Using the Logistic Functional Form for Modelling International

Price Transmission in Net Trade Simulation Models

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Abstract:

Various reasons including cif/fob spread, differing political price protection depending on the net trade situation, and domestic transportation cost contribute to situations in which domestic prices are different in an exporting compared to an importing situation. Net trade models that take these differences into account must somehow deal with the problem of products that are not exported at the export-based price, because it is too low, and are not imported at the import-based price, because it is too high. In such a case, the equilibrium price lies somewhere between the export- and the import-based price. This paper presents the application of the Logistic functional form for depicting price transmission from international to domestic prices in the net trade model ESIM.

On the basis of the EU beef market it is shown that the Logit functional form is a flexible tool for the formulation of price transmission in net trade models. A smooth transition can be depicted from an import to an export based price. Also the effects of TRQs and quantity restricted export subsidies can be included.

Preliminary results of the application of this approach to the EU beef market show that each, the abolishment of ES as well as the doubling of preferential market access for beef, may result in a price decline on the EU market of 7-9% and the EU would become a net importer of beef under both options. Combined, the price decline may amount 15% and net exports may amount 15% of EU domestic use.

1   Introduction

In the real world, various reasons including cif/fob spread, differing political price protection depending on the net trade situation, and domestic transportation cost contribute to situations in which domestic prices are different in an exporting compared to an importing situation. In bilateral trade models using the Armington approach, this poses no problem as different price wedges are typically imposed for imports and exports at the same time and adjustments to price

changes are smooth. For net trade models, however, different price wedges in an importing and an exporting situation are more difficult to handle. Some modelling approaches abstract from such details and simply model uniform policy determined price wedges independent from the trade situation (FAO, 2001). Other models that take these differences into account must somehow deal with the problem of products that are not exported at the export-based price, because it is too low, and are not imported at the import-based price, because it is too high. In such a case, the equilibrium price lies somewhere between the export-based and the import-based price. One option applied in some spread sheet models is to generate a stepwise price adjustment in situations were the net trade situation is close to zero (Münch, 2002). Another option is to repeatedly solve the model to reconcile net trade position and the resulting domestic price (Grethe, 2004).

Surry (1992) applies the logistic functional form in an econometric model in order to depict EU price formation within the price band between intervention price and threshold price dependent on the net trade situation. This concept is also applied in equilibrium simulation models, e.g. the MISS model (Guyomard et al., 1993), WATSIM (von Lampe, 1999), GTAP (van Meijl and van Tongeren, 2002) and a CGE of the French economy (Gohin et al., 2002).

This paper presents the application of the Logistic functional form for depicting price transmission from international to domestic prices in the net trade model ESIM (Banse et al., 2005). While the above applications use the Logistic functional form only for products for which EU prices are fixed institutionally, domestic price formation in ESIM is based on the Logistic functional form for all products. Furthermore, the approach is extended to cover the application of export subsidies (ES) for WTO limited quantities and imports within tariff rate quotas (TRQs). Section 2 of the paper gives a short overview of ESIM in general and describes in detail how the Logistic functional form is used in the current ESIM version to depict price transmission from international to domestic markets. Section 3 then shows the application of these concepts to one specific market in ESIM, the EU beef market. Price formation on international and EU beef markets is compared

among various scenarios under the variation of EU TRQs and ES. Finally, in Section 4, some conclusions are drawn and shortcomings of the chosen approach are discussed.

2 Application of the Logistic Functional Form in ESIM

### 2.1 Short General Model Description

ESIM is a comparative static partial equilibrium multi-country model of agricultural production, consumption of agricultural products, and some first-stage processing activities. ESIM has recently been updated and extended in terms of base period, product and country coverage, policy formulation and software platform (GAMS) (Banse et al., 2005). As a world model it includes all countries, though in greatly varying degrees of disaggregation. Some countries are explicitly modelled and others are combined in an aggregate: the so-called rest of the world (ROW). In its current version ESIM includes the ten new EU member states, Bulgaria, Romania, Turkey, the EU-15 and the US. All other countries are aggregated as the ROW. Trade is modelled as net trade for all countries. ESIM is a static model, as adjustments in time are not explicitly covered. There are, for example, no lagged price responses or price expectations modelled at the supply side. Therefore, all simulation results have to be interpreted as long term equilibrium states. Nonetheless, ESIM is a projection model as shifters at the supply as well as the demand side (e.g. productivity or income growth) are accounted for. Projections are made for a period of 11 years (2003-2013) after the base period. But all of these projections are independent comparative static equilibria.

ESIM depicts a high variety of policy instruments like specific and ad valorem tariffs, tariff rate quotas, intervention and threshold prices, ES, product subsidies, direct payments for keeping land in agricultural use, production quotas and voluntary as well as obligatory set aside. All behavioural functions in ESIM are isoelastic. Supply at farm level is defined for 15 crops and 6 animal products.

