# QUANTITATIVE MODELLING OF POST-BREXIT SCENARIOS: TECHNICAL REPORT 2019 UPDATE

Final report for the UK levy boards, AHDB, QMS and HCC

Submitted by

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## S1. Executive summary

This 2019 Report for the UK levy boards, AHDB, QMS and HCC by Dr Dylan Bradley and Professor Berkeley Hill, updates and builds on a previous (2017) study Quantitative Modelling for Post-Brexit Scenarios undertaken by Agra CEAS Consulting (in association with Promar International) for the Agriculture and Horticulture Development Board (AHDB). That earlier work, carried out in the light of the uncertainty for the agricultural sector created by the UK's decision to leave the European Union (EU), its Single Market and the Common Agricultural Policy (CAP), both reviewed existing literature and developed independent quantified estimates of the impacts on farm incomes under three scenarios, initially identified by the AHDB. These scenarios incorporated four main areas of concern; (i) the terms of international trade, both with the remaining EU-27 and with other countries; (ii) domestic agricultural policy, as manifest in support payments, rural development and market management; (iii) migrant labour and its availability; and, (iv) the UK regulatory environment.

The three scenarios used in the 2017 study were intended to set a boundary for the likely possibilities resulting from the UK's exit from the EU and thus enable the wider agricultural industry make sense of the issues facing it over the course of the negotiations for UK exit from the EU and beyond. The first represented essentially a 'Business as Usual' option where the policy, regulatory framework and trading relations remained as close to the status quo as is possible given that the UK would no longer be part of the EU's Single Market. The other two scenarios involved, in addition, degrees of reduction in support payments to UK farmers and restrictions to migrant labour, plus either the adoption by the UK of a liberal approach to trading which implied increased competition from imports outside the EU, or an alternative in which trade only took place under World Trade Organisation (WTO) Most Favoured Nation (MFN) tariffs. The 2017 study explored the impacts of each scenario on the incomes seven types of farming found within the Farm Business Survey (FBS) that covers England: cereals, general cropping (with special attention given to potatoes), dairy, pigs, beef and sheep (uplands), beef and sheep (lowland) and horticulture.

Together these cover the main production sectors of UK agriculture. The all-farms situation was also described. Subsequently, similar studies were carried out for Scotland and Wales and for selected areas (the Lake District) and sectors (poultry).

By early 2019 circumstances had changed, reducing or removing some of the uncertainty and requiring an update.

- First, it has become clear that the regulatory environment is unlikely to change significantly, as the demands of markets in the UK and in export markets (in particular in the EU) will remain closely aligned with the present. Consequently, changes in costs faced by UK producers in meeting regulations are unlikely to be lowered and can then, for practical purposes, be ignored when assessing the impact of Brexit on UK producers.
- Second, Ministerial statements and the contents of the 2018 Agriculture Bill that will shape the agricultural policy in England after UK exit from the EU and the Common Agricultural Policy make it clear that, in England, direct income payments will be phased out by 2027. However, in the first year of national policy (2022), which sees the first stage of reduction, what is lost from this type of support will be added to land management schemes, keeping the total amount of public support unchanged. As agriculture is a devolved responsibility, what happens to domestic agricultural policy in Wales and Scotland will differ; at the time of writing the situation in Scotland and Wales is not known.
- Third, concerning access to labour from EU-27 countries, the UK government has indicated, as part of its preparation for leaving the EU, that a Seasonal Agricultural Workers Scheme (SAWS) will be introduced for migrants entering the UK on a seasonal basis to work in agriculture. If the volume of labour covered by these schemes matches the numbers that farmers require, labour costs of casual labour would be expected not to rise as a direct consequence of Brexit. Such schemes would not apply to non-UK regular labour, access to which would be restricted, with what we estimate is a resultant increase in a 50% increase in the cost of this category of labour.
- Fourth, trade policy can be expected to affect the prices of farm-produced commodities on the UK domestic market. This may range from good access for

the UK to the EU market, probably in the form of a Free Trade Agreement (FTA), to a more distant relationship likely to involve a more fundamental change to border arrangements and import tariffs. While the nature of this UK-EU relationship is still not settled, and a range of possibilities need to be modelled, it is nevertheless clear that, in the absence of a UK-EU FTA, the UK will apply tariffs to agricultural imports (announced in March 2019) which, in most cases, are lower than those currently operated by the EU. This represents a substantial step towards unilateral trade liberalisation, though at the same time retaining a degree of protection for sectors (such as livestock production) that are deemed to be vulnerable.

Thus, when devising scenarios as part of this 2019 Updating Study, the only factor that is allowed to vary is the trade relationship. Domestic policy and labour costs, though different from the *status quo*, remain the same across the scenarios. Initial work used three scenarios, but the announcement of the UK's proposed tariffs meant that this could be reduced to two; together these are intended to set boundaries of the likely possibilities resulting from the UK's exit from the EU. The first (***UK-EU FTA***) is a scenario that represents essentially a 'Business as Usual' option where trading relations remain as close to the status quo as is possible given that the UK will no longer be part of the EU's Single Market. The second scenario (***WTO: UK import tariffs***) implies that the UK unilaterally applies its reduced tariffs on imports of agricultural commodities (and fertilisers), including those from the EU. The EU however, treats the UK as a third-country in trading terms, applying its current World Trade Organisation (WTO) Most Favoured Nation (MFN) tariffs.

Though not strictly part of a scenario, it is instructive to observe how much of the income of farms in 2022 is still made up of direct income payments. Estimation of FBI after their exclusion can point to the degree of adaptation necessary if they were removed (as is the intention under the present government).

### S1.1. Methodology

The basic methodology follows the two-stage approach described in our 2017 Report to estimate first-order changes in incomes at the farm level, though using updated data and some modification of detail to improve the quality of the results (such as greater disaggregation of poultry meat, pork and dairy products to achieve a more robust estimate of resultant changes in farm-level prices of the commodities as they leave the farm). There has also been an expanded review of literature to cover studies that have appeared since 2017 and to consider evidence on how farm operators respond in the longer-term.

First, in the two-stage process, changes in commodity prices resulting from trade conditions were estimated for 2022 using a gravity model (for commodities in which the UK is a net importer, which is the majority) and economic analysis (the few for which the UK is a net exporter, barley and sheepmeat, for example). These were sense-checked against alternative estimates produced by other researchers and the expectations of sector experts within AHDB.

These were then fed into the second stage, a static micro-economic farm-level model using, for England, data from the FBS, to estimate the short-term implications for average revenues, costs and Farm Business Income (FBI) in 2022. Changes in the cost of regular labour were introduced by increasing its current costs at group average level by 50%. Changes in revenues from subsidies were estimated by lowering direct payments in aggregate by £150 million (the first announced reduction within England's national agricultural policy) and reallocating this to Pillar 2-type payments according to group-average baseline levels; these extra payments are assumed to represent additions to income. To observe the significance of the remaining direct payments, calculations were made with these lowered to zero, without reintroducing them in the form of Pillar 2-type schemes (beyond the £150 million in aggregate of the first step in this direction in 2022). The impacts of the two scenarios were expressed in comparison with the baseline position provided by the present CAP and trade relationships and reflected in the finding of the FBS for the average of the years 2015/16, 2016/17 and 2017/18.

