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Assessing the impact of GM animal feed restrictions in the UK/EU livestock sectors

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Assessing the impact of GM animal feed restrictions in the UK/EU livestock sectors.

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Modelling the impact of GM feed restrictions in the UK/EU livestock sectors.

1. Background

With the advent of biotechnology and its perceived competitive advantages to commercial agriculture, there has been a rapid proliferation of genetically modified organism (GMOs) over the last 10 years. In contrast, in the European Union (EU), enthusiasm for GMOs has been seriously hampered by scientific concerns relating to the possible long term impacts on the food chain and ultimately consumer health and safety issues. At the current time, the EU adopts a zero tolerance policy toward the import of GMOs not yet approved within the EU zone. Consequently, even if trace levels of unapproved GMO are found in the imported commodity, the whole shipment is refused entry to the EU market. With more widespread usage of GMOs in non-EU regions, there is greater reluctance by EU traders to import bulk feed commodities which could be affected by a trace finding of a new variety of GM feed crop approved in the supplier country, but not yet in the EU. To further complicate matters, the authorisation process in the EU has so far failed to keep pace with the speed with which new strains of crops are being adopted and accepted in the non-EU regions with the result that over time the EU could end up isolating itself.

This uncertainty casts a long shadow over those feed imports upon which the EU has high dependence. Indeed, due to climatic and agronomic factors, Europe is unable to produce much of the oilseed meal (particularly soybean) and other protein-rich feedstuffs required to feed its livestock. Protein-rich crops are needed by livestock producers (particularly pig and poultry production systems) in the EU to achieve a balanced diet for their animals. Imported substitutes for these feed ingredients are only available in very limited quantities and there is no viable prospect for developing EU production of protein rich plants at short notice. Even stepping up the production of substitute protein crops such as field peas, field beans and sweet lupines as alternatives for soybean, would still leave something of a shortfall in meeting EU demand requirements. The immediate focus of concern for the EU relates to the adoption of a new type of GM soybean which is being grown for seed production in the US this year and is anticipated to have a full commercial launch within 2 years. Adoption in South America is expected to follow one or two years behind the US. With over 90% of EU soybean imports originating from Argentina, Brazil and the USA, the EU's zero tolerance policy could seriously interrupt essential supplies of soybean derivative feeds which in turn threatens the viability of the livestock sectors. In the past, the EU's position was protected by its status as a key customer market, however, the emergence of large importers such as India and China, both of which employ more liberal regimes with respect to acceptance of GMOs, threatens to reduce the EU's leverage over supplier countries to delay introduction of new GMOs until EU approval is granted.

2. Study aims and objectives

This study aims to quantitatively assesses the impact on UK/EU livestock, meat and dairy sectors from a hypothetical EU import ban on unapproved GMO varieties of soybean and maize imports from one or more of the major suppliers (Argentina, Brazil and the USA). As a basis, the Global Trade Analysis Project (GTAP) database (version 6) (Dimaranan, 2006) is employed. In its sixth incarantion, the data details the trade-production links between 87 countries/regions and 57 commodities, whilst also representing a significant advance on version 5 in terms of (*inter alia*) broader regional coverage (87 regions), improved trade and demand elasticity estimates and significant refinements to the support and protection data. In concert with the underlying GTAP model framework (Hertel, 1997), it is possible to conduct trade policy impact assessments which yield estimates of prices (world prices, feed prices, livestock prices etc.), outputs (feed and livestock sectors) and trade.

The main modelling tasks are to:

i. Create an appropriate sector/region aggregation for the analysis and implement a suitable baseline run for the model.

ii. Implement an additional module into the Defra-Tap model to allow simulation of a (partial) import 'ban'.

iii. In recent years, the production of liquid bio fuels has increased rapidly in response to ever growing demand for alternative energy sources. This trend has already had marked impacts on agricultural commodity prices and land usage across the globe which will have an impact on alternative land uses (including feed crop production). In the standard model database, there is no consideration of bio-fuels. Thus, the model data and code are modified to capture this additional source of land usage which is then updated to current day usage trends via the baseline simulation. It is anticipated that a more accurate depiction of land use trends across the world will improve the credibility of the simulation results.

iv. Compared with the baseline scenario, run the following three scenarios:

1. No imports of genetically modified (GM) soybean/oilseeds and maize from the US to the EU
2. No imports of genetically modified (GM) soybean/oilseeds and maize from Argentina and the US to the EU
3. No imports of genetically modified (GM) soybean/oilseeds and maize from Argentina, Brazil and the US to the EU

3. The Defra-Tap Model - Overview.[1]

This study employs a variant of the GTAP CGE model Hertel (1997) and accompanying version 6 database (Dimaranan, 2006). Version 6 data represents a significant advance on version 5 in terms of (*inter alia*) broader regional coverage (87 regions), improved trade and demand elasticity estimates and significant refinements to the support and protection data. The 'standard' GTAP model employs neo-classical optimising behaviour to derive Hicksian consumer and intermediate demands. Regional utility is aggregated over private demands (non-homothetic), public demands and savings (investment demand). Production, which is 'demand driven' through a series of accounting conventions and market clearing balances, is characterised employing a perfectly competitive, constant-returns-to-scale technology, and bilateral imports are differentiated by region of origin using the Armington specification. The model incorporates five factors of production, where skilled/unskilled labour and capital are perfectly mobile, whilst land and natural resources are both sector specific with the former moving 'sluggishly' between productive sectors. In all factor markets, full employment is assumed (long run). Finally, investment behaviour functions through the creation of a fictitious 'global bank'. This entity collects investment funds (savings) from each region and disburses them across regions according to a rate of return *or* a fixed investment share mechanism.

The version of the GTAP employed in this study is the in-house Defra model known as Defra-Tap, which more closely follows the GTAP-AGR (Keeney and Hertel, 2005) model variant. Defra-Tap more accurately captures the nuances of agricultural markets. For example, substitution possibilities are now modelled between primary factors and intermediate inputs (i.e., changes in fertiliser use in land is now price dependent), whilst it is

[1] For a full description of the Defra-Tap model, see Renwick et al., (2007)

now possible to identify in more detail the impact of feeds in the livestock sector through the inclusion of substitution possibilities between alternative feed crop usage; a feature which is not inherent within the standard GTAP framework.[2] The model also incorporates rigidities on the movement of mobile factors between agricultural and non-agricultural sectors. In this way, the model characterises differentials (between agric and non agric sectors) in the rewards to the factors of production.

In addition to these modelling refinements, Defra-Tap also includes the following features:

i. An econometrically estimated endogenous land supply function
ii. Varying degrees of land substitutability between competing primary agricultural sectors
iii. Explicit modelling of the CAP budget (including UK rebate, re-nationalisation and EU enlargement 'dummies')
iv. CAP Support Mechanisms: Single farm payment, Milk and Sugar Quotas, Set-Aside and Land idling, export subsidy limits and stock purchases.
v. Improved characterisation of 'coupled' and 'decoupled' support
vi. Tariff rate quotas
vii. Deep integration intra-EU trade elasticities to reflect greater trade homogeneity between countries within the EU single market.

4. Additional Modelling and Data Features

4.1 Modelling an import ban

In GTAP the standard method for modelling an import ban involves performing a closure swap, where one exogenises the import quantity of commodity 'i' from region 'r' to region 's' ($q_{i,r,s}$) and 'swap' with the corresponding tariff variable ($tms_{i,r,s}$). In this way, the modeller may exogenously reduce imports of 'i' to region 's' from region 'r' by a fixed percentage and the tariff variable will adjust such that the price rise on that import is compatible for the required quantity reduction. Employing this approach implies that rising import prices are causing the fall in imports – which is not an accurate depiction of the EU's ban on GMO imports.

In this study, an alternative is employed where import reductions are associated with reductions in utility associated with their consumption. That is, reduced confidence in GM commodities (due to food safety fears) leads to a reduction in utility in the importing

[2] In the standard GTAP model, these substitution possibilities are modelled as Leontief.

region, which in turn motivates import reductions. To implement this idea, we start with the Armington CES import demand function represented in equation (1). This CES function incorporates an *exogenous* utility scaling variable (Z) to characterise 'tastes and preferences' without compromising the model's underlying theoretical structure:

$$U_{i,s} = \left[\sum_r \delta_{i,r,s} Q_{i,r,s}^{-\rho} Z_{i,r,s} \right]^{-\frac{1}{\rho_i}} \tag{1}$$

where $U_{i,s}$ is the level of sub-utility from the consumption of commodity 'i' in import region 's'; $Q_{i,r,s}$ is demand in import region 's' for commodity 'i' from export region 'r'; $\delta_{i,r,s}$ is a CES share parameter; and ρ_i is an elasticity parameter.

In the benchmark data each exogenous scaling variable ($Z_{i,r,s}$) is assigned an identical levels value of unity to indicate equal confidence across all product categories. Implementation of the import prohibition (say of feeds from the USA to the EU) is characterised as a downturn in 'confidence' for GM, which is captured by swapping the variable $Z_{FEED,USA,EU}$ with the value of imports $V_{FEED,USA,EU}$ (see section 5 for further discussion). Thus, the required exogenous shock is given to $V_{FEED,USA,EU}$ which implies endogenous downturns in $Z_{FEED,USA,EU}$ (i.e., consumer confidence). Similarly, any hypothetical removal of the ban would involve simply reversing the confidence shock necessary to return the relevant scaling variable Z to its pre-ban value (i.e., complete confidence recovery).

Employing cost minimisation procedures to (1) and expressing as percentage changes (denoted by lowercase letters) gives:[3]

$$q_{i,r,s} = u_{i,s} - \sigma_i [p_{i,r,s} - p_{i,s}] + \sigma_i z_{i,r,s} \tag{2}$$

$$p_{i,s} = \sum_r S_{i,r,s} p_{i,r,s} + \frac{1}{\rho_i} z_{i,s} \tag{3}$$

$$z_{i,s} = \sum_r S_{i,r,s} z_{i,r,s} \tag{4}$$

$$\rho_i = \frac{1}{\sigma_i} - 1 \tag{5}$$

[3] A full set of mathematical derivations are provided in Appendix A.

