacture of machinery and equipment.

Product differentiation at the firm level was first suggested by Krugman [1980] and provided an intuitive explanation for intra-industry trade. He developed a theory of trade under large-group monopolistic competition among symmetric firms producing under the same increasing returns to scale technology. In the Krugman [1980] model trade allows consumers to benefit from new foreign varieties not available in autarky. Aggregating the differentiated firm-level goods through a CES activity generates a composite commodity available for consumption or intermediate use. This CES aggregation is consistent with the Dixit & Stiglitz [1977] love-of-variety formulation and therefore indicates industry-wide scale effects from new varieties reflected in additional gains for agents. These gains

[7] See Armington [1969], Dervis *et al.* [1982], pp. 221-223 and 226-227.

constitute purely demand-side variety gains independent of the increasing returns to scale formulation.

Extending the Krugman [1980] model to include multiple sectors, where resource reallocations indicate endogenous firm entry, allows for adjustments along the extensive margin as a response to trade cost changes. Though, such a model specification with trade induced entry considers gains from new varieties that did not exist before, the gains under monopolistic competition could be lower than in the Armington formulation if trade leads to an exit of firms.

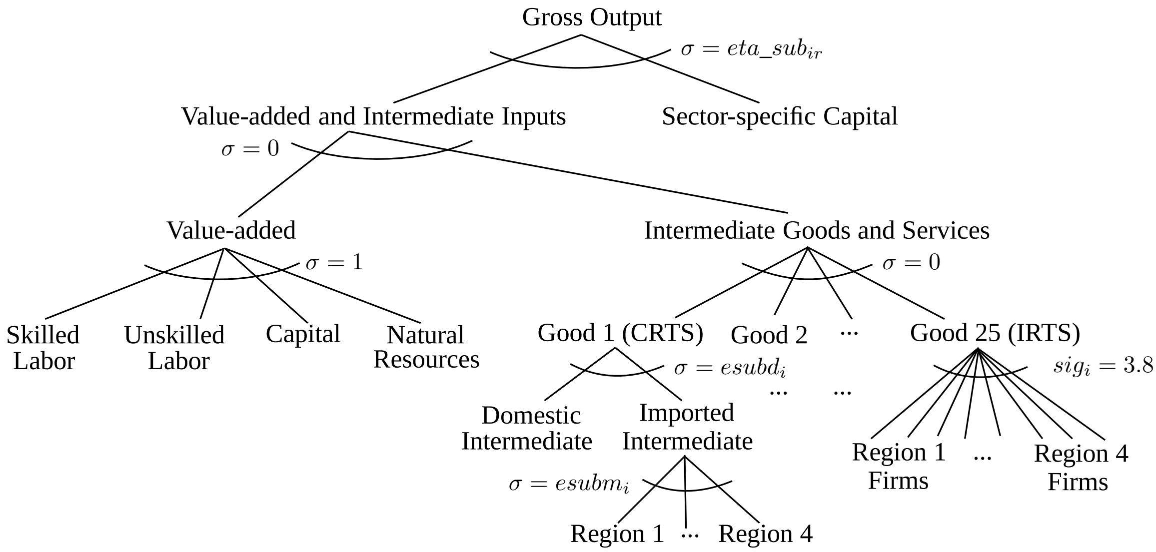
Melitz [2003] introduces a model with monopolistic competition within and across borders but adds competitive selection of heterogeneous firms. Just as in the Krugman model differentiated firm-level goods are aggregated according to the Dixit-Stiglitz specification of preferences, but these varieties are produced under firm specific productivity draws. Firms incur a sunk cost associated with realizing a given productivity. With the productivity realized and a well defined demand system the firm selects into or out of each potential bilateral market. Firms face market-specific fixed costs, and the relationship between the fixed costs and productivity indicates if a given bilateral market will be profitable for the firm. Firms with high productivity will service multiple (export) markets. Whereas firms with low productivity will only service the domestic market, or find it optimal to simply exit. Given a Pareto distribution of productivity draws the model of competitive selection is well specified. The exit and entry induced by changes in trade costs naturally reallocates resources with in the industry from more or less productive firms. Thus in the Melitz [2003] model overall productivity is impacted through the competitive selection of firms into export markets.

4 Model description

Our empirical model is directly developed from the model presented by Balistreri & Rutherford [2012]. The backbone of the modeling exercise consists of a standard CGE model with perfect competition, constant returns to scale and regional differentiation (Armington). Though, we allow for imperfect competition and increasing returns to scale in some manufacturing sectors and services. Figure 1 illustrates the structure of production for each sector and region of the model. It involves a combination of intermediate inputs and primary factors. We assume a Cobb-Douglas function over the mobile primary factors (skilled and unskilled labor, capital and natural resources)[8] and a Leontief production function combining intermediate goods and services with the factors of production composite. Sector-specific capital enters the top nest of the production function together with an aggregate of mobile production factors and intermediate inputs with an elasticity of substitution eta_sub_{ir}, which is calibrated according to the specific elasticity of supply

[8]These production factors are mobile across sectors within a region, but immobile across regions.

Figure 1: Production structure



used for modeling of Krugman and Melitz based goods.[9]

Each region of the model has two agents: a government and a single representative household. Consumption of final goods is given by a Cobb-Douglas utility function over sectoral commodity bundles. Final as well as intermediate demand are composed of the same Armington aggregate of domestic and imported goods. In the CRTS formulation, this Armington aggregate is modeled as a nested CES function where consumers first allocate their expenditures among domestic and foreign goods and then decide between imported varieties from different regions (this structure is presented for good 1 in Figure 1). Allowing for imperfect competition and IRTS in some selected manufacturing sectors and services, we differentiate between domestic and foreign products on the firm level. This requires an assumption of the same elasticity between firms and products. Thus, the composite of differentiated firm level goods is modeled by a single level CES function with all domestic and imported varieties competing directly (this structure is illustrated for good 25 in Figure 1). General equilibrium is then defined by zero profits for all producers, balanced budgets for representative households and government in each region, as well as market clearance for all goods and factor markets.

The description of our general equilibrium (GE) model still does not include the specification of Krugman and Melitz formulation for the IRTS sectors as these are captured by two partial equilibrium (PE) models. Thus, we use a decomposition algorithm[10] described by Balistreri & Rutherford [2012] which subdivides the system into two related equilibrium problems:

⇒ A PE model either for Krugman or for Melitz industrial organization and

[9] This supply elasticity is used in the partial equilibrium models for Krugman and Melitz formulation, which are described later in this section.

[10] This technique is also used by Balistreri *et al.* [2011].

⇒ A constant-returns GE model of global trade in composite input bundles.

The PE models incorporate the industrial organization in selected IRTS sectors and the associated impact on prices as well as on productivity in case of Melitz structure. Hereby, aggregate income and supply schedules are taken as given. The GE model takes industrial structure as given (including bilateral trade patterns, price indices, number of operating firms and productivity) and determines relative prices, comparative advantage and the terms of trade. Thus, we iterate between the two subsystems so that industrial structure is passed from the PE to the GE module, whereas aggregate demand and supply prices of inputs are passed back from the GE to the PE module. We iterate until the models get consistent and we receive a solution to the multi-regional and multi-sectoral general equilibrium with monopolistic competition and even competitive selection of heterogenous firms (in Melitz formulation). Solving the industrial organization models in isolation from aggregate income changes allows us to avoid dealing with computational limits caused by excessively high dimensionalities that would otherwise arise in case of a large number of commodities, regions and agents.

Let us now specify the equations of the two PE models. In terms of notation $i \in I$ indicate a commodity or sector, $r \in R$ and $s \in R$ indicate a region. The set of commodities is decomposed into the Armington, Krugman ($k \in K \subset I$) and Melitz ($m \in M \subset I$) goods. All the equations of PE models are listed in Table 1 together with associated variables.

Table 1: Equations of the partial equilibrium models

Equation description	Associated variable		Equation number Krugman	Equation number Melitz
Demand by sector	P_{kr} or P_{mr}:	Composite commodity price	(1)	(1)
Composite price index	Q_{kr} or Q_{mr}:	Aggregate quantity	(2)	(7)
Firm-level demand	p_{krs} or $\tilde{p}_{mrs}$:	Firm-level price	(3)	(8)
Firm-level price	q_{krs} or $\tilde{q}_{mrs}$:	Firm output	(4)	(9)
Firm-level productivity	$\tilde{\varphi}_{mrs}$:	Average productivity		(12)
Free entry (zero profit)	N_{kr} or M_{mr}:	Entered firms	(5)	(11)
Composite-input market	c_{kr} or c_{mr}:	Unit cost index	(6)	(13)
Zero cutoff profits	N_{mrs}:	Number of operating firms		(10)

In both PE models producers face the same regional demand (Q_{kr}) for the sectoral composite commodity (including imported and domestic varieties) which is determined in the GE. At this point we present the aggregate demand equation only for Krugman[11] goods:

$$Q_{kr} = \bar{Q}_{kr} \left(\frac{\bar{P}_{kr}}{P_{kr}} \right)^{\eta}, \tag{1}$$

where $\eta \geq 0$[12] is the price elasticity of demand, P_{kr} is a composite price of commodity k

[11] The aggregate demand equation for Melitz goods is the same, only index k is replaced by m.

[12] The price elasticity of demand is assumed to be equal 0.75.

in region r and symbols with a bar indicate benchmark (calibrated) levels. Thus, for each iteration of the PE model aggregate demand is recentered on the last GE solution point.

Specifying Krugman PE model first, let p_{krs} be the firm-level price (gross of trade cost and taxes) set by a firm from region r selling in market s. Then the Dixit-Stiglitz price index for a composite commodity k in region s is given by:

$$P_{ks} = \left[\sum_r \lambda_{krs} N_{kr} p_{krs}^{1-\sigma_k} \right]^{\frac{1}{1-\sigma_k}}, \tag{2}$$

where $\sigma_k > 1$ is the elasticity of substitution, λ_{krs} indicates the bilateral preference weights and N_{kr} is the number of active firms in region r. The corresponding bilateral firm-level demand q_{krs} (i.e. import quantity delivered to region s by a firm from r) is defined by:

$$q_{krs} = \lambda_{krs} Q_{kr} \left(\frac{P_{ks}}{p_{krs}} \right)^{\sigma_k}. \tag{3}$$

Assuming large-group monopolistic competition we allow firms to have market power over their unique variety. However, their pricing has a negligible impact on the composite price P_{ks}, so they face a constant-elasticity demand with P_{ks} assumed constant. The firms maximize their profits by setting a price with an optimal markup over marginal cost:

$$p_{krs} = \frac{\tau_{krs} c_{kr} (1 + t_{krs})}{1 - \frac{1}{\sigma_k}}, \tag{4}$$

where t_{krs} indicates the tariff rate and c_{kr} is a composite input unit cost, so that $\tau_{krs} c_{kr}$ constitute the marginal cost of delivering product k from region r to s under the iceberg cost assumption.

