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THE LONG RUN IMPACTS OF THE BSE BEEF BAN IN THE UK

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1. Abstract

Hubbard and Philippidis (2001) employ the standard GTAP computable general equilibrium model to analyse the impacts of the BSE-induced ban on exports of UK beef. This paper extends their study by employing the dynamic GTAP version which incorporates additional features such as interregional capital allocation, endogenous capital accumulation and net foreign equity ownership. Moreover, from a policy perspective, improvements have been made through inclusion of the foot and mouth crisis and varied consumer confidence scenarios, whilst impact analysis is now compared *through time* using detailed annual projections and agricultural policy shocks. Despite full restoration of foreign consumer confidence in UK beef exports, long run comparisons with a 'no-ban' baseline suggest that output and export recovery in affected meat sectors is not complete, although speculative confidence gains from remedial safeguards and assurances provided in the wake of the BSE and FMD crises are estimated to have potential benefits to UK meat sectors.

2. Introduction

In March 1996, the European Union (EU) banned exports of British beef after the UK government admitted that there was a probable link between BSE and a variant of Creutzfeld-Jacob Disease (CJD), a fatal brainwasting condition in humans. By the end of 2000, further cases of the disease had appeared in Belgium, France, Germany, Ireland and Spain resulting in immediate response measures (i.e., significant intervention purchases of beef) and longer term strategic management initiatives (i.e., the reorientation of production toward extensification). Meanwhile, from the UK's

perspective, the EU maintained ban was not lifted until August 1999, whilst the financial implications of the crisis to the UK exchequer between 1996 and 2002 were estimated to total 4.6 billion (Hubbard, 2003). To make matters even worse, just as the UK beef sector was still recovering from the BSE crisis, an outbreak of Foot and Mouth disease occurred at the beginning of 2001 resulting in further EU imposed export restrictions on UK livestock which were finally lifted a year later.

In assessing the impacts of the BSE-induced ban on UK exports, Hubbard and Philippidis (2001) employ a modified version of the comparative static (CS) Global Trade Analysis Project (GTAP) computable general equilibrium (CGE) model. Using sequential CS simulations, they examine the extent to which the cattle, slaughtering and meat processing sectors recover their pre-ban positions after the ban is lifted. One shortcoming of their study, highlighted by the authors, is the relatively poor treatment of long run behaviour. Indeed, CS models have been criticised for theoretical inconsistency in that consumers and producers follow complex optimisation procedures to determine decision making (e.g., allocation of expenditure between food and services), whilst exhibiting relatively simplistic behaviour in the allocation of long-run investment. The dynamic version of the GTAP model (Ianchovichina and McDougall, 2000) employed here, addresses these weaknesses in the CS approach by incorporating a more complex characterisation of savings-investment behaviour, whilst modifying the CS database to incorporate net foreign investment flows.

In this paper the key aim remains the same as in Hubbard and Philippidis (2001), although the extent to which sectors recover is compared *through time* with a hypothetical baseline scenario in which the export ban is not imposed. Results are

therefore improved from a policy perspective, in that we now project through annual interdependent time periods using detailed annual projections and agricultural policy reform shocks, to make a more realistic comparison with the time path had the ban never occurred. Additionally, we incorporate the impact of the foot and mouth disease (FMD) crisis in the UK in 2001, which compounded the effects of the BSE-induced ban on exports.

3. Methodology and Data

3.1 Dynamic GTAP Model and Data

The standard comparative static GTAP trade model (Hertel, 1997) relies on nested neo-classical optimisation techniques (utility maximisation; cost minimisation) to characterise both nested final and intermediate demands. Production activities are determined by market clearing equations, assuming constant returns to scale and perfect competition. The 'regional household' accrues income from the ownership of factors and net tax revenues, which are apportioned over three forms of final demand: non-homothetic private expenditures, public expenditures and future expenditures (savings). Bilateral trade relations between regions are characterised with an Armington (1969) specification, which avoids complete specialisation effects from otherwise homogeneous goods. Finally, 'long run' closure involves the use of a fictitious agent, known as the 'global bank', which collects each region's investment funds (savings) and allocates them such that changes in expected rates of return across all regions are equalised (i.e., perfect capital mobility). In the single period comparative static model treatment, all investment is region specific and does not affect the current level of productive capital services.[i] The accompanying GTAP database (Dimaranan and McDougall, 2002) consists of three principal data inputs: domestic input-output tables

for the regions; bilateral gross trade flows; and protection and support data represented as *ad valorem* price wedges.[ii] Finally, the model is calibrated to a benchmark year employing 'borrowed' trade, factor and input substitution parameter estimates.