2.2 The Logistic Function for Depiction of the Switch from Import to Export Based Price

Price transmission between domestic and import prices is determined by a Logistic functional form and thus allows for a smooth course between higher import based prices to lower export based prices. Graph 1 depicts an example of a price transmission function for wheat in the EU in the ESIM base period (2000-2002). The horizontal axis depicts the share of net exports in total domestic use (in %), and the vertical axis depicts the wheat price in €/t.

Graph 1: Price Transmission for Wheat (EU-15)

Net Trade Share (%)

calibrated Logit-Function
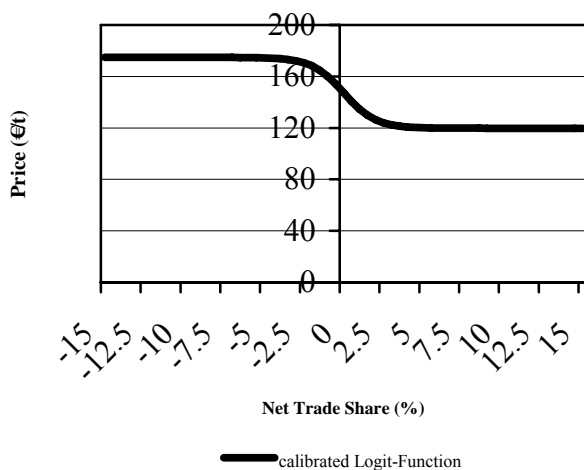
Graph 1 shows, that in a situation in which the share of net exports in total domestic use is larger than 5%, i.e. the EU is in a very clear net export situation, the domestic price is at the lower price bound P_{LO}, which is the maximum of the intervention price level and the world market price.

which for wheat is the maximum of the world market price and the EU threshold price for cereals, which is 155% of the intervention price. In a situation where the net export share is in between −5 and 5% of domestic use, the domestic price is in between upper and lower bound, subject to the course of the Logistic function, which is differentiable throughout.

This may depict reality quite well: The closer the net trade situation comes to zero, the less the domestic price is determined by the respective import or export price alone, and the more it is subject to domestic price formation, but also to the effects of import and export prices at the same time, as considerable intra-industry trade may be hidden behind a net export situation of zero. The precise course of the Logistic function, however, may be subject to discussion – and the functional form allows for adjustments. The specification of the Logistic function depicted in Graph 1 is

$$(1) \quad PD = \left(P_{UP} - P_{LO}\right) \cdot \frac{-\alpha \cdot e^{\beta \cdot TRADSHR}}{1 + \alpha \cdot e^{\beta \cdot TRADSHR}} + P_{UP}, \text{ with } TRADSHR = \frac{NX}{TUSE} \cdot 100, \text{ with } \alpha \text{ and } \beta = 1.$$

But it may be empirically evident that the domestic price is more closely linked to international prices even in case of relatively low net trade shares. In such a case one may like to model the price transmission function steeper. This can be done by setting α different from 1. Also one may find empirically that the trade share at which the domestic price is predominantly determined by international prices is asymmetric. Such asymmetric course of the Logistic function can be modelled by adjusting parameter β.

But more complex policy determined price transmission mechanisms may apply. For example, an ES may allow keeping the domestic price significantly above international level, but only up to a certain limit, the WTO bound quantity limit. After that limit the domestic price would fall to the world market level for a comparable quality. On the other hand, TRQs may allow for considerable imports, without causing the price to move in the direction of the upper price bound consisting of threshold price or world market price and tariff, because imports occur at tariff levels below the Most-Favoured-Nation (MFN) level, potentially without any tariffs at al. Both these situations can be depicted by the Logistic function model of price transmission. Graph 2 shows the price transmission function applied in ESIM for beef, taking into account ES commitments of the EU.

Graph 2: Price Transmission for Beef with ES
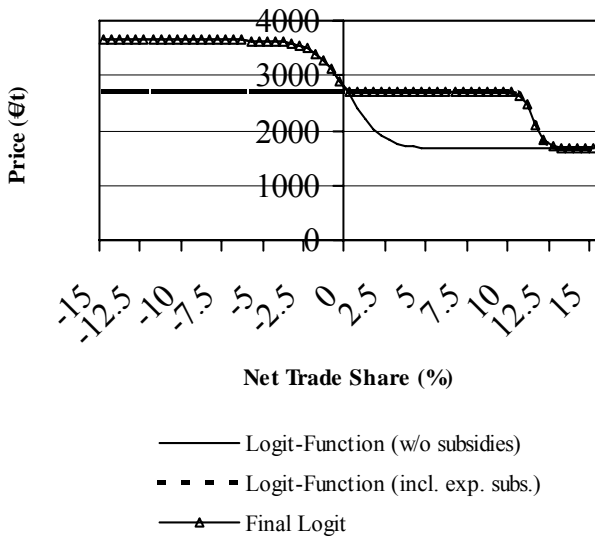
The final price transmission function consists of two separate Logistic function specifications by defining the maximum of those two separate functions as the relevant price transmission function. The upper bound is valid in a clear net import situation. If net trade comes close to zero the price begins to fall and reaches the upper bound of the second Logistic function (P_{UP_2}) at a net export level of about 0%, and begins to fall further at an export level of 9.7%, which results from transforming the WTO bound quantities into an export share equivalent. At about 15% export share the price transmission function reaches its lower bound, which is the world market price.