As the firms incur a fixed cost f_k[13] in addition to marginal cost, zero profit condition indicates that the number of firms (a complementary variable) will adjust so that nominal fixed cost payments equal profits:

$$c_{kr} f_k = \sum_s \frac{p_{krs} q_{krs}}{\sigma_k (1 + t_{krs})}. \tag{5}$$

The last equation of the Krugman PE model is a market clearance condition for the composite input:

$$\bar{Y}_{kr} \left(\frac{c_{kr}}{\bar{c}_{kr}} \right)^{\mu} = N_{kr} (f_k + \sum_s \tau_{krs} q_{krs}). \tag{6}$$

The left-hand side represents the regional input supply Y_{kr} with the supply elasticity $\mu \geq 0$[14] which is determined in the GE and recentered on the last GE solution for each iteration. The right-hand side constitutes the total demand for composite inputs where

[13] f_k is measured in composite input units as well as the iceberg trade cost τ_{krs}

[14] This supply elasticity is taken into account by calibrating the top nest elasticity eta_sub_{ir}.

τ_{krs} is considered as a real cost of delivering q_{krs} units to the foreign market.

Specifying the Melitz PE model we can see in Table 1 that it includes the same equations as the Krugman model. However, according to heterogeneity of firms it additionally includes firm-level productivity and zero-cutoff-profit condition which determines the competitive selection of firms into the various bilateral markets. As the firms are heterogenous and have market power over their unique varieties, there is a continuum of firm-level prices, quantities and productivities. Following the initial Melitz's representation, we simplify this by using a representative (or average) firm's price $\tilde{p}_{mrs}$,[15] quantity $\tilde{q}_{mrs}$ and productivity $\tilde{\varphi}_{mrs}$. Considering this simplification we get a similar to the Krugman specification Dixit-Stiglitz price index for a composite commodity m in region s:

$$P_{ms} = \left[\sum_r \lambda_{mrs} N_{mrs} \tilde{p}_{mrs}^{1-\sigma_m} \right]^{\frac{1}{1-\sigma_m}}, \tag{7}$$

where N_{mrs} is the number of firms operating on the r to s link. Demand for variety of the average firm shipping from r to s at a gross of trade costs and taxes price $\tilde{p}_{mrs}$ is:

$$\tilde{q}_{mrs} = \lambda_{mrs} Q_{mr} \left(\frac{P_{ms}}{\tilde{p}_{mrs}} \right)^{\sigma_m}. \tag{8}$$

Having the same assumptions as in the Krugman model, the average firm chooses an optimal price $\tilde{p}_{mrs}$:

$$\tilde{p}_{mrs} = \frac{\tau_{mrs} c_{mr} (1 + t_{mrs})}{\tilde{\varphi}_{mrs} \left(1 - \frac{1}{\sigma_m} \right)}, \tag{9}$$

where the level of marginal cost is determined by the productivity of the average firm: $c_{mr}/\tilde{\varphi}_{mrs}$.

Let M_{mr} denote the number of entered firms in region r. We assume that each of the entered firms choosing to pay entry cost receives a firm-specific productivity draw φ from a Pareto distribution. Taking the fixed cost of operation on the r to s link (f_{mrs}) into account, there will be a marginal firm with the level of productivity such that the operating profits are zero. Linking this marginal firm in a given bilateral market to a representative firm with positive profits,[16] we can specify a zero-cutoff-profit condition in terms of average firm revenues:

$$c_{mr} f_{mrs} = \frac{\tilde{p}_{mrs} \tilde{q}_{mrs}}{(1 + t_{mrs})} \frac{(a + 1 - \sigma_m)}{a \sigma_m}, \tag{10}$$

where a is the shape parameter of the Pareto distribution.[17] This condition defines the

[15] $\tilde{p}_{mrs}$ is defined as the price set by a small firm with the CES weighted average productivity $\tilde{\varphi}_{mrs}$.

[16] Detailed description is provided by Balistreri & Rutherford [2012], pp. 13-14, Balistreri *et al.* [2011], pp.98-99.

[17] This shape parameter of Pareto distribution is assumed to be 4.582, the central value estimated by Balistreri *et al.* [2011].

number of operating firms (N_{mrs}) meaning that the average-firm revenues ($\tilde{p}_{mrs}\tilde{q}_{mrs}$) fall with more firms shipping from r to s.

Each of the entered firms pays fixed entry costs of f^s_{mr} input units, so the nominal entry payment is equal to $c_{mr}f^s_{mr}$. Let δ be a probability of a bad shock that forces exit in each future period. Considering this, the firm-level annualized flow of entry payments is $c_{mr}\delta f^s_{mr}$. Setting these entry payments equal to the expected profits[18] from each potential market derives the free entry condition:

$$c_{mr}\delta f^s_{mr} = \sum_s \frac{\tilde{p}_{mrs}\tilde{q}_{mrs}}{(1+t_{mrs})}\frac{(\sigma_m - 1)}{a\sigma_m}\frac{N_{mrs}}{M_{mr}}, \tag{11}$$

where N_{mrs}/M_{mr} indicate the probability that a firm from M_{mr} will operate in the market s. Given this probability and applying the Pareto distribution[19] we get the productivity of the average firm:

$$\tilde{\varphi}_{mrs} = b\left(\frac{a}{a+1-\sigma_m}\right)^{\frac{1}{\sigma_m - 1}}\left(\frac{N_{mrs}}{M_{mr}}\right)^{-\frac{1}{a}}, \tag{12}$$

where b is the minimum productivity determined by the Pareto distribution.[20]

After specifying the number of entered and operating firms, we can close the PE model with the market clearance condition for the composite input:

$$Y_{mr} = \delta f^s_{mr}M_{mr} + \sum_s N_{mrs}\left(f_{mrs} + \frac{\tau_{mrs}\tilde{q}_{mrs}}{\tilde{\varphi}_{mrs}}\right). \tag{13}$$

Supply of the composite input (Y_{mr}) is consistent with the Krugman PE model (left-hand side of the equation (6)), whereas composite input demand consists of three components:

1. inputs used in fixed entry costs ($\delta f^s_{mr}M_{mr}$),
2. inputs used in operating fixed costs ($\sum_s N_{mrs}f_{mrs}$) as well as
3. operating inputs ($\sum_s N_{mrs}\frac{\tau_{mrs}\tilde{q}_{mrs}}{\tilde{\varphi}_{mrs}}$).

Calibration issues concerning the both PE models are fully described by Balistreri & Rutherford [2012].

5 Data sources and scenarios

Our model is calibrated to an aggregation of the GTAP 8.1 dataset. Table 2 shows sectors, primary factors of production and regions included. To analyze the DCFTA

[18] Average profit of a firm from r operating in s is given by $\tilde{\pi}_{mrs} = \frac{\tilde{p}_{mrs}\tilde{q}_{mrs}}{(1+t_{mrs})\sigma_m} - c_{mr}f_{mrs}$. Substituting the operating fixed cost with (10) leads to $\tilde{\pi}_{mrs} = \frac{\tilde{p}_{mrs}\tilde{q}_{mrs}}{(1+t_{mrs})}\frac{\sigma_m - 1}{a\sigma_m}$.

[19] For details see Balistreri *et al.* [2011], pp. 98-99.

[20] Following Bernard *et al.* [2007], this parameter is assumed to be equal 0.2.

between Ukraine and the EU we include these regions together with the Commonwealth of Independent States (CIS) and the rest of the world (ROW). Detailed mapping of regions is presented in Table A.10. The 57 GTAP sectors are aggregated into 25 activities which are to a large extent consistent with the activities of the national input-output table of Ukraine.[21] 9 sectors with a share of intra-industry trade (IIT) over 60% produce under increasing returns to scale technology. Table A.11 demonstrates the detailed aggregation of the GTAP sectors.

Table 2: Scope of the model

CRTS goods:		IIT*	Regions:	
AGR	Agriculture and hunting	57.55	UKR	Ukraine
FRS	Forestry	12.02	EU	EU
FSH	Fishing	4.67	CIS	CIS and Georgia
COL	Coal	42.71	ROW	Rest of the world
HDC	Production of hydrocarbons	13.25		
OMN	Minerals nec	86.69	Factors:	
FPI	Food-processing	56.89	lab	Unskilled labor
MET	Metallurgy and metal processing	30.05	skl	Skilled labor
OIL	Petroleum, coal products	51.28	cap	Capital
ELE	Electricity	0.62	res	Natural resources
GDT	Gas manufacture, distribution	0		
WTR	Water	0		
CNS	Construction	53.30		
FNI	Financial services, insurance	8.19		
ROS	Recreational and other services	50.43		
OSG	Public services	55.21		
IRTS goods:				
TEX	Textiles and leather	86.35		
CNM	Chemical and mineral products	91.04		
OMF	Manufactures nec	97.39		
WPP	Wood, paper products, publishing	89.75		
MEQ	Manufacture of machinery and equipment	85.46		
OBS	Business services nec	61.71		
TRD	Trade	89.97		
CMN	Communications	91.25		
TRS	Transport	65.24		

*Calculation of the intra-industry trade share (in %) is based on the UN Comtrade data.

All the distortions in the GTAP dataset (import tariffs, export subsidies and different taxes) are incorporated in the model. As Ukraine is the country in focus, we use import tariffs taken from the Law of Ukraine "About the Customs Tariff of Ukraine" including all amendments made due to Ukraine's accession to the WTO in 2008. Due to different types of tariff rates (ad valorem, specific and mixed) we use the WTO *et al.* [2007] methodology to calculate the ad valorem equivalents (AVEs) of specific and mixed tariffs. The resulting tariff rates are transformed from the HS2000 into the NACE Rev.1 using correspondence tables and applying different averages (simple, weighted, import-weighted). The applied import-weighted Most Favored Nation (MFN) tariff rates on Ukraine's imports are shown

[21] This aggregation helps to combine the GTAP data with the national data for Ukraine.

in Table A.12.[22]

To simulate the establishment of the DCFTA between Ukraine and the EU we also need to apply the AVEs for non-tariff barriers (NTBs) to trade and for barriers to efficient trade facilitation. The values of all applied distortions for Ukraine and the EU are presented in Table A.12 and A.13. Concerning NTBs, we aggregate the AVEs estimated by Kee *et al.* [2009]. We use the values for the Overall Trade Restrictiveness Index (OTRI) and for the Tariff-only OTRI (OTRI_T).[23] The first index measures the uniform tariff equivalent of the country's tariffs and NTBs that would generate the same level of import value for the country in a given year. The second one focuses only on tariffs of each country.[24] Both indices are available for over 100 countries and for only two types of aggregated products: agricultural and manufacturing goods. Calculating the difference between OTRI and OTRI_T gives us an AVE for NTBs only. These AVEs are aggregated first to the GTAP regions and then to the regions of our model according to mapping given in Table A.10. Hereby, we simply assign the calculated values for Ukraine and the EU, whereas for CIS and ROW we compute weighted averages using GTAP countries' total imports at market prices as weights.

Concerning the AVEs for poor trade facilitation, we use the values based on the research of Hummels [2007], Hummels *et al.* [2007] and Hummels & Schaur [2013]. They estimate the value of one day saved in transit for more than 600 HS 4-digit level products. Using these estimates Minor [2013] provides country and product specific AVEs for trade time costs as a separate package of the GTAP 8.1 database.[25] To calculate the overall trade time costs by country and product we combine these estimates with the number of days needed to export or import goods in each country taken from the World Bank's Doing Business dataset for 2012. Aggregating these values to the model-specific regions and sectors gives us the bilateral AVEs of time in trade to import or export goods. The use of bilateral and sector-specific AVEs of time in trade is an important improvement in comparison to most CGE modeling of trade facilitation issues with a single AVE across all products.

