Agricultural and Food Economics

Impact of Input and Output Taxes on Agriculture in the UK

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Myles Patton, John Davis and Lichun Zhang

(Agri-Food & Biosciences Institute & Queen's University Belfast)

Julian Binfield and Patrick Westhoff

(FAPRI, University of Missouri)

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EXECUTIVE SUMMARY

An EU partial equilibrium modelling system is used to examine the impact of a range of input and output taxes on the UK agricultural sector. The output taxes are based on per head methane emission factors for different categories of livestock and the price of carbon. Two output tax scenarios are considered based on the source of emissions, namely (i) enteric emissions only and (ii) enteric and manure emissions. An input tax, broadly equivalent in revenue terms to the output tax, is applied to feed and fertilisers. The taxes are applied on both a unilateral basis in the UK and across the whole of the EU.

The output taxes have a particularly significant impact on the dairy, beef and sheep sectors since these taxes are computed on the basis of methane emission factors and ruminants are an important source of methane. Applying the combined enteric and manure taxes on a unilateral basis in the UK has the greatest negative impact on livestock numbers. Compared to the no-tax Baseline it is projected that by 2020 UK beef and dairy cow numbers are 37 and 9 per cent lower respectively, while ewe numbers decline by 16 per cent. The input tax also has a negative, though smaller, impact on cattle and sheep numbers. Projected beef and dairy cow numbers are 12 and 4 per cent lower respectively compared to the Baseline following the levying of an input tax, while ewe numbers decline by 5 per cent. The input tax also has a marked negative impact on the pig and poultry sectors since feed represents an important component of costs in these sectors.

Applying the output and input taxes across the whole of the EU results in less significant falls in ruminant animal numbers in the UK compared to the unilateral UK taxes. This is due to positive price responses across the EU that partially offset the impact of the taxes. Following the application of the enteric and manure output tax across the EU, projected UK beef cow numbers are 22 per cent lower compared to the Baseline by 2020. The dynamics change throughout the projection period due to the pattern of EU price response, leading to a relatively rapid reduction in UK beef cow numbers in the short-run which then moderates towards the end of the projection period. Under the EU-wide scenarios the pig and poultry sectors benefit from higher prices due to cross-price effects from the beef and sheep sectors. These effects more than offset the impact of the taxes and it is projected that production of pigmeat and poultry actually increases.

The input and output taxes contribute to the UK's Climate Change Act targets by reducing UK Greenhouse Gas emissions from agriculture. The simulations in this analysis indicate that the greatest fall occurs under the UK-only enteric and manure output tax scenario, with total UK methane and nitrous oxide emissions from agriculture declining by 13 per cent relative to the Baseline by 2020. However, the impact on the UK agricultural sector income is considerable with market receipts minus costs falling by 23 per cent. Moreover, unless the taxes lead to higher prices and reduced UK consumption, the impact on global emissions is limited due to an offsetting increase in UK imports.

Impact of Input and Output Taxes on Agriculture in the UK

1. Introduction

Growing concerns about the threats posed by climate change have resulted in ambitious targets to reduce greenhouse gas emissions. In 2008 the UK Climate Change Act set binding targets to reduce greenhouse gas emissions compared to 1990 levels by at least 34 per cent by 2020 and 80 per cent by 2050. Initiatives are being pursued to reduce greenhouse gas emissions from agriculture through mitigation strategies that reduce emissions per unit of output, e.g. the farming industry Greenhouse Gas Action Plan. An alternative approach is the implementation of taxation policies designed to reduce greenhouse gas emissions. Livestock emit considerable methane emissions and proposals to tax methane emissions of cows and other livestock have been mooted in Ireland and Denmark in response to EU reduction targets[1]. In addition, input taxes (e.g. fertiliser and feed taxes) could potentially be imposed to reduce greenhouse gas emissions from agriculture. It is important to stress that the analysis in this report is hypothetical. We understand that the input-output policies analysed in this report are not under consideration and it is the government's objective to reduce emissions per unit of output. The analysis is undertaken to explore the potential implications of the input-output policies.

In this study, the FAPRI-UK modelling system is simulated to determine the sectoral impact of input and output taxes on agriculture in the UK. UK agricultural markets are integrated with EU markets and linked to world markets; and so measures enacted in the UK will produce offsetting reactions elsewhere and vice versa. In order to identify potential differential impacts the modelling system is simulated with (i) taxation policies implemented in only the UK and (ii) across the EU.

2. Methodology

The FAPRI-UK modelling system (created and maintained by personnel in AFBI-QUB) captures the dynamic interrelationships among the variables affecting supply and demand in the main agricultural sectors of England, Wales, Scotland and Northern Ireland (Moss *et al.*, 2011). The model consists of a system of equations covering the dairy, beef, sheep, pigs, poultry, wheat, barley, oats, rapeseed and biofuel sectors. The UK model is fully incorporated within the EU grain, oilseed, livestock and dairy (GOLD) run by FAPRI at the University of Missouri. Consequently, the UK model is not run in isolation but solves simultaneously within the FAPRI integrated partial equilibrium modelling system. It thereby yields UK projections which are consistent with equilibrium at the EU-level and

[1] Note these proposals have not been implemented in Ireland and Denmark and are no longer under consideration.

takes account of the impact of changes in EU trade through a reduced form world market equations.

The UK model consists of sub-models for England, Wales, Scotland and Northern Ireland. In general, supply is modelled for each of the four constituent countries of the UK, while demand is modelled at the UK level. This yields projections of livestock numbers, slaughterings, production and market prices for each of the countries in the UK. Commodity production from each of the four constituent countries of the UK is summed to yield UK production. Commodity domestic use, imports and exports are projected at the UK level.

The commodity sub-models solve at the European level by ensuring EU export supply equals EU export demand in all markets. The key price in each model is adjusted until equilibrium is attained. Changes in the key price lead to adjustments not only in supply and utilisation in the key country, but via price linkage equations to changes in the supply and utilisation totals in all the other markets modelled. The iterative equilibrating process continues until all product markets in all years are in equilibrium (net EU export supply equal to net EU export demand). Thus, the UK commodity prices are consistent with equilibrium at the EU-level. When a policy scenario is undertaken a reduced form world model is used which captures the impact of changes in trade from the EU through representative world prices. Trade for the EU is subject to the constraints of either the agreements made under the Uruguay Round Agreement on Agriculture (URAA) or scenario assumptions.

The UK model covers the following commodities: dairy, beef, sheep, pigs, poultry, wheat, barley, oats, rapeseed and liquid biofuels.

The UK dairy model consists of submodels for liquid milk, cheese, butter, skim milk powder and whole milk powder. The producer price of liquid milk in England and Wales, Scotland and Northern Ireland is modelled as a weighted function of the prices of the dairy commodities cheese, butter, SMP and WMP. The UK has experienced difficulties in filling its milk quota in recent years. The model assumes milk production is equal to the quota providing milk production yields economic rents. If milk producer prices, however, fall below certain levels, milk production is determined by upward sloping supply functions in each country. Milk production per cow is modelled as a function of a linear trend to proxy for technical change and producer's milk price. Finally, dairy cow numbers are derived as an identity, whereby milk production is divided by milk production per cow.

There are four livestock models in the FAPRI-UK system. The beef, pig and sheep models share a similar structure. The key supply side variable in each of the livestock models is

the stock of female breeding animals (cows, sows, and ewes). This stock determines the number of young animals available for fattening and/or slaughter, which in turn determine meat production. Owing to its much shorter production cycle and the lack of Common Agricultural Policy (CAP) policy measures, the poultry model is much simpler. It does not include animal numbers, but models production directly.

The various livestock models are linked primarily through their demand side specifications. The demand side specifications are log specifications of per capita demand. Per capita meat demand is modelled as a function of the prices of the meat in question and of the other meats, all of which are all assumed to be gross and net substitutes in consumption. All of the meat goods are normal, none are treated as luxuries. The beef production model is linked with the dairy models via cow slaughter and calf production from the dairy herd.

Within the crops model, land is allocated as a two-step process. Firstly, total cereal and oilseed area is projected as a function of weighted returns, where the weight reflects the share of the grain in total grain area. Having determined total cereal and oilseed area, land is distributed across different crops on the basis of expected returns of the crop in question relative to the other crops. Crop yield per hectare is primarily projected as a function of a trend term, which reflects technology change. To a lesser degree, yields are also affected by prices (small positive impact reflecting higher-yielding varieties from induced innovation) and area devoted to crop production (negative impact due to lower productivity as area increases). The supply of oilseed meals and oils is also projected. Production of oil and meal for each of the oilseeds is determined by the quantities crushed times the appropriate extraction rate.

The modelling system is firstly simulated to generate Baseline projections based on the assumptions that current policies remain in place, specific macroeconomic projections hold and average weather conditions apply. Baseline projections of key variables for each country in the UK are generated for a ten year period. These Baseline projections provide a benchmark against which projections derived from policy scenarios can be compared and interpreted. Within this study, the modelling system is further simulated to incorporate input and output taxes and the results are compared against the Baseline to isolate the impact of these taxation policies over the ten-year projection period.