The final Logistic function takes the maximum value out of both individual Logistic functions. Eq. (2) shows the specification of the Logistic function establishing the middle level of the price transmission function, which applies in the range of net exports which are assumed to take place while receiving ES.

$$(2) \quad PD^* = \left(P_{UP\_2} - P_{LO}\right) \cdot \frac{-\alpha \cdot e^{\beta \cdot TRADSHR^*}}{1 + \alpha \cdot e^{\beta \cdot TRADSHR^*}} + P_{UP}, \text{ with } TRADSHR^* = \frac{NX - subsquant}{TUSE} \cdot 100,$$

with $\alpha = 1$, and $\beta = 3$.

What now, if TRQs come into play, which are widely applied by the EU, among others for beef from ACP countries as well as minimum and current access TRQs for beef which are bound in the WTO? Such TRQs can take the form of predetermined imports, which may result from the fact that the TRQ is clearly binding as well as a situation where the quantity which can be delivered to the EU market is rather fixed at a level below the TRQ due to restricted production potential in the

exporting country. If further the assumption is that they enter the market at zero or low tariffs and thus do not drive the domestic market price up to the level of the world market price plus MFN tariff, their influence on the price transmission function can simply be modelled as a leftward shift: Although considerable imports take place, the domestic price still is at the lower price bound. Graph 3 shows the resulting price transmission function for beef applied in ESIM.

Graph 3: Price Transmission for Beef with ES and TRQs

Price (€/t)

Net Trade Share (%)

—— Logit-Function (with TRQ, w/o ES)
—▲— Final Logit (with ES and TRQ)
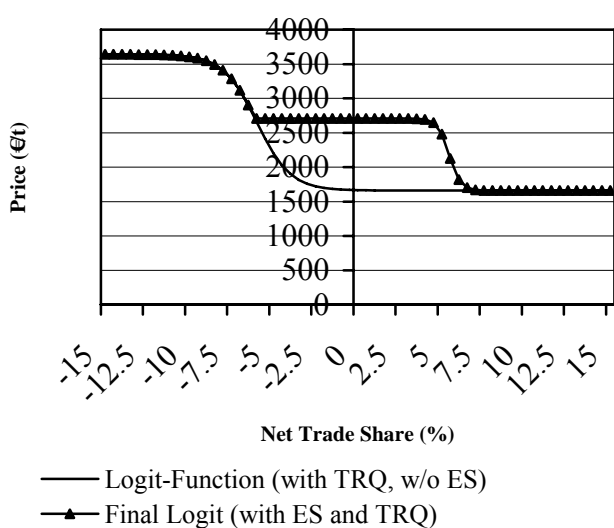
The complete price transmission-function is shifted leftward compared to Graph 2 above. Without ES, the domestic price would remain at the lower (world market) bound up to an import level of about 4%. This is because imports would occur at the world market price without any tariff until the TRQ is filled. Alternatively, a preferential tariff with a reduced rate could be modelled.

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2.3 Determination of the Upper and Lower Bounds of the Price Transmission Functions

Three commodity groups are distinguished in ESIM with respect to the way in which upper and lower bounds of their respective price transmission functions are determined. For the first group the upper as well as the lower bound consist of the world market price plus any tariff in case of the upper bound or any ES in case of the lower bound. If no tariffs or ES exist, the Logistic function is a horizontal price line without any step. For a second commodity group the lower price bound is the maximum of the intervention price and the world market price. If the intervention price is above world market price the EU is willing to buy each quantity – resulting in a situation where the intervention price is thus the absolute price minimum. ES are not modelled for these products,

they are derived from model results as the difference between intervention price and world market price multiplied by supply minus demand, up to the ES limit of the EU. If market surplus exceeds the WTO bound it is modeled as going into stocks. The upper price bound for products in the set FLOOR is the world market price plus tariff, which would be the domestic price in a clear net import situation. For a third commodity group the lower bound is modeled as for the second group, but the upper bound is defined relative to the lower bound. In the current ESIM version this group only includes some cereals and the level of the upper bound is 155% of the intervention price.