In order to analyze the DCFTA between Ukraine and the EU we conduct three different simulations. The first one (S1) reflects the simple FTA incorporating a bilateral elimination of import tariffs. In addition, we reduce the NTBs and barriers to efficient trade facilitation by 20% on the both sides in the second counterfactual simulation (S2).

[22]These tariff rates apply only to Ukraine's imports from the EU and from the rest of the world. Commodity trade with the CIS region is classified as free trade because of existing agreements between Ukraine and the CIS countries (since 1999).

[23]The dataset is available at `http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/0,,contentMDK:22574446~pagePK:64214825~piPK:64214943~theSitePK:469382,00.html`.

[24]We use the values for OTRI and OTRI_T based on applied tariffs which take into account the bilateral trade preferences.

[25]The dataset is available at `http://mygtap.org/resources/#Estimates`. It includes three different AVEs depending on the treatment of the missing values on the HS 4-digit level. As the first two methodologies are biased down, we apply the AVEs where missing estimates are replaced with the average value for the same GTAP category ($tau - 3$).

Table 3: Central scenarios

Policy	Trade structure		
	Armington	Krugman	Melitz
Tariffs	S1.A	S1.K	S1.M
Tariffs + 20% NTB + 20% trade facilitation	S2.A	S2.K	S2.M
Tariffs + 20% NTB + intra-EU trade facilitation	S3.A	S3.K	S3.M

An analysis of such a modest percentage cut is motivated by the fact that these barriers cannot be eliminated completely. Thus, to be able to simulate an upper bound for trade liberalization between Ukraine and the EU we reduce the trade facilitation barriers to the intra EU level in the third simulation (S3). For this purpose we use the existing barriers between Greece and Germany which are situated on the approximately similar distance as the average distance between Ukraine and the member countries of the EU.

For comparison of results under different trade theories we run each simulation three times (see Table 3). The first run of each counterfactual simulation (S1.A, S2.A and S3.A) provides the results under Armington trade formulation. In the second run (S1.K, S2.K and S3.K) we assume Krugman trade and in the third one we apply Melitz structure with competitive selection of heterogenous firms.

6 Results

The aggregate results of all counterfactual experiments are represented in Table 4. Trade liberalization occurs to be welfare increasing for Ukraine and the EU, what is supported by a rise in real GDP and real consumption. Thereby, higher reductions of trade barriers are associated with higher benefits for the both trade partners. However, while the EU can gain from the policy reform only with a small rise of welfare up to 0.05%, Ukraine's benefits are much higher with a welfare increase up to 12.31%. Only in scenario S1.K and S1.M Ukraine suffers from trade liberalization with a reduction of real GDP by approximately 0.1% and a decline of welfare by 0.16%. The reason is the trade-induced net exit of firms and therefore a lower number of available varieties in the monopolistic competitions models. This finding is consistent with Balistreri *et al.* [2010] and Arkolakis *et al.* [2012]. Due to trade liberalization only between Ukraine and the EU, the other regions are affected slightly negatively. While trade diversion from the rest of the world is relatively small and has almost no impact on real GDP, consumption and welfare, the CIS region suffers more from trade diversion with a welfare decrease between 0.01% and 0.12%.

The bilateral reduction of trade barriers between Ukraine and the EU leads to an increase in imports and exports in all scenarios. Moreover, the higher the reductions, the stronger the effects on exports and imports are observed. These changes are between 2.25% and 13.78% for Ukraine. For the EU the effects are also positive, but under 1% in all simulations. Taking competitive selection of heterogenous firms into account (S1.M, S2.M, S3.M) leads to the highest impacts on trade flows as there is a reallocation of resources towards most productive exporting firms. Concerning the other regions, we find a small diversion of trade from ROW and CIS. Hoverer, a decline of exports and imports in these regions remains under 0.7% across the simulations and the negative changes for ROW are smaller that for the CIS.

Table 4: Aggregate results

	S0	S1.A	S1.K	S1.M	S2.A	S2.K	S2.M	S3.A	S3.K	S3.M
Welfare (Hicksian welfare index), percentage change										
UKR		0,60	-0,19	-0,12	6,20	3,11	3,43	11,26	6,68	7,43
EU		0,00	0,00	0,00	0,01	0,02	0,03	0,03	0,05	0,05
CIS		-0,01	-0,01	-0,01	-0,05	-0,06	-0,05	-0,11	-0,11	-0,10
ROW		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Real GDP, bn USD										
UKR	64.6	64.8	64.5	64.6	66.5	65.5	65.6	68.1	66.5	66.8
EU	13269.6	13270.7	13270.6	13270.7	13271.7	13272.7	13272.8	13273.0	13275.0	13275.1
CIS	697.0	697.0	697.0	697.0	696.8	696.8	696.8	696.6	696.6	696.6
ROW	28166.2	28166.1	28166.4	28166.4	28165.8	28166.5	28166.6	28165.6	28166.5	28166.5
Reall GDP, percentage change										
UKR		0.28	-0.13	-0.10	2.96	1.36	1.55	5.38	2.97	3.39
EU		0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.04	0.04
CIS		-0.01	0.00	0.00	-0.03	-0.03	-0.02	-0.06	-0.06	-0.05
ROW		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Real Consumption, bn USD										
UKR	36.0	36.2	35.9	35.9	38.2	37.1	37.2	40.0	38.4	38.6
EU	7900.6	7900.8	7900.7	7900.7	7901.6	7902.5	7902.6	7902.7	7904.3	7904.4
CIS	365.8	365.7	365.7	365.7	365.6	365.6	365.6	365.4	365.4	365.4
ROW	17540.8	17540.5	17540.8	17540.8	17540.2	17540.9	17540.9	17540.0	17540.7	17540.8
Exports, percentage change										
UKR		2.45	2.99	3.75	4.89	7.30	9.11	7.44	10.97	13.78
EU		0.07	0.07	0.10	0.19	0.21	0.26	0.32	0.35	0.43
CIS		-0.09	-0.08	-0.12	-0.26	-0.25	-0.36	-0.39	-0.37	-0.55
ROW		-0.05	-0.05	-0.06	-0.11	-0.11	-0.13	-0.17	-0.17	-0.21
Imports, percentage change										
UKR		2.25	2.77	3.48	4.43	6.69	8.41	6.67	9.99	12.65
EU		0.06	0.07	0.08	0.17	0.19	0.23	0.29	0.31	0.39
CIS		-0.10	-0.08	-0.13	-0.33	-0.29	-0.41	-0.54	-0.47	-0.66
ROW		-0.04	-0.05	-0.05	-0.09	-0.09	-0.12	-0.14	-0.15	-0.18

Concerning factor earnings (see Table 5), we observe an increase of remuneration for all factors in Ukraine. Thus, the highest rise is found for unskilled labor and natural resources. This indicates a reallocation of production to the sectors producing with an intensive use of these two production factors.[26] For the EU we get somewhat opposite results. While factor returns for labor and capital rise slightly, the remuneration for provision of natural resources declines illustrating an opposite specialization of the EU. Concerning other regions, natural resources constitute the only production factor which loses from trade liberalization in ROW and benefits in the CIS region. That demonstrates a deepening of the CIS specialization on resource-intensive goods and away from them for ROW.

Comparing the Ukraine's welfare results across different trade theories we see that under

[26]Ukraine's specialization in labor-intensive goods is also found by Frey & Olekseyuk [2014].

Table 5: Factor earnings, change in %

	S1.A	S1.K	S1.M	S2.A	S2.K	S2.M	S3.A	S3.K	S3.M
Capital returns									
UKR	1.30	0.67	0.61	4.36	1.61	1.57	7.96	3.70	3.80
EU	0.02	0.02	0.02	0.04	0.06	0.05	0.05	0.08	0.08
CIS	-0.02	-0.02	-0.02	-0.08	-0.07	-0.09	-0.11	-0.10	-0.13
ROW	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01
Remuneration for the provision of natural resources									
UKR	-0.23	-0.15	0.01	2.01	2.71	2.97	5.17	5.89	6.53
EU	-0.03	-0.03	-0.04	-0.05	-0.09	-0.10	-0.08	-0.15	-0.16
CIS	0.02	0.00	-0.01	0.11	0.05	0.02	0.21	0.10	0.06
ROW	0.00	-0.01	-0.01	-0.01	-0.03	-0.05	-0.03	-0.06	-0.08
Skilled labor remuneration									
UKR	1.18	0.15	-0.07	4.84	0.50	0.10	8.81	2.12	1.67
EU	0.02	0.02	0.02	0.04	0.04	0.04	0.04	0.06	0.05
CIS	-0.02	-0.02	-0.03	-0.07	-0.10	-0.10	-0.10	-0.14	-0.14
ROW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unskilled labor remuneration									
UKR	2.33	1.39	1.22	6.96	3.10	2.85	12.24	6.40	6.23
EU	0.03	0.03	0.02	0.04	0.04	0.04	0.04	0.05	0.04
CIS	-0.02	-0.03	-0.03	-0.08	-0.11	-0.12	-0.11	-0.16	-0.17
ROW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Armington structure they are much higher than under Krugman and Melitz specification. This indicates that traditional CGE models may overstate the gains from the DCFTA between Ukraine and EU.

Table 6: Number of firms under Krugman trade formulation, change in %

	S1.K				S2.K				S3.K			
	UKR	EU	CIS	ROW	UKR	EU	CIS	ROW	UKR	EU	CIS	ROW
CMN	-0.61	-0.01	0.01	0.00	-0.53	0.00	0.03	0.00	-0.94	0.00	0.03	0.01
CNM	-11.43	0.02	0.11	0.01	-45.81	0.09	0.34	0.04	-77.25	0.17	0.63	0.07
MEQ	-0.88	0.00	-0.07	0.00	-1.38	0.00	-0.31	0.00	-1.52	0.00	-0.47	0.00
OBS	-0.61	-0.01	0.02	0.00	-0.90	0.00	0.04	0.01	-2.00	0.00	0.06	0.01
OMF	-6.19	0.00	0.02	0.01	-18.68	0.01	0.06	0.01	-28.57	0.03	0.09	0.01
TEX	5.86	0.00	-0.05	-0.01	7.50	0.01	-0.11	-0.01	8.76	0.02	-0.13	-0.01
TRD	-0.32	0.00	0.00	0.00	0.21	0.01	-0.01	0.00	0.45	0.02	-0.02	0.00
TRS	-0.71	0.00	0.01	0.00	-0.95	0.01	0.02	0.00	-2.20	0.03	0.03	0.00
WPP	-0.81	0.00	0.02	0.00	-24.74	0.03	0.24	0.01	-12.98	0.01	-0.09	0.01

Such diverging welfare results occur due to the weak trade links[27] and comparative disadvantage of Ukraine's IRTS goods on the EU markets. Under Krugman formulation policy reform induces an exit of Ukrainian firms in all IRTS sectors except textile industry (TEX) and trade services (TRD), while the number of European firms remains almost unchanged or slightly increased (see Table 6). Therefore, trade liberalization leads to a reduction of the set of goods produced in Ukraine. Under Melitz trade structure we can