### S1.2. Estimates of FBI in 2022 for the two scenarios

**England**

The output from the process takes the form of estimates of FBI per farm in 2022 for the two scenarios, (***Scenario A: UK-EU FTA*** and ***Scenario B: WTO, UK tariffs***) and comparisons of them with the baseline of the FBI average of the years 2015/16, 2016/17 and 2017/18.

The general picture for England (see Figure below) is that under ***Scenario A: UK-EU FTA***, compared with the baseline, FBI falls markedly in 2022 for the all-farms average and for each individual type of farming, with the exception of the sheep and beef sectors where they remain at close to the baseline level. A key explanatory factor in the income drop is the projected increase in labour costs. In most cases at the sector level the reduction in Pillar 1 payments is offset to some extent by the reallocation of support under Pillar 2-type schemes; there will be differences by farm size within this, in line with the difference in the relative importance of Pillar 1 and Pillar 2 payments. LFA beef and sheep is the only sector where production revenue declines under Scenario A. Under ***Scenario B: WTO: UK tariffs***, FBI falls further than under Scenario A. This is driven by the same increases in labour costs, but under this scenario, all sectors see falls in production revenue to varying extents as well.

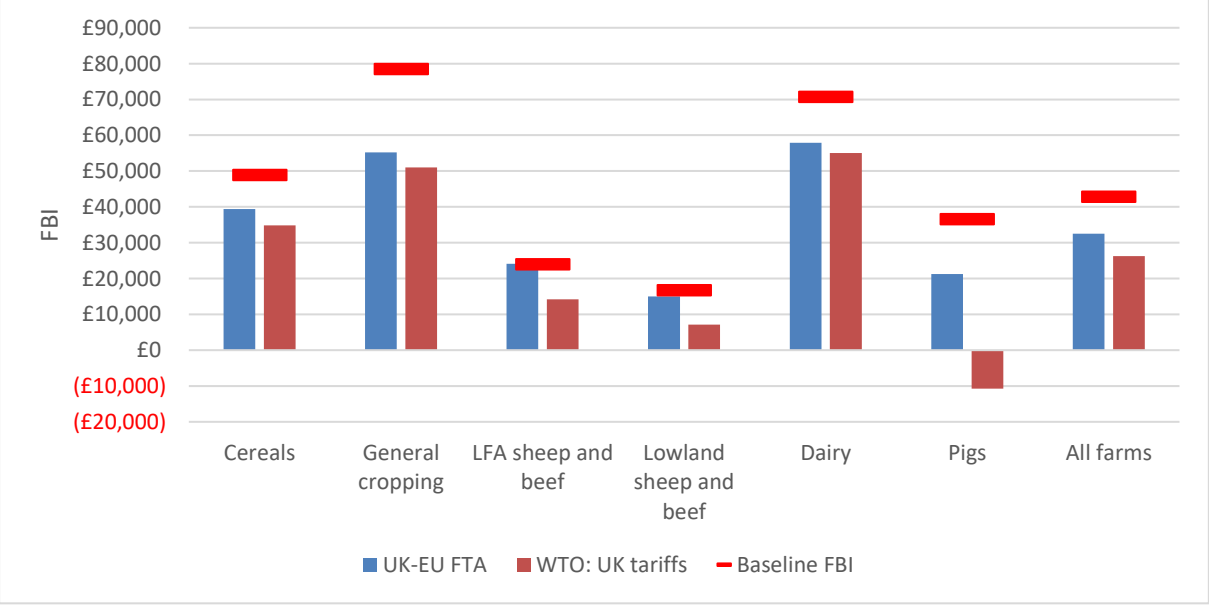


**Figure 0.1: Farm Business Income (2022) for each sector compared to the baseline (England)**

Attention is drawn to the importance of the contribution to FBI in 2022 of the remaining direct income payments (the UK replacement for the CAP's Pillar 1 Basic Payments Scheme). These are scheduled to be phased out in England by 2027, though the precise pattern has not been announced, nor has what may happen the resources they represent beyond 2022 (the first year of scaling down, when the implication is that the savings will be reallocated to Pillar 2-like schemes). Purely for illustrative purposes, in the Figure below FBI for 2022 is also shown with the remaining direct income payments removed; for the all-farm average, the hypothetical removal of these payments would have a major impact on the remaining income of businesses.

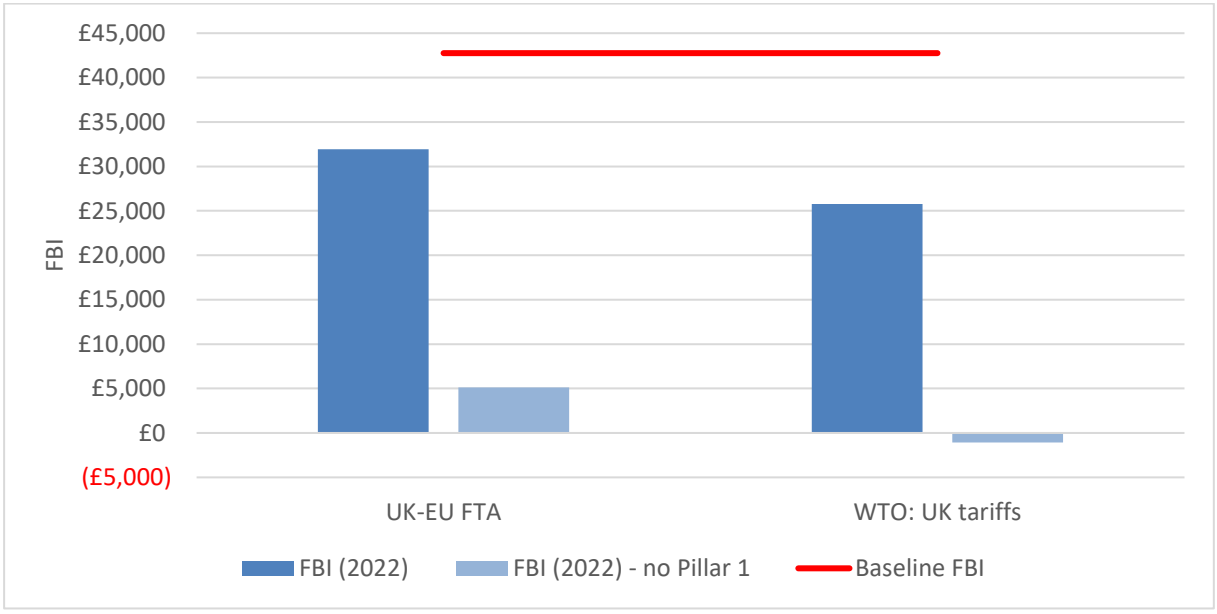



**Figure 0.2: Impact of the scenarios on 2022 FBI: All farms (England)**

Consideration is given to the causes of the change is estimated FBI in each farming type, together with similar calculations for synthesized potato and carrot enterprises and poultry (meat) production; these latter forms of farming are not represented in the FBS sample and an alternative approach is used, based on what is thought to be a representative producer. The causal changes are linked to elements of revenue (from the market, from diversified activities, from Pillar 1-type and Pillar 2-type

subsidies, etc.) and from variable costs (including feed, fertiliser, casual labour and contracting) and fixed costs (including that of regular labour).