Linearised import demands ($q_{i,r,s}$) in (2) are a function of commodity prices ($p_{i,r,s}$) and utility ($u_{i,s}$), i.e., Hicksian, as well as the scalar ($z_{i,r,s}$).[4] Composite price ($p_{i,s}$) is an average of commodity prices weighted by expenditure shares ($S_{i,r,s}$) and composite utility ($z_{i,s}$) (equation 3), where composite utility is itself an expenditure share weighted average (equation 4). Finally, the elasticity parameter, ρ_i, is defined in (5) in relation to the elasticity of substitution (σ_i). Note that on non-feed related EU27 imports, the percentage change in $z_{i,r,s}$ is zero, which implies that the demand and price functions are standard Hicksian.

4.2 The Inclusion of Bio fuels in the GTAP data and model.

The incorporation of bio fuels draws on two studies by Taheripour et al. (2008) and Birur et al. (2008) respectively.

4.2.1 Introducing bio fuels into the GTAP database - overview

In Taheripour et al. (2008), the authors introduce three additional sectors into the standard version 6 database to capture the production of liquid bio-fuels. In broad terms, these three sectors are divided into bio diesel from oilseeds crops (largely based in the EU); bio ethanol from starchy cereals crops (largely produced in the USA and to a lesser extent the EU) and bio ethanol based on sugar cane (mainly produced in Brazil). To avoid compromising the underlying equilibrium accounting conventions of the standard database, these three sectors are split out of the 'vegetable oils and fats' sector (bio diesel), 'other food processing' (bio ethanol from cereals) and the 'chemicals rubber and plastics' sector (ethanol from cane). A perceived advantage of having three separate sectors, is that the database better characterises the different production processes for each bio fuel output.

To estimate output levels and the intermediate input/primary factor mix for these sectors in 2001 (benchmark year), the authors draw on an array of literature sources. For estimates of production levels and trade, a report by the International Energy Agency (IEA, 2004) is employed. Similarly, assuming zero profits the value of production is divided between intermediate inputs (i.e., feed stocks, chemicals, energy, other) and primary factors labour and capital employing cost component estimates from Tiffany and Eidman (2003) (cereals based ethanol), USDA (2006), Geller (1985) and OECD (2006) (sugar cane based ethanol) and Haas et al. (2005) for bio diesel based on oilseeds. Due to data availability constraints, it is assumed that all inputs are produced domestically, except for the feedstock used in the bio diesel industry in the EU. It is noted that the EU imports an important

[4] Note that in all UK import demands, and in all ROW import demands other than for feed related products, the percentage change in $z_{i,r,s}$ is zero, which implies that the demand and price functions are standard Hicksian.

portion of its oilseeds consumption, where these same trade shares are applied to the bio diesel industry imports.

Whilst this work undoubtedly represents an important first step into developing the GTAP database in this direction, it is clear that the quality of this type of venture is typically restricted by both the availability and reliability of the underlying data sources. In their treatment, the authors had to assume that production processes for each of the bio fuels sectors are homogeneous across regions. Moreover, the production and trade information employed is not exhaustive and some degree of creative accounting will have been required to fill in missing gaps in the database. Finally, a lack of data restricted the possibility of representing other possible sources of bio fuels production (i.e., from palm oils, sugar beet, wine). Notwithstanding, in

4.2.2 Capturing bio fuels demand within the model framework.

In the Defra-Tap model (as in GTAP), private and public consumption of all commodities are characterised by a non-homothetic constant difference elasticity (CDE) and homothetic Cobb-Douglas (CD) function respectively. Since the usage of bio fuels are directly substitutable with petrol, a further CES nesting structure is introduced into Defra-Tap to characterise an improved treatment of energy demand which allows the user to more easily capture the dramatic increases in 'demand driven' bio fuels production which have occurred since 2001 (benchmark year). Figure 1 shows the modified structure of private and public demands in Defra-Tap and follows a similar structure as employed in Taheripour et al. (2008).

In the top nest, all energy commodities (i.e., gas, oil, coal, electricity, petrol, bio-fuels) are grouped into a single composite commodity within the CDE (private) and CD (public) function demands. The energy composite is divided into coal, oil, gas, electricity and a petroleum and bio fuels composite. Typically, energy demands are very price inelastic, which is reflected in the elasticity of substitution (0.1) between energy types by private household/government (ESUBPEN, ESUBGEN). This value (applied in all regions) is taken from Taheripour et al. (2008) who in turn have borrowed from an in-house econometric study of Beckman et al. (2008). In the lower nest, final demands are allocated between petroleum and bio fuel products, whilst substitution elasticity estimates are again taken from Taheripour et al. (2008). In the case of Brazil, the EU, and the USA (which dominate bio fuel production), elasticities have been calibrated to reproduce historical percentage increases in bio fuels production between 2001 and 2006 in response to increases in the price of crude oil. Thus, in Brazil, the EU, and the USA the values of ESUBGFU/ESUBPFU are 1.35, 1.65 and 3.95 respectively. Based on the historical data employed (2001-2006) the authors note that the elasticity estimates show that Brazil currently has less scope to increase bio-fuel usage in response to rising crude oil prices, whilst the USA shows the greatest potential for substituting conventional fuel usage in vehicles. As in Taheripour et al. (2008), in the remaining regions a default elasticity value of 2 is employed.

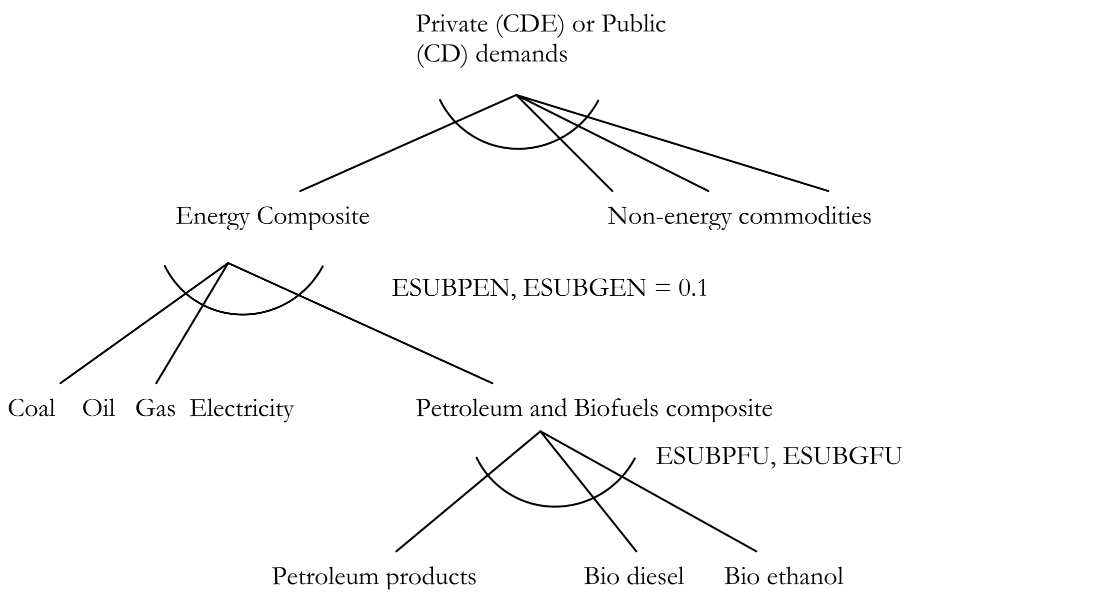

Figure 1: A modified private/public nesting structure for the Defra-Tap model

5. Aggregation and Scenario Design

5.1 Aggregation

The choice of model aggregation is provided in figure 2. All primary agricultural sectors are disaggregated including the three livestock sectors of cattle/sheep, pigs/poultry and raw milk. In the food processing sectors, red and white meat sectors and dairy are disaggregated to capture the impacts of increasing feed costs in these downstream sectors. The 'new' bio fuels sectors are disaggregated along with an energy composite (gas, coal, electricity), crude oil and petroleum. The remaining sectors are captured within the composites of manufacturing and services. The EU consists of the 'big-three' (France, Germany, UK), Spain (major EU pork producer) and three composite EU regions.[5] The

[5] Due to the modelling of the CAP budget, the EU3 (Austria, Netherlands, Sweden) must be separated from other EU regions.

non EU regions consist of the main suppliers of maize and soybean to EU27 markets (Argentina, Brazil, USA). In addition, 'large' agricultural players (e.g., AusNZ, Canada, China, India) on world markets as well as other potentially important EU trade partners (e.g., RussiaFSB, Turkey) are featured.

24 Sectors: rice, wheat, other grains, vegetables fruits and nuts, oilseeds, raw sugar; other crops, cattle/sheep, pigs/poultry, raw milk, wool, red meat, white meat, dairy, other food processing, beverages and tobacco, energy (gas, coal, electricity), Bio diesel, Bio ethanol (cereals and cane based), crude oil, refined petroleum, manufacturing; services.

19 Regions: UK, Germany, EU3 (Austria, Netherlands, Sweden); France, Spain, Rest of EU15, Accession 10, Accession 2, RussiaFSB (Russia and Former Soviet Bloc), Turkey, USA, Canada, Argentina, Brazil, RoLatAme (Rest of Latin America), Australia & New Zealand, China, India, ROW.

Figure 2: Sectors and Regions in the Model Aggregation

5.2 Assumptions/shocks shaping the scenarios

In the first part of this experiment we run a baseline scenario (see Figure 3) which is designed to capture the main trade policy drivers which have occurred since the benchmark year (2001). The main trade policy shocks are the enlargement of the EU from 15 to 27 members, the completion of the Uruguay Round trade liberalisation commitments by developing countries and Chinese accession to the WTO under the Most Favoured Nation clause. Importantly, all of these shocks are calculated taking into account the tariff overhang between the bound and applied tariff rates employing the work of Jean et al., (2005). In addition, the 2003 Mid Term Review CAP reforms are implemented for the EU27 employing supporting data on budget allocations, whilst the milk quota is eliminated. Finally, to capture the increased importance of bio fuels as an alternative form of land usage, we implement a shock to the world price of crude oil which corresponds to the price rise between 2001 and 2008.

Baseline Assumptions

1. Uruguay Round Commitments (+)

- Enforce developed country commitments (export subsidy limits, applied tariff levels)
- Complete developing country commitments (export subsidy limits, applied tariff levels)

2. EU Enlargement to 27 Members (+)

- Remove border protection between existing and 'new' member states.
- Impose common external tariff for all new EU members of the customs union.