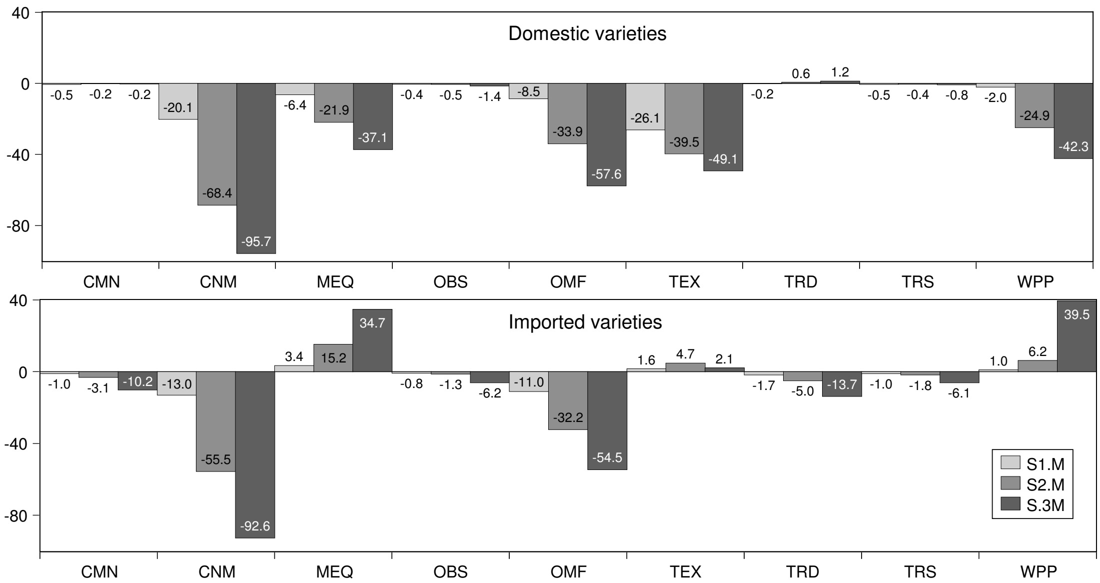
[27] The import shares of the EU from Ukraine are very low for the IRTS goods with the values between 0.22% and 1.12% (see Table A.14 in the appendix). Thus, for the CRTS goods there are import shares up to 10.6%. In Ukraine the situation is opposite. All the import shares from the EU are relatively high as the region is the most important trading partner after the CIS. Therefore, the import shares from the EU exceed 40% for the IRTS goods.

also observe a decline of number of Ukrainian firms operating in domestic and foreign markets for all IRTS sectors except manufacture of machinery and equipment (MEQ) and wood and paper industry (WPP) abroad (see Table A.15 in the appendix). Thus, the number of European firms operating in Ukraine increases strongly in all considered sectors. This approves the EU's comparative advantage in the IRTS goods on Ukrainian market.

Table 7: Consumed varieties and Feenstra ratio, change in %

Reported variable	IRTS sector	S1.M	S2.M	S3.M	S1.M	S2.M	S3.M
			Ukraine			EU	
Total varieties consumed	CMN	-0.62	-0.90	-2.71	0.01	0.18	0.83
	CNM	-18.34	-65.21	-94.93	1.71	5.11	7.16
	MEQ	-3.92	-12.59	-19.17	0.76	1.98	2.95
	OBS	-0.53	-0.67	-2.59	0.00	0.00	0.34
	OMF	-9.16	-33.49	-56.87	1.19	5.60	9.55
	TEX	-19.17	-28.47	-36.29	2.65	4.23	5.18
	TRD	-0.56	-0.77	-2.50	0.10	0.42	1.34
	TRS	-0.60	-0.72	-2.12	0.02	0.09	0.47
	WPP	-1.27	-17.11	-21.84	0.25	1.96	3.29
Feenstra ratio	CMN	-0.15	0.02	0.20	0.00	0.00	0.00
	CNM	0.58	5.57	9.56	0.00	0.01	0.01
	MEQ	0.00	3.18	6.20	0.00	0.00	0.01
	OBS	-0.10	-0.08	-0.05	0.00	0.00	0.00
	OMF	0.11	3.69	6.77	0.00	0.00	0.00
	TEX	0.93	4.71	7.02	0.00	0.01	0.02
	TRD	-0.03	0.32	0.73	0.00	0.00	0.01
	TRS	-0.09	0.01	0.25	0.00	0.01	0.01
	WPP	0.07	3.57	7.85	0.00	0.00	0.02

Figure 2: Domestic and imported varieties in Ukraine, change in %



The percentage changes in the number of firms under Melitz trade structure indicate the number of varieties consumed. While the number of total varieties consumed in the EU increases across all the IRTS sectors (see Table 7), it falls in Ukraine due to reduction of both domestic and imported varieties (see Figure 2).[28] However, counting up the varieties to explain the welfare changes along the extensive margin can be misleading as the varieties enter the expenditure system under different prices. Comparing equilibriums t versus $t-1$, Feenstra [2010] shows that the variety gains can be measured by deviations in the following ratio from unity:

$$\left(\frac{\lambda_{hr}^{t}}{\lambda_{hr}^{t-1}}\right)^{-1/(\sigma_h-1)},$$

where λ_{hr}^{z} is region-r's share of expenditures at equilibrium z on good-h varieties available in both equilibria to the total expenditures on good-h varieties at z. The bottom panel of Table 7 shows the percentage change of this Feenstra ratio. The results indicate no losses along the extensive margin for the EU. Though, for Ukraine we observe some losses from liberalization-induced changes in the number of varieties, in particular, in such sectors as business services (OBS), communications (CMN), transport (TRS) and trade (TRD).

Table 8: Productivity growth, in %

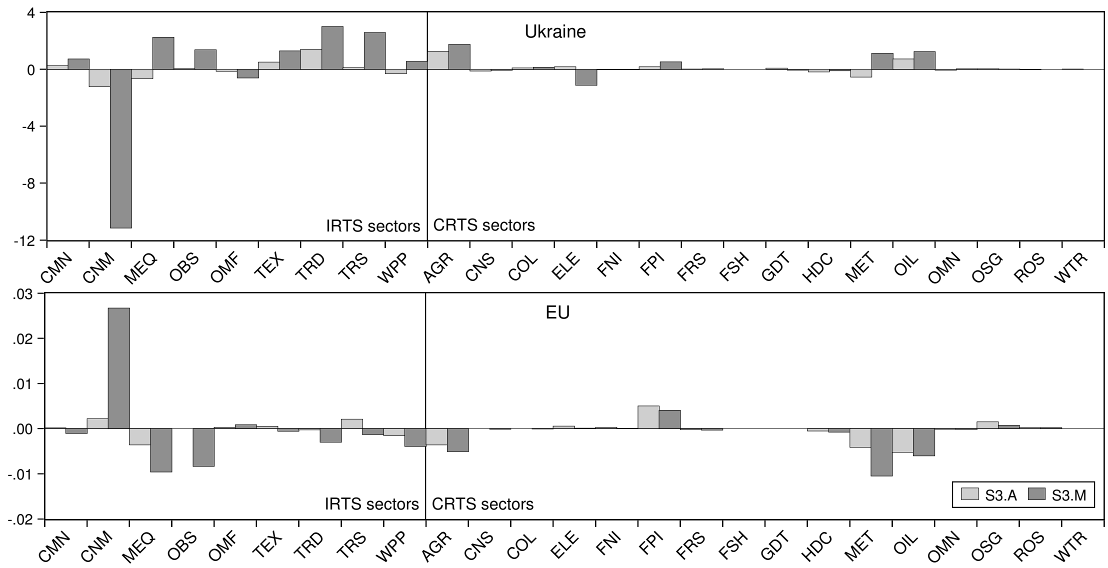
Reported variable	IRTS sector	S1.M	S2.M	S3.M	S1.M	S2.M	S3.M
		Ukraine			EU		
	CMN	-0,01	-0,06	-0,21	0,00	0,00	0,00
	CNM	1.25	5.35	8.93	0.01	0.02	0.03
	MEQ	1.31	5.44	10.77	0.00	0.01	0.01
Domestic firm	OBS	-0.01	-0.02	-0.13	0.00	0.00	0.00
productivity growth	OMF	-0.15	0.38	1.07	0.00	0.01	0.02
(φ_{mrr})	TEX	8.24	13.53	18.23	0.02	0.03	0.03
	TRD	-0.02	-0.07	-0.19	0.00	0.00	0.00
	TRS	-0.03	-0.10	-0.38	0.00	0.00	0.00
	WPP	0.34	4.09	12.83	0.00	0.00	0.01
	CMN	-0.02	-0.13	-0.48	0.00	0.02	0.07
	CNM	1.43	5.76	9.00	0.13	0.20	0.16
	MEQ	1.53	5.94	10.39	0.07	0.14	0.17
Industry wide	OBS	-0.02	-0.04	-0.25	0.00	0.00	0.03
productivity growth	OMF	-0.22	0.43	1.10	0.09	0.17	-0.01
($\sum_s \frac{N_{mrs}}{\sum_t N_{mrt}} \varphi_{mrs}$)	TEX	8.61	13.72	17.82	0.18	0.20	0.20
	TRD	-0.06	-0.22	-0.62	0.01	0.04	0.10
	TRS	-0.04	-0.13	-0.52	0.00	0.01	0.04
	WPP	0.41	4.58	11.66	0.02	0.13	0.18

In addition to variety effects, under Melitz formulation we detect higher changes in aggregate productivity for Ukraine than for the EU (see Table 8). For such Ukrainian sec-

[28] Only manufacture of machinery and equipment (MEQ), textiles (TEX) and wood and paper industry (WPP) demonstrate an increase of imported varieties in Ukraine.

tors as chemicals and production of mineral products (CNM), machinery and equipment (MEQ), textiles (TEX), wood and paper industry (WPP) we find a strong productivity growth across Ukrainian firms active in their domestic market. This indicates an exit of the least productive firms due to import competition. However, this measure does not incorporate the industry wide productivity gains attributed to entry of relative productive firms into export markets. Such an impact is captured by the weighted average productivity across all markets, which rises for the same sectors. Comparing the both measures we can see that productivity is growing because of domestic exit and not because of selection into export markets, as the domestic firms' productivity growth is relatively large.

Figure 3: Revenue shares, change in %



Described productivity changes occur together with entry of new firms in the mentioned sectors and therefore with reallocation effects. Figure 3 illustrates sectoral reallocation by examining how revenue shares of gross output change.[29] We see that in Ukraine the revenue shares of machinery and equipment (MEQ), textiles (TEX), wood and paper industry (WPP), trade (TRD) and transport (TRS), increase up to three percentage points. Moreover, most of this reallocation comes from the lost share of chemical and mineral products (CNM).[30] Concerning the reallocation effects in the EU, they are mach smaller and opposite to the changes in Ukraine.