3. Scenarios

The output taxes used in the scenario analyses are based on per head methane emission factors for different livestock and the carbon value, i.e. emissions per head multiplied by the carbon price. The per head methane emission factors for different livestock are based on the enteric and manure emission factors from the UK Greenhouse Gas Inventory System (Jackson *et al.*, 2009). This approach yields differential taxes based on livestock

emissions. Two output tax scenarios are considered, which differ in terms of source of emissions, i.e. enteric emissions only or enteric and manure emissions.

The carbon prices are obtained from the non-traded carbon value (central estimate) used by UK government in economic appraisals (DECC, 2011), see Table 1. Within the UK carbon valuation appraisal system, the non-traded carbon value is used for sectors outside the EU Emissions Trading Scheme.

Table 1: Non-traded carbon value used to compute output taxes

	2012	2013	2014	2015	2016	2017	2018	2019	2020
Non-traded carbon price (£/tonne CO_2)	56	57	58	59	60	61	62	63	64

For example, the computed enteric and manure output tax for a beef cow in 2012 is computed as follows:

Beef cow output tax = [49.8+2.74]*21*0.001*56 = £62 per cow per year

= [Enteric + manure methane emission factors (kg CH4/head/year)] * Carbon dioxide conversion coefficient * 0.001* Carbon Price (£/tonne CO_2eq.)

The computed taxes per animal for other livestock for the year 2012 are shown in Table 2. The taxes increase slightly over the projection period in line with the carbon prices shown within Table 2. These taxes are implemented in the UK beginning in 2012. Within the rest of the EU the taxes are converted using exchange rate projections.

Table 2: Computed enteric and enteric & manure taxes (£) per animal (2012)

	Enteric	Enteric & Manure
Beef cow	59.06	62.31
Calf	38.90	42.41
Beef Replacement	8.54	9.61
Dairy cow	133.78	166.63
Dairy replacement	14.23	16.01
Breeding ewe	9.49	9.71
Lamb	1.90	1.94
Breeding pig	1.78	10.15
Other pig	1.78	10.15
Poultry		0.09

The output taxes are incorporated within the costs for different livestock. The tax is applied to all ruminant animals, not just the breeding animal. Consequently, the beef cow equation incorporates costs for the calf and the beef cow replacement (replacement rate 0.15), in addition to the beef cow. In addition, the calf price within the beef cow equation is influenced by the tax for finishing beef animals. Within the dairy sector, the tax incorporated within the costs variable includes taxes for the dairy cow and the dairy cow replacement (replacement rate 0.25). Within the breeding ewe equation, taxes are added to the costs for the breeding ewe and the lamb. The calculation for the lamb output tax is halved since lambs are typically only alive for six months of a given year (this assumption is consistent with the GHG inventory calculation of emissions). The output tax for pigs includes sows and other pigs.

The feed and fertiliser tax is applied in percentage terms. A 20 per cent tax is applied on the basis that the historic data indicated that this percentage approximately yields the same level of input tax revenue as the full enteric and manure emission output tax. Note that, under the scenario analysis the tax revenue generated during the projection period changes in line with projected livestock numbers.

In practice the impact of the taxes would depend on how it is applied. For example, for beef the timing of the output tax has the potential to impact carcass weights, in particular in a pasture based system, or in the relative profitability of veal production. The modelling system captures behavioural responses due to changes in gross margins following the introduction of a tax. It is important to be aware of the limitations of the modelling system where extreme policies are introduced outwith previous experience. The introduction of such policies could potentially lead to radical changes in production systems.

The modelling system is simulated with the taxes levied in just the UK (UK-only) and across the whole of the EU (EU-wide). In total, six scenarios are simulated:

1) UK-only
   A) Enteric Emissions Output Tax
   B) Enteric and Manure Emissions Output Tax
   C) 20% Fertiliser and Feed Tax

2) EU-wide
   A) Enteric Emissions Output Tax
   B) Enteric and Manure Emissions Output Tax
   C) 20% Fertiliser and Feed Tax

4. Results

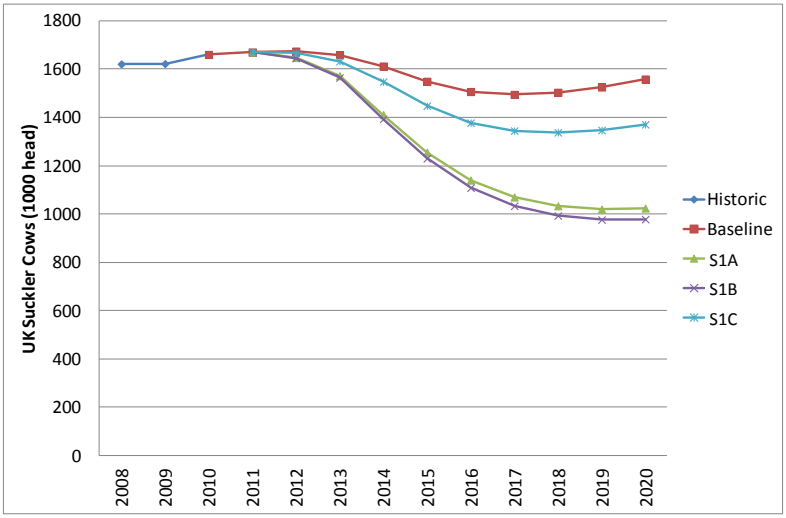
The results for the UK-only and EU-wide scenarios are shown in Tables A1 to A5 and A6 to A10 in the appendix, respectively. The tables compare the difference between each of the scenarios and the Baseline at the end of the projection period (2020) for key variables.

4.1 UK-only scenarios

4.1.1 Scenario 1A - Full Output Tax - Enteric Emissions

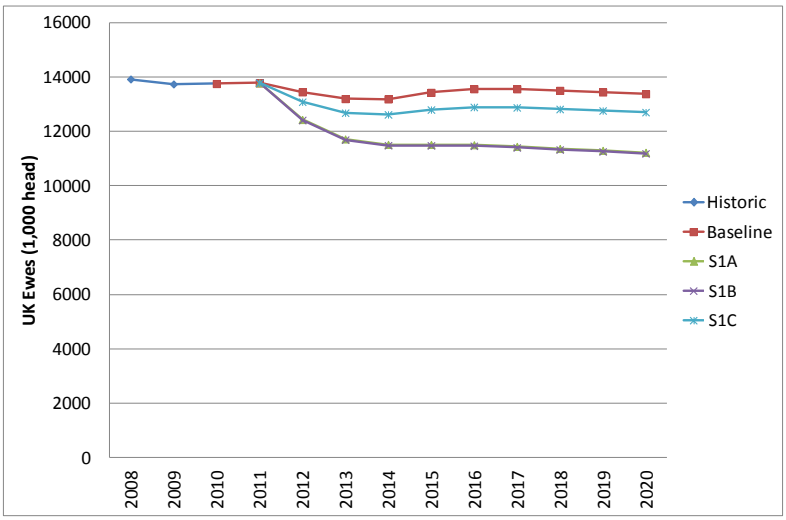
The enteric output taxes have a significant negative impact on livestock numbers in the beef, dairy and sheep sectors. It is projected that the number of UK beef cows is 34 per cent lower under Scenario 1A compared to the Baseline in 2020 (Figure 1), while UK dairy cow numbers are 7 per cent lower. Projected UK ewes are 16 per cent lower at the end of the projection period (Figure 2). The impact is greater in these sectors compared to the pig and poultry sectors (projected UK sows and poultry production are unchanged) since ruminants are the primary source of enteric emissions, which is reflected in the level of the output taxes. Beef cow numbers fall to a greater extent than dairy cow numbers partly because the output tax accounts for a larger proportion of the margin in the beef sector compared to the dairy sector. Also, within the beef sector the taxes that are levied on the older animals are partly transmitted back to cows.