The dynamic (intertemporal) GTAP characterisation extends the standard model and data treatment by incorporating capital accumulation effects, adaptive (lagged) expectations and modifications to the accounting conventions of the data to incorporate international capital mobility.[iii] Regional capital stock accumulation is a function of 'continuous' time which is consistent with the GTAP database where stock and flow data refer to a single temporal point. Investor 'expectations' of the actual rate of return on an asset are based on the extent to which *current* period capital stock growth diverges from a reference or *'natural'* growth rate which is consistent with constant growth in the actual rate of return through time.[iv] If current capital stock growth exceeds the 'natural' growth rate, investors adjust their expectations of the actual rate of return downwards in the next period (i.e., lagged expectations). Over the long run, the adaptive expectations treatment employs an error correction mechanism such that lag errors between expected and actual rates of return in each region are eventually eliminated and expected return rates across regions converge, although this long run effect may not be realised within the chosen time frame of the model scenario.[v]

The dynamic treatment also extends the standard GTAP data by drawing a distinction between domestic and foreign wealth or equity (i.e., capital ownership). Unfortunately, due to data constraints the model cannot measure the impacts of FDI from specific bilateral partners.[vi] Accordingly, a 'second-best' approach is employed incorporating a 'global trust', which assumes the duties of the global bank whilst also handling foreign

investments. Thus, data by region for household (domestic) equity consists of 'home' ownership of domestic capital (HW_{DK}) and the stake in the trust (i.e., 'home' ownership of foreign capital - HW_{FK}):

$$HW_D \equiv HW_{DK} + HW_{FK} \quad (1)$$

This must be distinguished from the region's equity (W_D), consisting of domestic (home) ownership (HW_{DK}) and foreign (trust) ownership (FW_{DK}):[vii]

$$W_D \equiv HW_{DK} + FW_{DK} \quad (2)$$

By definition, the total stake the trust holds in all regions (inward foreign investment funds) is equal to the sum of each region's stake in the trust (outward foreign investment):

$$\sum_{reg} FW_{DK} \equiv \sum_{reg} HW_{FK} \quad (3)$$

where income (rent) streams accruing from equity are administered by the trust.

3.2 Modelling Imperfect Competition and Consumer Confidence

Production activities in food processing, services and manufacturing are oligopolistic, combining strategic (Cournot) conjecture with freedom of entry and exit of firms. Mark-ups are calibrated, *inter alia*, to the number of firms in each sector, adjust endogenously and vary according to the seller's market (i.e., domestic vs export).[viii] A fuller description of the imperfectly competitive industries is given in the appendix. In the

remaining primary agricultural sectors, a perfectly competitive constant returns to scale framework is assumed.

Employing standard economic theory, both the Cournot oligopolistic and perfectly competitive paradigms dictate that commodity demands are homogeneous. Accordingly, we maintain a perfectly homogeneous Armington demand structure, but include an exogenous utility scaling variable (Z) to characterise consumers' tastes and preferences without compromising the model's underlying theoretical structure:

$$U_{i,s} = \left[\sum_{r} \alpha_{i,r,s} Q_{i,r,s}^{\rho_i} Z_{i,r,s}^{\rho_i}\right]^{\frac{1}{\rho_i}} \qquad (4)$$

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'; $\alpha_{i,r,s}$ is a CES share parameter; and ρ_i is an elasticity parameter.