3. Additional Trade Policy shocks (+)

- Chinese Accession

4. Agenda 2000 (A2000) commitments and the Mid Term Review (MTR) up to 2013

- Modelling of CAP mechanisms (CAP budget, modulation, quotas, set-aside, intervention prices)
- Reduction of intervention prices under A2000 and MTR reforms
- Imposition of set-aside for the 'new' EU member states
- Milk quota abolished. Sugar quota unchanged.
- Removal of ALL coupled support in the AC12 and MTR agreed components of coupled support (#) in the EU15.
- CAP budget including the implementation of Modulation funding and the UK Rebate mechanism.
- Full implementation of the SFP and land idling shocks.

5. Crude Oil Price Shock of 166%

+ = All tariff shocks account for the binding overhang

= data taken from DEFRA

Figure 3: Policy Assumptions Shaping the Baseline

In a subsequent set of experiments, we employ the updated data from the baseline as the benchmark year in the subsequent policy scenarios (see Figure 4). As noted in section 4.1, to model an import prohibition, the exogenous percentage change in consumer confidence, $z_{i,r,s}$ is swapped with the corresponding percentage change in import demand along that bilateral route, $q_{i,r,s}$. It is important to note that in the GTAP database, there is no separate soybean or maize sector, but rather these are subsumed within the sectors 'oilseeds', 'other cereals' and the large aggregate sector of 'other food processing'.[6]

[6] Prepared animal feeds appear in the 'other food' sector. For information on the GTAP concordance with specific disaggregate sectors, see Dimaranan (2006).

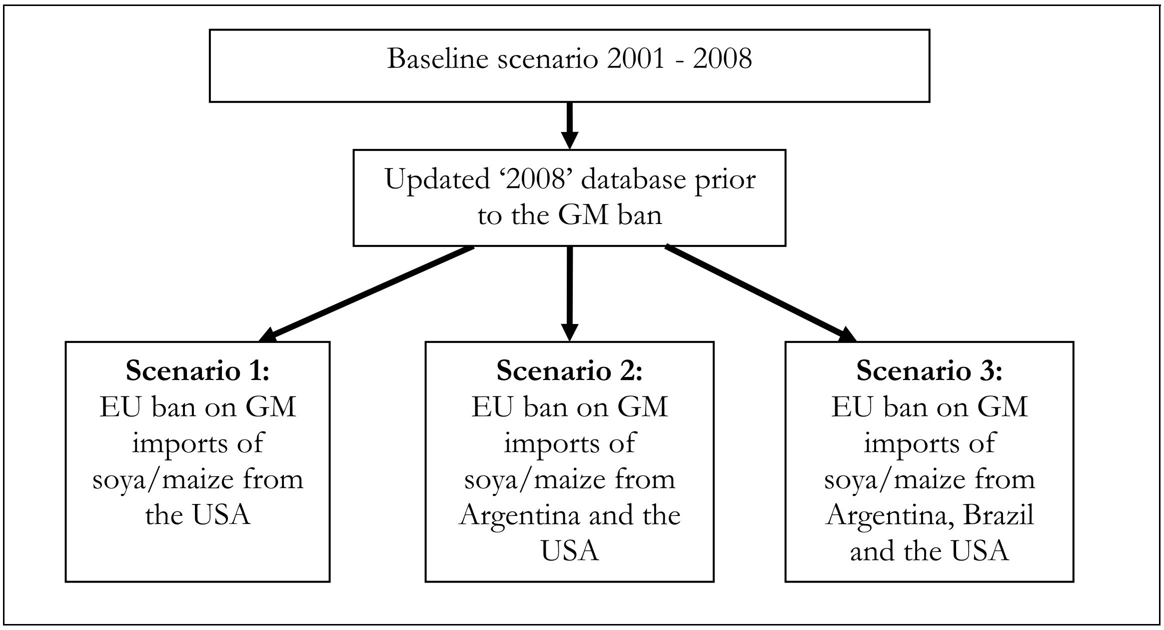

Figure 4: Scenario design schematic

Thus, import reductions in 'oilseeds', 'ograins' and 'ofoodpro' are based on the average proportion of the affected crops within each sector. To acquire this information, data were solicited from the UN COMTRADE (2008) database for a series of recent years (2001-2007) and averages were calculated. Thus, in Table 1, the average proportions are calculated are implemented as exogenous negative shocks. Thus, for example, the required negative shock to remove GM maize and soybean feeds from the 'ofoodpro' sector on exports from Argentina to the UK is -17.7%.

	share of 'maize' in 'ograins'			**share of 'soybean' in 'oilseeds' imports**			**Share of soya/maize feed in 'ofoodpro'**		
(%)	**Arg**	**Bra**	**USA**	**Arg**	**Bra**	**USA**	**Arg**	**Bra**	**USA**
UK	98.0	43.4	3.3	6.7	96.5	53.8	17.7	32.7	0.8
EU3	86.1	51.3	17.4	8.8	99.1	88.8	50.5	20.2	1.2
Ger	13.4	23.9	5.5	24.4	99.7	93.5	27.1	18.4	0.2
Fra	70.0	50.0	49.4	2.3	99.3	77.4	32.1	69.5	0.7
Spa	97.6	92.5	23.4	30.2	99.5	85.5	42.0	15.6	1.1
Ro15	92.5	55.4	27.0	64.3	99.5	87.2	59.8	23.8	2.9
AC10	53.2	74.3	67.9	5.1	47.4	15.5	56.3	41.3	4.2
AC2	63.8	74.6	72.3	24.3	50.0	38.6	39.8	12.2	2.0

Table 1: EU trade share data (2001 - 2007 average)
Source: UN COMTRADE (2008) and own calculations

The GTAP database also has data on the value of total imported feed inputs (i.e., oilseeds, ograins, other food) to the livestock sectors. Thus, in addition to the bilateral import shocks above, we also impose exogenous reductions on the intake of aggregate imported feed inputs of 'oilseeds' and 'other food' commodities[7] into the EU livestock sectors.[8] Once again, estimates from the surrounding literature is needed in order to apply reasonable shocks.

For the oilseeds shocks, data from USDA (2002) are employed, which suggests that 76% of all 'oilseed' imports to the EU are soybean. Subsequently, we the following assumptions are imposed:

Scenario 1: It is assumed (following EC, 2007) that imports from other destinations (i.e., Argentina and Brazil) could compensate for this loss in soybean. Thus, no reductions in imported farm imports occur.

Scenario 2: Approximately 45% of the total (i.e., 76%) soybean imports come from both the USA and Argentina. Thus, the exogenous reduction in oilseeds imports to the livestock sectors would be (0.45*76%=) -34.2%. Following EC (2007) it is assumed that Brazil could compensate around 40% of this loss, such that the final shock imposed is (0.6*34.2=) -20.5%.

Scenario 3: Approximately 93% of the total (i.e., 76%) soybean imports come from Argentina, Brazil and the USA. Thus, the exogenous reduction in oilseeds imports to the livestock sectors would be (0.93*76%=) -71%. We assume that there is no compensation from other regions (i.e., a worst case scenario).

A similar logic is employed for the imported 'ofoodpro' commodity reductions to the livestock sectors. Employing UN COMTRADE (2008) data averaged over 2001-2007, we estimate that on <u>average</u> 67% of EU27 feed imports are soya based. Unlike oilseeds, which is a relatively narrow sectoral definition, 'other food' covers *all* animal feed preparations, where the share of imported soya based feeds for pigs and poultry is likely to be considerably higher than that for cattle and sheep and raw milk production. Thus, we assume that 80% of the costs of 'other food' inputs to the pigs and poultry sector are soya based, whilst 36% of the costs of 'other food' to cattle and sheep and raw milk are soya based.[9]

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[7] In EC (2007) it is stated that the loss of maize imports from these three routes could be replaced by EU substitutes, by other domestic cereals or by imports from elsewhere. For this reason, we do not consider 'ograins' reductions here.

[8] The standard GTAP data does not allow the user to pinpoint the exact usage of feed type 'i' from exporting region 'r' in livestock sector 'j' in importing region 's'.

[9] The cattle and sheep/raw milk percentage is in proportion with the percentage of soya in the diet compared with pigs and poultry (see below)

Scenario 1: It is assumed (following EC, 2007) that imports from other destinations (i.e., Argentina and Brazil) could compensate for the loss in soybean in the sector 'other food'. Thus, no reductions in imported farm inputs are imposed.

Scenario 2: Approximately 45% of the total soybean imports come from both the USA and Argentina. Thus, the reduction in 'ofoodpro' imports to the pigs/poultry sector is (0.45 * 80% =) -36.0%. Similarly, for cattle/sheep and raw milk, the corresponding percentage reduction is (0.45 * 36% =) -16.2%. Following EC (2007) it is assumed that Brazil could compensate around 40% of this loss, such that the final exogenous reduction in pigs/poultry (cattle/sheep and raw milk) imported feed reductions is 0.6 * -36.0 = –21.6% (0.6 * -16.2 = -9.7%).

Scenario 3: Approximately 93% of the total soybean imports come from Argentina, Brazil and the USA. Thus, the reduction in 'other food' imports to the pigs/poultry sector would be (0.93 * 80% =) -74.4%, whilst for the cattle/sheep and raw milk, the aggregate feed import reduction is -33.5%. We assume that there is no import compensation from other regions (i.e., a worst case scenario).

Finally, estimates of average feed cost rises are exogenously implemented owing to the imposition of a GM ban on soya products.[10] Once again, it was necessary to rely on various literature sources to estimate these expected average feed cost rises, which will differ between livestock sectors due to differing dietary requirements for soybean based feeds. Indeed, to provide the animal with greater quantities of energy and protein as well as more rapid weight gain feed concentrates are needed, of which the most important are grains (maize) and oilseed meal derived from soya. Pigs and poultry are largely fed on such feed concentrates. On the other hand, ruminant animals (cattle and sheep) can digest only certain quantities of such high concentrate feeds, whilst cheap 'on-farm' (i.e., pasture based) sources of forage provide important sources of fibre.

According to Brookes et al. (2005), approximately 22% of broiler feed is soya related, whilst in Cardy-Brown (2008), it is stated that 20% of high performance pig feed is soya based. In addition, data from FEDNA (2008) gives tables of limits for the usage of soya ingredients in different types of Spanish livestock production. Importantly, the limits for Soymeal use in feed for pork and poultry are also around 20%, whilst for cattle and sheep the value is closer to 9% and in dairy production, 8%.

[10] As before, it is noted in EC (2007) that the loss of maize imports from these three routes could be replaced by EU substitutes, by other domestic cereals or by imports from elsewhere. For this reason, the analysis is simplified by not considering any feed cost implications from the usage of maize from other routes.