Figure 1: Projected UK Suckler Cows under the Baseline and Scenarios 1A, 1B and 1C



Scenario 1A: Full Output Tax - Enteric Emissions (UK-only)
Scenario 1B: Full Output Tax - Enteric and Manure Emissions (UK-only)
Scenario 1C: 20% Fertiliser and Feed Tax (UK-only)

Figure 2: Projected UK Ewes under the Baseline and Scenarios 1A, 1B and 1C

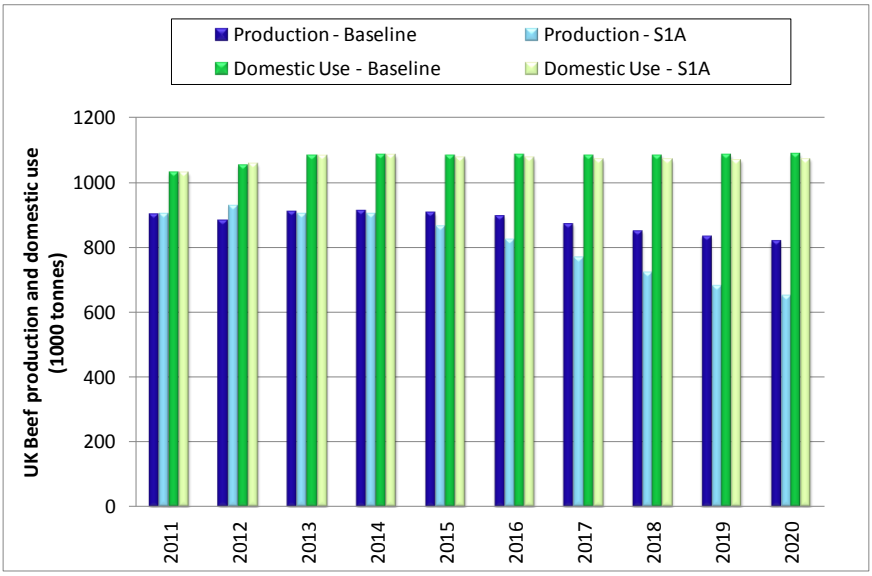


Scenario 1A: Full Output Tax - Enteric Emissions (UK-only)
Scenario 1B: Full Output Tax - Enteric and Manure Emissions (UK-only)
Scenario 1C: 20% Fertiliser and Feed Tax (UK-only)

The decline in beef and dairy cows leads to an overall fall in UK beef production (Figure 3). By the end of the projection period beef production in the UK is 21 per cent lower under Scenario 1A compared to the Baseline. Note that it is projected that the cow herd is still contracting at the end of the projection period. As a result, fewer heifers are required for replacement purposes and these enter the beef production chain. In addition, more cows are slaughtered. This exerts an upward impact on beef production. Projected UK domestic use falls slightly (-1 per cent) since the UK beef price rises (+4 per cent) in response to the overall decline in beef production. The projected increase in the

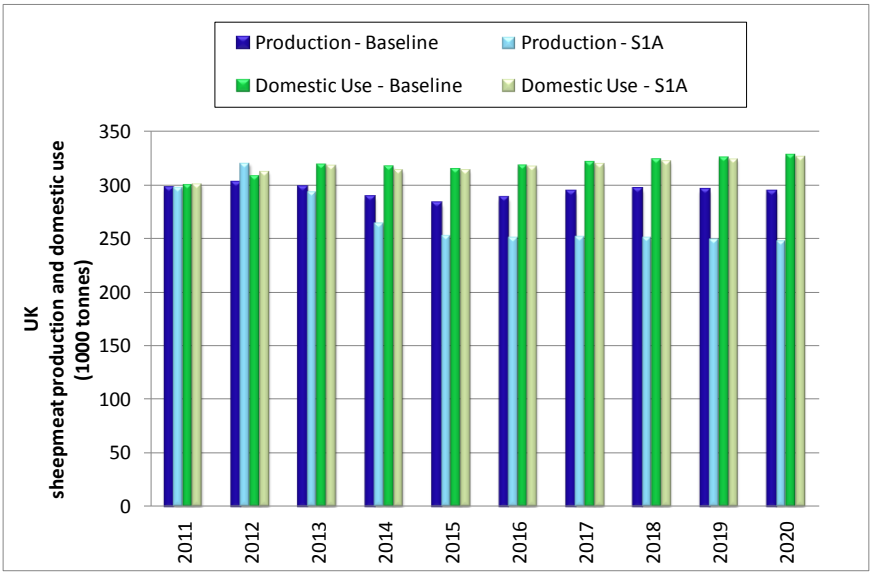
beef price is modest since the tax is only implemented in the UK and the overall decrease in EU production is small (-2 per cent). The decline in UK beef production relative to domestic use leads to an increase in imports and a decrease in exports. Consequently, it is projected that UK beef net exports decrease by 154 thousand tonnes (-58 per cent).

Figure 3: Projected UK Beef Production and Domestic Use under the Baseline and Scenario 1A



Within the sheep sector it is projected that UK sheepmeat production declines in line with the fall in ewe numbers. By 2020 UK sheepmeat production is 16 per cent lower following the implementation of the output tax (Figure 4). Projected UK sheepmeat domestic use falls slightly (-1 per cent) in response to a slight increase in the sheepemat price (+ 2 per cent). It is projected that there is a significant decline in sheepmeat net exports (minus 44 thousand tonnes) due to the decrease in production relative to domestic use.

Figure 4: Projected UK Sheepmeat Production and Domestic Use under the Baseline and Scenario 1A



Projected UK milk production is 8 per cent lower following the application of the enteric output tax. In turn, milk for manufacturing falls by a greater amount (-18 per cent) since liquid milk consumption remains unchanged. As a consequence, it is projected that there are significant falls in the production of dairy commodities. Dairy cow numbers, rather than yields, account for most of the drop in milk production. The output tax is applied on a per head basis and therefore producers respond to the levying of a tax by reducing dairy cow numbers. Reductions in milk yield would have a limited impact in terms of reducing the tax burden.

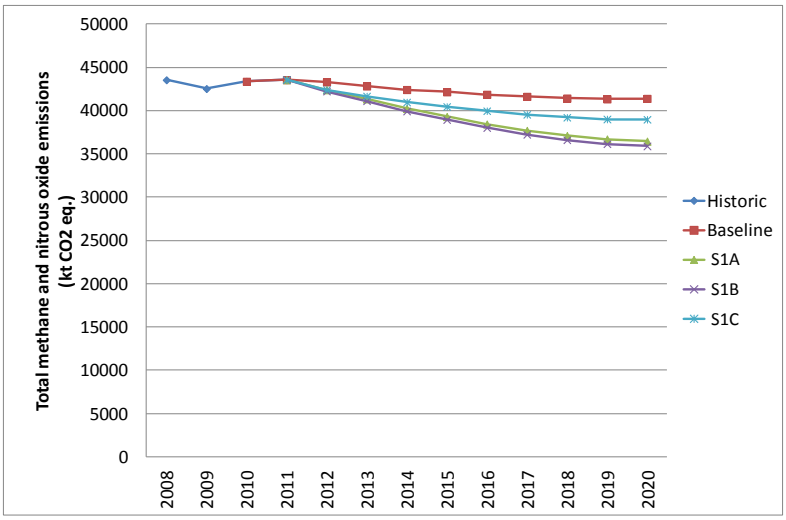
The application of an output tax based on just enteric emissions has a negligible impact on the pig and poultry sectors. Based on the greenhouse gas emission factors, the enteric tax for the pig sector is relatively small and is zero for the poultry sector.

Unsurprisingly, livestock output taxes have a relatively small impact on production in the crop sector. UK barley production falls by 1 per cent. This largely reflects a projected decline in barley production in Scotland (-4 per cent), which falls in response to the lower livestock numbers since a significant proportion of barley is of low quality and used solely for feed purposes. At the UK level, the decline in demand for animal feed has a negative impact on crop domestic use. It is projected that UK domestic use for wheat and barley falls by 3 and 4 per cent, respectively. The projected decline in domestic use has a positive impact on UK crop net exports (in absolute terms UK wheat and barley net exports increase by 388 and 123 thousand tonnes, respectively).

Overall, it is projected that UK market receipts minus costs (including taxes) are 20 per cent lower under Scenario 1A compared to the Baseline.

The projected decline in livestock numbers following the levying of the full enteric output tax leads to a reduction in greenhouse gas emissions from agriculture. As shown in Figure 5, total UK methane and nitrous oxide emissions from agriculture decline by 12 per cent under Scenario 1A compared to the Baseline in 2020. Methane emissions fall to a greater extent than nitrous oxide emissions (-15 per cent compared to -9 per cent) due to the decline in ruminant livestock, which are the main source of methane emissions. The decline in total methane and nitrous oxide emissions is greater in Scotland (-16 per cent) compared to elsewhere in the UK (-10, -15 and -16 per cent in England, Wales and Northern Ireland respectively) due to the importance of the beef sector in Scotland.

Figure 5: Projected Methane and Nitrous Oxide Emissions under the Baseline and Scenarios 1A, 1B and 1C



Scenario 1A: Full Output Tax - Enteric Emissions (UK-only)
Scenario 1B: Full Output Tax - Enteric and Manure Emissions (UK-only)
Scenario 1C: 20% Fertiliser and Feed Tax (UK-only)

4.1.2 Full Output Tax - Enteric and Manure Emissions (Scenario 1B)

A livestock tax based on both enteric and manure emissions has a slightly greater negative impact on projected beef and dairy cows, compared to a tax based on just enteric emissions. It is projected that UK beef and dairy cow numbers are 37 and 9 per cent lower under Scenario 1B compared to the Baseline in 2020. The additional impact is modest since per head methane manure greenhouse gas emission factors, which are used to compute the tax, are relatively small compared to enteric emission factors for ruminant animals. The per head methane manure emission factors are especially small for sheep and hence, it is projected that there is no further decrease in ewe numbers.

In contrast, the manure component accounts for a greater proportion of greenhouse gas emissions than the enteric component for pigs and poultry. This is reflected in the greenhouse gas emission factors and hence, the computed taxes for pigs and poultry in this analysis. It is projected that UK pigmeat production declines by 3 per cent in 2020 under the full enteric and manure emissions tax (Scenario 1B) compared to the baseline, while UK poultry production declines by 2 per cent. The projected decrease in production leads to a decrease in UK net exports of pigmeat (-3 per cent, or 23 thousand tonnes in absolute terms) and poultry (-8 per cent, or 31 thousand tonnes in absolute terms).