As in Hubbard and Philippidis (2001), the impacts of the BSE-induced ban are modelled employing structural changes to demands for UK meat exports. Thus, in the benchmark data each 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 1996 BSE-induced export beef ban and further impacts on UK livestock exports from FMD in 2001 is characterised as a downturn in foreign consumer confidence for UK beef, captured through negative shocks to $Z_{i,UK,ROW}$, where i relates to primary and processed meat. Subsequent removal of the ban involves reversing the confidence shock necessary to return the relevant scaling variables to their pre-ban values (i.e., 100 per cent

confidence recovery). Further variations on this theme are introduced to realise 75 per cent and 120 per cent confidence recovery, the latter motivated by remedial safeguards and assurances provided in the wake of the BSE and FMD crises.

This modelling treatment is seen as preferential to exogenous export shocks (through closure swaps with tariff variables) since it avoids having to restrict exports exogenously by allowing a tariff wedge to raise the export price to a level commensurate with the desired reduction in quantity exported. This would present a problem in that, since sectoral aggregation in the GTAP database does not allow separation of cattle from sheep, nor of beef products from other meat products, the required reduction in exports of primary and processed meats is less than 100 per cent (see below), and any bias in export prices will affect sheep and non-beef meat products in subsequent time periods.

Employing cost minimisation procedures to (4) and expressing as percentage changes (denoted by lowercase letters) gives:[ix]

$$q_{i,r,s} ? u_{i,s} ?? _i[p_{i,r,s} ? p_{i,s}] ?? _i z_{i,r,s} \quad (5)$$

$$p_{i,s} ? \sum_r S_{i,r,s} p_{i,r,s} ? \frac{1}{?_i} z_{i,s} \quad (6)$$

$$z_{i,s} ? \sum_r S_{i,r,s} z_{i,r,s} \quad (7)$$

$$?_i ? \frac{1}{?_i} ? 1 \quad (8)$$

Linearised import demands ($q_{i,r,s}$) in (5) are a function of commodity prices ($p_{i,r,s}$) and utility ($u_{i,s}$), i.e., Hicksian, as well as the scalar ($z_{i,r,s}$).[x] 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 6), where composite utility is itself an expenditure share weighted average (equation 7). Finally, the elasticity parameter, $?_i$, is defined in (8) in relation to the elasticity of substitution ($?_i$), taken from a modified GTAP data set (Swaminathan and Hertel, 1996).

3.3 Data Manipulation

This study employs version 4 of the GTAP dynamic database where the benchmark year is 1995.[xi] Whilst the subsequent version 5 has a superior characterisation of domestic support structures in EU countries,[xii] its benchmark year is 1997 which is one year after the imposition of the ban thereby ruling out the possibility of a 'no-ban' scenario. Whilst it would have been possible to 'project' version 5 data back two years, this was seen as problematic given the necessary changes required to replicate the UK economy prior to the ban. To circumvent this problem we decided to employ version 4 dynamic data, although this required us to make changes to the representation of agricultural support in the UK. Thus, as in Hubbard and Philippidis (2001), we follow Bach *et al*. (2000) by stripping out de-coupled payments from the cereals and livestock output subsidy wedges in the standard GTAP database and recalibrating them as input subsidies.[xiii] Finally, following Hubbard and Philippidis (2001), the regional aggregation focuses on the UK, with a residual Rest of the World (ROW) composite to capture foreign demand. The commodity aggregation incorporates key primary agricultural and food sectors in the UK, along with aggregated manufacturing and services sectors capturing activities in the remaining part of the model.[xiv]

4. Experimental Design

The inter-temporal 'no-ban' *baseline* scenario includes macro shocks (population, productivity growth, gross domestic investment, skilled and unskilled labour), tariff and support shocks from the Uruguay Round (UR) of the GATT, and relevant Common Agricultural Policy (CAP) reform shocks.[xv] Projections and UR shocks are applied employing data from Walmsley *et al.* (2000) and the authors' own calculations, whilst explicit representation of CAP policy mechanisms, liberalisation under Agenda 2000 and export subsidy reductions follow Philippidis and Hubbard (2003).[xvi] The period of study ranges between 1995 and 2020.