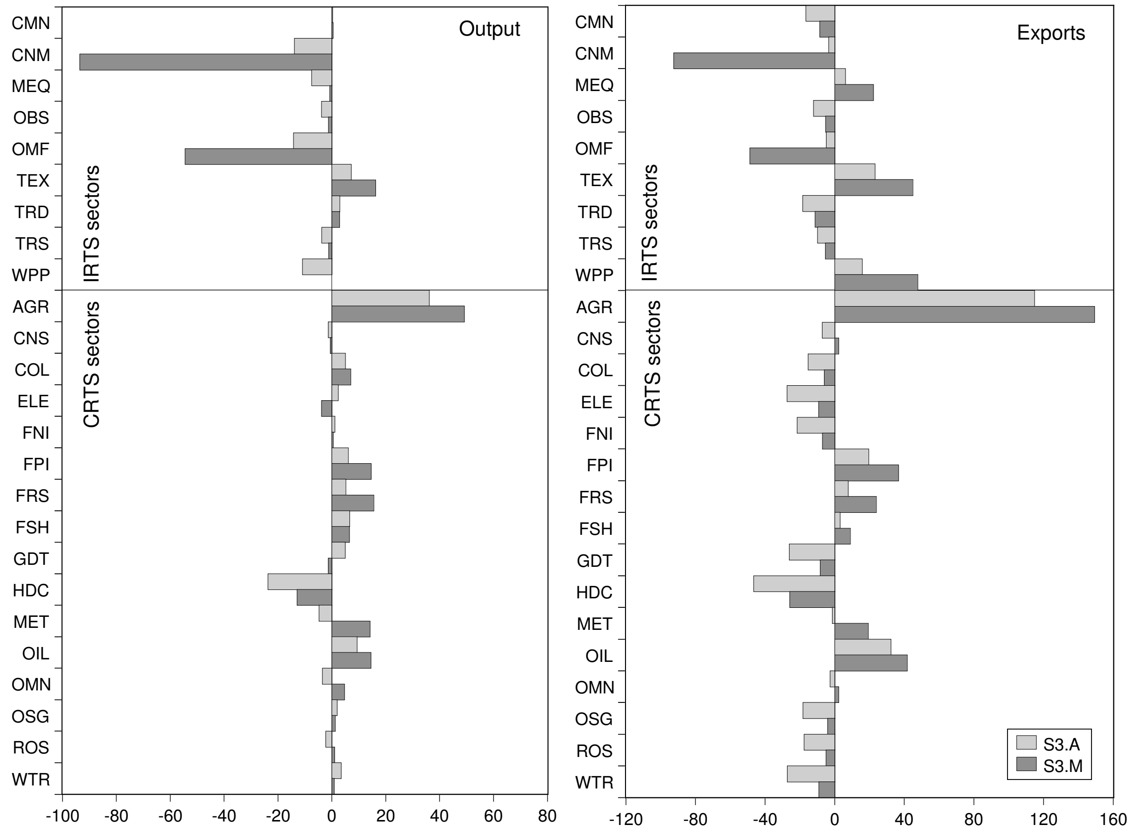
Concerning disaggregate results (see Figure 4 and Tables A.16 and A.17 in the appendix), the highest increase of output and exports is observed in Ukrainian sectors such as agriculture, food processing, textile and leather industry, forestry and petroleum in-

[29] The revenue share for sector i is given by $c_{ir}Q_{ir}/\sum_j c_{ir}Q_{ir}$.

[30] In this sector we observe a strong decrease of number of existed and entered firms meaning that productivity growth is driven by an exit of unproductive firms.

dustry. As all of these sectors except textiles produce under constant returns to scale, this confirms Ukraine's comparative disadvantage in the IRTS goods. The European expanding sectors with increased exports include chemical and mineral products, food processing, other manufacturing and textiles.

Figure 4: Disaggregate results for Ukraine, change in %



7 Robustness

To check the sensitivity of our results with respect to assumed values of the key parameters and elasticities, we conduct a number of robustness checks. First of all we execute a piecemeal sensitivity analysis which shows how the results change when we vary the value of parameters one-by-one. This means that we run the model with central values for all parameters except the one under consideration. Table 9 illustrates the lower and upper bound of parameters assumed for sensitivity analysis whereas the welfare results are shown in Tables A.18 and A.19. Only the elasticity of substitution between firm varieties in imperfectly competitive sectors (sig) has a very strong impact on the model outcome. Under Melitz trade structure we observe negative welfare results for Ukraine in all three scenarios at the low end of the elasticity rage (2.4 in all IRTS sectors). Therefore, a lower value of *sig* leads to a qualitative switch of the welfare results for Ukraine in S2.M and S3.M while the welfare gains rise for the EU. Lower values of this elasticity imply that varieties are less close substitutes meaning that additional varieties are worth more. Though, the negative welfare results for Ukraine are intuitive given the net loss of varieties illustrated before. The opposite case is observed for the EU: the increased number of total varieties causes higher welfare gains at the lower end of *sig*. However, the lower the elasticity *sig* the higher are the mark-ups on variable costs which is unrealistic at some point. Moreover, the assumed central value of 3.8 seems to be realistic as it follows the plant-level empirical analysis of Bernard *et al.* [2003].

Table 9: Piecemeal sensitivity analysis: parameter values

	Parameter	lower	central	upper
esubd	Elasticity of substitution between imported and domestic goods (CRTS)	×0.5	×1	×1.5
esubm	Elasticity of substitution between imported goods from different regions (CRTS)	×0.5	×1	×1.5
sig	Inter-variety elasticity of substitution (IRTS)	2*	3.8	5.6
esuppy	Resource supply elasticity (IRTS PE)	0.5	2	3.5
a	Shape parameter for the Pareto distribution (Melitz)**	3.924	4.582	5.171

*For Melitz structure we used the lower bound on *sig* of 2.4 to avoid numerical instability.

**All assumed values for *a* are estimated by Balistreri *et al.* [2011].

We also check how the results change in the following cases:

- The elasiticities of substitution in the CRTS sectors (*esubd* and *esubm*) are equal to the elasticity of substitution between firm varieties ($sig = 3.8$) or to the doubled elasticity ($2sig = 7.6$);
- The Armington elasticities of substitution in the CRTS sectors (*esubd*) are equal to the doubled GTAP elacticities.

As all the welfare results are very close to the initial outcomes (see Table A.20), our results appear rather robust to the values of aforementioned elasticities.

The last robustness check is devoted to equivalence of results under Armington and Melitz structure. Dixon *et al.* [2014] show in a stylized model with two sectors, two regions and one factor of production that the results of Armington model with the elasticity of substitution of 8.45 are equivalent to the results of Melitz model with the elasticity of 3.8. Assuming 8.45 for *sig* (and for *esubd*) for Armington structure and 3.8 for Melitz structure, we run all three scenarios and observe still different welfare results which are pretty close to the initial values (see Table A.20). This indicates that the real world complexities accommodated in a multi-region and multi-sector CGE model with several production factors lead to diverging results under different trade theories.

8 Conclusions

To analyze the establishment of the DCFTA between Ukraine and the EU we develop a GTAP 8.1 based multi-regional general-equilibrium simulation model with three different setups. First is a standard specification of manufacturing and services trade based on perfect competition and the Armington assumption of regionally differentiated goods. Second, we consider Krugman [1980] style monopolistic competition in the manufacturing and services sectors. Third, we elaborate upon the monopolistic competition structure to include competitive selection of heterogenous firms as proposed by Melitz [2003]. Considering these alternative structures allows us to evaluate trade growth in new varieties and changes of aggregate productivity due to the reallocation of resources across as well as within an industry, among more or less productive firms. Standard simulations of integration and trade liberalization between the EU and Ukraine, which only consider perfect competition, fail to consider these effects. We provide new insights into the possible outcomes of integration through the lens of the new trade theories.

Simulating trade liberalization between Ukraine and the EU by reduction of NTBs and barriers to efficient trade facilitation as well as tariff elimination, we find relatively large increases in real income and substantial welfare impact for Ukraine (up to 12.31%). In comparison, the EU benefits less with the highest welfare gain of 0.05% as the share of European trade with Ukraine is quite low. The trade policy reform leads to significant trade growth between the partners. The effects are larger under the Melitz trade structure due to reallocation of resources to the most productive exporting firms. The results on factor remuneration indicate a deeper specialization of Ukraine in labor and resource-intensive goods whereas an opposite specialization is observed for the EU. Considering the other regions, there is limited trade diversion from ROW and CIS combined with a slight decrease in real GDP and welfare mainly for the CIS region, which is specialized in the resource-intensive goods.

A comparison of the welfare results for Ukraine across the different model specifications shows that the impact is much higher under Armington structure than under Krugman or Melitz trade formulation. This result runs contrary to much of the literature (e.g., Balistreri *et al.* [2011]) which generally predicts larger gains under monopolistic competition. Ukraine's deep integration with the EU, however, intensifies import competition in the increasing returns sectors, while inducing a movement of resources into Ukraine's traditional export sectors which produce under constant returns (agriculture). Consistent with Balistreri *et al.* [2010] and Arkolakis *et al.* [2012] the gains from trade can be lower under an assumption of monopolistic competition if trade reduces the set of goods produced. This is our finding for Ukraine. This insight may carry over to many other developing countries that specialize in labor and resource-intensive goods produced under constant returns to scale (see, e.g., Akyüz [2003], p. 48). The implication is that traditional numeric simulation models may overstate the overall gains from trade liberalization for developing countries.

We caution, however, that our static model does not include capital flows, and so EU firms supply Ukraine's markets on a cross-border bases only. Allowing for capital flows and FDI might change the story if liberalization induced EU firms to engage in FDI, which would increase the number of EU varieties available in Ukraine while at the same time increasing demand for Ukrainian workers. Incorporation of FDI is an important consideration for further research.

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9 Appendix

Table A.10: Mapping of the GTAP regions

Aggregate regions	GTAP 8.1 regions	
UKR	UKR	Ukraine
EU	AUT	Austria
	BEL	Belgium
	DNK	Denmark
	FIN	Finland
	FRA	France
	DEU	Germany
	GRC	Greece
	IRL	Ireland
	ITA	Italy
	LUX	Luxembourg
	NLD	Netherlands
	PRT	Portugal
	ESP	Spain
	SWE	Sweden
	GBR	United Kingdom
	CYP	Cyprus
	CZE	Czech Republic
	EST	Estonia
	HUN	Hungary
	LVA	Latvia
	LTU	Lithuania
	MLT	Malta
	POL	Poland
	SVK	Slovakia
	SVN	Slovenia
	BGR	Bulgaria
	ROU	Romania
	HRV	Croatia
CIS	XEE	Moldova Rep. of
	BLR	Belarus
	RUS	Russian Federation
	KAZ	Kazakhstan
	KGZ	Kyrgyzstan
	ARM	Armenia
	XSU	Rest of Former Soviet Union
		-Tajikistan
		-Turkmenistan
		-Uzbekistan
	AZE	Azerbaijan
	GEO	Georgia
ROW		All other GTAP regions