It is projected that domestic use for crops falls by a slightly greater amount under Scenario 1B compared to Scenario 1A due to the more significant fall in livestock numbers and hence, demand for animal feed. Under the full enteric and manure emissions tax scenario (Scenario 1B) UK domestic use for wheat falls by 3 per cent, while that for barley declines by 5 per cent. Consequently, the projected increase in UK net exports for wheat and barley is greater under Scenario 1B compared to Scenario 1A. Similar to the previous scenario, Scottish barley production declines (-5 per cent) in response to the lower demand for animal feed.

Overall, it is projected that UK market receipts minus costs (including taxes) are 23 per cent lower under Scenario 1B compared to the Baseline. This is slightly greater than that experienced under the enteric emissions tax scenario (Scenario 1A) due to the greater decline in production. In terms of emissions, it is projected that there is a slightly greater decline in greenhouse gas emissions from agriculture under Scenario 1B compared to 1A. This partly reflects the reduction in pig and poultry numbers.

4.1.3 Input taxes on fertilisers and feed (Scenario 1C)

The application of a 20 per cent input tax has a negative impact on all livestock numbers. Cattle and sheep numbers are impacted by both the feed and fertiliser taxes. It is projected that beef and dairy cows are 12 and 4 per cent lower under Scenario 1C compared to the Baseline in 2020. Projected ewes are 5 per cent lower. While the pig and poultry sectors are just affected by the tax on feed, the impact of this tax on the pig and poultry sectors is significant since feed represents a large component of costs. It is projected that UK pigmeat production falls by 7 per cent following the application of a 20 per cent input tax (Scenario 1C) compared to the Baseline at the end of the projection period, while UK poultry production falls by 6 per cent. The decline in production has a negative impact on exports and a positive impact on imports. Overall, it is projected under Scenario 1C that UK net exports fall by 5 and 21 per cent in the pig and poultry sectors, respectively.

The higher costs associated with the input tax has a negative impact on milk production. It is projected that UK milk production is 4.5 per cent lower under Scenario 1C compared to the end of the projection period. This is mostly accounted for by a drop in dairy cow numbers, which are 4.3 per cent lower. The rest is due to a small drop in milk yield. The drop in milk production leads to a decline in milk for manufacture.

The application of a 20 per cent fertiliser tax has a small impact on crop production. It is projected that UK wheat production falls by 0.3 per cent, while UK barley production falls by 1.3 per cent. The limited impact reflects the inelastic relationship between the total area of crops and total returns. However, it is projected that domestic use declines in response to the fall in livestock numbers, particularly the feedstock intensive pigmeat and poultry sectors. Projected UK wheat and barley domestic use fall by 2 and 3 per cent respectively under Scenario 1C compared to the Baseline in 2020. The decline in domestic use leads to a projected increase in UK net exports of wheat and barley. In absolute terms, projected UK wheat net exports are 294 thousand tonnes higher under Scenario 1C compared to the Baseline in 2020, while UK barley net exports are 113 thousand tonnes higher.

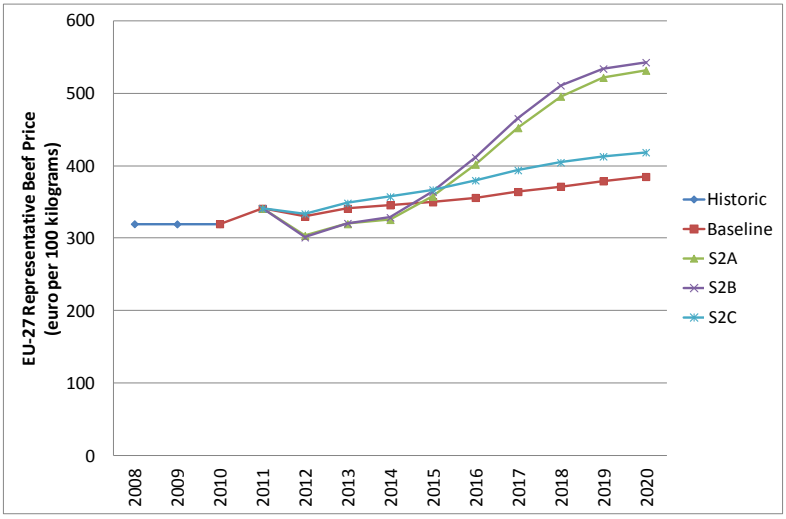
Overall, it is projected that UK market receipts minus costs (including taxes) are 20 per cent lower under Scenario 1C compared to the Baseline. While the decline in market receipts is less compared to the output tax scenarios, the projected increase in costs is greater and hence the overall impact is comparable to the other UK-only scenarios. Projected methane and nitrous oxide emissions fall in line with the reduction in livestock numbers. It is projected that total UK methane and nitrous oxide emissions decline by 6 per cent following the levying of the 20 per cent input tax. Underlying this methane emissions fall by 7 per cent, while nitrous oxide emissions fall by 5 per cent.

4.2 EU-wide scenarios

4.2.1 Full Output Tax - Enteric Emissions (Scenario 2A)

Implementing the full enteric output tax in other EU countries, as well as the UK, has a marked impact on the beef sector, with important dynamic effects. The introduction of taxes across the EU prompts a reduction in the size of the EU cow herd. The reduction comes in the form of an increase in cow slaughterings and a reduction in the number of heifers that are bred, which in the short-run leads to an increase in EU slaughterings. EU beef production increases by 4 per cent in the first year and the beef price falls by 8 per cent (Figure 6). Projected EU Beef production does not fall below the Baseline until 2015, which is also where the change in beef price becomes positive. By 2020 EU beef production is 17 per cent below the baseline and the beef price is 38 per cent above the baseline, up €147 per 100kg. Given the structure of the model the cow herd takes about four years to fully adjust to the new taxes, after which the increase in beef prices result in some recovery in the beef cow herd. The speed to which the beef cow herd would adjust is dependent on the expectations of producers. If the introduction of the taxes were signalled in advance then there could be a shorter period of adjustment and producers would realise that prices in the short term would be depressed by the liquidation of the herd and would rise in the longer term. A shorter adjustment period would mean lower prices in the shorter term and higher prices in the medium term.

Figure 6: Projected EU Beef Price under the Baseline and Scenarios 2A, 2B and 2C

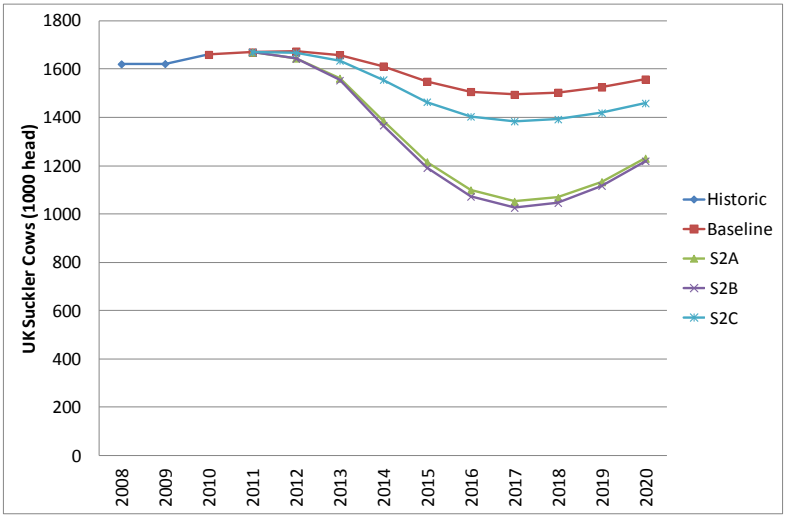


Scenario 2A: Full Output Tax - Enteric Emissions (EU-wide)
Scenario 2B: Full Output Tax - Enteric and Manure Emissions (EU-wide)
Scenario 2C: 20% Fertiliser and Feed Tax (EU-wide)

It should be noted that the taxes implemented in these scenarios are high and therefore either the price must adjust to reflect the increase in cost, or there must be a dramatic drop in livestock numbers. The part that each of these plays depends on the reaction of imports. Imports are subject to very high tariffs in many cases 100 per cent or more and these generally protect the EU market. In the early 2000s some beef entered the EU paying these full tariffs because the Brazilian price was very low relative to the EU beef price. In recent years, a number of factors have led to these prices converging. In this scenario 576 thousand tonnes of extra beef is imported into the EU (plus 68 per cent), with a world price up 5 per cent. It is difficult to be confident about how world markets would react to such an extreme scenario, i.e. at what point would beef tariffs cease to protect EU markets. Clearly, a return to prices in Brazil at historical lows relative to Europe would see imports at a higher level, a smaller increase in prices and a larger drop in EU beef production.