Percentage reductions in aggregate feed imports to the livestock sectors.			
	Scenario 1	**Scenario 2**	**Scenario 3**
Oilseeds	0.0	-20.5	-71.0
Other grains	0.0	0.0	0.0
Other food processing	0.0	-21.6/-9.7	-74.4/-33.5
Percentage increases in average feed costs by livestock sector.			
	Scenario 1	**Scenario 2**	**Scenario 3**
Cattle and sheep	0.0	7.8	Threefold increase
Pigs and poultry	0.0	23.0	Threefold increase
Raw milk	0.0	7.0	Threefold increase

Table 2: Description and magnitude of the shocks employed in the policy scenarios

Sources: USDA (2002); Brookes et al. (2005); EC (2007); Cardy-Brown (2008); FEDNA (2008); UN COMTRADE (2008) and own calculations/assumptions.

Having approximated the cost proportion of feeds in the different livestock sectors, it is necessary to employ further assumptions to impose plausible cost rises from a hypothetical GM ban on soya.[11] In EC (2007), it is estimated that average feed costs in the EU livestock sectors, from the loss of US and Argentinean soya imports, could rise by 23%. We employ this estimate in our scenario 2 for 'pigspoultry', whilst we assume proportionate average feed cost rises of 7.8% for cattle/sheep and 7.0% for raw milk production.[12] In scenario 3, EC (2007) suggest that feed costs could increase by at least 600% from the loss of Argentinean, Brazilian and US soya imports. This percentage increase is well beyond the limits of the Defra-Tap model (i.e., that is, to obtain an acceptable level of accuracy with such a large shock would 'at best' require many hours of run time). Consequently, more moderate percentage rises are assumed, where we implement a three-fold increase in feed costs compared with scenario 2. Whilst these cost estimates should not be taken as definitive, they at very least provide a useful guide to potential threat posed by a potential GM related ban to each of the three livestock sectors and their associated downstream meat sectors. A summary of the shocks implemented in each policy scenario is provided in Figure 5

[11] To implement feed cost increases, an exogenous Hicks neutral technical change variable is employed. For example, a 10% reduction implies that to attain the same level of feed productivity, the unit cost of feed inputs is now 10% higher. Assuming that the price elasticity of demand for feed was zero, employing the previous example, feed costs would rise by 10%. Given knowledge of the price elasticity of demand for feeds (calibrated to -0.2 in GTAP), it is possible to impose the necessary shocks to technical change to meet the feed expenditure rises in scenario 2.

[12] These values are based on the relative proportions of soya in the feed diets of pigs and poultry, cattle and sheep and raw milk production.

Policy scenario assumptions

Policy Scenario 1

Import ban on GM imports of maize and soya from the USA through country specific negative shocks calculated in Table 1

Specific negative shocks in aggregate imports of 'oilseeds' and 'ofoodpro' to the EU27 livestock sectors.

No average feed cost increases.

Policy Scenario 2

Import ban on GM imports of maize and soya from Argentina and the USA through country specific negative shocks calculated in Table 1.

Specific negative shocks in aggregate imports of 'oilseeds' and 'ofoodpro' to the EU27 livestock sectors.

Increased average feed costs of 23% (pigs/poultry), 7.0% (raw milk) and 7.8% (cattle/sheep).

Policy Scenario 3

Import ban on GM imports of maize and soya from Argentina, Brazil and the USA through country specific negative shocks calculated in Table 1.

Negative shocks in aggregate imports of 'oilseeds' and 'ofoodpro' to the EU27 livestock sectors.

Three-fold increase in average feed costs compared with scenario 2.

Figure 5: Assumptions Shaping the Policy Scenarios

6. Results[13]

6.1 Scenario 1

In scenario 1 (S1), it is assumed that there is no impact on feed costs from the EU27 ban on GM feeds from the USA. Due to the loss of the US import market for maize and soybean, Tables B1 and B2 shows concomitant falls in EU27 livestock sector demands for feed in response to the mild increase in animal feed prices. In this experiment the model estimates per unit feed cost increases of less than 0.1% for France, Germany and the UK. These cost rises are slightly higher in Spain and the EU3 (Austria, Netherlands, Sweden) suggesting that the US constututes a more important trade route for feeds and that feed costs have a larger share of total costs. Consequently, higher per unit feed prices have a minor and consistent negative impact on EU27 livestock production (Table B3). In the UK, cattle/sheep production drops by -0.03%, whilst raw milk and pigs/poultry production falls are negative, although close to zero.[14] Given the contractions in the livestock sectors, Table B3 reveals that UK agricultural output falls by -0.03% (compared with an EU27 fall of -0.05%).

[13] A full set of tables with results are provided in Appendix B.

[14] In the absence of any exogenous average feed cost shocks, the relative percentage changes in production for different livestock activities reflect the importance of livestock products in the total intermediate demands of downstream meat sectors. In turn, changes in meat demand (which is now more expensive – see Table B2) are dependant on the income and price elasticities of final demand for meat products.

With slightly higher feed costs, there is a slight, yet systematic, increase in market prices of EU27 livestock produce and agricultural output in general (see Table B4), which is passed onto the downstream meat sectors leading to concurrent percentage reductions in demand driven production levels (Table B3). Once again, it is noted that the minor impact of the EU ban on GM imports of soya and maize from the US results in only moderate endogenous changes in downstream meat sectors.

Examining exports (Table B5),[15] there are slight falls in aggregate livestock exports from the EU27 regions, whilst there are relatively larger rises in USA livestock exports. Since US feed prices have fallen due to the loss of the EU27 export market, this has subsequently improved the export competitiveness of the USA livestock sector and downstream meat sectors. Changes in EU27 imports reflect domestic supply and demand imbalances in each of the EU27 regions. With only slight reductions in domestic livestock and meat production, there is no clear trend for imports across the EU27 regions (Table B6), whilst at the EU27 level, imports of cattle/sheep, raw milk and red meat rise, whilst pigs/poultry, white meat and dairy imports fall slightly.

6.2 Scenario 2

The imposition of the GM ban on Argentinean and US imports of maize and soya has marked repercussions on the UK livestock sectors. Assuming that the resulting increase in animal feed costs in pigs/poultry, cattle/sheep and raw milk rise by 23%, 7.8% and 7% respectively, the fall in feed demands in the EU livestock sectors are presented in Table B7. Thus, in the UK pigs/poultry sector, feed demands fall by 7.21%, whilst in cattle/sheep and raw milk sectors, corresponding falls in UK feed demands are estimated at 1.53% and 1.75% respectively. These estimates compare with the EU27 average feed demands falls of 8.16% (pigs/poultry), 1.83% (cattle/sheep) and 2.35% (raw milk).[16]

With marked increases in average feed costs, UK market prices of pigs/poultry (Table B9) rise notably (5.07%), whilst more moderate average feed cost rises in cattle/sheep and raw milk lead to market price increases of 0.92% and 0.78% respectively. Consequently, in Table B8, UK production of cattle/sheep and raw milk is estimated to fall -0.69% and -1.00% respectively, whilst in pigs/poultry UK production falls 5.96%.

[15] It should be noted that raw milk is traded in very small quantities. The vast majority of milk product trade is recorded in the dairy sector.
[16] The inelastic demand falls in each of the livestock sectors are determined by the elasticity of substitution parameter between feed inputs.

Given that the feed cost rises are assumed uniform across EU livestock activities, the differences in EU market price rises for livestock are attributed to the share of feed costs in the total costs of production. Equally, the transmission of prices from upstream livestock to downstream meat sectors reflects both the magnitude of the livestock/raw milk price rises and the livestock cost share to the total intermediate and value added costs of meat/dairy production in the underlying input-output tables. The UK price rises in pigs/poultry and white meat (3.57% - see Table B9) production appear relatively favourable compared with France, Germany and the EU27 average. Consequently, UK production in the upstream and downstream white meat sectors does not deteriorate to the same extent as France, Germany of the EU27 average.

Given the strategic importance of the EU livestock sectors in agriculture, it is estimated that the GM ban in scenario 2 could produce an aggregate agricultural output fall of 1.76% in the UK (Table B8), compared with 2.00% in France, 2.43% in Germany and an average EU27 fall of 2.99%. In the AC2, the greater share of agricultural activity in total agricultural and economic output leads to an agricultural output contraction of 7.36% resulting in lost real growth of 1.85% (Table B8). Examining aggregate price indices, agricultural prices in the UK show increases of 1.42% (see Table B9) from the increased cost of feed input, which results in a retail price index (RPI) rise of 0.06%. In Table B9, these UK estimates compare with corresponding EU27 projections of 1.77% (agricultural price index) and 0.07% (RPI).

An examination of the trade impacts on EU livestock sectors from the feed ban in scenario 2 is presented in Table B10 (exports) and Table B11 (imports). In the GTAP database, the vast majority of 'animal' related trade occurs in the downstream meat sectors (i.e., red meat, white meat, dairy). In contrast, livestock trade is much smaller, especially on extra-EU trade routes. Furthermore, it is important to note that raw milk is largely non-tradable, so the percentage changes are calculated from a small base. With the fall in domestic production, Table B10 shows the resulting deterioration of EU exports of animal, meat and dairy products. In the UK, exports of white meat, red meat and dairy fall by 4.73%, 2.89% and 0.33% respectively, whilst cattle/sheep, pigs/poultry and raw milk exports are estimated to decrease by 2.33%, 6.84% and 1.58% respectively. Comparing with other European partners, UK export falls appear to be less accentuated given the more moderate impacts on UK output noted above. At the EU27 level, the results indicate that pigs/poultry and white meat trade could fall by between 8-9%.

With marked deteriorations in EU meat production, there is greater consumer dependency on non-EU sources of white meat, red meat and dairy products. In white meat, extra-EU imports rise by between 10-18% (Table B13), whilst in red meat and dairy, extra-EU imports rise by magnitudes of approximately 3% and 2% respectively (see Table B13). Notwithstanding, given the traditional dominance of intra-EU import trade in the meat sector, contractions in EU meat production lead to decreasing intra-EU imports and an overall contraction in downstream meat and dairy import demand (see Table B11). In the UK, the relatively moderate impacts of the GM ban in scenario 2 results in smaller aggregate import falls (see Table B11). Examining the EU27 trade balances for livestock and meat/dairy products (Table B12), the results show deteriorations in upstream balances of -€4m (raw milk), -€8m (cattle/sheep) and -€66m (pigs/poultry, whilst larger base trade volumes in downstream commodities result in larger trade deteriorations of -€217m (dairy), -€173m (red meat) and -€1,341m (white meat).