2.4 Changes in TRQ and Export Subsidy Levels

For the base situation the observed amount of preferential imports under TRQs and applied ES are included in the calibration of the price transmission functions. Therefore, the observed domestic market price is a function of the given level of net exports including TRQs and ES. If the level of ES and imports under TRQs remains unchanged over the projected period of time, no additional impact on domestic market prices is expected. However, if the limit of ES or the level of imports under TRQs alters, changes in domestic prices are expected.

For changes in ES the second Logistic function will shift to the left and domestic prices will begin to fall to P_{LO} at lower export shares (see Graph 2). An expansion of TRQs, on the other hand, will have two effects: first, a leftward shift of the price transmission function (see Graph 3), and second an (exogenous) increase of supply of the commodity concerned which affect market-clearing. Consequently, net-exports will increase, i.e. the domestic price will move towards the lower export price P_{LO}. The second effect is covered technically by adding any change of imports under TRQs to the right hand side of the net trade equation in the EU, i.e. net exports = supply + Δ TRQ − domestic use. The additional quantity Δ TRQ is deducted on the right hand side of the net export equation for the rest of the world.

3   Depiction of Future Developments on EU-Beef Markets

For illustration of the approach developed above, various scenarios with changing TRQ and ES assumptions for beef are described and results are discussed in this section. All examples are for beef, as beef is a product for which ES as well as TRQs play a major role in the EU trade regime, but market supply in the EU is not regulated by production quotas, as it is for sugar and dairy.

3.1 Development of EU Beef Prices without any Change in ES and TRQs

First, a BASELINE scenario is developed in which the accession of the 10 NMS in 2004 as well as the accession of Bulgaria and Romania in 2007 are included. The "rest of the world" component in the BASELINE is calibrated such that FAPRI world market price projections (FAPRI, 2004) for 2013 are met. For all other scenarios world market prices can deviate from FAPRI projections. All scenarios include full implementation of the 2003 Reform, i.e. the decrease in institutional prices and partial decoupling of direct payments. In the BASELINE, ES as well as TRQs are assumed to stay at the base period level. Graph 4 depicts the change in the course of the Logistic function between the ESIM base period and the year 2010 unter the BASELINE scenario.

Graph 4: Price Transmission for Beef under the BASELINE Scenario (Base Period to 2011)
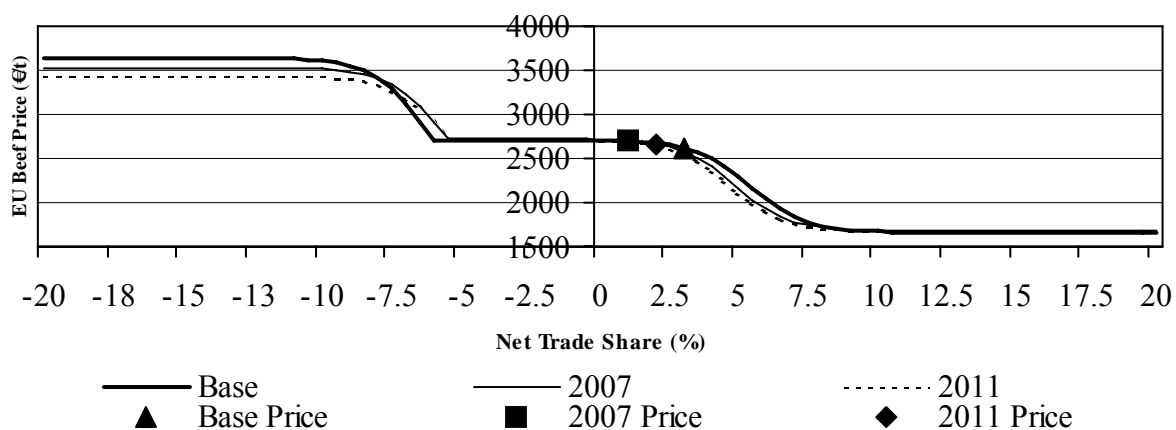
The price transmission function depicted in Graph 4 is shifted leftward due to TRQs of in total 430,000 t beef which are imported under preferential conditions, which is about 5% of domestic market volume. Additionally, the price transmission function has a second step because of the use

of ES which are limited at 820,000 t in the WTO. In the base period as well as over all simulations, the EU is close to its quantity limit in the WTO, i.e. any further increase in net exports would result in a strongly declining price. Over the simulation period the upper bound of the price transmission function is coming down slightly whereas the lower bound remains rather constant. This is due to specific tariffs, which are deflated in real terms each year by an assumed annual inflation rate of 1.5%. The rather constant lower bound reflects stable world market prices between 2000/2002 and 2011. Also the EU beef price is rather stable. In 2007 it is slightly higher than in the base period which is mainly due to the accession of Bulgaria and Romania, which are net importers of beef at EU-price level in 2007.