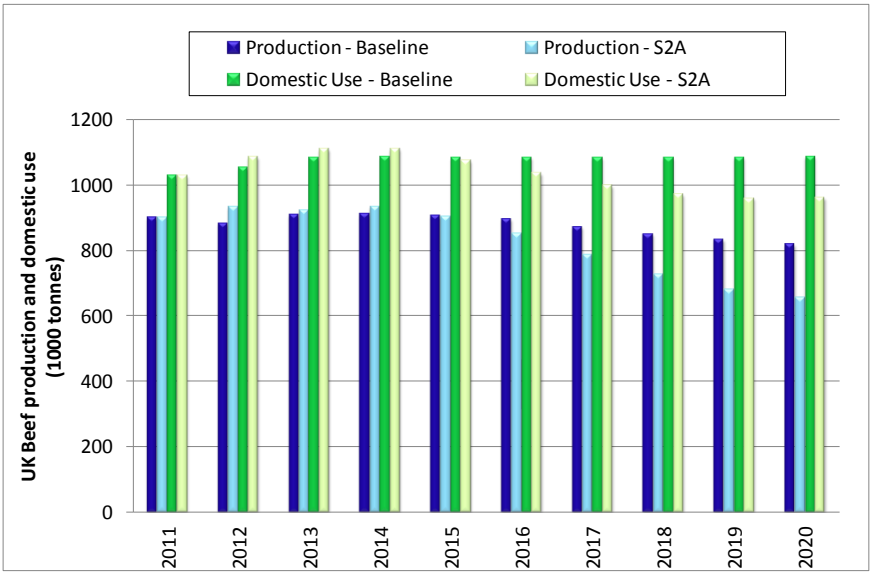
The price response in the EU is transmitted to the UK. Consequently, the projected finished producer beef price in the UK decreases in the short-run, but increases in the longer-run. The combined impact of this price response and the enteric emissions tax on UK suckler cow numbers is shown in Figure 7. It is projected that the output tax has a negative impact relative to the Baseline on UK suckler cow numbers throughout the projection period. The gap is greatest in 2017 (-30 per cent), but diminishes thereafter as the beef herd builds up again in response to the positive price. While the increase in the finished producer price is significant, it is not fully transmitted to suckler producers due to the taxes that are levied on the older animals. By the end of the projection period, the number of UK suckler cows is 21 per cent below the Baseline. The projected changes in the beef and dairy herds (see below for a discussion of the dairy sector) impact UK beef production. As shown in Figure 8, UK beef production initially increases relative to the Baseline but decreases in the medium to long-run. By 2020, it is projected that UK beef production is 20 per cent lower under Scenario 2A compared to the Baseline. The expansion of the cow herd in the latter part of the projection period exerts a downward impact on beef production since fewer cows are slaughtered and more heifers are required for replacement purposes.

Figure 7: Projected UK Suckler Cows under the Baseline and Scenarios 2A, 2B and 2C



Scenario 2A: Full Output Tax - Enteric Emissions (EU-wide)
Scenario 2B: Full Output Tax - Enteric and Manure Emissions (EU-wide)
Scenario 2C: 20% Fertiliser and Feed Tax (EU-wide)

Figure 8: Projected UK Beef Production and Domestic Use under the Baseline and Scenario 2A

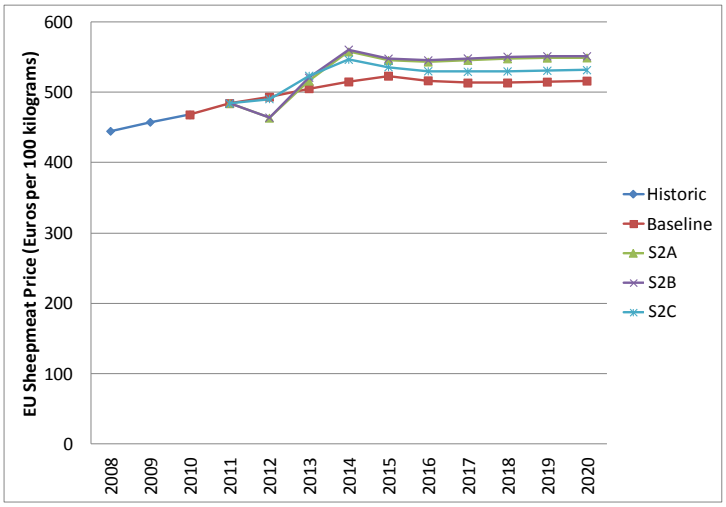


The positive beef price response in the long-run partly shifts the burden of the tax from the producer to the consumer and exerts a downward impact on consumption. Under Scenario 2A, it is projected that UK beef domestic use is 12 per cent lower compared to the Baseline at the end of the projection period. As a result, the projected decline in UK beef exports is considerably less marked under the EU-wide scenario compared to the equivalent UK-only scenario. Under Scenario 2A UK beef exports are 13 per cent lower compared to the Baseline (-35 thousand tonnes), while they are 58 per cent lower under Scenario 1A (154 thousand tonnes). Note that there is a degree of uncertainty as to

whether beef domestic use could fall to this extent due to the extreme nature of the scenario. As with all quantitative approaches, care should be taken in the interpretation of the projected impacts with extreme scenarios. If the decline in UK beef consumption was less marked, then the projected fall in net exports would be greater.

The EU sheepmeat sector responds in much the same way as the beef sector, with EU sheepmeat production increasing in the short-run as the flock is contracting and then falling in later years. Consequently, the EU sheepmeat price initially falls, but increases in the medium to long-run (Figure 9). The EU sheepmeat price is 6 per cent higher under Scenario 2A compared to the Baseline at the end of the projection period. The increase in the sheepmeat price is less marked compared to the beef price partly because the projected decline in overall EU production is lower, in line with the lower incidence of the enteric emissions tax. For lamb, imports are not able to react to the drop in production in the EU given the binding nature of preferential agreements, so the price increase is significant. However, cross elasticities of demand are smaller than with other meats and so the impact of the increase in beef prices is lower than for poultry and pork.

Figure 9: Projected EU Sheepmeat Price under the Baseline and Scenarios 2A, 2B and 2C

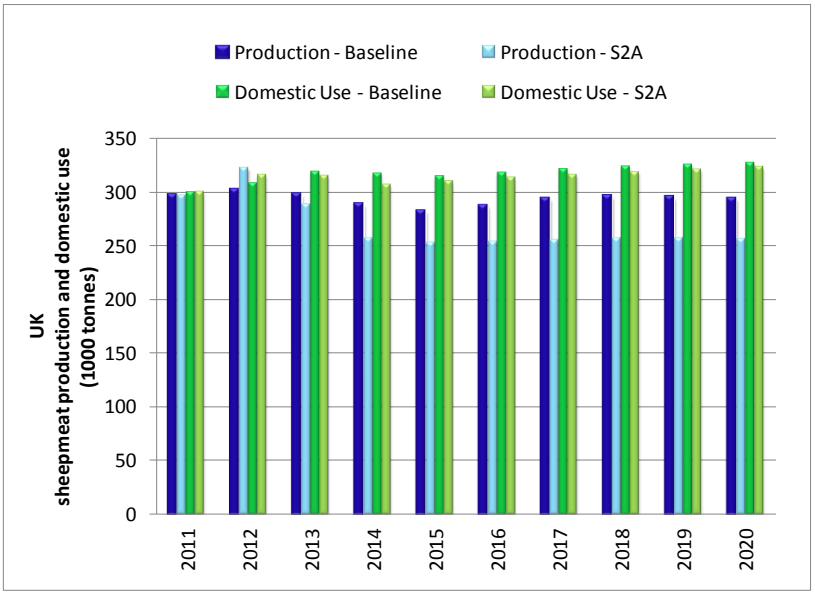


Scenario 2A: Full Output Tax - Enteric Emissions (EU-wide)
Scenario 2B: Full Output Tax - Enteric and Manure Emissions (EU-wide)
Scenario 2C: 20% Fertiliser and Feed Tax (EU-wide)

The projected UK sheepmeat price follows the EU price. Following the application of an enteric emissions tax across the EU the UK sheepmeat price is 6 per cent higher than the Baseline in at the end of the projection period. The positive price response partially offsets the impact of the taxes. Overall, it is projected that ewes and sheepmeat production in the UK decline by 13 per cent under Scenario 2A (Figure 10). The increase in the sheepmeat price has a small downward impact on UK sheepmeat domestic use under Scenario 2A compared to the Baseline (-1 per cent). Production falls by a greater

amount than domestic use and consequently, it is projected that there is a fall in UK sheepmeat net exports. UK sheepmeat net exports are 93 per cent lower under Scenario 2A compared to the Baseline in 2020 (32 thousand tonnes in absolute terms).

Figure 10: Projected UK Sheepmeat Production and Domestic Use under the Baseline and Scenario 2A



Within the pig and poultry sectors the large reduction in EU beef production (and to a lesser extent sheepmeat production) pulls EU pigmeat and poultry meat prices up. By the end of the projection period, the price increases under Scenario 2A are 4 per cent for pigmeat and 3 per cent for poultry. The positive price response offsets the effect of the enteric output taxes and EU production of pigmeat and poultry actually ends the period above that in the Baseline (both plus 2 per cent). Similarly, in the UK it is projected that both UK pigmeat and poultry production increase slightly following the application of enteric emissions taxes across the whole of the EU. Under Scenario 2A, UK pigmeat and poultry production increase by 2 per cent compared to the Baseline. The impact on domestic use is small and it is projected that there is a slight increase in net exports. By the end of the projection period UK pigmeat net exports are 19 thousand tonnes higher, while UK poultry net exports are 13 thousand tonnes higher.