In terms of the impact on the non-EU regions of the aggregation, the main exporters of red meat to the EU are Australia and New Zealand (39%), Brazil (23%), Argentina (6%), USA (6%), and rest of Latin America (6%). In white meat trade, Brazil has the largest trade share (19%), followed by Turkey (13 per cent), the USA (7%), China (7%) and Australia and New Zealand (7%).[17] Finally in dairy trade, Australia and New Zealand have a 35% trade share, followed by Turkey (16%) and RussiaFSU (9%). In Table B10, the model estimates show consistent non-EU region export trade rises in response to greater EU dependency, whilst as expected, white meat export increases are considerably more marked.

Since soybean and maize feeds from the USA have been prohibited by the EU, USA and Argentinean livestock becomes more competitive due to the associated impact of the EU feed ban feed prices in these regions.[18] With a relatively large trade share in EU red meat imports, USA and Argentinean red meat trade balances improve €38m and €24m respectively. For the same reasons, the USA's white meat trade balance improves by €304m (followed by China with a trade balance improvement of €135m).[19] Given the size of their initial trade share, Australia and New Zealand realise the largest trade surplus gains in dairy of €50m respectively.

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[17] In the case of Turkey, this is due to poultry trade only, whilst for China, white meat trade is largely dominated by pork production.

[18] Due to EU GM embargo on USA and Argentinean soybean and maize exports, per unit feed costs in the USA (Argentina) fall by -0.13% (-1.34) in cattle/sheep, -0.43% (-1.78%) in pigs/poultry and -0.13% (-1.46%) in raw milk production

[19] Examining the overall per capita real income change, it appears that in Argentina, increased livestock competitiveness does not compensate for lost feed sales to the EU27, such that real per capita utility falls -0.13%. In the USA, per capita utility remains static.

Finally, per unit world feed costs (see Table B14) are estimated to rise by 0.68%, 2.95% and 1.02% for cattle/sheep, pigs/poultry and raw milk respectively, due to the weighted increase in average EU animal feed costs.[20] Given the transmission of feed prices into higher livestock (and eventually) meat/dairy prices, the trade weighted index of world prices in these products are also expected to rise (see Table B14). In scenario 2, pigs/poultry and white meat world price increases are estimated at 2.25% and 1.57% respectively. Equally, in remaining livestock, meat and dairy sectors, world prices increase by 0.59% (cattle/sheep), 0.49% (red meat), 0.43% (raw milk) and 0.56% (dairy).

6.3 Scenario 3

In addition to the losses in Argentinean and USA imports of soybean and maize, the EU also imposes a ban on imports of Brazilian equivalents. It is assumed that there is no compensation from other import/domestic sources whilst the low substitutability of soybean derived feeds for other feed ingredients result in significant feed cost increases. In this scenario, average feed costs are increased three-fold across all EU members. Accordingly, the model estimates considerable deteriorations in livestock production (see Table B16), particularly in the pigs/poultry sector, which has a higher protein feed demand. In the UK, pigs/poultry declines by one-quarter, compared with a corresponding contraction in EU27 pigs/poultry activity of just over one third. Cattle/sheep and raw milk production falls (Table B16) are much more modest, although the notably larger feed cost share in AC2 livestock sectors leads to EU27 declines of 7.47% (cattle/sheep) and 9.32% (raw milk). Overall UK agriculture contracts by 7.86% in scenario 3, whilst the size of the pigs/poultry sector in Member States such as Germany and Spain lead to larger agricultural output falls of 10.54% and 13.22% respectively. In terms of the final product, white meat production falls by one-tenth in the UK, with a similar fall in France; however, in Germany and the EU27, the falls are closer to one fifth. Similarly, UK red meat and dairy produce see production falls of approximately 2%, whilst UK real growth deteriorates by 0.16%. With agriculture playing a smaller role in the UK economy, this result is to be expected when compared with other EU members (especially the AC2 – see Table B16).

With three-fold increases in feed costs and consequent reductions in competitiveness/productivity, livestock feed demands fall by an even higher percentages in all EU regions (Table B15) compared with scenario 2, whilst input price rises are passed on

[20] Since feed is largely contained within the GTAP sector of 'other food', recorded price increases are typically small reflecting the small share of animal feed in this broadly defined food sector. Thus, instead of calculating the trade weighted average increase in 'other food' sector prices, it is preferable to calculate the weighted global change in average feed costs for each livestock activity.

in the form of higher product prices in the livestock sectors (Table B17). Given the assumptions shaping scenario 3, it is estimated that UK pigs/poultry price rises of 39.89% lead to increases in white meat prices of 20.41%. The highest white meat price increases occur in Spain, reflecting both the high pig/poultry input price rise and the its cost share in white meat production. In contrast, the significant price rise in pigs/poultry (over 100%) only leads to a relatively moderate white meat price increase of 21.28%.[21] The retail price index (RPI) in the UK rises by 0.29% (close to the EU27 average), whilst in the recent accession members, larger RPI rises reflect the greater importance of agro-food products in consumer expenditures.

As expected, reduced trade competitiveness in EU27 livestock and meat/dairy sectors result in reduced EU27 exports. In the most seriously affected sectors of pigs/poultry and white meat, EU27 exports decrease by 51.11% and 39.44% respectively. Given more tempered output falls in the UK, exports of pigs/poultry and white meat fall by a smaller magnitude (42.28% and 37.89% for pigs/poultry and white meat respectively). As in scenario 2, despite increases in extra-EU import demand for downstream meat and dairy produce (Table B21), reductions in intra-EU trade from contractions in EU27 meat production result in aggregate reductions in EU member state imports (Table B19). In scenario 3, it is estimated that the EU27 trade balance (Table B20) in white meat trade worsens by -€5,991m, whilst in red meat and dairy, corresponding trade balance deteriorations are recorded as -€996m and -€1,058m respectively.[22]

Table B19 shows that with the reduction in EU27 exports, non-EU region imports fall. At the same time, non-EU regions exploit the reduced competitiveness in the EU livestock sectors with consistent export increases across all livestock, meat and dairy sectors (Table B18). With prohibitions on EU imports of Argentinean, Brazilian and US soybean and maize animal feeds, the principal source of livestock costs fall in all three regions.[23] Consequently, the USA and Brazil realise significant improvements in their white meat trade balances (see Table B20) of €1,135m and €847m respectively, whilst China (€557m), Canada (€347m) and Turkey (€278m) also see notable trade balance improvements.[24] Much of the remaining EU white meat trade deficit is picked up collectively by the ROW

[21] Examining the GTAP data set, it appears that the share of white meat costs related to pigs/poultry inputs is smaller than in other EU regions - this result should be treated with caution.

[22] For the UK the trade balance deteriorations are -€110m (red meat), -€292m (white meat) and -81m (dairy).

[23] In Argentina and the USA, the average feed costs falls are of a similar magnitude to scenario 2. In Brazil, per unit feed costs fall on average by 1.64% (cattle/sheep), 1.75% (pigs/poultry) and 1.64% (raw milk).

[24] Whilst USA feed prices fall by less than Brazil, the value of their global exports of white meat is almost three times the size of Brazil in the data. Argentina, by contrast, has a relatively small global export base of white meat in the GTAP trade data.

composite region. In dairy trade, the largest positive gains accrue to Australia and New Zealand (€257m) on account of its large EU trade share, whilst that of the USA also improves €130m. Finally, with its large share of EU import markets and improved trade competitiveness, Brazil realises a red meat trade balance improvement of €134m, followed by the USA (€124m) and Australia and New Zealand (€105m). With greater competitiveness in animal production and a 6% EU import trade share, Argentina also experiences a red meat trade balance gain of €39m. That this gain is smaller than the USA (despite larger feed price falls in Argentina) can be attributed to the fact that USA global exports of red meat are over twelve times the magnitude of Argentina.[25]

Table B22 shows the impacts of scenario 3 on trade weighted world prices of livestock/meat/dairy products and animal feeds. In terms of livestock, meat and dairy prices, the rising costs of EU27 animal and meat production have inflated trade weighted world prices by 3.41% (cattle/sheep), 14.97% (pigs/poultry) and 2.19% (raw milk), whilst in related downstream sectors, prices rise by 2.60 (red meat), 10.05% (white meat) and 2.92% (dairy). Similarly, with steep increases in EU average costs of feeds, per unit world feed costs rise by 8.93% for cattle/sheep enterprises, whilst in pigs/poultry and raw milk corresponding rises are estimated at 25.38% and 6.73% respectively.

7. Final comments

In this report, a quantitative assessment is conducted on the impact of an EU GM feed (maize and soybean) ban on imports from the USA (scenario 1); Argentina and the USA (Scenario 2); and Argentina, Brazil and the USA (scenario 3). The methodology employed is an in-house variant of the GTAP CGE trade model, nicknamed 'Defra-Tap'. The perceived advantage of this model is that is can yield useful predictions of the impacts of feed cost rises on livestock sectors, whilst additional vertical linkages allow the user to examine the potential implications for the EU meat and dairy sectors. With the addition of detailed bilateral trade data and the generous global coverage of regions, the model provides a detailed picture of the expected secondary impacts on trade flows between EU and non-EU regions. Finally, in its Defra-Tap incarnation, the model presents a superior treatment of agricultural factor and product markets, whilst the further addition of bio fuels activities in the baseline scenario presents a more plausible picture of agricultural land usage in response to contemporary needs for alternative energy sources. Consequently, it is

[25] It is interesting to note, that despite livestock sector improvements, both Argentinean and Brazilian real income per capita fall -0.12% and -0.14% from the loss of feed exports. In the USA, there is a slight per capita real income gain of 0.01%.

expected that the results presented in this report have much greater credibility than those of the standard GTAP treatment.

On the other hand, as with all modelling approaches, the quality of the results are only as goos as the underlying data upon which they are based and the modelling assumptions employed. In the policy scenarios investigated here, the varied impacts on given livestock activities depsite uniform feed cost increases is symptomatic of the differing cost share of feed in the total costs of livestock production across EU members. Equally, the cost share of primary livestock in downstream meat/dairy production influences the diverse outcomes (i.e., production, prices) in these sectors. This point should be borne in mind when comparing the UK with other EU members.

In addition, the standard GTAP data base does not contain a detailed treatment of animal feeds, which are largely contained within the aggregate sector of 'other food processing', whilst soybean and maize crops can also be found in 'oilseeds' and 'other grains' sectors. This data restriction has led to the less than ideal treatment of imposing proportional EU import reductions, which have been based on UN COMTRADE (2008) time series data over the baseline period (2001 – 2007).