3.2 The Impact of ES Reduction and Changes in TRQs on the EU Market

For the next set of scenarios, the scenario BASELINE is taken as the reference. Three scenarios in which ES and TRQs are varied are compared to the BASELINE. All other scenario formulation is kept unchanged compared to BASELINE. The scenarios are:

- A scenario ES-RED, under which beef ES are phased out in 4 equal steps from 2008 to 2011.

- A scenario TRQ-INC, under which TRQs are doubled in 4 equal steps from 2008 to 2011.

- A scenario TRQ-RED, under which TRQs are abolished in four equal steps between 2008 and 2011. This scenario is chosen only for illustrative reasons and not as a policy relevant scenario.

- A scenario BOTH, under which ES for beef are phased out and TRQs are doubled between 2008 and 2011. Such a policy change would probably be accompanied by other simultaneous policy changes. As the focus of this paper is on the illustration of the price formation mechanism and not on a forecast of the development on EU beef markets, all these policy changes are not depicted in order keep results easier to trace.

As a first step in looking at the results of these scenarios, price formation is depicted in Graphs 5 to 7. Graph 5 shows the change in the course of the Logistic function between the years 2007 and the year 2011 unter the ES-RED scenario.

Graph 5: Price Transmission for Beef under the ES-RED Scenario, 2007-2011
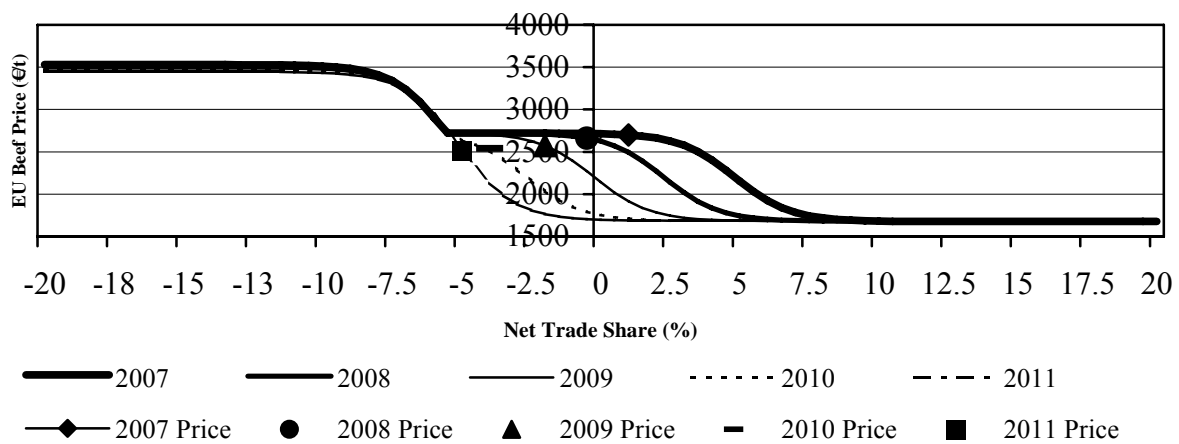
Graph 5 shows how the step in the price transmission function which represents the ES for beef is abolished in four steps. In this process, the EU becomes a net importer of beef. Although net imports amount to 4.5% of domestic use in 2011, the domestic price is closer to the lower than to the upper bound of the price transmission function. This is because of the TRQs which are still in force and shift the price transmission function to the left. In total, the EU price after full abolishment of ES is about 7% below the EU price in 2008. Graph 6 shows the change in the course of the Logistic function between the years 2007 and 2011 unter the TRQ-INC scenario, under which TRQs are doubled in four equal annual steps.

**Graph 6: Price Transmission for Beef under the TRQ-INC Scenario, 2007-2011**
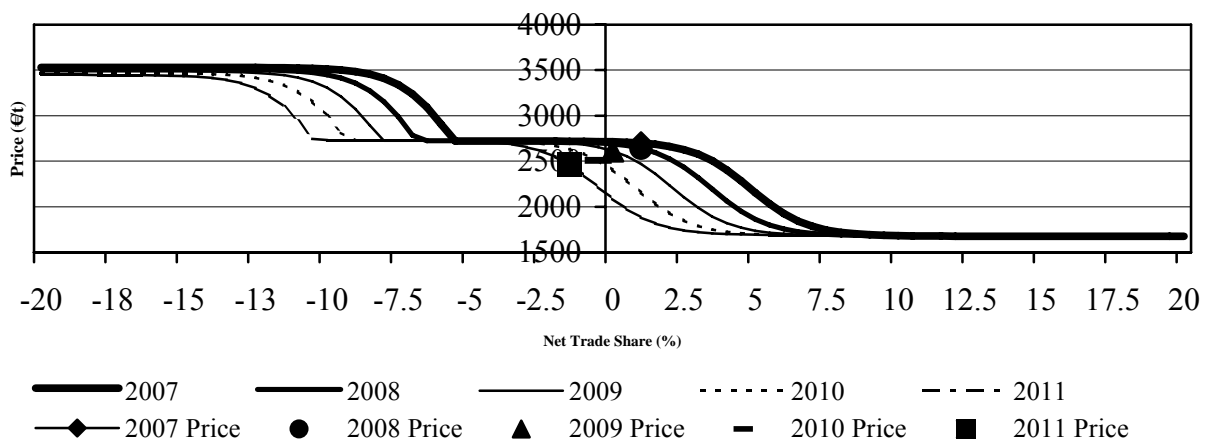
Graph 6 shows that the increase in TRQs is equivalent to a shift of the price transmission function to the left. Therefore, the increase in TRQs has the same kind of effect as the abolishment of the