Table A.11: Mapping of GTAP sectors

Model specific sectors		GTAP 8.1 sectors	
		CRTS Sectors	
AGR	Agriculture and hunting	PDR	Paddy rice
		WHT	Wheat
		GRO	Cereal grains nec
		V_F	Vegetables fruit nuts
		OSD	Oil seeds
		C_B	Sugar cane sugar beet
		PFB	Plantbased fibers
		OCR	Crops nec
		CTL	Bovine cattle sheep and goats horses
		OAP	Animal products nec
		RMK	Raw milk
		WOL	Wool silk worm cocoons
FRS	Forestry	FRS	Forestry
FSH	Fishing	FSH	Fishing
COL	Coal	COA	Coal
HDC	Production of hydrocarbons	OIL	Oil
		GAS	Gas
OMN	Minerals nec	OMN	Minerals nec
FPI	Food-processing	CMT	Bovine meat products
		OMT	Meat products nec
		VOL	Vegetable oils and fats
		MIL	Dairy products
		PCR	Processed rice
		SGR	Sugar
		OFD	Food products nec
		B_T	Beverages and tobacco products
OIL	Petroleum, coal products	P_C	Petroleum, coal products
MET	Metallurgy and metal processing	I_S	Ferrous metals
		NFM	Metals nec
		FMP	Metal products
ELE	Electricity	ELY	Electricity
GDT	Gas manufacture, distribution	GDT	Gas manufacture distribution
WTR	Water	WTR	Water
CNS	Construction	CNS	Construction
FNI	Financial services, insurance	OFI	Financial services nec
		ISR	Insurance
ROS	Recreational and other services	ROS	Recreational and other services
OSG	Public services	OSG	Public administration, defense, education, health
		IRTS Sectors	
TEX	Textiles and leather	TEX	Textiles
		WAP	Wearing apparel
		LEA	Leather products
CNM	Chemical and mineral products	CRP	Chemical rubber plastic products
		NMM	Mineral products nec
OMF	Manufactures nec	OMF	Manufactures nec
WPP	Wood, paper products, publishing	LUM	Wood products
		PPP	Paper products, publishing
MEQ	Manufacture of machinery and equipment	MVH	Motor vehicles and parts
		OTN	Transport equipment nec
		ELE	Electronic equipment
		OME	Machinery and equipment nec
OBS	Business services nec	OBS	Business services nec
TRD	Trade	TRD	Trade
CMN	Communication	CMN	Communication
TRS	Transport	OTP	Transport nec
		WTP	Water transport
		ATP	Air transport

Table A.12: Benchmark distortions for Ukraine, in %

Sector		Import tariffs*	NTBs	Barriers to efficient trade facilitation on Ukraine's exports to			Barriers to efficient trade facilitation on Ukraine's imports from		
				EU	CIS	ROW	EU	CIS	ROW
FRS	Forestry	1.71	3.30	8.03	8.03	8.03	13.05	13.05	13.05
FSH	Fishing	5.00	3.30	5.05	5.86	4.16	7.87	4.94	7.91
OIL	Petroleum, coal products	1.63	19.40	15.96	15.96	15.96	25.93	25.93	25.93
OMN	Minerals nec	2.23		7.20	7.20	7.20	11.70	11.72	11.70
TEX	Textiles and leather	8.06	19.40	4.92	5.64	4.99	9.70	11.47	8.73
ELE	Electricity	3.50	19.40						
OMF	Manufactures nec	1.85	19.40	7.98	8.68	7.54	14.70	12.22	13.49
COL	Coal	0.00							
GDT	Gas manufacture, distribution		19.40						
WTR	Water		19.40						
AGR	Agriculture and hunting	5.63	3.30	17.57	18.77	16.51	24.48	30.92	27.11
HDC	Production of hydrocarbons	0.50	19.40						
FPI	Food-processing	13.66	19.40	12.25	11.17	12.03	21.95	16.62	19.58
WPP	Wood, paper products, publishing	0.98	19.40	4.73	13.50	8.94	19.91	21.44	14.27
CNM	Chemical and mineral products	4.06	19.40	12.13	14.07	11.29	18.90	22.01	19.91
MET	Metallurgy and metal processing	1.93	19.40	14.85	15.38	15.55	16.56	21.88	17.26
MEQ	Manufacture of machinery and equipment	3.09	19.40	5.03	6.90	5.35	14.69	15.55	17.33

*Tariff rates on imports from the EU and ROW.

Table A.13: Benchmark distortions for the EU, in %

Sector		Import tariffs*	NTBs	Barriers to efficient trade facilitation on the EU's exports to			Barriers to efficient trade facilitation on the EU's imports from		
				EU	CIS	ROW	EU	CIS	ROW
FRS	Forestry	0.51	27.00	4.65	4.69	5.40	6.75	4.99	5.35
FSH	Fishing	4.46	27.00	2.95	3.14	2.79	3.27	2.05	2.94
OIL	Petroleum, coal products	1.19	2.30	12.11	11.13	10.80	16.92	12.06	11.96
OMN	Minerals nec	0.21		7.67	5.38	5.17	6.31	4.87	4.41
TEX	Textiles and leather	7.04	2.30	5.09	4.98	4.83	3.48	4.08	3.37
ELE	Electricity	0.00	2.30						
OMF	Manufactures nec	0.09	2.30	6.41	5.79	5.53	5.02	3.70	4.17
COL	Coal		2.30						
GDT	Gas manufacture, distribution		2.30						
WTR	Water	0.00							
AGR	Agriculture and hunting	19.40	27.00	10.06	10.10	9.14	14.26	13.14	10.94
HDC	Production of hydrocarbons	0.00							
FPI	Food-processing	12.56	2.30	10.13	8.31	6.77	9.05	7.62	6.81
WPP	Wood, paper products, publishing	0.53	2.30	9.39	7.96	7.16	3.35	4.40	5.05
CNM	Chemical and mineral products	2.13	2.30	8.93	7.58	6.27	9.46	7.72	6.37
MET	Metallurgy and metal processing	1.38	2.30	7.87	7.03	8.28	12.29	9.49	7.82
MEQ	Manufacture of machinery and equipment	0.47	2.30	6.43	5.57	4.82	3.87	4.50	4.63

*Tariff rates on imports from Ukraine.

Table A.14: Benchmark trade shares for Ukraine and the EU, in %

	The EU import shares from:			Ukrainian import shares from:		
	CIS	ROW	UKR	CIS	EU	ROW
CRTS Sectors						
AGR	2.32	96.44	1.23	19.53	35.21	45.26
CNS	9.40	90.20	0.39	3.42	53.16	43.42
COL	18.13	80.91	0.97	99.38	0.03	0.59
ELE	16.31	73.09	10.60	6.54	60.29	33.17
FNI	0.84	99.09	0.08	0.37	52.14	47.50
FPI	1.97	97.04	0.99	19.67	40.18	40.15
FRS	34.98	61.89	3.13	70.31	11.61	18.08
FSH	0.37	99.61	0.02	0.43	44.22	55.36
GDT	63.25	34.77	1.98	5.26	11.02	83.72
HDC	30.57	69.41	0.01	99.48	0.01	0.51
MET	15.89	80.60	3.51	43.80	42.77	13.44
OIL	29.33	66.16	4.51	74.73	19.17	6.11
OMN	6.58	90.80	2.61	29.45	15.64	54.91
OSG	1.70	97.52	0.78	0.78	29.44	69.78
ROS	1.55	98.11	0.34	0.47	44.95	54.58
WTR	5.97	92.80	1.23	2.65	39.39	57.96
IRTS sectors						
CMN	3.52	95.60	0.88	1.22	51.90	46.87
CNM	3.84	95.35	0.81	26.83	54.51	18.66
MEQ	0.43	99.35	0.22	18.37	60.09	21.53
OBS	2.79	96.87	0.34	0.94	58.75	40.31
OMF	2.08	97.65	0.27	3.25	53.66	43.09
TEX	1.30	97.69	1.01	6.47	53.32	40.21
TRD	1.70	97.74	0.56	1.21	46.98	51.81
TRS	4.65	94.30	1.05	1.99	43.28	54.73
WPP	6.41	92.47	1.12	19.68	72.74	7.58
	The EU export shares to:			Ukrainian export shares to:		
	CIS	ROW	UKR	CIS	EU	ROW
CRTS Sectors						
AGR	10.61	87.55	1.85	14.46	35.60	49.94
CNS	31.13	67.69	1.18	10.99	50.78	38.23
COL	6.83	92.88	0.29	7.90	67.80	24.29
ELE	22.83	75.78	1.39	25.56	61.83	12.61
FNI	3.52	95.93	0.55	1.70	41.48	56.82
FPI	8.72	90.20	1.09	59.23	18.84	21.93
FRS	3.50	96.26	0.24	1.17	51.81	47.02
FSH	2.88	96.66	0.46	12.20	37.75	50.05
GDT	3.54	96.28	0.18	0.78	58.13	41.09
HDC	0.02	99.97	0.02	0.06	37.21	62.73
MET	5.21	93.82	0.97	20.03	25.96	54.01
OIL	2.24	97.06	0.69	8.21	61.27	30.52
OMN	1.71	97.65	0.64	11.24	73.67	15.09
OSG	4.47	94.81	0.72	1.93	28.32	69.75
ROS	6.51	92.58	0.91	2.72	48.75	48.53
WTR	7.93	90.95	1.12	2.86	47.63	49.52
IRTS sectors						
CMN	6.61	92.67	0.72	2.32	53.68	43.99
CNM	5.36	93.47	1.17	21.99	33.14	44.87
MEQ	5.47	93.57	0.96	49.88	19.37	30.74
OBS	5.82	93.58	0.59	2.14	51.42	46.44
OMF	4.05	95.19	0.76	8.09	56.75	35.16
TEX	7.32	90.55	2.13	5.80	78.74	15.46
TRD	4.91	94.43	0.66	2.76	47.73	49.51
TRS	4.35	95.00	0.65	1.94	45.04	53.02
WPP	8.17	90.03	1.80	45.84	41.59	12.57

Table A.15: Number of operating firms under Melitz trade formulation, change in %

	S1.M				S2.M				S3.M			
	UKR	EU	CIS	ROW	UKR	EU	CIS	ROW	UKR	EU	CIS	ROW
Number of Ukrainian firms operating in foreign and domestic markets												
CMN	-0.50	-0.92	-1.08	-1.00	-0.17	-2.90	-3.37	-3.05	-0.22	-9.89	-10.49	-10.08
CNM	-20.12	-6.22	-16.26	-16.54	-68.44	-45.09	-60.53	-61.00	-95.71	-89.38	-94.14	-94.25
MEQ	-6.36	5.45	2.30	2.52	-21.85	25.91	9.39	10.30	-37.12	86.73	8.13	9.20
OBS	0.00	-0.70	-0.86	-0.79	-0.47	-1.09	-1.53	-1.25	-1.40	-5.91	-6.47	-6.10
OMF	-8.54	-10.66	-11.22	-11.19	-33.94	-25.22	-35.68	-35.58	-57.65	-41.37	-61.15	-61.08
TEX	-26.10	30.26	-12.72	-12.69	-39.53	41.99	-13.98	-13.86	-49.09	52.83	-23.28	-23.14
TRD	-0.18	-1.61	-1.79	-1.67	0.64	-4.75	-5.32	-4.88	1.22	-13.37	-14.08	-13.53
TRS	-0.48	-0.90	-1.02	-0.93	-0.36	-1.66	-2.02	-1.69	-0.79	-6.01	-6.39	-5.98
WPP	-2.03	3.00	0.03	0.06	-24.89	15.43	1.45	1.79	-42.28	112.12	2.78	3.53
Number of European firms operating in foreign and domestic markets												
CMN	0.42	-0.01	-0.17	-0.09	2.81	0.00	-0.49	-0.16	10.74	0.01	-0.66	-0.21
CNM	20.34	0.00	0.27	-0.07	60.16	0.03	1.03	-0.17	83.72	0.07	1.74	-0.22
MEQ	9.48	-0.01	-0.26	-0.05	25.02	-0.02	-0.92	-0.09	37.06	-0.05	-1.08	-0.09
OBS	0.26	0.00	-0.16	-0.09	0.63	0.00	-0.44	-0.16	4.81	0.01	-0.59	-0.19
OMF	14.53	-0.01	-0.09	-0.05	67.82	-0.02	-0.30	-0.13	115.29	-0.01	-0.34	-0.17
TEX	32.64	-0.07	-0.09	-0.06	52.05	-0.10	-0.28	-0.13	63.74	-0.13	-0.32	-0.14
TRD	1.45	0.00	-0.18	-0.06	5.66	0.01	-0.59	-0.13	16.87	0.02	-0.80	-0.16
TRS	0.42	0.00	-0.13	-0.04	1.34	0.01	-0.34	-0.01	5.59	0.04	-0.37	0.06
WPP	3.20	0.00	-0.10	-0.07	24.29	-0.01	-0.48	-0.15	40.93	-0.06	-0.80	-0.08