Though in most farming types the FBI under ***Scenario A: UK-EU FTA*** is lower than the baseline, there are variations between types in the size of this gap and its underlying causes. This also applies to the further gap to the FBI under ***Scenario B: WTO: UK tariffs***. A prominent cause of the fall below the baseline in both is the higher costs of regular hired labour, a factor that is independent of the trade relationship, though these are more important in some types of farming than in others because of the different quantities per business that they employ. Consideration is also given at farm-type level to the contribution in 2022 of direct payments due to be phased out by 2027; the implications are more significant for some types that currently receive higher levels of these payments (such as LFA cattle and sheep farms) than those which receive relatively little (such as pig farms).

Despite these variations between farming types, there are some common features within each type. This applies to the analysis by size, where larger farms generally have larger FBIs than smaller ones even under ***Scenario B: WTO: UK tariffs***. But, in particular, analysis by performance level (ratio of the value of output to the value of inputs) sees a consistent pattern in which low-performing farms have lower FBIs that are often negative in both the baseline and in the two scenarios. However, high-performing farms have higher FBIs that are always positive even in ***Scenario B: WTO: UK tariffs*** where incomes are generally lower than in the baseline or Scenario A. The Figure below illustrates the general situation for all-farms in England. The message for businesses is therefore clear; to be most resilient to what might otherwise be adverse economic conditions, they should adapt in ways that enable the business to achieve a relatively good ratio between output and input values.

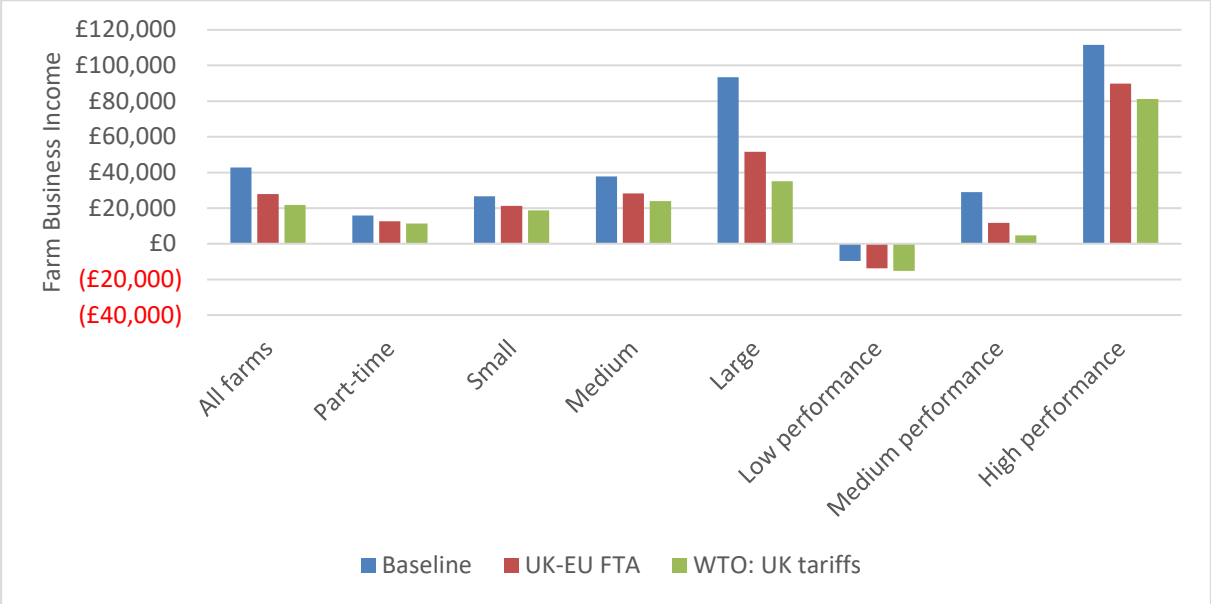



**Figure 0.3: 2022 FBI by farm size and performance level: All farms (England)**

### S1.3. Longer-term adaptations

The farm-level model generates estimates of first-order indications of the impact on current income by 2022; it does not take into account the responses that farm operators may make in the face of such signals as they adjust longer-term enterprise mixes, cost structures and embrace more fundamental structural changes, including scale, investment and labour-saving innovation, and exit decisions. These are the subject of a further step in our analysis. A literature review of the wide variety of responses to past income crises ('no-change' being the conscious choice of a substantial number) was discussed with AHDB experts and board members, themselves farmers, with the intention of encouraging a broader consideration of how the farming industry may develop. While the direction of change is usually discernible from the literature, and fleshed out in the discussions, turning these into quantified estimates of structural change is beyond the scope of the present project. Ways of filling this information gap are suggested.

### S1.1. Other comments

Our analysis of the impacts of the scenarios, as with any study of this sort, inevitably involves assumptions and simplifications. As in our 2017 Report to the AHDB, we have attempted to make clear our assumptions and the implications they entail, not

least by the use of sensitivity analysis where appropriate (such as for changes in exchange rates, in the costs of labour, and shifts in production caused by factors such as weather that can change the UK from being a net importer to a net exporter of a particular commodity). However, it follows that our results in terms of shifts in incomes (FBI) should be regarded primarily as indications of where the greatest economic pressures are likely to be felt within the agricultural industry and the predominant causes of these changes. It should be remembered that FBI does not include off-farm income earned by farmers and/or other family members, pensions, or interest on (non-farm) investments, etc. Incomes from such non-agricultural sources may enable farms to be sustainable even in the face of negative FBIs, as often applies currently under the baseline for low performing farms and will be the case for some farms when FBI becomes negative under some scenarios. Similarly, capital gains (and losses) are not covered. Nevertheless, anticipated falls in FBI can be a useful indicator of where the AHDB and other organisations tasked with supporting the agricultural industry can best deploy their resources and focus their attention.

### S1.1. Conclusions

The results in terms of the implications at the farm level for the various scenarios chosen by the AHDB carry lessons for both farmers and for organisations such as the AHDB that support the agricultural industry. As expected, there are substantial impacts on projected levels of FBI. Though these should not be interpreted as precise predictions (see methodology) they are reasoned indications of where the greatest levels of financial pressure on farms will be felt, and to which farmers can be expected to respond by longer-term adjustments, such as structural change (including exiting the sector).

There are significant expected impacts from moving from the present situation to ***Scenario A: UK-EU FTA***, the scenario that involves not only a trading situation that is little different (apart from higher trading costs) but also changes in the pattern of domestic support and higher costs of regular labour. The impacts are generally more pronounced when moving to the more extreme scenario that also includes reductions in UK tariffs on imports (***Scenario B: WTO, UK tariffs***). Though for the industry as a

whole incomes can be expected to fall in these situations, there are differences between farming types. Trade issues are relevant for all types (sometimes in different directions) and critical for a few. So too is the way that greater restrictions on migrant labour can be expected to affect regular labour costs, with the impact felt most on those types of farming and sizes which employ greater amounts of regular labour. For most farming types, and thus the industry as a whole, the postulated removal of direct income payments would have a substantial impact on incomes.