ES: the EU becomes a net importer and the beef price falls. The overall price effect is more pronounced than under the abolishment of the ES: the price falls by about 9%.

Graph 7 shows the change in the course of the Logistic function between the years 2007 and 2011 unter the TRQ-RED scenario, under which TRQs are abolished in four equal annual steps. As outlined in section 2.4, the reduction of TRQs affects the domestic market like an exogenous decline of beef supply. This "shortage" reduces total net-exports and in 2011 the EU-27 is projected to be a net-importer of beef. The domestic price, however, remains largely unchanged, as it is determined by the world market price plus ES also in 2011.

**Graph 7: Price Transmission for Beef under the TRQ RED Scenario, 2007-2011**
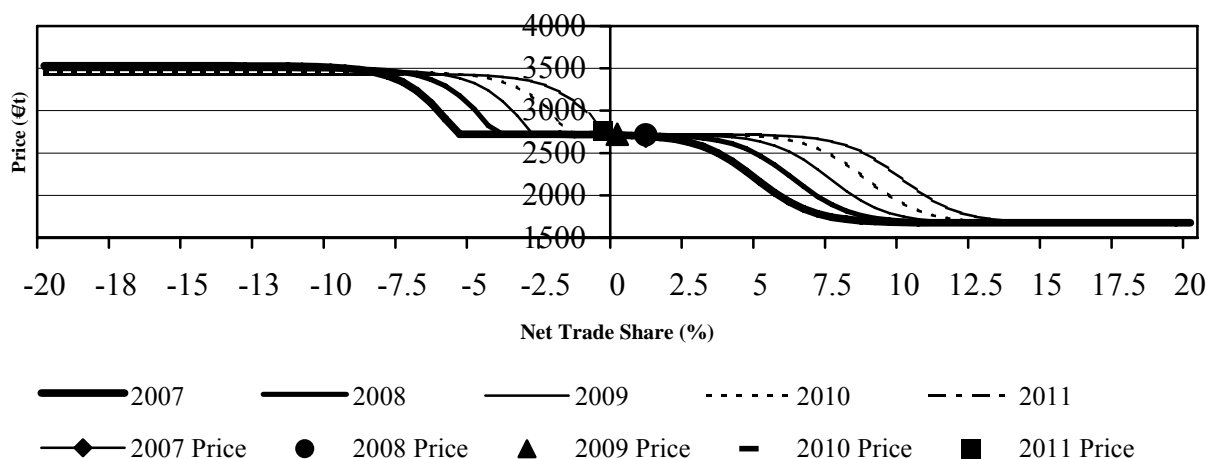
Graph 8 shows the change in the course of the Logistic function from 2007 to 2011 under the BOTH scenario, under which ES are abolished and TRQs are doubled in four equal annual steps. The EU becomes a net importer at a level of about 9% of its domestic use under the BOTH scenario. Nonetheless, the domestic price is much closer to the lower bound than the upper bound of the price transmission function because TRQs for beef amount to 860,000 t, which is almost 10% of domestic use in 2011. The total decline in the EU price which results from the abolishment of ES and the doubling of TRQs is about 15%.