Table A.16: Disaggregate results for Ukraine, change in %

		S1.A	S1.K	S1.M	S2.A	S2.K	S2.M	S3.A	S3.K	S3.M
						Output				
IRTS sectors	CMN	-0,43	-0,33	-0,23	0,22	0,58	0,72	0,21	0,75	0,43
	CNM	-2.38	-11.04	-15.04	-9.40	-45.20	-59.44	-13.91	-76.86	-93.56
	MEQ	-1.48	-1.27	-0.84	-5.07	-2.77	-1.29	-7.50	-3.70	-0.80
	OBS	-0.74	-0.36	-0.19	-1.93	-0.16	0.28	-3.86	-1.25	-1.23
	OMF	-2.93	-5.64	-8.64	-9.89	-17.57	-31.82	-14.28	-27.06	-54.51
	TEX	6.10	9.21	9.91	6.18	11.60	13.01	7.17	14.11	16.18
	TRD	0.12	0.13	0.19	1.77	1.78	1.90	2.90	2.98	2.83
	TRS	-0.63	-0.30	-0.13	-1.85	-0.04	0.32	-3.77	-1.23	-1.16
	WPP	-1.13	-0.77	-0.33	-9.26	-25.27	-10.82	-10.94	-14.37	-0.06
CRTS sectors	AGR	14.43	15.49	16.06	24.26	29.82	31.52	36.05	46.26	49.12
	CNS	0.02	0.24	0.19	-0.80	0.14	-0.14	-1.39	-0.09	-0.57
	COL	-0.04	0.16	0.25	1.88	2.99	3.11	4.98	6.63	6.92
	ELE	0.00	-0.77	-1.01	1.28	-2.11	-2.73	2.27	-3.12	-3.85
	FNI	-0.07	-0.21	-0.16	0.74	0.29	0.39	1.04	0.27	0.47
	FPI	4.45	5.28	5.79	4.86	8.60	10.15	6.08	12.32	14.49
	FRS	-1.34	-0.13	0.26	3.79	8.82	10.35	5.10	13.79	15.52
	FSH	0.96	0.75	0.90	3.93	3.21	3.72	6.52	5.55	6.43
	GDT	0.04	-0.83	-0.99	2.68	-0.88	-1.40	4.91	-0.93	-1.36
	HDC	-3.96	-2.22	-1.63	-12.86	-5.74	-4.68	-23.72	-14.41	-12.91
	MET	-1.91	0.44	1.24	-1.69	9.09	11.01	-4.79	11.41	14.08
	OIL	0.53	1.07	1.30	3.82	6.56	7.06	9.33	13.69	14.46
	OMN	-0.97	0.08	0.45	-1.75	2.97	3.82	-3.56	3.44	4.63
	OSG	0.36	0.23	0.25	1.25	0.81	0.85	1.88	1.08	1.23
	ROS	-0.87	-0.51	-0.25	-1.20	0.44	1.08	-2.30	0.02	0.96
	WTR	0.04	-0.37	-0.38	1.86	0.28	0.24	3.35	0.73	0.83
						Exports				
IRTS sectors	CMN	-2.17	-1.09	-0.65	-9.07	-2.21	-1.85	-16.50	-7.01	-8.54
	CNM	-0.25	-10.04	-12.66	-1.79	-42.51	-55.09	-3.39	-75.31	-92.50
	MEQ	0.61	0.83	2.71	2.93	5.53	11.85	6.13	10.65	22.13
	OBS	-1.79	-0.96	-0.46	-6.50	-1.56	-0.34	-12.24	-5.62	-5.28
	OMF	-3.04	-7.26	-10.35	-5.29	-16.34	-28.70	-4.79	-23.04	-48.75
	TEX	14.95	18.50	25.31	19.02	25.71	35.94	23.08	31.92	44.81
	TRD	-2.71	-1.27	-1.19	-10.20	-2.71	-3.31	-18.34	-7.85	-11.31
	TRS	-1.42	-0.98	-0.63	-5.14	-1.48	-0.82	-9.91	-5.20	-5.37
	WPP	-0.19	0.12	1.43	2.04	-19.28	6.03	15.71	10.12	47.73
CRTS sectors	AGR	43.69	46.64	47.76	73.65	89.27	92.49	114.79	143.43	149.27
	CNS	-1.29	-0.47	0.35	-2.63	1.08	3.58	-7.11	-1.43	2.28
	COL	-1.99	-0.66	-0.15	-7.44	-1.97	-0.77	-15.23	-7.39	-5.94
	ELE	-5.49	-2.45	-1.58	-15.58	-3.47	-1.67	-27.41	-11.30	-9.22
	FNI	-4.03	-1.67	-1.02	-12.56	-3.31	-1.80	-21.57	-8.62	-7.02
	FPI	14.39	16.34	17.17	17.03	25.57	28.03	19.43	33.27	36.58
	FRS	-2.42	-0.43	0.14	6.14	15.40	16.83	7.67	22.09	23.83
	FSH	3.57	4.32	4.60	4.97	8.24	8.96	3.04	8.00	8.91
	GDT	-5.26	-2.41	-1.52	-14.70	-3.13	-1.19	-26.07	-10.56	-8.28
	HDC	-7.33	-3.26	-1.73	-26.13	-11.56	-8.11	-46.53	-29.58	-25.87
	MET	-1.62	0.94	1.78	0.63	12.38	14.44	-1.34	16.44	19.28
	OIL	1.76	2.65	3.01	12.61	16.99	17.94	32.27	40.01	41.57
	OMN	-0.50	0.12	0.36	-1.51	1.20	1.74	-2.59	1.45	2.18
	OSG	-3.05	-0.89	-0.19	-10.11	-1.51	0.21	-18.30	-5.98	-4.04
	ROS	-3.02	-1.15	-0.53	-9.81	-2.10	-0.70	-17.54	-6.72	-4.98
	WTR	-5.44	-2.43	-1.52	-15.53	-3.52	-1.59	-27.30	-11.34	-9.04
						Imports				
IRTS sectors	CMN	1.67	0.93	0.71	9.90	3.54	3.66	18.67	8.77	10.95
	CNM	3.51	7.31	9.42	4.96	19.62	25.11	5.92	30.95	34.32
	MEQ	1.23	1.61	2.53	-0.28	1.05	4.29	-1.69	0.23	5.55
	OBS	0.92	0.78	0.55	4.27	2.01	1.45	7.79	4.86	5.00
	OMF	3.68	6.40	9.45	15.43	23.21	38.62	24.40	37.15	66.15
	TEX	7.23	6.99	10.51	9.99	9.47	14.70	12.69	11.96	18.35
	TRD	2.80	1.58	1.73	12.74	5.30	6.52	24.06	12.03	17.07
	TRS	0.64	0.78	0.69	3.32	2.20	2.10	6.17	5.04	5.64
	WPP	1.01	1.51	2.02	2.64	13.93	11.42	4.81	10.42	17.89
CRTS sectors	AGR	13.03	12.66	12.77	26.36	25.00	25.60	45.75	44.47	45.58
	CNS	0.36	0.43	0.15	-0.34	-0.09	-1.07	0.11	0.25	-1.30
	COL	1.07	0.64	0.52	6.19	4.61	4.20	14.50	11.76	11.37
	ELE	8.67	6.55	5.96	21.25	11.45	10.04	29.52	13.90	12.16
	FNI	1.24	0.38	0.26	5.00	1.56	1.26	8.68	3.25	3.02
	FPI	14.30	13.71	13.79	24.99	22.71	23.04	33.14	29.73	30.49
	FRS	2.00	1.56	1.57	7.23	4.06	5.37	13.71	10.71	12.12
	FSH	3.81	3.49	3.62	7.47	6.30	6.75	11.03	9.34	10.18
	GDT	2.23	0.21	-0.28	10.73	1.91	0.65	19.34	4.99	3.62
	HDC	-0.25	-0.47	-0.59	1.23	0.70	0.05	3.60	2.38	1.77
	MET	1.59	2.06	2.33	6.96	9.90	10.72	9.56	14.49	15.92
	OIL	1.24	1.49	1.61	6.37	7.83	8.03	12.46	14.71	15.03
	OMN	-1.56	0.28	0.90	-2.26	6.17	7.60	-5.64	6.75	8.79
	OSG	1.47	0.61	0.42	5.02	1.55	1.05	8.92	3.37	2.91
	ROS	0.51	0.04	0.06	3.73	1.83	1.96	6.65	3.71	4.04
	WTR	2.33	0.71	0.36	12.65	5.46	4.68	20.97	9.47	8.63