Two general findings from our 2017 report can be underlined by this 2019 work. First, the opportunities to influence outcomes or to mitigate them vary, with the ability of farmers, even acting collectively, to influence the outcome of the final trading relationship between the UK and EU likely to be limited, though there are grounds for thinking that the projected impact of an extreme liberal approach to tariff removal contributed to the design of national tariffs that afforded some protection to vulnerable sectors (such as sheep). However, the nature of domestic support in the UK's agricultural policy will be decided at national level (UK or devolved administrations) and can be expected to be more responsive to evidence and proposals. Awareness of the importance of the postulated removal of direct income payments will be useful to the AHDB and to governments, not least in their design of Pillar 2-type schemes that are commonly seen as being easily justified (on public-goods arguments) and pragmatically useful in partially compensating for the withdrawal of Basic Payments. Similarly, a demonstration of the impact of increased labour costs resulting from restrictions on migrant labour should assist with the design of targeted measures to ease this specific problem. Already concessions in the restrictions on migrant seasonal labour have been won, though it remains to be seen whether they are adequate to avoid poor availability and higher labour costs. Given that higher regular labour costs contribute in a major way to falling incomes in many farming types by 2022, this is another issue on which a case for a targeted relaxation of restrictions could help the farming sector, though there would be an administrative problem of preventing transfer of workers to other sectors suffering from reduced labour availability.

There are also important messages to be conveyed to the agricultural industry by the AHDB and other organisations that support farmers. Perhaps the most significant is that, according to the evidence, high performing farms (in terms of their output/input ratios) are shown to be in a far stronger position to cope with the changes associated with the scenarios. This should focus attention on farmers knowing their relative performance (such as by using benchmarking) and on pursuing practical ways of improving output and containing costs. High performance is not necessarily associated with larger farms, and there is the possibility of improving performance across the size spectrum. Another general lesson is the importance of adaptation; the literature points to the proven ability of UK farmers as a group to absorb and adjust to shocks and pressures. Again, support organisations and governments could promote this ability by identifying and tackling constraints; knowledge transfer and skills training are likely to play prominent parts in the assistance provided to farmers.

# 1. Introduction

One role of the Agriculture and Horticulture Development Board (AHDB) is to assess and inform levy payers and policy makers of the potential impact of policy changes through the provision of high quality and impartial evidence. The UK's decision to leave the EU has created a great deal of uncertainty for the agricultural sector, and the AHDB wishes to understand, and, to the extent possible, quantify the potential impact of this exit.

This 2019 Report is a successor to a piece of research commissioned in 2017 by the AHDB from Agra CEAS Consulting (in association with Promar International) that provided an impact assessment and analysis of three scenarios of exiting the EU on the UK agricultural industry.[1] The 2017 Technical Report formed the basis of a Horizon publication by the AHDB that conveyed the main findings.[2] The 2017 Technical Report also contained a review of all the then-published studies from other authors (more than 20). This 2019 Report, by Dr Dylan Bradley and Professor Berkeley Hill, updates and revises the earlier work in several ways.

The AHDB previously identified four main areas of concern for UK agriculture, each of which was explored:

1. agricultural policy, support payments, rural development and market management (interpreted as how these will be treated in UK domestic agricultural policy after leaving the EU);
2. international trade, both within and outside the EU (interpreted as how trade with the remaining EU-27 countries, as well as other countries, would be affected once the UK has left the EU);
3. migrant labour (from the EU) and its availability; and,
4. the UK regulatory environment.

[1] https://media.ahdb.org.uk/media/Default/Programmes/Fit%20For%20The%20Future/Quantitative_Modelling_For_Post_Brexit_Scenarios-12oct17.pdf

[2] https://ahdb.org.uk/knowledge-library/brexit-scenarios-an-impact-assessment

For the 2017 work the AHDB outlined three scenarios using combinations of these four factors. The scenarios were not meant to describe definitive policy options, rather, these were intended to set boundaries for the likely possibilities resulting from the UK's exit from the EU. Subsequently some of the uncertainty has been reduced or removed.

- First, it has become clear that the regulatory environment is unlikely to change significantly, as the demands of markets in the UK and in export markets (in particular in the EU) will remain closely aligned with the present. Consequently, changes in costs faced by UK producers in meeting regulations are unlikely to be lowered. This factor can then, for practical purposes, be ignored when assessing the impact of Brexit on UK producers. It is not affected by the trading or other arrangements finally agreed.
- Second, the UK's long-standing position on the direction of reform within domestic agricultural policy (towards payments for public goods and away from direct payments) has been confirmed by Ministerial statements and the contents of the 2018 Agriculture Bill that will shape agricultural policy in England after UK exit from the EU and the Common Agricultural Policy. In England, direct income payments will be phased out by 2027, though in the first year of national policy (2022), which sees the first stage of reduction, what is lost from this type of support will be added to land management schemes, keeping the total amount of public support unchanged. (In the former terminology of the CAP, what is lost from Pillar 1 support will be added to Pillar 2). However, how this is done is important; redistributing at group level according to how much Pillar 2-type payments are currently received means that the transferred funds will not be evenly spread, and some farm types will be net losers and others net gainers. As agriculture is a devolved responsibility, what happens to domestic agricultural policy in Scotland and Wales will differ; at the time of writing the situation is not known. An update to this report will add analysis for Scotland and Wales when the domestic policy is announced. A key feature of domestic policy is that it is not directly affected by which trading relationship is finally adopted between the UK and EU.

- Third, concerning access to labour from EU-27 countries, the UK government has indicated, as part of its preparation for leaving the EU, that schemes will be introduced for migrants entering the UK on a seasonal basis to work in agriculture. These will be similar in nature to the former Seasonal Agricultural Workers Scheme (SAWS) mechanism, but the scheme is a pilot only and the numbers outlined for the first season are lower than industry requirements. The idea is though based on the UK having ongoing access to EU migrant workers and we assume that the scheme will deliver this. As a result, labour costs of casual labour would be expected not to rise as a direct consequence of Brexit. Such schemes would not apply to non-UK regular labour, access to which would be restricted. In order to induce labour from other industries, or to retain it in the face of competition from other sectors, higher wages will have to be paid, increasing the costs to agriculture. For reasons set out in our previous Report, we assume that a 50% reduction in non-UK permanent labour will result in a 50% increase in the cost of this category of labour. It is recognised that there may be some seepage between casual and regular labour, and that regional conditions vary (such as alternative employment opportunities). However, the important point is that changes in labour costs are not dependent directly on the trading arrangement adopted between the UK and EU.
- Fourth, trade policy will be affected, and this may range from good access for the UK to the EU market, probably in the form of a Free Trade Agreement, to a more distant relationship likely to involve a more fundamental change to border arrangements and import tariffs. The Government has released a tariff schedule which the UK would use in the event of leaving the EU without a specific trade deal.