Graph 8: Price Transmission for Beef under the BOTH Scenario, 2007-2011
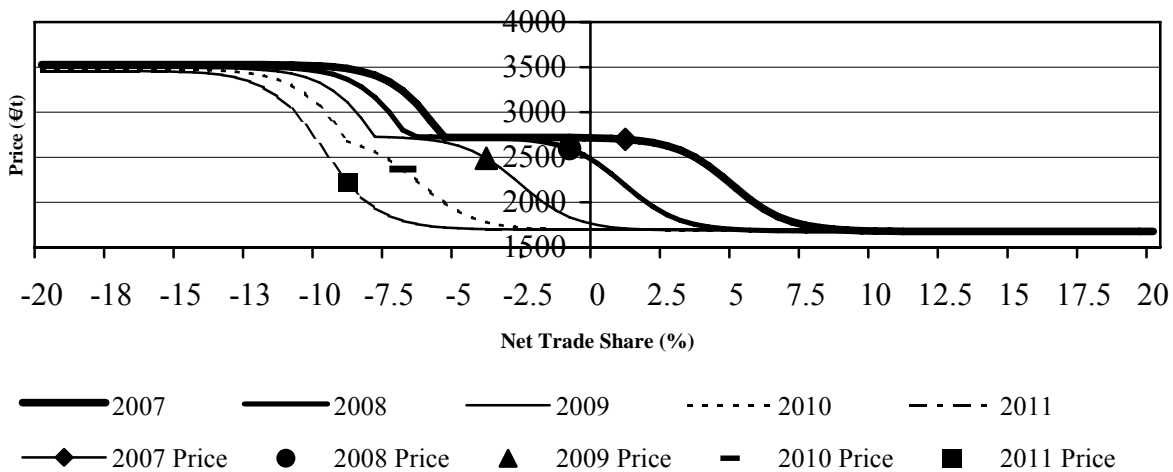
Graphs 9 and 10 show the development of EU and world market prices for beef under all scenarios compared to the BASELINE which is set at 100.

Graphs 9 and 10: EU Producer Price and World Market Price for Beef (BASELINE = 100)
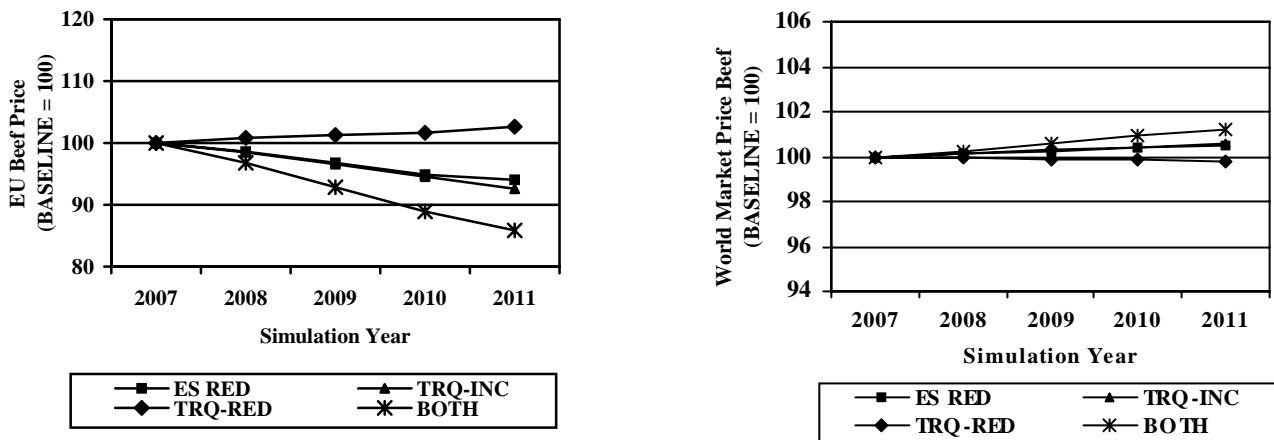
A reduction of TRQs under the TRQ-RED scenario leads to an increasing EU price and thus a decreasing world market price compared to the BASELINE. Under all other scenarios EU prices are lower and world market prices are higher than under the BASELINE. The maximal decrease of the EU price under the BOTH scenario of about 15% results in an increase of the world market price by 1.2% compared to the BASELINE.

Graphs 11 and 12 present the development of EU production and consumption of beef compared to the BASELINE, which is set at 100.

Graphs 11 and 12: EU Production and Consumption of Beef (BASELINE = 100)
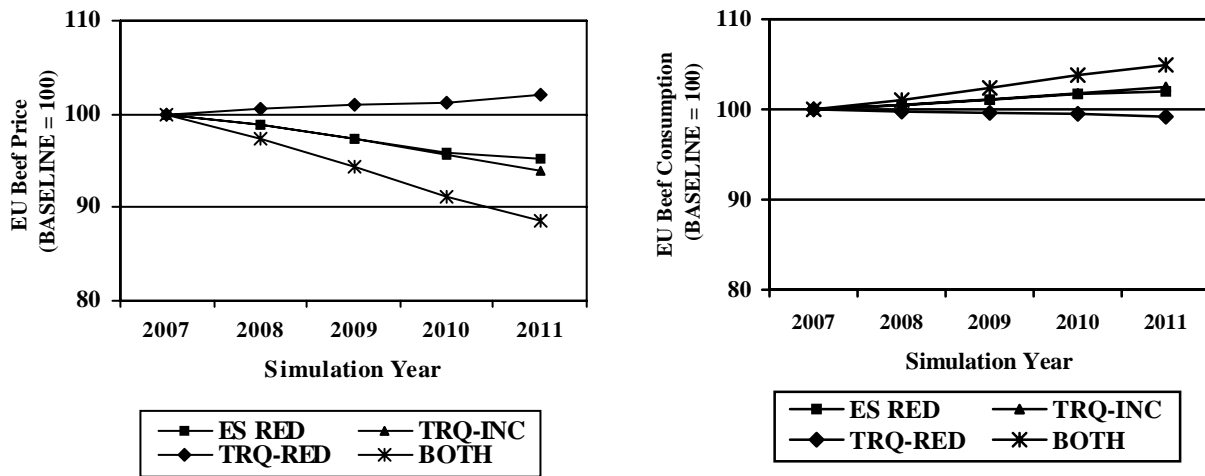
Graphs 11 and 12 show that supply reacts stronger to changing prices than demand. This is due to the level of own price elasticities applied in ESIM: own price elasticities of supply for beef are between 0.79 and 1.14 in the EU-15, the NMS 10 and Bulgaria and Romania, and own price elasticities of demand are between -0.33 and -0.55. Under the BOTH scenario EU-beef production is about 11.5% lower in 2011 than under the BASELINE. But demand is only 5% higher, which results in higher net imports. Net trade under all scenarios is depicted in Graph 13.