Table A.17: Disaggregate results for the EU, change in %

		S1.A	S1.K	S1.M	S2.A	S2.K	S2.M	S3.A	S3.K	S3.M
						Output				
IRTS sectors	CMN	0.01	0.01	0.01	0.02	0.02	0.02	0.04	0.04	0.04
	CNM	0.02	0.05	0.06	0.04	0.16	0.20	0.05	0.28	0.33
	MEQ	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02
	OBS	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.04	0.04
	OMF	0.00	0.01	0.01	0.03	0.04	0.06	0.05	0.07	0.11
	TEX	0.01	0.01	0.01	0.03	0.03	0.03	0.05	0.04	0.05
	TRD	0.00	0.00	0.00	0.01	0.02	0.02	0.03	0.04	0.04
	TRS	0.01	0.01	0.01	0.03	0.02	0.02	0.05	0.04	0.05
	WPP	0.01	0.01	0.01	0.02	0.07	0.03	0.00	0.04	-0.01
CRTS sectors	AGR	0.01	0.00	0.00	-0.08	-0.12	-0.12	-0.21	-0.28	-0.29
	CNS	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03
	COL	0.01	0.00	0.00	0.02	-0.02	-0.02	0.03	-0.02	-0.02
	ELE	0.03	0.02	0.02	0.04	0.03	0.02	0.06	0.04	0.04
	FNI	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.03
	FPI	0.09	0.09	0.09	0.11	0.11	0.11	0.13	0.12	0.12
	FRS	0.01	0.00	0.00	-0.05	-0.05	-0.07	-0.08	-0.11	-0.14
	FSH	0.03	0.03	0.03	0.05	0.05	0.05	0.06	0.06	0.06
	GDT	0.01	0.01	0.01	0.02	0.01	0.00	0.05	0.02	0.02
	HDC	-0.09	-0.10	-0.10	-0.16	-0.23	-0.24	-0.21	-0.33	-0.35
	MET	0.02	0.01	0.00	-0.06	-0.15	-0.15	-0.09	-0.24	-0.25
	OIL	0.00	-0.01	-0.01	-0.10	-0.12	-0.12	-0.30	-0.33	-0.33
	OMN	0.02	0.02	0.02	0.01	-0.01	-0.01	-0.01	-0.03	-0.02
	OSG	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.04
	ROS	0.01	0.00	0.00	0.01	0.02	0.02	0.03	0.04	0.04
	WTR	0.02	0.01	0.01	0.02	0.03	0.03	0.03	0.04	0.04
						Exports				
IRTS sectors	CMN	-0.03	-0.05	-0.08	0.00	-0.09	-0.14	0.06	-0.07	-0.12
	CNM	0.09	0.16	0.21	0.25	0.52	0.69	0.38	0.85	1.00
	MEQ	0.03	0.03	0.04	0.07	0.06	0.12	0.13	0.12	0.22
	OBS	-0.04	-0.05	-0.08	-0.04	-0.10	-0.15	-0.02	-0.10	-0.15
	OMF	0.03	0.04	0.07	0.20	0.23	0.41	0.35	0.42	0.75
	TEX	0.41	0.41	0.64	0.66	0.62	0.99	0.86	0.79	1.23
	TRD	-0.02	-0.03	-0.04	0.02	-0.06	-0.10	0.10	-0.02	-0.06
	TRS	-0.02	-0.02	-0.03	0.00	-0.02	-0.02	0.07	0.06	0.08
	WPP	0.00	0.00	0.00	0.14	0.38	0.29	0.34	0.40	0.61
CRTS sectors	AGR	0.59	0.57	0.57	1.36	1.21	1.22	2.73	2.49	2.50
	CNS	-0.03	-0.03	-0.04	-0.06	-0.08	-0.10	-0.02	-0.06	-0.10
	COL	-0.04	-0.04	-0.04	-0.03	-0.05	-0.05	0.02	-0.01	-0.01
	ELE	0.24	0.16	0.14	0.67	0.30	0.25	1.01	0.44	0.38
	FNI	-0.04	-0.04	-0.04	-0.03	-0.07	-0.06	0.00	-0.07	-0.06
	FPI	0.68	0.66	0.66	1.19	1.06	1.05	1.58	1.36	1.36
	FRS	-0.03	-0.04	-0.03	0.05	-0.01	-0.02	0.18	0.08	0.09
	FSH	0.03	0.03	0.03	0.06	0.04	0.05	0.11	0.08	0.09
	GDT	-0.07	-0.10	-0.10	-0.03	-0.18	-0.19	0.05	-0.18	-0.19
	HDC	-0.15	-0.13	-0.12	-0.17	-0.19	-0.15	-0.16	-0.18	-0.14
	MET	0.11	0.07	0.07	0.64	0.44	0.43	1.10	0.82	0.81
	OIL	0.05	0.05	0.06	0.39	0.39	0.39	0.81	0.80	0.81
	OMN	0.01	0.02	0.02	0.04	0.05	0.06	0.06	0.09	0.10
	OSG	-0.03	-0.05	-0.04	0.00	-0.08	-0.08	0.06	-0.07	-0.07
	ROS	-0.04	-0.05	-0.04	-0.02	-0.08	-0.07	0.02	-0.06	-0.05
	WTR	-0.05	-0.07	-0.07	0.22	0.04	0.04	0.38	0.10	0.10
						Imports				
IRTS sectors	CMN	0.04	0.05	0.08	0.03	0.10	0.15	0.00	0.11	0.16
	CNM	0.09	0.02	0.05	0.18	-0.12	-0.07	0.26	-0.31	-0.29
	MEQ	0.03	0.04	0.05	0.06	0.07	0.12	0.12	0.14	0.24
	OBS	0.05	0.06	0.09	0.07	0.12	0.17	0.08	0.15	0.20
	OMF	0.02	0.02	0.02	0.06	0.05	0.07	0.09	0.06	0.07
	TEX	0.22	0.23	0.34	0.31	0.34	0.51	0.40	0.44	0.65
	TRD	0.02	0.03	0.05	0.02	0.08	0.11	0.01	0.09	0.12
	TRS	0.02	0.03	0.04	0.00	0.02	0.02	-0.04	-0.05	-0.07
	WPP	0.06	0.07	0.11	0.18	-0.04	0.32	0.60	0.54	1.30
CRTS sectors	AGR	0.81	0.83	0.84	1.65	1.86	1.90	2.80	3.23	3.30
	CNS	0.05	0.05	0.05	0.06	0.08	0.09	0.06	0.09	0.10
	COL	0.02	0.02	0.02	0.01	0.00	-0.01	-0.02	-0.04	-0.04
	ELE	-0.38	-0.14	-0.08	-1.13	-0.13	0.00	-2.12	-0.76	-0.61
	FNI	0.05	0.05	0.05	0.07	0.09	0.09	0.09	0.13	0.12
	FPI	-0.14	-0.12	-0.12	0.11	0.23	0.25	0.42	0.65	0.68
	FRS	0.04	0.07	0.08	0.57	0.78	0.79	0.83	1.17	1.17
	FSH	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	GDT	0.03	0.06	0.06	0.03	0.15	0.17	-0.03	0.15	0.17
	HDC	0.02	0.01	0.01	-0.05	-0.08	-0.09	-0.18	-0.22	-0.24
	MET	0.00	0.06	0.08	0.82	1.22	1.27	1.36	2.05	2.14
	OIL	0.08	0.09	0.10	0.62	0.69	0.71	1.60	1.74	1.77
	OMN	0.02	0.02	0.02	0.00	-0.02	-0.01	-0.02	-0.05	-0.05
	OSG	0.04	0.05	0.05	0.03	0.08	0.08	0.02	0.09	0.09
	ROS	0.05	0.05	0.04	0.06	0.09	0.09	0.06	0.12	0.11
	WTR	0.05	0.07	0.07	0.01	0.13	0.13	-0.07	0.10	0.10

Table A.18: Piecemeal sensitivity analysis: welfare results for Ukraine, change in %

	S1.A			S1.K			S1.M		
	lower	central	upper	lower	central	upper	lower	central	upper
esubd	0.71	0.60	0.52	-0.22	-0.19	-0.17	-0.14	-0.12	-0.11
esubm	0.29	0.60	0.78	-0.08	-0.19	-0.37	-0.02	-0.12	-0.29
sig	0.74	0.60	0.52	-0.32	-0.19	-0.16	-8.50	-0.12	-0.16
esuppy	0.60	0.60	0.60	-0.14	-0.19	-0.20	-0.10	-0.12	-0.11
a	0.60	0.60	0.60	-0.19	-0.19	-0.19	-0.15	-0.12	-0.11
	S2.A			S2.K			S2.M		
esubd	6.49	6.20	5.96	3.03	3.11	3.18	3.37	3.43	3.49
esubm	5.15	6.20	7.03	3.33	3.11	2.62	3.51	3.43	2.87
sig	6.54	6.20	6.10	2.35	3.11	3.52	-5.12	3.43	3.52
esuppy	6.16	6.20	6.21	3.18	3.11	3.10	3.43	3.43	3.45
a	6.20	6.20	6.20	3.11	3.11	3.11	3.29	3.43	3.54
	S3.A			S3.K			S3.M		
esubd	11.71	11.26	10.90	6.50	6.68	6.85	7.42	7.43	7.51
esubm	9.36	11.26	13.13	6.85	6.68	6.07	7.44	7.43	7.78
sig	11.46	11.26	11.47	4.60	6.68	7.71	-4.90	7.43	7.71
esuppy	11.18	11.26	11.29	6.78	6.68	6.65	7.52	7.43	7.46
a	11.26	11.26	11.26	6.68	6.68	6.68	7.13	7.43	7.70

Table A.19: Piecemeal sensitivity analysis: welfare results for the EU, change in %

	S1.A			S1.K			S1.M		
	lower	central	upper	lower	central	upper	lower	central	upper
esubd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
esubm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sig	0.00	0.00	0.00	0.00	0.00	0.00	1.55	0.00	0.00
esuppy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S2.A			S2.K			S2.M		
esubd	0.01	0.01	0.01	0.02	0.02	0.03	0.02	0.03	0.03
esubm	0.01	0.01	0.01	0.02	0.02	0.03	0.02	0.03	0.03
sig	0.01	0.01	0.01	0.03	0.02	0.02	1.57	0.03	0.02
esuppy	0.01	0.01	0.01	0.02	0.02	0.03	0.02	0.03	0.03
a	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03
	S3.A			S3.K			S3.M		
esubd	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.05	0.05
esubm	0.03	0.03	0.03	0.04	0.05	0.06	0.04	0.05	0.06
sig	0.02	0.03	0.03	0.06	0.05	0.05	2.03	0.05	0.05
esuppy	0.03	0.03	0.03	0.04	0.05	0.05	0.04	0.05	0.05
a	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.05	0.05

Table A.20: Other robustness checks

	S1.A	S1.K	S1.M	S2.A	S2.K	S2.M	S3.A	S3.K	S3.M
				Ukraine					
Initial values for elasticities	0.60	-0.19	-0.12	6.20	3.11	3.43	11.26	6.68	7.43
$esubd_i = 3.8$	0.54	-0.17	-0.10	6.05	3.19	3.50	11.04	6.86	7.54
$esubd_i = 7.6$	0.35	-0.10	-0.04	5.52	3.42	3.68	10.24	7.30	7.89
$esubm_i = 3.8$	0.49	-0.14	-0.08	5.64	3.20	3.42	10.30	6.72	7.33
$esubm_i = 7.6$	0.90	-0.38	-0.31	7.09	2.47	2.69	13.40	5.77	7.50
$esubm_i = 3.8$ & $esubd_i = 3.8$	0.41	-0.11	-0.06	5.44	3.27	3.48	9.99	6.86	7.45
$esubm_i = 7.6$ & $esubd_i = 7.6$	0.63	-0.28	-0.22	6.42	2.81	2.99	12.46	6.10	7.84
$esubd \times 2$	0.45	-0.15	-0.09	5.76	3.26	3.55	10.60	7.00	7.62
$sig_i = 8.45$	0.45			6.18			12.22		
$sig_i = 3.8$			-0.12			3.43			7.43
$sig_i = 8.45$ & $esubd_i = 8.45$	0.29			5.75			11.58		
$sig_i = 3.8$ & $esubd_i = 3.8$			-0.10			3.50			7.54
				EU					
Initial values for elasticities	0.00	0.00	0.00	0.01	0.02	0.03	0.03	0.05	0.05
$esubd_i = 3.8$	0.00	0.00	0.00	0.01	0.03	0.03	0.03	0.05	0.05
$esubd_i = 7.6$	0.00	0.01	0.01	0.01	0.03	0.03	0.03	0.06	0.06
$esubm_i = 3.8$	0.00	0.00	0.00	0.01	0.02	0.02	0.03	0.04	0.04
$esubm_i = 7.6$	0.00	0.00	0.00	0.01	0.03	0.03	0.03	0.06	0.06
$esubm_i = 3.8$ & $esubd_i = 3.8$	0.00	0.00	0.00	0.01	0.02	0.02	0.02	0.04	0.04
$esubm_i = 7.6$ & $esubd_i = 7.6$	0.00	0.01	0.01	0.02	0.04	0.04	0.03	0.08	0.08
$esubd \times 2$	0.00	0.01	0.01	0.01	0.03	0.03	0.03	0.05	0.05
$sig_i = 8.45$	0.00			0.02			0.03		
$sig_i = 3.8$			0.00			0.03			0.05
$sig_i = 8.45$ & $esubd_i = 8.45$	0.01			0.02			0.03		
$sig_i = 3.8$ & $esubd_i = 3.8$			0.00			0.03			0.05