A further issue relates to the production structure of CGE models. Through the introduction of multistage budgeting,[26] production decisions are compartmentalised into various levels of nesting each with an individual elasticity of substitution. Consequently, when faced with supply constraints, CGE models have a tendency to 'substitute around' problems, thereby mitigating the impacts on product markets. In the context of this research, aggregate imports of 'other food' inputs to the livestock sectors are effectively confined to animal feeds, whilst the cost share of these imports is relatively small.[27] Thus, with a large reduction in 'other food' feed imports (i.e., due to the GM ban) and substitution possibilities in favour of cheaper 'domestic' equivalents, the total cost rise in livestock sectors is moderate. An immediate response would be to assume Leontief (i.e., zero) substitution technology (or something very close to zero), although one would then be affecting the substitutability of *all* animal feed inputs just for one particular component (i.e., soybean), which is quite hard to justify in policy terms whilst it would also have major implications on the model results for EU livestock sectors. To reinforce the point further, if soybean usage by pigs/poultry in the UK were expected to fall by say, 50% (exogenous

[26] That is, the splitting up of cost minimisation over all inputs into different degrees of aggregation. For example, the division between domestic and imported inputs may be determined at a different level to the determination of imported inputs by region of origin.

[27] Between 6-10% share in the GTAP database.

reduction), then by virtue of the Leontief production structure, one would be imposing the restriction that all inputs, and therefore output, would also be falling by 50%.

Under these conditions, it was seen as more desirable to implement exogenous estimates of average feed cost rises from the loss (primarily) of soybean derived feeds. This approach captures the essential nature of this feed component without purging the essential substitutability which characterises input decision making in these models. The disadvantage of this approach is that the model results are largely dependent on the reliability of the feed cost shocks implemented. There are a paucity of cost estimates within the literature (estimates from EC (2007) are employed) whilst other secondary data sources are employed to implement plausible differences in cost rises in diverse systems of livestock production resulting variations in soybean feed compositions. No attempt has been made to implement different feed cost rises by EU member state.

In the context of the comments above, the underling message of the results shows that in scenario 1, the impacts for the EU are likely to be minimal given the assumption that alternative feed sources can compensate for the loss of US maize and soybean imports. As the discussion in sections 6.2 and 6.3 shows, the repercussions for EU livestock sectors in policy scenarios 2 and 3 are much more serious, where in scenario 3 EU27 pigs/poultry production declines by just over one-third, whilst white meat witnesses reductions of just under one fifth. Compared with other EU partners the UK fairs relatively well, whilst in the ‘old’ EU15 the traditionally larger producers of pork meat (Germany and Spain) witness production reductions of close to 40% in scenario 3. In trade terms, EU27 pigs/poultry and white meat trade decline by 50% and 40% respectively, whilst the USA and Brazilian livestock sectors in particular benefit given their large export presence on world markets.

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Appendix A: Deriving Modified Linearised CES Hicksian Demand Functions

Starting with the modified CES function:

$$U_{i,s} = A_{i,s}\left[\sum_r \delta_{i,r,s} Q_{i,r,s}^{-\rho_i} Z_{i,r,s}\right]^{-\frac{1}{\rho_i}} \tag{A.1}$$

where $U_{i,s}$ is the level of sub-utility from the consumption of differentiated commodity 'i' in region 's'; $Q_{i,r,s}$ is consumer demand in region 's' for representative variety 'i' from region 'r'; $Z_{i,r,s}$ is bilateral hierarchical utility associated with the consumption of the representative variety; $A_{i,s}$ is a scale parameter; $\delta_{i,r,s}$ is a CES share parameter; and ρ_i is an elasticity parameter. Minimising cost subject to (A.1) gives first order conditions:

$$P_{i,r,s} = \Lambda A_{i,s}\left[\sum_r \delta_{i,r,s} Q_{i,r,s}^{-\rho_i} Z_{i,r,s}\right]^{-\frac{(1+\rho_i)}{\rho_i}} \delta_{i,r,s} Q_{i,r,s}^{-(1+\rho_i)} Z_{i,r,s} \tag{A.2}$$

$$U_{i,s} = A_{i,s}\left[\sum_r \delta_{i,r,s} Q_{i,r,s}^{-\rho} Z_{i,r,s}\right]^{-\frac{1}{\rho_i}} \tag{A.3}$$

where $P_{i,r,s}$ is the price of representative varieties. Substituting (A.3) into (A.2):

$$P_{i,r,s} = \Lambda A_{i,s}^{-\rho_i} U_{i,s}^{(1+\rho_i)} \delta_{i,r,s} Q_{i,r,s}^{-(1+\rho)} Z_{i,r,s} \tag{A.4}$$

Following the approach of Dixon *et al.* (1992), linearisation of (A.3) gives:

$$u_{i,s} = \sum_r S_{i,r,s}\left[q_{i,r,s} - \frac{1}{\rho_i} z_{i,s}\right] \tag{A.5}$$

where lower case letters are percentage changes in the corresponding upper case variables, and $z_{i,s}$ is a linearised expenditure share weighted average of bilateral hierarchical utilities, with expenditure shares given as:

$$S_{i,r,s} = \frac{P_{i,r,s}Q_{i,r,s}}{\sum_{r}\left[P_{i,r,s}Q_{i,r,s}\right]} \qquad \text{(A.6)}$$

Linearisation of (A.4) gives:

$$p_{i,r,s} = \lambda + (1+\rho_i)u_{i,s} - (1+\rho_i)q_{i,r,s} + z_{i,r,s} \qquad \text{(A.7)}$$

where λ is a lagrangian variable. Thus, equations (A.5) and (A.7) are linearised first order conditions. Rearranging (A.7) in terms of $q_{i,r,s}$ gives:

$$q_{i,r,s} = -\sigma_i p_{i,r,s} + \sigma_i \lambda + u_{i,s} + \sigma_i z_{i,r,s} \qquad \text{(A.8)}$$

where σ_i is the elasticity of substitution between all pair-wise types of representative varieties in the nest:

$$\sigma_i = \frac{1}{1+\rho_i} \qquad \text{(A.9)}$$

Substituting (A.8) into (A.5) and rearranging in terms of $\sigma_i\lambda$ yields:

$$\sigma_i \lambda = \sigma_i \sum_{r} S_{i,r,s} p_{i,r,s} - \sigma_i \sum_{r} S_{i,r,s} z_{i,r,s} + \left[\frac{1}{\rho_i}\right]\sum_{r} S_{i,r,s} z_{i,r,s} \qquad \text{(A.10)}$$

Substituting (A.10) into (A.8) eliminates λ. Factorising the resulting expression gives linearised CES Hicksian primary factor demands:

$$q_{i,r,s} = u_{i,s} - \sigma_i\left[p_{i,r,s} - \left[\sum_{r} S_{i,r,s} p_{i,r,s}\right]\right] + \sigma_i\left[z_{i,r,s} - z_{i,s}\right] + \frac{1}{\rho_i} z_{i,s} \qquad \text{(A.11)}$$

where

$$z_{i,s} = \sum_{r} S_{i,r,s} z_{i,r,s} \qquad \text{(A.12)}$$

For consistent aggregation:

$$P_{i,s}U_{i,s} = \sum_{r} P_{i,r,s}Q_{i,r,s} \qquad \text{(A.13)}$$

By linearising (A.13), substituting (A.5) and rearranging:

$$p_{i,s} = \sum_{r} S_{i,r,s}\left[p_{i,r,s} + \left[\frac{1}{\rho_i}\right] z_{i,r,s}\right] \qquad \text{(A.14)}$$

Using the weighted composite hierarchical utility variable expression (A.12) and rearranging gives:

$$\sum_r S_{i,r,s} p_{i,r,s} = p_{i,s} - \left[\frac{1}{\rho_i}\right] z_{i,s} \tag{A.15}$$

Substitution of (A.15) into (A.11), expanding the brackets and collecting terms gives:

$$q_{i,r,s} = u_{i,s} - \sigma_i [p_{i,r,s} - p_{i,s}] + \sigma_i [z_{i,r,s} - z_{i,s}] - \sigma_i \left[\frac{1}{\rho_i} z_{i,s} - \frac{\sigma_i}{\rho_i} z_{i,s}\right] \tag{A.16}$$

Rearranging (A.9) in terms of ρ_i and substituting the result into (A.16):

$$q_{i,r,s} = u_{i,s} - \sigma_i [p_{i,r,s} - p_{i,s}] + \sigma_i z_{i,r,s} \tag{A.17}$$

Appendix B: Results Tables.

Feed prices	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27
Cattle/sheep	-0.00	-0.01	-0.04	-0.00	-0.06	-0.02	-0.00	-0.00	-0.01
Pigs/poultry	-0.00	-0.00	-0.05	-0.00	-0.04	-0.01	-0.00	-0.00	-0.01
Raw milk	-0.00	-0.01	-0.04	-0.01	-0.04	-0.01	-0.00	-0.00	-0.01

Table B1: Percentage change in EU livestock feed demands in scenario 1

Feed prices	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27
Cattle/sheep	0.02	0.03	0.21	0.05	0.27	0.08	0.01	0.00	0.06
Pigs/poultry	0.02	0.02	0.21	0.04	0.24	0.08	0.01	0.00	0.07
Raw milk	0.03	0.03	0.21	0.06	0.26	0.08	0.01	0.00	0.06

Table B2: Percentage change in EU feed prices in scenario 1

Production	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27
Cattle/sheep	-0.03	-0.03	-0.12	-0.01	-0.08	-0.03	-0.01	0.00	-0.03
Pigs/poultry	0.00	0.00	-0.16	-0.01	-0.13	-0.04	0.02	-0.01	-0.04
Raw milk	0.00	0.00	-0.07	-0.01	-0.10	-0.03	0.00	-0.01	-0.02
Agriculture	-0.03	-0.06	-0.12	-0.07	-0.10	-0.05	0.00	-0.02	-0.05
Red meat	-0.01	-0.01	-0.07	-0.01	-0.06	-0.02	-0.01	0.01	-0.02
White meat	0.00	-0.01	-0.14	0.00	-0.11	-0.03	0.02	0.03	-0.03
Dairy	0.00	0.00	-0.07	-0.01	-0.08	-0.03	-0.01	0.00	-0.02

Table B3: Percentage change in EU livestock, meat and agricultural production in scenario 1