The export ban scenario has the same 'background' shocks as the baseline, with the addition of an export ban implemented in the cattle and sheep (C&S), slaughtering and meat processing (SMP) and other meat processing (OMP) sectors in 1996, with corresponding percentage reductions in UK exports of 72, 45 and 45 per cent. Whilst the ban was officially lifted in 1999, France and Germany continued to refuse imports of UK beef. In the case of France, the main purchaser of UK beef and veal exports, trade did not resume until 2002. Moreover, the FMD crisis in 2001 had a further negative impact on livestock exports. Consequently, in modelling the lifting of the ban we do not allow foreign consumer confidence to recover until 2002.[xvii] In reinstating consumer confidence for UK beef, we examine three scenarios based on the level of recovery, namely 75%, 100% and 120% of the level of confidence in the baseline. The last of these is to allow for the possibility that the additional safeguards and assurances now evident in the beef supply chain, in the wake of BSE and FMD, may have boosted

consumer confidence to a level higher than would have been expected in the absence of these crises (Hubbard, 2003).

5. Results

We present results based on differences between the 'no ban' baseline scenario and the alternative export ban scenario, where the recovery in consumer confidence is varied between 75% and 120%. Whilst the simulation covers twenty-five annual periods between 1995 and 2020, the results presented are for the year of the ban (1996), for the year in which exports deteriorated further due to the FMD crisis (2001), and for the long-run recovery year (2020). We focus our discussion on the results for 2001 and 2020.

5.1 Results for 2001

The effects on UK exports in the directly affected meat sectors are shown in Table 1, where further reductions in 2001 are apparent in the C&S sector (92 per cent reduction on the 'no-ban' baseline), the SMP sector (49 per cent) and the OMP sector (49 per cent). The impact of the ban and the subsequent FMD crisis is estimated to have reduced UK primary agricultural exports by 10 per cent, and food processing exports by six per cent, compared with the no-ban scenario.

Output reductions in 2001 in the three directly affected sectors are seven per cent, eight per cent and three per cent (Table 2).[xviii] Moreover, the output reductions in UK meat processing sectors are concurrent with rises in mark-ups, falls in output per firm and rising average costs. The impact of these specific sector effects on composite primary

agricultural and food processing output is also negative. Total UK agricultural output is almost 2 per cent lower in 2001, and that of food processing 1 per cent lower.

With agro-food related sectors contracting, there are concurrent expansions in manufacturing and services as resources are reallocated to non-food sectors. Results in Table 3 show marked reductions in labour employment in 2001 of nine per cent in C&S and eight per cent in SMP. Capital usage falls by eight per cent in SMP, whilst that of pasture land falls by five per cent in the C&S sector.

The deterioration in meat related exports results in a loss of over US$ 1.6 billion in 2001 (Table 4). Results suggest that the BSE and FMD crises actually led to an improved overall UK trade balance in 2001, as non agro-food (i.e., manufacturing and services) trade balances improve. This general equilibrium outcome arises as a consequence of the protection afforded to UK agriculture under the CAP. Finally, price effects (Table 5) are small for sectorally mobile factors, whilst sector-specific factors witness larger changes. This is particularly apparent for pasture land, as the contraction in C&S production depresses the price by around nine per cent in 2001. As a result, the fall in the agricultural retail price index (RPI) is almost one per cent.

5.2 Results for 2020

From 2002 onwards three confidence recovery scenarios are modelled all of which embody a reverse shock to that imposed during the ban and in the wake of the FMD crisis. As expected, all three confidence recovery scenarios lead to long run improvements in output, exports, agricultural and food related trade balances and factor uptake from the lows of 2001. Implementing full consumer confidence recovery (i.e.,

100%) leads the downstream meat sectors to practically recover their 'no-ban' scenario positions in 2020. However, output in the upstream C&S sector is still 1 per cent below the 'no-ban' level (Table 2), and exports are 14 per cent lower (Table 1), which explains why labour employment (Table 3) and rents to pasture land (Table 5) do not completely recover their 'no-ban' levels. The trade balances (Table 4) for C&S, SMP and OMP under 100% confidence recovery are all negative, -$US 45 million, -$US 15 million and -$US 8 million respectively, whilst the impact on the UK net total balance is negligible (- $US 8 million).