Within the dairy sector, EU milk production under the Baseline is restricted by quota in the early years, with quotas growing each year and then being eliminated in the later years. Under the Baseline strong dairy prices means that milk quotas are binding in some countries, leading to quota rents. In these countries the impact of an enteric emissions tax on production is dampened by the existence of quota rents in the early years of the projection period prior to quota elimination, where an increase in costs is reflected in a

reduction in rents[2]. Under Scenario 2A, the levying of the output tax results in a reduction of EU milk production of about 3 per cent at the end of the projection period. Dairy cow numbers, rather than yields, account for most of the drop in milk production. Production decreases are mainly achieved through reductions in cow numbers since the taxes are levied on a per cow basis. The impact of the reduction in EU milk production on dairy products depends to a large extent on trade. In the case of WMP, under the baseline trade occurs without export subsidy and so as production falls and price rises, there is a large impact on exports and on the world price. As a result, the price increase for WMP compared to the other dairy commodities is the smallest (3%). Butter is more dependent on export subsidies and so trade is less responsive and the price increase is larger (6 per cent, or €20 per 100kg in absolute terms).

Within the UK, the price impact varies across the constituent countries due to differences in the dairy industry. The projected increase in the producer milk price is more marked in Northern Ireland (plus 4 per cent), compared to England, Wales and Scotland (all plus 2 per cent), due to the large proportion of raw milk that is allocated to the manufacture of dairy commodities in Northern Ireland. Overall, it is projected that UK dairy production falls by 6 per cent under Scenario 2A. Underlying this there are larger drops in milk production in England and Scotland (minus 7 per cent) compared to Wales and Northern Ireland (minus 4 per cent) since the increase in the output price is less marked in England and Scotland.

The introduction of the enteric output tax has an indirect impact on the EU crop sector through the demand for feed. In general, EU crop prices are close to their world counterparts and therefore changes in demand and supply that impact price levels in the EU have a direct impact on trade. For example, under this scenario feed demand for wheat falls by about 0.4 million tonnes and there is a corresponding increase in net exports of wheat.

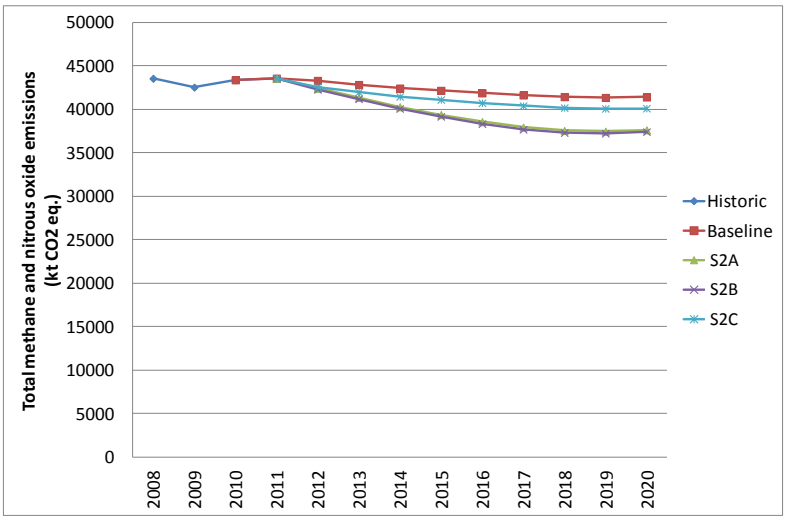
Within the UK, it is projected that UK wheat and barley domestic use decline in response to the application of enteric emissions tax across the whole of the EU. The decline in animal numbers exerts a downward impact on feed use for these commodities. As a consequence, it is projected that UK net exports of wheat and barley increase (plus 268 and 58 thousand tonnes, respectively). The increase in net exports is less significant compared to the equivalent UK-only scenario (under Scenario 1A UK wheat and barley net exports increased by 388 and 123 thousand tonnes) since the demand for animal feed does not fall to the same extent.

Overall, it is projected that UK market receipts minus costs (including taxes) are 6 per cent lower under Scenario 2A compared to the Baseline. This is lower than the equivalent UK-only scenario (Scenario 1A) due to the positive output price impacts when the tax is applied across the EU. As shown in Figure 11, it is projected that total UK methane and

[2] This does not apply to the UK as it is projected that the UK milk quota is not filled in the Baseline.

nitrous oxide emissions decline following the levying of the output tax across the EU. By the end of the projection period, total emissions in the UK are 9 per cent lower under Scenario 2A compared to the Baseline. The reduction in emissions is lower under the EU-wide scenario compared to the UK-only scenario due to the smaller projected decline in livestock numbers.

Figure 11: Projected Methane and Nitrous Oxide Emissions under the Baseline and Scenarios 2A, 2B and 2C



Scenario 2A: Full Output Tax - Enteric Emissions (EU-wide)
Scenario 2B: Full Output Tax - Enteric and Manure Emissions (EU-wide)
Scenario 2C: 20% Fertiliser and Feed Tax (EU-wide)

4.2.2 Full Output Tax - Enteric and Manure Emissions (Scenario 2B)

The inclusion of manure emissions within the output tax has a relatively minor impact on the EU beef and sheep sectors. As shown in Figures 6 and 9, the EU beef and sheepmeat prices show similar dynamics under Scenario 2B compared to Scenario 2A. The projected EU beef and sheepmeat prices are marginally higher under Scenario 2B compared to Scenario 2A at the end of the projection period. Similarly, the additional impact of including manure emissions within the output tax on the EU dairy sector is small. The projected decline in EU milk production is slightly greater under Scenario 2B compared to 2A and the EU milk price is marginally higher. It follows that the inclusion of manure emissions within the output tax has a relatively minor additional negative impact on projected UK beef and dairy cow numbers and a negligible impact on projected UK ewes.

In contrast, the inclusion of manure emissions within the output tax leads to significant increases in the pigmeat and poultry prices. Unlike the other livestock sectors, enteric taxes are small relative to those associated for manure (the former are zero for poultry).

Therefore, their introduction has a much bigger impact than in the beef or sheep sectors. Under Scenario 2B the EU pigmeat price is 11 per cent higher compared to the Baseline at the end of the projection period, while the poultry price is 6 per cent higher. Compared with Scenario 2A, this represents an additional impact of plus 7 per cent for the pigmeat price and plus 3 per cent for the poultry price. This reflects the fact that the manure emissions are an important source of methane emissions in the pig and poultry sectors.

In response to these price impacts, it is projected that UK sow numbers and pigmeat production are both 5 per cent higher under Scenario 2B compared to the Baseline in 2020, while poultry production is 2 per cent higher. This contrasts with the equivalent UK-only scenario (under Scenario 1B it is projected that pigment and poultry production declines). The price impact in these sectors offsets the effects of the output tax.

The projected impact of the enteric and manure emissions output tax on the EU and UK crop sector is similar to Scenario 2A.

Overall, it is projected that UK market receipts minus costs (including taxes) are 7 per cent lower under Scenario 2B compared to the Baseline.

4.2.3 Input taxes on fertilisers and feed (Scenario 2C)

The introduction of feed and fertiliser taxes across the EU increases the cost of producing both milk and calves and leads to reduction in the size of the EU dairy and beef cow herds. Under Scenario 2C, it is projected that there is a slight increase in EU beef production in the short-run. As this is occurring, however, it is projected that production also declines for the other meats. Both pork and poultry production can react more rapidly to the taxes and pork and poultry production falls, with poultry falling further as it can react the fastest. This leads to an increase in the price of these meats, which has a cross-price impact on beef. Under Scenario 2C, the increases in the price of the other meats are enough to bring about an increase in the price of beef in the short-run despite the increase in production. Consequently, in contrast to the output taxes, the introduction of an input tax has a positive impact on the EU beef price throughout the projection period (Figure 6). By the end of the projection period, the EU beef price is 9 per cent higher under this scenario compared to the Baseline. The increase in beef prices is not enough to offset the increase in costs and so the EU beef cow herd (along with the dairy cow herd) continues to fall, leading to a decrease in EU beef production (minus 3 per cent in 2020).

Within the UK, the feed and fertiliser taxes exert a downward impact on projected beef and dairy cow numbers. Under Scenario 2C, it is projected that UK beef cow numbers are 6 per cent lower compared to the Baseline in 2020, while UK dairy cows are 2 per cent lower. The impact is less marked compared to the equivalent UK-only scenario (Scenario 1C) due to the projected increase in producer prices throughout the EU, including the UK.

Under Scenario 2C, projected EU pork and poultrymeat production falls as a result of the increase in feed costs. In 2020 production of EU pork and poultrymeat are both down 1 per cent. Production falls more in the early years but as production in the other sectors falls and meat prices are forced up there is some recovery in production levels. It is projected that EU prices of pork and poultrymeat are up 11 and 12 per cent compared to the Baseline at the end of the projection period.