Mrkt prices	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27
Cattle/sheep	0.00	0.00	0.01	0.01	0.09	0.01	0.01	0.00	0.02
Pigs/poultry	0.01	0.01	0.08	0.02	0.14	0.03	0.01	0.00	0.04
Raw milk	0.00	0.01	0.03	0.02	0.17	0.02	0.01	0.00	0.02
Agriculture	0.00	0.03	0.01	0.04	0.04	0.01	0.01	0.00	0.02
Red meat	0.01	0.00	0.01	0.01	0.03	0.01	0.01	0.00	0.01
White meat	0.01	0.01	0.04	0.00	0.08	0.02	0.01	0.00	0.02
Dairy	0.00	0.01	0.02	0.01	0.04	0.01	0.01	0.01	0.01

Table B4: Percentage change in EU livestock and meat market prices in scenario 1

Exports	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27	RusFSU
Cattle/sheep	-0.20	-0.13	-0.24	-0.06	-0.33	-0.19	-0.02	-0.02	-0.10	-0.26
Pigs/poultry	0.00	-0.03	-0.16	-0.03	-0.30	-0.08	-0.01	-0.04	-0.08	-0.06
Raw milk	-0.14	-0.17	-0.37	-0.20	-1.39	-0.27	-0.39	-0.24	-0.25	-0.27
Red meat	-0.16	-0.05	-0.06	-0.17	-0.30	-0.06	-0.01	0.02	-0.03	-0.04
White meat	-0.04	0.02	-0.18	-0.04	-0.57	-0.09	0.05	0.05	-0.08	-0.16
Dairy	-0.07	-0.02	-0.07	-0.05	-0.26	-0.07	-0.03	0.00	-0.05	-0.02
	Turkey	**USA**	**Canada**	**Argentina**	**Brazil**	**RoLaAm**	**AusNZ**	**China**	**India**	**ROW**
Cattle/sheep	-0.08	0.55	-0.19	-0.04	-0.27	-0.18	-0.09	-0.15	-0.24	-0.22
Pigs/poultry	0.05	0.26	0.01	0.12	-0.01	-0.02	-0.02	-0.06	-0.06	-0.03
Raw milk	0.06	1.56	0.32	0.47	0.14	0.01	-0.01	-0.12	-0.11	0.00
Red meat	0.01	0.46	0.03	0.21	0.00	-0.10	-0.18	-0.18	-0.28	-0.12
White meat	0.03	0.44	0.03	0.38	0.15	0.06	-0.02	-0.02	-0.05	-0.02
Dairy	0.00	0.47	0.10	0.25	0.00	0.03	0.05	-0.01	0.01	0.00

Table B5: Percentage changes in exports in scenario 1

Imports	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27	RusFSU
Cattle/sheep	0.09	-0.02	-0.12	0.02	0.04	0.00	0.00	-0.01	0.01	0.01
Pigs/poultry	0.01	-0.00	-0.06	0.01	-0.03	-0.01	0.03	-0.00	-0.01	0.01
Raw milk	0.05	0.07	0.10	0.11	0.58	0.11	-0.00	0.04	0.06	0.05
Red meat	0.05	0.01	-0.02	0.02	0.06	-0.00	0.02	0.04	0.01	0.01
White meat	-0.01	-0.01	0.01	-0.02	0.24	-0.03	-0.01	-0.02	-0.00	0.09
Dairy	0.01	-0.00	-0.10	0.00	0.04	-0.01	-0.00	0.01	-0.02	0.00
	Turkey	USA	Canada	Argentina	Brazil	RoLaAm	AusNZ	China	India	ROW
Cattle/sheep	-0.027	-0.29	0.14	-0.04	-0.02	-0.01	0.02	0.06	0.01	0.03
Pigs/poultry	0.02	-0.09	-0.01	-0.01	0.01	0.03	-0.00	0.09	0.01	0.04
Raw milk	-0.05	-0.66	-0.22	-0.28	-0.13	-0.08	-0.12	-0.01	-0.01	-0.08
Red meat	0.28	-0.21	0.01	-0.14	0.00	0.01	-0.03	0.02	0.01	0.10
White meat	0.03	-0.21	0.08	-0.14	-0.08	0.02	0.01	0.01	0.00	0.03
Dairy	-0.02	-0.25	-0.02	-0.12	0.03	0.00	-0.02	0.02	-0.02	-0.00

Table B6: Percentage changes in imports in scenario 1

(%)	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27
Cattle/sheep	-1.53	-2.07	-3.42	-1.87	-2.23	-2.45	-1.80	-5.96	-2.83
Pigs/poultry	-7.21	-7.64	-7.74	-7.00	-7.89	-8.35	-8.47	-10.22	-8.16
Raw milk	-1.75	-1.79	-3.12	-1.82	-2.42	-2.14	-1.44	-5.07	-2.35

Table B7: EU livestock feed demands in scenario 2

(%)	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27
Cattle/sheep	-0.69	-0.92	-2.24	-1.37	-2.09	-1.38	-1.68	-6.45	-1.92
Pigs/poultry	-5.96	-9.41	-8.28	-8.76	-9.74	-8.11	-7.70	-14.10	-9.00
Raw milk	-1.00	-1.21	-1.35	-1.62	-4.27	-2.03	-1.59	-7.83	-2.43
Agriculture	-1.76	-2.43	-2.49	-2.00	-3.12	-2.26	-2.73	-7.36	-2.99
Red meat	-0.43	-0.71	-1.70	-0.71	-0.53	-1.27	-1.08	-4.78	-1.28
White meat	-2.90	-5.49	-6.08	-2.99	-4.51	-5.79	-8.37	-5.31	-5.09
Dairy	-0.53	-0.92	-1.01	-0.73	-0.71	-1.00	-1.51	-4.71	-1.04
Real Growth	-0.04	-0.04	-0.05	-0.06	-0.08	-0.03	-0.23	-1.85	-0.05

Table B8: EU livestock, meat, agricultural and economic production in scenario 2

(%)	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27
Cattle/sheep	0.92	0.63	0.76	1.18	1.62	1.01	1.44	3.14	1.31
Pigs/poultry	5.07	7.02	5.57	7.23	7.97	5.91	5.70	9.36	6.89
Raw milk	0.78	0.82	0.88	1.00	2.67	1.29	1.11	3.72	1.40
Agriculture	1.42	1.54	1.50	1.38	2.07	1.35	1.64	3.61	1.77
Red meat	0.75	0.89	0.36	0.82	0.75	1.08	0.89	1.82	0.97
White meat	3.57	4.49	4.09	3.67	4.70	4.23	4.94	3.87	4.16
Dairy	0.49	0.78	0.66	0.70	0.75	0.71	0.85	1.28	0.72
RPI	0.06	0.05	0.06	0.07	0.09	0.06	0.20	0.63	0.07

Table B9: EU livestock, meat agricultural and consumer price indices in scenario 2

(%)	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27	RusFSU
Cattle/sheep	-2.33	-0.62	-1.07	-1.30	-3.08	-1.94	-1.38	-5.81	-2.25	0.34
Pigs/poultry	-6.84	-10.38	-7.85	-10.98	-12.10	-8.68	-7.32	-18.37	-9.18	0.44
Raw milk	-1.58	-2.00	-2.67	-2.75	-14.19	-4.88	-6.34	-21.07	-4.18	1.73
Red meat	-2.89	-2.01	-3.78	-2.35	-1.98	-2.67	-0.56	-5.31	-1.44	2.59
White meat	-4.73	-9.79	-6.18	-4.77	-12.51	-11.01	-9.97	-0.94	-8.64	7.36
Dairy	-0.33	-1.67	-1.20	-1.43	-1.59	-1.64	-1.69	-4.12	-1.63	1.46
(%)	**Turkey**	**USA**	**Canada**	**Argentina**	**Brazil**	**RoLaAm**	**AusNZ**	**China**	**India**	**ROW**
Cattle/sheep	0.54	0.89	0.23	5.06	0.44	0.36	0.32	0.42	0.44	0.34
Pigs/poultry	0.08	1.31	0.71	3.73	0.28	0.24	0.68	0.57	0.84	0.50
Raw milk	1.90	3.18	1.72	11.62	2.58	2.13	1.36	1.70	1.82	1.57
Red meat	0.70	0.89	0.14	8.88	1.37	0.64	0.24	0.41	0.41	0.73
White meat	10.74	6.01	5.14	19.66	7.82	6.98	7.56	6.15	8.18	6.87
Dairy	1.68	1.70	1.33	7.72	-0.01	1.05	1.11	1.34	1.43	1.29

Table B10: Aggregate exports in scenario 2

(%)	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27	RusFSU
Cattle/sheep	0.03	-1.59	-2.66	-0.59	-1.25	-1.93	-2.87	-1.03	-1.56	-0.96
Pigs/poultry	-4.06	-6.56	-6.9	-4.86	-6.8	-5.65	-4.83	-2.79	-5.76	-2.42
Raw milk	0.68	1.36	0.71	1.2	6.38	1.91	-0.61	4.58	0.62	-1.23
Red meat	-0.38	-0.42	-0.63	-0.91	-2.83	-0.4	-1.84	-0.77	-0.60	-1.41
White meat	-2.04	-2.52	-3.09	-3.51	1.1	-3.14	-0.57	-5.84	-2.77	-4.60
Dairy	-1.31	-0.63	-1.16	-0.68	-0.33	-0.92	-0.6	-2.56	-0.86	-0.89
(%)	**Turkey**	**USA**	**Canada**	**Argentina**	**Brazil**	**RoLaAm**	**AusNZ**	**China**	**India**	**ROW**
Cattle/sheep	-0.92	-0.16	0.23	-2.30	0.00	-0.33	-0.05	-0.16	-0.18	-0.28
Pigs/poultry	-4.21	-0.33	-0.43	-1.56	-1.99	-0.34	-0.43	-0.38	-1.93	-0.87
Raw milk	1.70	-1.51	-1.19	-4.97	-1.40	-1.28	-0.95	-0.95	-1.48	-1.03
Red meat	0.48	-0.17	0.08	-4.30	0.72	0.14	-0.43	-0.06	1.19	0.09
White meat	-3.62	-4.49	-1.22	-6.61	-5.35	-2.05	-4.34	-3.63	0.61	-2.51
Dairy	-1.51	-1.62	-0.89	-3.81	0.86	0.20	-0.54	-0.42	-1.25	-0.75