Given the 100% confidence recovery outcomes, partial (75%) confidence recovery results unsurprisingly in each of the three meat sectors falling short of their 'no-ban' output and export positions, and a poorer UK trade balance of -$US 80 million in 2020. In contrast, with meat sectors surpassing their 'no-ban' output and export levels under conditions of 120% confidence, trade balances improve for C&S ($US 21 million), SMP ($US 121 million) and OMP ($US 121 million), with an overall improvement in the UK trade balance of $US 56 million by 2020 (Table 4).

5.3 Dynamic Financial Effects

Table 6 presents the aggregate welfare and net dynamic financial effects and real income (equivalent variation - EV)[xix] for the UK. The capital earnings effect is income from the total domestic stock of capital in the UK, which existing in the CS version of the model, is now the difference in *cumulative* temporal earnings from endogenous capital accumulation in the ban and no-ban scenarios. Unlike the CS version, the dynamic model corrects the capital earnings effect for net foreign ownership, where some UK capital stock is equity owned abroad (outflows), whilst further incomes accrue

to the UK on domestically owned foreign equity (inflows). Thus comparing the capital earnings and net financial rows in Table 6 reveals the CS misspecification of financial effects on EV.

As the ban shocks pertain to relatively small UK sectors, the impacts on UK investment and real income are limited, where for the latter, even at the peak (2001) of the crisis, real income falls a mere 0.002% below the no-ban scenario. In terms of investment, slight reductions in UK real growth in 2001, under the ban scenario, reduces the level of capital stock accumulation and therefore capital earnings. In 2020, capital earnings recover with increases in UK real growth in response to the foreign confidence recovery on UK meat exports. Notably, the 120% confidence recovery scenario results in capital earnings above the baseline. Net foreign earnings are a function of global rates of return on foreign equity and UK rates of return. Thus, falls in the rate of return on UK owned equity abroad result in declines in inward FDI, whilst falls in the rate of return on foreign owned equity in the UK result in declines in outward FDI. However, these cumulative falls are lessened as the economy slowly returns to the long run 'no-ban' baseline trend.

6. Conclusions

This paper extends the Hubbard and Philippidis (2001) study of the BSE-induced ban on exports of beef from the UK. More specifically, a dynamic model variant of the GTAP enhances the quality of the results incorporating additional features such as interregional capital allocation, endogenous capital accumulation and net foreign equity ownership. From a policy perspective, improvements have been made by including the impacts of the FMD crisis and varied consumer confidence scenarios, whilst impact

analysis is now compared *through time* using detailed annual projections and agricultural policy shocks.

The results suggest that the legacy of BSE and FMD will continue for some time. Under 100% confidence recovery, output and exports in the upstream cattle sector are still below their level in the hypothetical no-ban scenario by the year 2020. However, under 120% confidence recovery, trade and production positions improve upon the no-ban scenario. Given the conditions of the model, this is not an unexpected result, however, the study does provide a tentative quantitative measure of the potential benefit of the remedial safeguards and assurances (greater traceability etc.) offered in the wake of the BSE and FMD crises.[xx]

Additionally, the inclusion of net foreign ownership income estimates reveals that the financial bias may have been as large as US$ 107 million at the peak of the ban (2001), although this is reduced considerably as the economy slowly reverts toward the no-ban trend.[xxi] Finally, EV results show the effect of the export ban and FMD crisis on the UK economy, where despite considerable disruption to the relevant meat sectors, the economy-wide impact is reported to be negligible both at its peak (2001) and in the long run (2020).

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8. Appendix: The composition of costs, mark-ups and free entry/exit of firms in imperfectly competitive industries.

Due to a lack of data, all firms in the imperfectly competitive sectors are assumed symmetric (i.e. the same cost and technology structure and face the same demand conditions) and treated as a micro-scaled version of the industry. Secondly, there is a one-to-one relationship between firms and domestic product variants where the *representative variety* 'i' from a given region 'r' is a composite of all product variants ($n_{i,r}$) in the industry. The representative variety price is equal to each firm's product variant price due to the assumption of symmetry between firms.