The price responses are transmitted to the UK. The rise in prices offset the effect of the input taxes and it is projected that UK pigmeat and poultry production are 1 per cent higher than the Baseline at the end of the projection period. This contrasts with the equivalent UK-only scenario (Scenario 1C) in which production in these sectors fell. The positive price impact also leads to a reduction in domestic use for UK pigmeat (minus 2 per cent) and poultry (minus 3 per cent). The increase in production and decrease in domestic use leads to an increase in net exports. It is projected that net exports of UK pigmeat increases by 41 thousand tonnes, while UK poultry net exports increases by 76 thousand tonnes.

Under Scenario 2C the increase in feed and fertilizer costs result in a reduction of EU milk production of 2.7 per cent, with 2.5 percent coming from a drop in cows of half a million head and the rest coming from a fall in yields. The reduction in EU milk production leads to an increase in dairy commodity prices. Within the UK, projected milk production falls by 2 per cent following the introduction of input taxes across the EU. The overall decline is less marked compared to the UK only scenario (Scenario 1C) since the increase in dairy commodity prices leads to higher producer milk prices. It is projected that the producer milk price increases by 4 per cent in England and Wales, 3 per cent in Scotland and 6 per cent in Northern Ireland. The drop in production is primarily achieved by a fall in dairy cow numbers rather than a decrease in yields. Within the modelling system the increase in input costs exerts a negative impact on costs, but this is partially offset by the projected increase in producer milk prices. In reality, applying an input tax may have a larger impact on yields depending on changes in dairy systems and the implementation of the tax in practice.

The introduction of an input tax has a limited impact on the EU crop sector. It is projected that EU crop prices fall by less than 1 per cent. Crop markets are impacted through the fertiliser tax and indirectly through the demand for feed. The fertiliser tax has a small negative impact on overall EU crop area since the total area of crops is relatively inelastic to total returns and the increase in fertiliser cost applies to all crops. It is projected that the EU area of wheat, corn and barley fall by 269 thousand hectares in this scenario. The impact of this reduction in crop area on price is offset by a reduction in the demand for feed. Feed demand falls and this is accounted for by an increase in exports as prices fall and an increase in the other categories of demand. For example, under this scenario EU feed demand for wheat falls by about 1.2 million tonnes, half of this is met by a reduction in production as area and yields fall and most of the rest of the grain is exported instead. Food use and fuel use (for ethanol) also replace feed demand as the price falls. Overall these differences are small in comparison to the changes in the livestock sectors.

The limited price response means that the impact of an input tax on crop production under Scenario 2C is similar to that under the UK-only scenario (Scenario 1C). It is projected that UK wheat production falls by 0.4 per cent in 2020, while UK barley production falls by 0.9 per cent. However, domestic use falls to a less extent since the fall in ruminant livestock numbers is lower and there is a small increase in pig and poultry numbers. Projected UK wheat domestic use falls by 0.4 per cent, while that for barley falls by 0.7 per cent. As a result, in contrast to the UK-only scenario, it is projected that there is a small decrease in UK net exports for wheat and barley.

Overall, it is projected that market receipts minus costs (including taxes) are 9 per cent lower under Scenario 2C compared to the Baseline in 2020. The projected total UK methane and nitrous oxide emissions under this scenario are shown in Figure 11. By the end projection period, total UK methane and nitrous oxide emissions are 3 per cent lower under Scenario 2F compared to the Baseline.

5. Conclusions

The analysis uses an EU partial equilibrium modelling system to examine the impact of a range of input and output taxes on the UK agricultural sector. Ruminants are an important source of methane emissions and this is reflected in the taxes implemented in the scenarios which are based on methane emission factors. The results illustrate the impact of applying the taxes in the UK on a unilateral basis or across the whole of the EU. In general, applying the taxes across the whole of the EU results in less significant falls in ruminant animal numbers compared to the unilateral UK taxes since the positive price impact partially offsets the impact of the tax. In the case of pigs and poultry, the positive price impact due to cross-price effects with the beef and sheep sectors more than offsets the impact of the taxes and production of pigmeat and poultry actually increases.

The significant increase in the projected beef price in the latter part of the period under the EU-wide output tax scenarios leads to a rebuilding of the beef herd in the UK. The conditions in agricultural markets before the taxes are applied are important in determining emission tax impacts. For example, the high relative price of Brazilian beef in relation to the EU beef price within the Baseline (i.e. under current policies) means that import tariffs are effective in restraining beef imports. Trade effects therefore are important in determining the impact of the taxes as the protection provided by the tariff allows EU beef prices to rise to partially offset the tax for producers.

The projected increase in prices under the EU-wide scenarios also exerts a downward impact on quantity demanded and some loss in consumer surplus. Consequently, there is a partial shift of the burden of the tax from the producer to the consumer. As a result, the decrease in UK net exports in the livestock sectors are less marked under the EU-wide scenarios compared to the UK-only scenarios. The impact of taxes on consumer prices and hence consumption again depends on the trade regime and world markets. The levying of taxes within a protected market environment leads to higher EU prices, decreases in consumption and reductions in global emissions. More open markets, however, lead to reductions in local production, but offsetting increases in production elsewhere and thus carbon leakage. Consequently, net global emissions would not decrease to the same extent. The impact on net global emissions would be exacerbated if the countries expanding production produce food at a higher level of greenhouse gas intensity than in the EU; e.g. Cederberg *et al.* (2009) argue that greenhouse gas emissions associated with Brazilian beef production are significantly higher than in the EU.

In terms of local emissions, the input and output taxes contribute to the UK's Climate Change Act targets by reducing UK greenhouse gas emissions from agriculture. The simulations indicate that the greatest falls occur under the UK-only output tax scenarios, with total UK methane and nitrous oxide emissions from agriculture declining by 12 to 13 per cent under Scenarios 1A and 1B relative to the Baseline. However, the impact on UK agricultural sector income is considerable with market receipts falling by 20 to 23 per cent under these scenarios. The financial impact on the UK agricultural sector is lower if the policies are implemented on an EU-wide basis due to the projected price responses, but the impact on greenhouse gas emissions is smaller.

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Appendix A: Scenario Summary Tables

UK-Only Scenarios

Table A1: Projected Changes in UK Livestock Sectors, UK-Only Scenarios (percentage difference in 2020 compared to the Baseline)

	S1A	S1B	S1C
Cattle			
Beef cows	-34%	-37%	-12%
Dairy cows	-7%	-9%	-4%
Total Cattle	-20%	-22%	-8%
Beef			
Production	-21%	-23%	-7%
Domestic use	-1%	-1%	0%
Net exports	-58%	-64%	-20%
Cattle price	4%	4%	1%
Sheep			
Ewes	-16%	-16%	-5%
Total Sheep	-16%	-17%	-5%
Sheepmeat			
Production	-16%	-16%	-5%
Domestic use	-1%	-1%	0%
Net exports	-128%	-130%	-42%
Sheepmeat price	2%	2%	1%
Pig			
Sows	0%	-3%	-7%
Total pigs	-1%	-4%	-8%
Pork			
Production	0%	-3%	-7%
Domestic use	0%	0%	0%
Net exports	0%	-3%	-5%
Pigmeat reference price	0%	0%	0%
Poultry			
Production	0%	-2%	-6%
Domestic use	0%	0%	0%
Net exports	0%	-8%	-21%
Poultry price	0%	1%	1%

Scenario 1A: Full Output Tax - Enteric Emissions (UK-only)
Scenario 1B: Full Output Tax - Enteric and Manure Emissions (UK-only)
Scenario 1C: 20% Fertiliser and Feed Tax (UK-only)

Table A2: Projected Changes in UK Dairy Sector, UK-Only Scenarios (percentage difference in 2020 compared to the Baseline)

	S1A	S1B	S1C
Dairy			
Cow's milk Production	-8%	-9%	-5%
Liquid consumption	0%	0%	0%
Manufacturing use	-18%	-21%	-10%
Prices			
Producer milk price	0%	0%	0%
Cheese price	0%	0%	0%
Butter price	0%	0%	0%
WMP price	0%	0%	0%
SMP price	1%	1%	1%
Dairy Commodity Production			
Cheese	-11%	-13%	-6%
Butter	-7%	-9%	-4%
SMP	-38%	-46%	-22%
WMP	-19%	-23%	-11%

Scenario 1A: Full Output Tax - Enteric Emissions (UK-only)
Scenario 1B: Full Output Tax - Enteric and Manure Emissions (UK-only)
Scenario 1C: 20% Fertiliser and Feed Tax (UK-only)

Table A3: Projected Changes in UK Crop Sector, UK-Only Scenarios (percentage difference in 2020 compared to the Baseline)