Graph 13: EU Beef Net Trade (Base to 2011, 1,000 t)
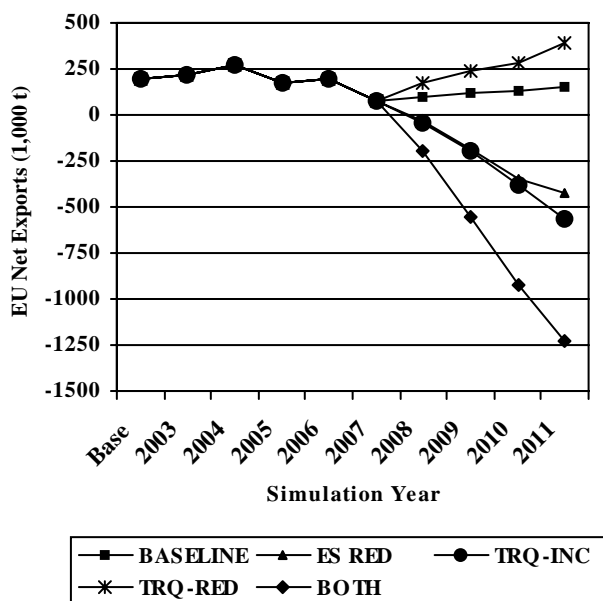
The EU is a relatively stable net exporter of beef at a level of about 200,000 t until 2006. With the accession of Bulgaria and Romania net exports fall to 73,000 t of beef because Bulgaria and Romania are net importers at EU-price level. Unter the BASELINE EU net exports recover and reach 150,000 t in 2011. Under the TRQ-RED scenario net exports increase up to almost 400,000 t. Under all

other scenarios the EU becomes a net importer of beef. Under the BOTH scenario the EU has net beef imports of about 1.2 Mill. t. This results from the reduced TRQ quantity (430,000 t) as well as lower domestic supply and higher domestic demand as a response to the lower price.

4   Conclusions

Examples discussed above show that the Logit functional form is a flexible tool to formulate price transmission in net trade models. A smooth transition can be depicted from an import based to an export based price, which may be at very different levels. Steepness and symmetry of the course of transition can be adjusted continuously. Also the effects of TRQs and ES which are quantity restricted can be included in the price transmission function.

With respect to the formulation of TRQs, however, this approach has some drawbacks, which result from the fact that any changes in preferential imports must be set exogenously by the researcher. A response of these quantities to world market as well as domestic price conditions is not depicted. With simulation of major policy changes this requires market knowledge and alertness by the model user in order to assess whether the preferential quantities which are established in the base period are still valid. For example with simulation of a reform of the EU sugar regime preferential TRQs for the countries under the ACP sugar protocol may not be fully used anymore – which would require to put this reduction in the model exogenously. This also limits the scope of depiction of preferential schemes: it is possible to depict preferences granted by the EU to the rest of the world. But at a more disaggregated level many industrialized countries grant preferential market access to a high variety of countries. The simulation of the effects of any change in preferential agreements on such a disaggregated level would require the explicit depiction of bilateral trade, for example with an Armington approach.

In the formulation of ES the simultaneous consideration of the quantity and the value restriction in the WTO is not easily depicted. Any change in the quantity constraint can be modelled as well as

a change in the ES rate per product unit. But we don't include the possibility to endogenously set the ES rate such that full use is made of the value limit.

Preliminary results of the application of this approach to the EU beef market show that each, the abolishment of ES as well as the doubling of preferential market access for beef, may result in a price decline on the EU market of 7-9% and the EU would become a net importer of beef under both options. Combined, the price decline may amount to about 15% and the EU could become a beef net importer at a level of 15% of its domestic use.

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