Thus when devising scenarios as part of this study, the only factor that is allowed to vary is the trade relationship. Domestic policy and labour costs, though different from the *status quo*, remain the same across the two scenarios, described in more detail in a later section. These scenarios are intended to set the boundaries of the likely possibilities resulting from the UK's exit from the EU. The first (***A: UK-EU FTA***) is a scenario that represents essentially a 'Business as Usual' option where trading

relations remain as close to the *status quo* as is possible given that the UK will no longer be part of the EU's Single Market. This is achieved by a comprehensive Free Trade Agreement (FTA) between the UK and EU, though there will be some increase in costs of trading resulting from checks, etc. at borders. No such FTA is reached in the other scenario (***B: WTO: UK tariffs***) and the UK trades with the EU and the rest of the world on World Trade Organisation (WTO) Most Favoured Nation (MFN) terms with imports subject to the UK's published tariff schedule and exports subject to the tariff schedules of the EU and other countries. This situation could occur by design as the manifestation of the UK's preferred trade outcome, or following the failure to ratify the EU Withdrawal Act and the UK leaving the EU without agreement. In the latter case, there would be short-term disruption caused by the failure to reach a withdrawal agreement in addition to impacts from the change in trade terms. Our analysis is for 2022 and therefore does not cover any potential short-term disruption.

**It should be noted that these scenarios are not comparable with those used in our previous study for the AHDB, and the results should not be compared.**

For ***England***, this study examines the impacts arising from the two scenarios for each of seven types of farming found within England's Farm Business Survey (FBS): cereals; general cropping; dairy; pigs; beef and sheep (uplands - LFA); beef and sheep (lowland); and, all farms. The study also examines the impact of the scenarios on a representative poultry farm; a potato enterprise; and, to represent the horticultural sector, a carrot enterprise. Together these cover the main production sectors of UK agriculture.

For ***Scotland*** three farming types will be explored: dairy; LFA sheep; and LFA cattle, reflecting the national composition of farming.

In ***Wales*** four farming types will be examined: dairy; specialist sheep in LFA Severely Disadvantaged Areas (SDA); LFA sheep and beef (excluding sheep in LFA-SDA); and, lowland sheep and beef.

Each farming type will face some of the same issues, though differences in type and magnitude of impact can be anticipated. For example, the restricted availability of non-UK regular labour is likely to have the biggest impacts in those types of farming with relatively high volumes of this type of labour requirements, such as dairying. Large-scale producers (in any farming type) tend to be efficient and more able to compete near the world market price, so would be relatively less affected by lower tariffs on imports. Easier availability of cheaper meat from Australia and New Zealand may make the sheep sector disproportionally vulnerable to competition. And, of course, within each farming type and size group there will be differences caused by location, management skills, personal circumstances, etc.

The approach taken in this study was, after clarifying the scenarios proposed by the AHDB, to turn them into levels of Farm Business Income (FBI) for 2022 in each type of farming, sub-divided by farm (economic) size and by level of performance (as measured by the ratio of the value of outputs to inputs). This was done in two stages, using steps as described in detail in our 2017 Report (though with revised and more recent basic data). First, changes in commodity prices resulting from trade conditions were estimated for 2022 using a gravity model (for commodities in which the UK is a net importer, which is the majority) and economic analysis (the few for which the UK is a net exporter, oilseed rape, barley and sheepmeat). These were sense-checked against alternative estimates produced by FAPRI (Davis, *et al.* 2017). These were then fed into a micro-economic farm-level model to estimate the short-term implications for average revenues, costs and FBI in 2022. Changes in the cost of regular labour are introduced by increasing its current costs at group average level by 50%. Changes in revenues from subsidies were estimated by lowering direct payments in aggregate by £150 million (the first announced reduction within England's national agricultural policy) and reallocating this to Pillar 2-type payments according to group-average baseline levels, which are assumed to represent additions to income. The impacts of the three scenarios were each expressed in comparison with the baseline position provided by the present CAP and trade relationships. Thus, there has been an attempt to quantify changes in the main components of income that are expected to flow from

the UK's exit from the EU in the scenarios chosen and to generate estimates of what they mean at the farm level in terms of changes in FBI in 2022.

The farm-level model is essentially static. While the modelled markets imply some response by supply, the changes in prices and incomes received by farmers in 2022 will no doubt lead to further change as they adjust longer-term enterprise mixes, cost structures and embrace more fundamental structural changes. These are the subject of a further step in our analysis presented in Chapter 6. A literature review has been undertaken of the pattern of farmer behaviour in past periods of income pressure and uncertainty and the coping strategies employed. Adjustments reflect the time horizon chosen. Attention to levels of costs and to cutting out unprofitable enterprises are common responses in the relatively short-term. However, there has been a wide variety of responses to past income crises, with 'no-change' being the conscious choice of a substantial number. It should also be recalled that Brexit could lead to higher incomes for some sectors. In the longer-term, decisions may involve changes in the scale of operation and decisions over succession and exit. This material has been discussed with AHDB experts and board members, themselves farmers, with the intention of encouraging a broader consideration of how the farming industry may develop.

Finally, we bring together the main conclusions of our analysis and draw attention to their implications for the agricultural industry and organisations that represent it or who help shape policy. Clearly some of these are of importance to the AHDB and to its levy payers.

Our analysis of the impacts of the scenarios, as with any study of this sort, inevitably involves assumptions and simplifications. The validity of our findings depends on their reasonableness. Some are based on the best information available from the literature on similar situations in the past, such as the effect on domestic prices resulting from the introduction of tariffs on trade. Others are simply unknowable at this stage. With the passage of time, more information will become available; to some

extent this has already happened in the area of domestic policy. In the meanwhile, analysis has to work with what is to hand.

As in our 2017 Report to the AHDB, we have attempted to make clear our assumptions and the implications they entail, not least by the use of sensitivity analysis where appropriate. However, it follows that our results in terms of shifts in incomes (FBI) should be regarded primarily as indications of where the greatest economic pressures are likely to be felt within the agricultural industry and the predominant causes of these changes. It should be remembered that FBI does not include off-farm income earned by farmers and/or other family members, pensions, or interest on (non-farm) investments, etc. Incomes from such non-agricultural sources may enable farms to be sustainable even in the face of negative FBIs, as often applies currently under the baseline for low performing farms and will be the case for some farms when FBI becomes negative under some scenarios. Similarly, capital gains (and losses) are not covered. Nevertheless, anticipated falls in FBI can be a useful indicator of where the AHDB and other organisations tasked with supporting the agricultural industry can best deploy their resources and focus their attention.

## 2. The scenarios

OECD (2006) explains that one of the uses of scenarios is to provide "*coherently structured speculation*". Scenarios are not predictions of what is likely to happen; rather, they provide a structured framework within which to think about outcomes. Scenarios offer a "*consistent and coherent description of alternative hypothetical futures*".

The OECD makes the point that scenarios can often be criticised for excessive complexity and that simple scenarios can be more effective. It is therefore important to limit the parameters defined in a scenario to a manageable number so that the scenarios can be easily understood. Sensitivity analysis can then be used within the scenarios to examine the impact of changes which can be compared across the scenarios.

Our previous work constructed three scenarios from the four key variables identified in the literature, namely:

- domestic UK policy (different at the England, Scotland and Wales level);
- access to migrant labour;
- the UK's trade relationship with the EU and the rest of the world; and,
- the UK's regulatory environment.