	S1A	S1B	S1C
Wheat			
Production	0%	0%	0%
Domestic use	-3%	-3%	-2%
Net exports	93%	122%	70%
Barley			
Production	-1%	-2%	-1%
Domestic use	-4%	-5%	-3%
Net exports	49%	70%	46%
Rapeseed			
Production	0%	0%	-1%
Domestic use	0%	0%	0%
Net exports	0%	0%	-9%
Area			
Wheat	0%	0%	0%
Barley	-1%	-2%	-1%
Rapeseed	0%	0%	-1%
Prices			
Wheat	0%	0%	0%
Barley	0%	0%	0%
Rapeseed	0%	0%	0%
Oats	0%	0%	0%

Scenario 1A: Full Output Tax - Enteric Emissions (UK-only)
Scenario 1B: Full Output Tax - Enteric and Manure Emissions (UK-only)
Scenario 1C: 20% Fertiliser and Feed Tax (UK-only)

Table A4: Projected Changes in UK Methane and Nitrous Oxide Emissions, UK-Only Scenarios (*percentage* difference in 2020 compared to the Baseline)

	S1A	S1B	S1C
UK			
CH_4 Enteric Fermentation	-17%	-18%	-7%
CH_4 Manure Management	-9%	-12%	-6%
N_2O Manure Management	-12%	-14%	-7%
N_2O Agricultural Soils	-9%	-10%	-5%
CH_4 Total Agriculture	-15%	-17%	-7%
N_2O Total Agriculture	-9%	-11%	-5%
Total CH_4 and N_2O Emissions	-12%	-13%	-6%
Regional Total CH_4 and N_2O Emissions			
England	-10%	-11%	-5%
Wales	-15%	-16%	-6%
Scotland	-16%	-18%	-7%
Northern Ireland	-13%	-15%	-6%

Scenario 1A: Full Output Tax - Enteric Emissions (UK-only)
Scenario 1B: Full Output Tax - Enteric and Manure Emissions (UK-only)
Scenario 1C: 20% Fertiliser and Feed Tax (UK-only)

Table A5: Projected Changes in Methane and Nitrous Oxide Emissions, UK-Only Scenarios (*absolute* difference in 2020 compared to the Baseline)

		S1A	S1B	S1C
UK				
CH_4 Enteric Fermentation	kt	-113	-124	-45
CH_4 Manure Management	kt	-12	-14	-8
N_2O Manure Management	kt	-0.7	-0.9	-0.5
N_2O Agricultural Soils	kt	-6.7	-7.5	-3.7
CH_4 Total Agriculture	*$ktCO_2$ eq.*	-2,614	-2,907	-1,116
N_2O Total Agriculture	*$ktCO_2$ eq.*	-2,323	-2,587	-1,297
Total CH_4 and N_2O Emissions	*$ktCO_2$ eq.*	-4,937	-5,495	-2,413
Regional Total CH_4 and N_2O Emissions				
England	*$ktCO_2$ eq.*	-2,631	-2,975	-1,427
Wales	*$ktCO_2$ eq.*	-677	-728	-268
Scotland	*$ktCO_2$ eq.*	-1,064	-1,162	-455
Northern Ireland	*$ktCO_2$ eq.*	-565	-629	-263

Scenario 1A: Full Output Tax - Enteric Emissions (UK-only)
Scenario 1B: Full Output Tax - Enteric and Manure Emissions (UK-only)
Scenario 1C: 20% Fertiliser and Feed Tax (UK-only)

EU-Wide Scenarios

Table A6: Projected Changes in UK Livestock Sectors, EU-Wide Scenarios (percentage difference in 2020 compared to the Baseline)

	S1A	S2B	S2C
Cattle			
Beef cows	-21%	-22%	-6%
Dairy cows	-6%	-7%	-2%
Total Cattle	-16%	-17%	-4%
Beef			
Production	-20%	-21%	-5%
Domestic use	-12%	-12%	-3%
Net exports	-13%	-16%	-3%
Cattle price	39%	42%	9%
Sheep			
Ewes	-13%	-13%	-3%
Total Sheep	-13%	-13%	-3%
Sheepmeat			
Production	-13%	-12%	-3%
Domestic use	-1%	-1%	0%
Net exports	-93%	-96%	-26%
Sheepmeat price	6%	6%	3%
Pig			
Sows	2%	5%	1%
Total pigs	3%	6%	2%
Pork			
Production	2%	5%	1%
Domestic use	0%	-2%	-2%
Net exports	2%	7%	5%
Pigmeat reference price	3%	10%	10%
Poultry			
Production	2%	2%	1%
Domestic use	1%	0%	-3%
Net exports	3%	9%	19%
Poultry price	3%	6%	12%

Scenario 2A: Full Output Tax - Enteric Emissions (EU-wide)
Scenario 2B: Full Output Tax - Enteric and Manure Emissions (EU-wide)
Scenario 2C: 20% Fertiliser and Feed Tax (EU-wide)

Table A7: Projected Changes in UK Dairy Sector, EU-Wide Scenarios (percentage difference in 2020 compared to the Baseline)

	S1A	S2B	S2C
Dairy			
Cow's milk Production	-6%	-7%	-2%
Milk quota	0%	0%	0%
Liquid consumption	0%	0%	0%
Manufacturing use	-14%	-17%	-4%
Prices			
Producer milk price	2%	3%	4%
Cheese price	3%	4%	6%
Butter price	5%	6%	7%
WMP price	3%	4%	3%
SMP price	6%	7%	8%
Dairy Commodity Production			
Cheese	-10%	-11%	-1%
Butter	-3%	-4%	4%
SMP	-30%	-36%	5%
WMP	-17%	-19%	-7%

Scenario 2A: Full Output Tax - Enteric Emissions (EU-wide)
Scenario 2B: Full Output Tax - Enteric and Manure Emissions (EU-wide)
Scenario 2C: 20% Fertiliser and Feed Tax (EU-wide)

Table A8: Projected Changes in UK Crop Sector, EU-Wide Scenarios (percentage difference in 2020 compared to the Baseline)

	S1A	S2B	S2C
Wheat			
Production	0%	0%	0%
Domestic use	-2%	-2%	0%
Net exports	64%	62%	-1%
Barley			
Production	-1%	-1%	-1%
Domestic use	-2%	-2%	-1%
Net exports	24%	22%	-4%
Rapeseed			
Production	0%	0%	-1%
Domestic use	0%	0%	0%
Net exports	0%	0%	-9%
Area			
Wheat	0%	0%	0%
Barley	-1%	-1%	0%
Rapeseed	0%	0%	-1%
Prices			
Wheat	0%	-1%	0%
Barley	0%	-1%	0%
Rapeseed	0%	0%	0%
Oats	0%	-1%	0%

Scenario 2A: Full Output Tax - Enteric Emissions (EU-wide)
Scenario 2B: Full Output Tax - Enteric and Manure Emissions (EU-wide)
Scenario 2C: 20% Fertiliser and Feed Tax (EU-wide)

Table A9: Projected Changes in UK Methane and Nitrous Oxide Emissions, EU-Wide Scenarios (percentage difference in 2020 compared to the Baseline)

	S2A	S2B	S2C
UK			
CH_4 Enteric Fermentation	-13%	-14%	-3%
CH_4 Manure Management	-7%	-7%	-2%
N_2O Manure Management	-8%	-9%	-2%
N_2O Agricultural Soils	-7%	-7%	-3%
CH_4 Total Agriculture	-12%	-13%	-3%
N_2O Total Agriculture	-7%	-8%	-3%
Total CH_4 and N_2O Emissions	-9%	-10%	-3%
Regional Total CH_4 and N_2O Emissions			
England	-8%	-8%	-3%
Wales	-12%	-12%	-3%
Scotland	-12%	-13%	-4%
Northern Ireland	-10%	-10%	-3%

Scenario 2A: Full Output Tax - Enteric Emissions (EU-wide)
Scenario 2B: Full Output Tax - Enteric and Manure Emissions (EU-wide)
Scenario 2C: 20% Fertiliser and Feed Tax (EU-wide)

Table A10: Projected Changes in UK Methane and Nitrous Oxide Emissions, EU-Wide Scenarios (absolute difference in 2020 compared to the Baseline)

		S2A	S2B	S2C
UK				
CH_4 Enteric Fermentation	kt	-89	-94	-23
CH_4 Manure Management	kt	-8	-8	-2
N_2O Manure Management	kt	-0.5	-0.5	-0.1
N_2O Agricultural Soils	kt	-5.1	-5.4	-2.3
CH_4 Total Agriculture	$ktCO_2$ *eq.*	-2,029	-2,146	-536
N_2O Total Agriculture	$ktCO_2$ *eq.*	-1,753	-1,844	-751
Total CH_4 and N_2O Emissions	$ktCO_2$ *eq.*	-3,781	-3,991	-1,287
Regional Total CH_4 and N_2O Emissions				
England	$ktCO_2$ *eq.*	-2,014	-2,143	-744
Wales	$ktCO_2$ *eq.*	-537	-559	-156
Scotland	$ktCO_2$ *eq.*	-810	-844	-260
Northern Ireland	$ktCO_2$ *eq.*	-421	-445	-128

Scenario 2A: Full Output Tax - Enteric Emissions (EU-wide)
Scenario 2B: Full Output Tax - Enteric and Manure Emissions (EU-wide)
Scenario 2C: 20% Fertiliser and Feed Tax (EU-wide)