Table B11: Aggregate imports in scenario 2

€m	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27	RusFSU
Cattle/sheep	-4	0	2	-1	0	7	2	-14	-8	0
Pigs/poultry	-6	-1	-16	-29	-8	3	0	-8	-66	3
Raw milk	0	0	0	-1	0	-1	0	-1	-4	0
Red meat	-18	-17	-49	-2	9	-40	-34	-23	-173	14
White meat	-21	-190	-106	-35	-109	-553	-271	-56	-1341	76
Dairy	-15	-43	-11	-29	-10	-40	-37	-32	-217	13
€m	Turkey	USA	Canada	Argentina	Brazil	RoLaAm	AusNZ	China	India	ROW
Cattle/sheep	0	6	3	1	0	0	3	0	0	5
Pigs/poultry	3	36	8	1	1	0	8	9	1	11
Raw milk	0	0	0	0	0	0	0	0	1	1
Red meat	0	38	2	24	12	2	16	0	2	4
White meat	38	304	92	20	120	13	40	135	2	425
Dairy	4	29	9	25	-1	2	50	2	1	71

Table B12: Trade balance changes in scenario 2 (€2001 millions)

(%)	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2
Cattle/sheep	0.75	0.43	-1.28	1.06	0.83	0.87	0.93	1.02
Pigs/poultry	0.15	-1.86	-0.83	0.12	-1.39	-0.92	-0.16	3.17
Raw milk	1.84	2.52	2.03	2.08	7.64	3.01	2.30	6.19
Red meat	2.71	2.65	2.97	2.82	2.83	3.05	1.28	2.86
White meat	12.90	14.96	11.75	13.62	17.64	14.07	13.83	10.67
Dairy	0.92	1.95	1.34	1.89	2.10	1.48	1.79	0.25

Table B13: Extra-EU imports in scenario 2

World commodity prices (%)				Per unit world feed costs (%)	
Cattle/sheep	0.59	**Red Meat**	0.49	**Cattle/sheep**	0.68
Pigs/poultry	2.25	**White Meat**	1.57	**Pigs/poultry**	2.95
Raw milk	0.43	**Dairy**	0.56	**Raw milk**	1.02

Table B14: World commodity prices and livestock feed costs in scenario 2.

(%)	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27
Cattle/sheep	-7.85	-10.58	-14.12	-9.84	-10.97	-12.04	-9.57	-14.98	-12.09
Pigs/poultry	-30.56	-33.09	-34.35	-33.16	-35.25	-33.00	-35.26	-37.87	-34.99
Raw milk	-8.08	-8.27	-10.32	-8.50	-10.66	-9.65	-6.93	-16.39	-10.37

Table B15: EU livestock feed demands in scenario 3

(%)	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27
Cattle/sheep	-2.51	-3.57	-8.74	-5.37	-8.09	-5.39	-6.66	-23.99	-7.47
Pigs/poultry	-25.25	-37.01	-32.71	-34.66	-37.20	-29.90	-28.73	-45.43	-33.95
Raw milk	-4.10	-4.70	-5.15	-6.35	-15.56	-7.80	-6.41	-28.32	-9.32
Agriculture	-7.86	-10.54	-10.57	-8.69	-13.22	-9.12	-11.17	-27.60	-12.29
Red meat	-2.35	-3.10	-6.26	-2.69	-2.16	-4.68	-3.98	-15.18	-4.08
White meat	-9.99	-21.20	-22.17	-11.57	-18.06	-18.75	-25.79	-11.01	-17.60
Dairy	-2.00	-3.38	-3.74	-2.69	-2.59	-3.73	-6.10	-16.16	-3.84
Real Growth	-0.16	-0.20	-0.22	-0.26	-0.37	-0.29	-1.00	-7.88	-0.38

Table B16: EU livestock, meat, agricultural and economic production in scenario 3

(%)	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27
Cattle/sheep	5.24	3.40	4.17	6.53	8.90	5.70	8.29	20.11	7.44
Pigs/poultry	39.89	58.44	44.39	60.21	66.26	45.90	44.45	108.73	56.15
Raw milk	4.36	4.38	4.76	5.47	14.76	7.14	6.35	24.53	7.87
Agriculture	9.42	9.93	9.73	8.94	13.63	8.80	10.91	26.79	11.73
Red meat	4.41	4.64	2.16	4.32	3.96	5.70	4.64	9.26	5.18
White meat	20.41	29.48	26.20	22.92	32.59	26.68	30.26	21.28	26.14
Dairy	2.52	3.97	3.45	3.59	3.77	3.70	4.58	6.46	3.68
CPI	0.29	0.21	0.28	0.36	0.49	0.31	1.14	4.67	0.36

Table B17: EU livestock, meat agricultural and consumer price indices in scenario 3

(%)	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27	RusFSU
Cattle/sheep	-16.95	-7.73	-9.93	-11.20	-19.74	-15.01	-12.27	-35.79	-16.79	2.70
Pigs/poultry	-42.28	-56.55	-46.43	-58.21	-61.47	-48.58	-41.42	-80.14	-51.11	4.85
Raw milk	-12.95	-13.88	-17.27	-17.88	-59.36	-27.89	-35.61	-81.13	-23.71	10.46
Red meat	-20.36	-14.31	-24.64	-15.83	-14.09	-17.25	-7.67	-27.77	-11.95	13.98
White meat	-37.89	-49.79	-34.42	-24.61	-62.07	-47.39	-42.16	-10.13	-39.44	34.15
Dairy	-6.26	-12.85	-10.91	-11.67	-12.09	-12.98	-14.26	-23.28	-12.90	7.69
(%)	**Turkey**	**USA**	**Canada**	**Argentina**	**Brazil**	**RoLaAm**	**AusNZ**	**China**	**India**	**ROW**
Cattle/sheep	2.80	2.75	1.20	7.17	8.28	2.01	1.80	2.67	2.80	2.15
Pigs/poultry	0.79	6.40	3.68	8.12	5.08	1.51	4.43	3.58	5.14	3.73
Raw milk	9.54	12.25	8.87	21.06	27.52	9.93	7.28	9.69	10.18	8.78
Red meat	3.51	2.86	0.89	14.02	14.86	3.52	1.68	2.55	2.68	4.37
White meat	77.53	23.05	19.42	85.00	56.83	35.20	44.49	26.33	54.80	38.48
Dairy	9.01	7.54	6.99	12.51	11.19	5.68	5.67	7.23	7.60	7.01

Table B18: Aggregate exports in scenario 3

(%)	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27	RusFSU
Cattle/sheep	-0.10	-8.46	-14.47	-3.32	-6.84	-10.30	-16.06	-3.73	-8.48	-5.28
Pigs/poultry	-22.59	-35.69	-36.59	-28.49	-36.57	-28.65	-25.41	-6.24	-30.38	-13.22
Raw milk	4.14	7.39	4.00	6.61	38.01	10.97	-1.89	35.17	4.23	-5.98
Red meat	-3.17	-2.26	-3.13	-4.80	-12.79	-1.92	-8.24	-3.24	-2.82	-7.03
White meat	-16.25	-7.21	-8.39	-11.98	22.83	-13.26	-0.57	-29.58	-10.38	-15.45
Dairy	-6.55	-3.32	-5.95	-3.62	-1.92	-4.48	-2.59	-13.31	-4.33	-4.34
(%)	Turkey	USA	Canada	Argentina	Brazil	RoLaAm	AusNZ	China	India	ROW
Cattle/sheep	-4.94	-0.79	0.26	-3.52	-1.63	-2.81	-0.49	-1.10	-0.57	-1.70
Pigs/poultry	-21.16	-2.11	-3.18	-5.41	-11.69	-3.28	-2.37	-2.45	-10.29	-5.06
Raw milk	14.28	-5.72	-5.36	-9.25	-10.35	-5.04	-3.95	-4.62	-6.63	-4.76
Red meat	1.9	-0.58	0.01	-5.53	-3.29	1.52	-1.93	-0.46	9.68	0.02
White meat	-11.53	-14.19	-4.07	-9.71	-21.93	-5.44	-13.94	-11.95	4.47	-8.01
Dairy	-7.37	-7.45	-4.39	-5.07	-4.28	-2.23	-2.48	-2.18	-6.04	-3.89

Table B19: Aggregate imports in scenario 3

€m	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2	EU27	RusFSU
Cattle/sheep	-21	4	11	-1	-1	37	14	-81	-38	1
Pigs/poultry	-40	2	-97	-151	-40	-42	-2	-60	-432	28
Raw milk	-1	-2	-1	-3	-1	-6	-1	-2	-18	2
Red meat	-110	-78	-267	-6	-42	-198	-193	-101	-996	76
White meat	-292	-1320	-615	-179	-722	-2279	-1108	524	-5991	276
Dairy	-81	-192	-50	-129	-43	-199	-225	-139	-1058	64
€m	Turkey	USA	Canada	Argentina	Brazil	RoLaAm	AusNZ	China	India	ROW
Cattle/sheep	2	21	17	1	0	0	16	1	0	36
Pigs/poultry	11	196	46	3	7	1	50	61	9	95
Raw milk	2	2	0	0	0	0	0	0	5	6
Red meat	1	124	17	39	134	13	105	2	10	16
White meat	278	1135	347	56	847	65	218	557	13	1941
Dairy	20	130	46	41	11	13	257	8	6	377

Table B20: Trade balance changes in scenario 3 (€2001 millions)

(%)	UK	Ger	EU3	Fra	Spa	R15	AC10	AC2
Cattle/sheep	3.61	2.19	-8.44	4.56	4.03	3.75	5.05	7.90
Pigs/poultry	2.40	-11.06	-3.51	-0.30	-8.03	-1.74	2.25	38.93
Raw milk	10.22	13.63	10.97	11.26	46.35	17.02	13.64	45.95
Red meat	15.79	13.50	15.18	13.80	14.85	15.26	6.14	14.18
White meat	93.84	125.79	92.99	112.40	175.99	117.56	107.37	76.22
Dairy	4.52	10.08	6.98	9.79	10.77	7.72	9.69	-1.91

Table B21: Extra-EU imports in scenario 3

World commodity prices (%)				Per unit world feed costs (%)	
Cattle/sheep	3.41	**Red Meat**	2.60	**Cattle/sheep**	8.93
Pigs/poultry	14.97	**White Meat**	10.05	**Pigs/poultry**	25.38
Raw milk	2.19	**Dairy**	2.92	**Raw milk**	6.73

Table B22: World commodity prices and livestock feed costs in scenario 3