(i) Mark-ups

In imperfectly competitive industries, each firm possesses sufficient market power to mark-up output price (P) over marginal cost (MC) leading to short-run profits. A symmetric firm´s profit function is:

$$? _i ? PQ_i ? TC_i \qquad (8.1)$$

where: $? _i$ is profit; P is *industry* price; Q_i is firm output; and TC_i is total costs. Under Cournot assumptions, profit maximisation involves employing output as the key strategic variable, where each symmetric firm conjectures the output responses of rivals to changes in its own output. Taking the derivative $?? _i / ?Q_i ?$, and manipulating the resulting first order conditions gives firm´s mark-up:

$$MARKUP_i ? \frac{P ? MC_i}{P} ? \frac{? _i}{N} . \left| \frac{1}{?} \right| \qquad (8.2)$$

$? _i ? \frac{?T}{?Q_i}$ is the conjectural variation parameter characterising changes in industry output (T) with respect to changes in firm output (Q_i); N is the number of firms in the industry; and $\left| \frac{1}{?} \right|$ is the *absolute* value of the inverse elasticity of demand for the industry tradable. Under the assumption of symmetry, 1/N is equivalent to Q_i/T. Thus, we can derive the conjectural variation elasticity:

$$\frac{? _i}{N} ? \frac{?T}{?Q_i} \frac{Q_i}{T} \qquad (8.3)$$

In this paper, standard Cournot-Nash equilibrium is used, where $? _i$ has a value of 1 (i.e., it is assumed that firms' output is given). Thus, firm 'i' believes that all rivals' outputs remain fixed. Note that the value of N is updated by changes in the number of firms entering/leaving the imperfectly competitive industry (see below). Further, the differentiation of mark-ups from region 'r' across foreign and domestic bilateral routes ('s') is a function of endogenous changes in the absolute value of the inverse elasticity of domestic (r=s) and foreign (r?s) demand. The aggregate industry mark-up in region 'r' is a weighted sales share of each of the bilateral sales mark-ups to regions 's' (r=s, r?s).

(ii) The structure of costs

In imperfectly competitive sectors, firms differentiate products through research and development and marketing expenditures, otherwise characterised as fixed costs, where the quantity demanded of fixed factors is directly proportional to the change in the number of product variants in the industry rather than the total sales of a particular variety. Examining mark-up expression (8.2), with constant returns to scale in production yielding constant average variable costs (equal to marginal costs), and long run zero profits in each imperfectly competitive sector, a mark-up of 0.3 implies average variable and fixed cost components constitute 70% and 30% of the output price (or average total cost) respectively. Thus, the composite (i.e., domestic and foreign) mark-up for each imperfectly competitive sector apportions *total* fixed and variable costs as fractions of total industry costs.

(iii) Entry/exit of firms/varieties

Long run profit is eliminated through entry/exit of firms (product variants) and is largely a function of (i) endogenous mark-up effects and (ii) changes in average fixed (and therefore total) costs due to changes in output per firm (scale effects), where (i) and (ii) combined are known as pro-competitive effects. Thus, a fall in the mark-up will signal, *ceteris paribus*, falling profits and therefore an exodus of firms from the industry (or *vice versa*). In linear terms, industry market clearing is given as:

$$qo_{i,r} \; ? \; qofm_{i,r} \; ? \; n_{i,r} \qquad (8.4)$$

In the absence of changing industry output ($qo_{i,r}$), a reduction in firm numbers ($n_{i,r}$), will signal an increase in output per firm ($qofm_{i,r}$) which is also consistent with the reduction in the mark-up (or *vice versa*).

9. Tables

Table 1 Exports in the UK (Cumulative %)

	1996	2001	2020 (100%)	2020 (75%)	2020 (120%)
Cattle & sheep	-72.07	-92.49	-13.54	-39.60	9.39
SMP	-45.26	-49.41	-1.29	-15.65	11.57
Other meat processing	-45.45	-48.63	-1.25	-17.52	13.44
Total agriculture	-7.10	-10.16	-2.33	-4.64	-0.30
Total food processing	-6.23	-5.71	-0.41	-1.73	0.78
Manufacturing	0.27	0.25	0.00	0.02	-0.01
Services	0.33	0.30	0.00	0.03	-0.01