The AHDB had hoped when commissioning this update that there would have been certainty in terms of these variables post-Brexit. In reality, this has not been the case, although the Government did publish the UK's tariff schedule towards the end of the research which allowed us to condense our initial two WTO trade scenarios (one with WTO MFN tariffs on imports and exports and one where the UK unilaterally removed tariffs on imports) into a single WTO scenario using the UK's tariff schedule for imports. The main certainty has been provided by the UK Agriculture Bill which sets out the intention to remove Direct Payments in England over a seven-year period by 2027. The government has also made clear that total public support to the agricultural sector will remain the same up until the end of 2022. For this reason,

this exercise considers the impact of Brexit in 2022 when we have the highest degree of certainty in terms of what the operating environment might look like. In 2022 Direct Payments in England will be reduced by £150 million in increments which increase with total payments received, such that those receiving higher payments bear larger cuts. The £150 million will then be added to environmental public good payments which are currently made under the CAP's Pillar 2.

The agricultural policy environment in Scotland and Wales remains unknown at this stage, so analysis in these countries has been held back until information emerges.

In discussion with the AHDB it was agreed that the government is likely to put in place an equivalent to the SAWS; on the assumption that this will be large enough to provide a volume of seasonal migrant labour that meets present requirements, access to migrant labour will not be affected post-Brexit. The implication from this is that the cost of seasonal labour will not change as a direct result of Brexit. In contrast, although the impact of the government's proposed approach to limiting non-UK permanent labour on the agricultural sector is unclear, it was felt likely that access would be restricted to around half the current levels; As in our previous work, the impact on the cost of regular labour is taken to be a rise of 50%; the rationale for choosing this figure is as before (opportunity costs backed up by case studies). Discussions with AHDB experts have found the 50% figure to be realistic, with evidence of movements already being experienced, though there is some dispute over the speed with which this will be achieved and how it will be affected by local conditions (such as the strength of local employment markets). Nevertheless, as a working assumption, the 50% rise in the cost of regular labour is defendable. For this analysis we have assumed that the same limits on non-UK labour, and hence the same rise in labour costs, will apply under both scenarios.

In our previous work we had considered that the costs of regulatory compliance might be reduced by 5%. However, it was felt that in practice, the potential to reduce the costs of compliance post-Brexit is marginal and so this variable was removed from the analysis.

This updated analysis therefore considers three variables, of which, only the nature of the trade relationship changes between scenarios. In taking this approach, our initial three scenarios (later condensed to two) match those of the ESRC/FAPRI-UK analysis (Hubbard, *et al.*, 2018) with respect to the trading relationship but go beyond their analysis by including labour. Our work also covers a wider range of commodities and addresses trade issues such as carcase balancing.

The scenarios examined are still designed to present the ***range*** of likely outcomes from the negotiations to exit the EU; it is felt likely that any actuality will lie within these bounds; the UK has yet to embark on trade negotiations which are likely to be more complicated and to take more time than negotiations on the Withdrawal Agreement. To this end, one scenario, termed "***UK-EU FTA***", presents an outcome which, as closely as possible in the circumstances, represents the continuation of the *status quo*, i.e. a Free Trade Agreement (FTA) between the UK and the EU (to replace membership of the single market). Inevitably, this leads to an increase in the costs of trading as various activities not necessary in a single market have to be introduced, such as inspections at the border ("trade facilitation costs", the expected magnitude of which can be estimated from literature on current experience). These facilitation costs have been modified from those used in our previous report and are now in line with those used in the ESRC-FAPRI work.

Our other scenario "***WTO: UK tariffs***" involves the UK trading with the EU (and the rest of the world) on World Trade Organisation (WTO) rules and Most Favoured Nation (MFN) tariffs, with imports subject to the UK tariff schedule. The UK tariff schedule was designed by the Government in an attempt to balance the competing interests of keeping consumer food price inflation to a minimum whilst also protecting the most at risk sectors of UK agriculture from lower priced competition which, as demonstrated by our previous work, could render many farm businesses economically unviable. It is important to be clear that this scenario examines the impact of trading with the EU on WTO terms in 2022; ***this is not an examination of the short-term***

*impact of leaving the EU without a withdrawal agreement* which would present a wide range of additional challenges.

The two scenarios sketch out a frontier of outcomes deemed possible by the AHDB and for which first-order impacts can be estimated and then compared. From this position, subsequent order responses can be considered. Together these allow a reasoned opinion to be developed of the implications of the scenarios for the agricultural industry and its various elements.

### 2.1. Operationalising the scenarios

Before it is possible to estimate first-round impacts on farms the scenarios need to be translated from text into numbers. These can then be used as inputs to the modelling process. Specifically, the change in domestic support levels needs to be quantified, the implications of restrictions on non-UK labour must be expressed in terms of higher labour costs, and the two trade relationships have to be realised as shifts in the market prices received by farmers. Table 2.1 sets out the treatment of the three key variables and the scenarios modelled. The implications for farm prices of the two trade relationships are dependent on modelling the various commodity markets. The details of each are explained in the Methodology in Chapter 4.

## Table 2.1: "Operationalisation" of the scenarios

| | Scenario A: UK-EU FTA | Scenario B: WTO: UK tariffs |
|---|---|---|
| **Public support (England)** | • Direct Payments (DPs) are reduced by £150 million<br>• Pillar 2 payments are increased so that support is increased by £150 million thus maintained total support at current levels | |
| | • A 5% reduction will be applied to the first £30,000 of DPs; 10% to payments between £30,000 and £50,000; 20% to payments between £50,000 and £150,000; and, 25% to payments in excess of £150,000. This calculation is applied at group average farm level<br>• Pillar 2 payments are increased by 142.2% across all farm type group averages so that total support is maintained at current levels | |
| **Public support (Scotland)** | • Not yet known | |
| | • Not yet known | |
| **Public support (Wales)** | • Not yet known | |
| | • Not yet known | |
| **Labour cost** | • Non-UK regular labour restricted to 50% of current levels<br>• Retained at the current level for seasonal (casual) workers | |
| | • 50% increase in regular labour cost at group average farm level; no change in seasonal labour cost | |
| **Trade relationship with the EU** | • Comprehensive FTA enabling tariff-free trade between the UK and the EU | • No trade deal between the UK and the EU is agreed<br>• UK-EU trade relationship the same as with the RoW |
| | • Additional costs of 2% for crops and 5% for livestock products to reflect the cost of trade friction in an FTA | • Additional costs of 4% for crops and 8% for livestock products to reflect the cost of trade friction without an FTA<br>• UK tariff schedule applies to imports, WTO tariffs applied to exports |

| | Scenario A: UK-EU FTA | Scenario B: WTO: UK tariffs |
|---|---|---|
| **Trade relationship with the RoW** | • WTO rules apply<br>• UK has access to a share of the EU's existing WTO TRQs and agrees FTAs with third countries which already have FTAs with the EU | • All trade is on WTO MFN terms with the UK tariff schedule applying to imports |
| | • Additional costs of 2% for crops and 5% for livestock products to reflect the cost of trade friction with RoW | • Additional costs of 4% for crops and 8% for livestock products to reflect the cost of trade friction without an FTA<br>• UK tariff schedule applies to imports, WTO tariffs applied to exports |

The sub-sections below set out some points to note in translating the scenarios.

### 2.1.1. Domestic support

**England**

Total Pillar 1 support (for the three years 2015/16-2017/18) has been reduced by £150 million and total Pillar 2 support increased by £150 million. The percentage change in Pillar 2 payments that this entailed (142.2%) each was then applied to Pillar 2 payments for the group average of each farm type. The underlying assumption is therefore that the distribution of Pillar 2 funds will remain as it is currently, although the total disbursed will increase. In increasing support under Pillar 2, it is assumed that the infrastructure exists to enable additional funds to be disbursed at the farm level. This implies a combination of more being channelled through existing schemes and the introduction of new ones (such as perhaps payments to farmers under agreements related to animal welfare).

Pillar 1 payments were reduced for the average of each farm type (and size and performance level within this) by the appropriate amount depending on the baseline payments as shown in Table 2.2.

**Table 2.2: Reduction schedule for Pillar 1 payments**

| Direct Payment band | Reduction percentage |
|---|---|
| Up to £30,000 | 5% |
| £30,000 - £50,000 | 10% |
| £50,000 - £150,000 | 20% |
| £150,000 or more | 25% |

Some important simplifying assumptions should be noted. First, despite Pillar I payments being nominally decoupled, the literature finds some evidence that there may be some links with decisions on production (Howley, *et al.*, 2012; Davis, *et al.*, 2017). However, any impact of reducing Pillar I payments on levels of production and hence on market prices and revenues are ignored in this study. Second, it is assumed that Pillar 2 payments can be treated as additional income rather than as compensation for income forgone. It should be noted that much of the payments

under EU-supported Rural Development Programme (RDP) agri-environment schemes is intended by design only to compensate for any income forgone or higher costs incurred by following prescribed actions; this is set out in the underlying Regulation. If this principle were to be maintained post-Brexit, expansion of Pillar 2-type funds would, if strictly applied, leave farm incomes unchanged, which is not the understanding generally given by commentators when this issue is discussed in the media. For simplicity, we have assumed that the expanded Pillar 2-type payments are in effect, a form of area payment for providing public goods.

Scotland

The agricultural policy environment in Scotland remains unknown at this stage, so analysis has been held back until information emerges.

Wales

The agricultural policy environment in Wales remains unknown at this stage, so analysis has been held back until information emerges.

### 2.1.2. Migrant labour

Economic analysis indicates that restricting migrant labour will result in increasing wages and labour costs; the workings of the market will lead to higher wages being paid to both UK and migrant labour. The case for using a 50% rise was made in Bradley and Hill (2017) and is contained in Appendix 1. Although a 50% increase in labour costs is ultimately expected, this may not be reached by 2022 for some sectors; this will also be influenced by general labour demand in other sectors and locally by local labour demand.

### 2.1.3. Trade issues

Although the scenarios include trade relationships between the UK with the EU and, separately, with the Rest of the World (RoW), in practice, goods will flow from whichever of these two blocs has the lower price (assuming otherwise comparable products and consumer preference). These two scenario elements are therefore reduced to one impact on UK prices.

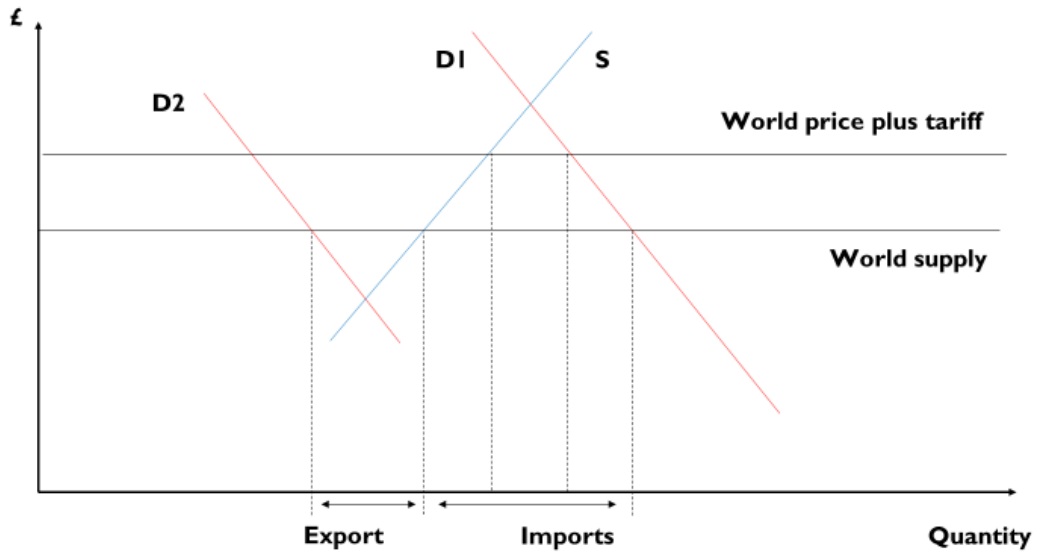
The different trade relationships that are part of the scenarios can be expected to have implications for the prices received by UK farmers from the domestic market which in turn shape their farm incomes. For commodities in which the UK is not self-sufficient, any increased costs of imports arising from higher costs of trading and/or the imposition of tariffs will raise price on the domestic market, which will benefit UK producers until a point is reached at which no imports occur because of a combination of increased domestic supply and reduced demand. Conversely, where the UK is an exporter, factors that constrain these exports (such as the imposition of a tariff by a foreign importer) will lower the domestic market price, a bottom in the market being when all production is absorbed by domestic demand (or when domestic prices fall to the point that exports become viable once again). In some cases (poultry, pigs, sheep and dairy) we have segmented the market to allow for carcase/market balancing whereby there are imports of some products and exports of others which are sufficiently significant to warrant taking account of. It is helpful to bear in mind the basis economics of the situation, shown in Box 2.1.

In reality, there will be a complex inter-play between supply and demand for specific products, and there will also be cross-impacts between products (higher prices for one product may lead to some substitution by another). The elasticities of supply and demand will be relevant here, as will be also the selection of appropriate tariffs to match the imports the UK might make and those that might be applied to UK exports by importing countries. Prices will ultimately settle at a new equilibrium which balances supply and demand. Without a sophisticated General Equilibrium Model, these interactions cannot be taken into account quantitatively; these interplays will be examined using a gravity model and qualitatively, in ways described below.

**Box 2.1: The basic economics of importing and exporting markets**

S represents the supply curve of production in the UK, showing the amounts farmers are willing to supply at a given range of prices. In reality, it would be steeper in the short-term (lower price elasticity of supply) and less steep in the longer-term (greater elasticity) as producers would be able to make more adjustments. Two situations of

demand are given. D1 corresponds to a commodity in which the UK is not self-sufficient and imports are required from the world market to meet domestic demand; many agricultural commodities are of this type in the UK. D2 is the situation in which there is a domestic surplus of production, and exports to the world market would be expected; only a few are of this type in the UK.




Supply from the world market is shown as infinitely elastic, that is any required quantity of product is available to be imported into the UK without affecting the world price (the so-called small country assumption where the quantities are insignificant compared with the total).

As a general principle, higher prices of commodities imported from outside the UK (whether caused by tariffs or higher costs of trading such as the need for more inspection) will cause UK market prices to drift upwards. The effect will be a reduction in imports as (a) domestic producers expand up their supply curves in response to the higher prices; and, (b) domestic consumption falls as users retreat up their demand curve.