Table 2 Output in the UK (Cumulative %)

	1996	2001	2020 (100%)	2020 (75%)	2020 (120%)
Cattle & sheep	-5.15	-7.23	-0.97	-3.19	0.99
SMP	-6.83	-7.75	-0.13	-1.88	1.44
Other meat processing	-2.24	-2.88	-0.03	-0.80	0.67
Total agriculture	-1.43	-1.83	-0.20	-0.61	0.19
Total food processing	-0.80	-0.88	-0.01	-0.21	0.16
Manufacturing	0.18	0.17	0.01	0.02	-0.01
Services	0.03	0.02	0.00	0.01	0.00
Real UK growth	-0.019	-0.030	0.007	-0.013	0.018

Table 3 Sectoral employment levels in the UK (Cumulative %)

	1996	2001	2020 (100%)	2020 (75%)	2020 (120%)
Cattle & Sheep					
Pasture land	-3.82	-5.48	-0.76	-2.53	0.78
Unskilled Labour	-6.43	-8.74	-1.11	-3.64	1.13
Skilled Labour	-6.44	-8.75	-1.11	-3.64	1.13
Capital	-2.75	-3.13	-0.46	-1.08	0.13
SMP					
Unskilled Labour	-6.63	-7.51	-0.11	-1.80	1.41
Skilled Labour	-6.67	-7.56	-0.12	-1.82	1.41
Capital	-6.62	-7.53	-0.10	-1.80	1.43
Other meat processing					
Unskilled Labour	-2.15	-2.75	-0.02	-0.75	0.65
Skilled Labour	-2.19	-2.80	-0.02	-0.76	0.65
Capital	-2.14	-2.78	-0.01	-0.76	0.66
Manufacturing					
Unskilled Labour	0.19	0.19	0.00	0.02	-0.01
Skilled Labour	0.14	0.14	0.00	0.01	-0.01
Capital	0.19	0.15	0.01	0.02	0.00
Services					
Unskilled Labour	0.04	0.05	0.00	0.01	-0.01
Skilled Labour	-0.01	-0.00	-0.00	0.00	-0.00
Capital	0.04	0.01	0.01	0.01	0.01

Table 4 Trade Balances in the UK (Cumulative US$ 1995)

	1996	2001	2020 (100%)	2020 (75%)	2020 (120%)
Cattle & sheep	-274.50	-380.05	-44.77	-118.73	20.80
SMP	-745.73	-784.56	-14.58	-165.14	120.58
Other meat processing	-377.18	-496.26	-7.70	-150.28	121.41
Total agriculture	-159.85	-259.40	-42.57	-103.28	11.10
Total food processing	-921.71	-1028.79	10.29	-244.44	240.22
Manufacturing	866.18	991.46	14.80	183.03	-138.45
Services	427.65	455.74	14.84	100.58	-61.48
Total Trade Balance	183.54	128.67	-7.53	-79.36	55.85

Table 5 Factor and consumer price indices in the UK (Cumulative %)

	1996	2001	2020 (100%)	2020 (75%)	2020 (120%)
Factor price:					
Arable Land	-0.11	-0.23	0.05	0.20	-0.07
Pasture land	-7.46	-8.77	-0.61	-2.17	0.80
Unskilled Labour	-0.07	-0.08	0.00	-0.01	0.01
Skilled Labour	-0.03	-0.04	0.00	0.00	0.01
Capital	-0.07	-0.05	0.00	-0.01	0.00
Natural Resources	0.24	0.19	0.00	0.01	-0.00
RPI	-0.08	-0.07	0.01	0.01	0.01
Agricultural RPI	-1.11	-0.98	0.17	0.09	0.24
Food Processing RPI	-0.30	-0.25	0.04	0.04	0.04

Table 6 Aggregate welfare and net foreign income flows in the UK (Cumulative US$ 1995)

	1996	2001	2020 (100%)	2020 (75%)	2020 (120%)
Equivalent variation (EV)	-10.91	-25.23	28.38	-3.06	42.06
EV as a % of National Income	-0.001	-0.002	0.002	-0.000	0.003
Dynamic Financial Effects					
Capital earnings effect	-27.87	-145.21	-16.33	-53.59	18.47
Financial inflows	-20.51	-14.78	-7.35	-11.97	-3.33
Financial outflows	77.69	121.64	19.40	37.49	2.98
Net financial effect	29.31	-38.35	-4.28	-28.07	18.12

10. Endnotes

[i] Since there is only one time period, the model does not capture the impacts of investment on 'capital accumulation' in the next period. This limitation is addressed in the dynamic specification.

[ii] In the model, percentage tariff or subsidy reductions can therefore be implemented as exogenous tariff/subsidy shocks between the relevant price wedges.

[iii] For a full description of the dynamic GTAP model version see Ianchovichina and McDougall (2000).

[iv] The natural rate of growth in each region is continuously revised in the next time period according to ongoing changes in the capital stock and the actual rate of return in the current time period.

[v] The use of adaptive expectations is used here to reconcile the apparent contradiction between economic theory and real observation where some regions with high rates of return exhibit low investment levels (Ianchovichina and McDougall, 2002).

[vi] Moreover, the model treatment favours a simpler characterisation of foreign investment behaviour over the potential model complexity and computational expense arising from a full characterisation of the financial sector.

[vii] In the model, changes in the allocation of foreign and domestic wealth respects observed data, which reveals that home bias exists in equity portfolios.

[viii] The number of firms in the UK and ROW oligopolistic sectors is taken from data sources used in Hubbard and Philippidis (2001).

[ix] See Dixon *et al.* (1992) for a thorough discussion of linearisation techniques and interpretation of percentage change functions in CGE models.

[x] Note that in all UK import demands, and in all ROW import demands other than for meat related products, the percentage change in $z_{i,r,s}$ is zero, which implies that the demand and price functions are standard Hicksian. That is, the last term drops out of equations (2) and (3), and equation (4) is equal to zero.

[xi] In terms of the domestic input and output values, bilateral trade flows and support and protection rates, Version 4 dynamic data is identical to version 4 CS data.

[xii] Version 5 represents decoupled support payments under the CAP more correctly as input subsidies, whilst in version 4, these are characterised as part of the output subsidy.

[xiii] This procedure of stripping out output subsidy wedges and reinserting them as input subsidy with minimal disturbances to the base data set employs a technique pioneered by Malcolm (1998).

[xiv] The sectors are: wheat, other grains, oilseeds, sugar, milk, cattle and sheep, pigs and poultry, fruit and vegetables, other agriculture, meat processing, other meat processing, sugar processing, dairy, vegetable oils and fats, other food processing, other primary, manufacturing and services.

[xv] The incorporation of agricultural policy mechanisms (with the exception of the CAP budget which is not included in this study) and Agenda 2000 reforms are detailed in Philippidis and Hubbard (2003). Further intervention price reductions in dairy are implemented under the Mid Term Review (MTR), although given the focus of the study, we do not go so far as to examine MTR decoupling options in the UK.

[xvi] To calculate the percentage reductions in trade protection and support for the ROW under the UR, a weighted average was calculated for developed countries and lesser developed countries based on protection and support share values.

[xvii] The BSE export shocks to the relevant meat sectors follow Hubbard and Philippidis (2001) and DEFRA export data for the period, whilst the magnitude of further downturns in export demand in the

wake of the FMD crisis are based on DEFRA data for 2001. The majority of the confidence downturn calibrated to the export data is from the BSE ban.

[xviii] Both downstream UK meat sectors are the largest purchasers of primary cattle and sheep production.

[xix] In seeking to incorporate a recursive dynamic feature into the standard GTAP treatment without constraining model size, a resulting cost is that the representative agent is not 'designed' to maximise inter-temporal equivalent variation (EV) in the strict sense. Indeed, total EV over the time horizon is the sum of successive period EV values, rather than employing initial period prices as is consistent with microeconomic theory.

[xx] This does impact negatively on manufacturing and services sectors which fall very slightly below their no-ban scenario positions.

[xxi] The bias is based on the comparison between the 'net financial effect' and the 'capital earnings effect'.


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