There is a limit to which prices on the domestic market will be raised by imposing tariffs or the imposition of trade facilitation costs. This is the point at which the D1 and S curves intersect, and no imports take place.

For commodities illustrated by D2, there is a domestic surplus available to export to the world market. Without this possibility, prices on the domestic market would fall to a low level (the point of intersection between D2 and S) as supply to the domestic market increases. Access to the world market enables farmers to avoid this low price in favour of the world price. Anything that prevents this access (such as trading regulations or the imposition of tariffs by importing countries) will, in effect, lower the prices obtained on the export market (not shown on the diagram).

# 3. Updated review of the literature on Brexit

Our previous Technical Report (Bradley and Hill, 2017) for the AHDB included a review of the 20 or so studies and reports of the anticipated impact of Brexit then available. The studies and reports displayed a diversity of approaches and generated a range of results. They differed in a number of ways.

(i) ***Coverage of impact factors.*** In the studies, four main factors were seen to be at work: (a) *The shape of possible domestic agricultural policy*, and in particular what may happen to the levels of Direct Payments (in particular, Basic Payments); (b) *The outcome of trade negotiations in the Brexit process that will impact on market prices received by UK farmers*, and which carry implications for trade with the rest of the world; (c) *The availability and cost of migrant labour*; and, (d) any change in the *regulatory burden* on farmers as a result of leaving the EU. Not many studies dealt with them all (though Bradley and Hill (2017) did so).

(ii) ***Detailed specification of impact factors.*** Each of the impact factors was capable of alternative specification, for example, the assumptions about tariff rates, world prices, etc. when considering impacts on trade.

(iii) ***Use of scenarios.*** Many studies used scenarios to explore the post-Brexit situation. However, these differed in the number of factors considered and what the scenario was intended to represent.

(iv) ***Sophistication of approach*** in modelling prices at national levels and farm-level impact on income.

(v) ***Sector coverage.*** Some studies did not differentiate by sector. Where a sector approach was used, coverage differed between studies.

(vi) ***Geographical coverage.*** Some studies were at the UK level, others differentiated England, Scotland, Wales and (less commonly) Northern Ireland.

The key points emerging from the 2017 literature review are reproduced in Annex 2.

The Bradley and Hill (2017) Technical Report on the anticipated impact of various Brexit scenarios constituted a major additional analysis and formed the basis of an AHDB Horizon Market Intelligence publication dealing with the same issues (AHDB,

2017). The farm-level model used to estimate income changes was developed using data from the FBS that related only to England. Following the publication of Bradley and Hill (2017) the same basic methodology was used to present analysis for Wales and Scotland (Bradley, 2017), i.e. market price changes were taken from the same gravity model and farm-level income estimation based on models developed from data taken from regional farm account surveys. Findings were published in separate AHDB Horizon Market Intelligence reports. A geographically specific report for the grazing farms of England's Lake District National Park was also produced (Bradley, 2018a). A modified approach was used at enterprise level to generate income estimates for the poultry and egg industry (Bradley, 2018b) using data supplied through the NFU.

Independent of this work from Agra CEAS Consulting, a small number of studies have been published.

The most significant publication to appear since Bradley and Hill, 2017 is that arising from ESRC-Newcastle University's research that forms part of the **ESRC-funded project** ***How might UK Agriculture Thrive or Survive?*** It builds on the aggregate models reported in Davis, *et al.* (2017), details of which were covered in the literature review in our previous 2017 study. These models comprise an agriculture-specific variant of the Global Trade Analysis multi-region computable general equilibrium (CGE) model to assess the impact of Brexit scenarios on the macro-economy and factor markets, and the FAPRI-UK partial-equilibrium model to make projections for prices, production and trade flows. The Newcastle University work reported here takes the analysis down to the impact at farm level. The full report was anticipated in December 2018 but has not yet been issued, though a summary has appeared in EuroChoices (Hubbard, *et al.*, 2018).

Rather than having to rely on group averages within classes of farm size and farming types to build farm-level models (as used by other studies, including ours for the AHDB), this Newcastle work has had access to individual farm data in the FBS in England and the equivalent surveys in the other parts of the UK; this followed because

of the sponsorship of the research by the four devolved agricultural government departments, though this access has been severely restricted to the research in hand. It did, however, enable several forms of analysis not available to other Brexit studies, such as averaging results over a run of years at the individual farm level, the consideration of income distributions, and analysis of the impact on farm household incomes (arguably more significant for assessing farm viability than the income from farming alone as shown in Farm Business Income). This last analysis has yet to be made public.

It should be noted that, while the aggregate models projected changes in product prices and factor costs to specific future dates (2026 represented the end of the period of adjustment), the farm-level modelling is only static, in that it assumes the cost structure of the base period to which the farm accounts data relate (a historic three-year average) and makes income estimates on this basis. It does not take into consideration the way that farmers react to the changed prices by altering their production patterns, constraints on production at the farm level, or structural change.

Scenarios were chosen to represent a broad range of feasible options for two main factors (out of the four identified in other studies): ***trade relations*** with the EU and the Rest of World, and the shape of ***domestic UK policy and support for farmers***. However, in addition, sensitivity analysis (not reported in the EuroChoices summary) was undertaken with regards to two other factors affecting the impact:

(i) restrictions on migrant labour (a factor explicitly covered in Bradley and Hill (2017)); and,
(ii) the sterling exchange rate, both with the Euro and with the US dollar.

The effect of changing the regulatory burden, covered in Bradley and Hill (2017) and several other studies, was not explored.

The three selected trade policy scenarios were designed to cover the range of likely outcomes of the UK-EU negotiations:

(i) a UK-EU Free Trade Agreement (***FTA***);

(ii) Unilateral Trade Liberalisation (***UTL***); and,
(iii) return to World Trade Organisation tariffs (EU Tariffs Schedule – ***WTO***).

For domestic agricultural policy, two options were selected:
(i) direct payments retained as currently under the CAP, and,
(ii) a gradual elimination of direct payments over a five-year period (2020-2025). It was also assumed that Pillar 2-type payments would continue after Brexit, and would do so at current levels, i.e. no recycling of payments from Pillar 1 to Pillar 2 were assumed.

According to the modelling, the anticipated impacts on the general economy that arise from the Brexit scenarios are relatively small. However, at the sector level there are potential impacts on farm production and market prices, confirmed by both the CGE and FAPRI models. As noted in other studies, the impact depends on the sub-sector concerned (e.g. beef, sheep, dairy, pigs, poultry, wheat and barley) and whether the UK is a net importer or net exporter of specific commodities.

The farm modelling showed interesting results regarding the distribution of farm business incomes across the devolved administrations and by farm type and the importance of retaining or eliminating direct payments (see Figure 3.1, in which + or - corresponds with the treatment of direct payments). The negative impact on farm business income of removing direct payments is reflected across all trade scenarios, especially UTL with or without direct payments (DPs). Average farm income varies significantly across the devolved administrations and by farm type, with most farms worse off (relative to the baseline) under all scenarios but one, (WTO+). Noticeably, under this scenario dairy farms particularly benefit as their average farm income could almost triple compared to the baseline scenario. Beef and sheep farms will be the most affected under UTL-.

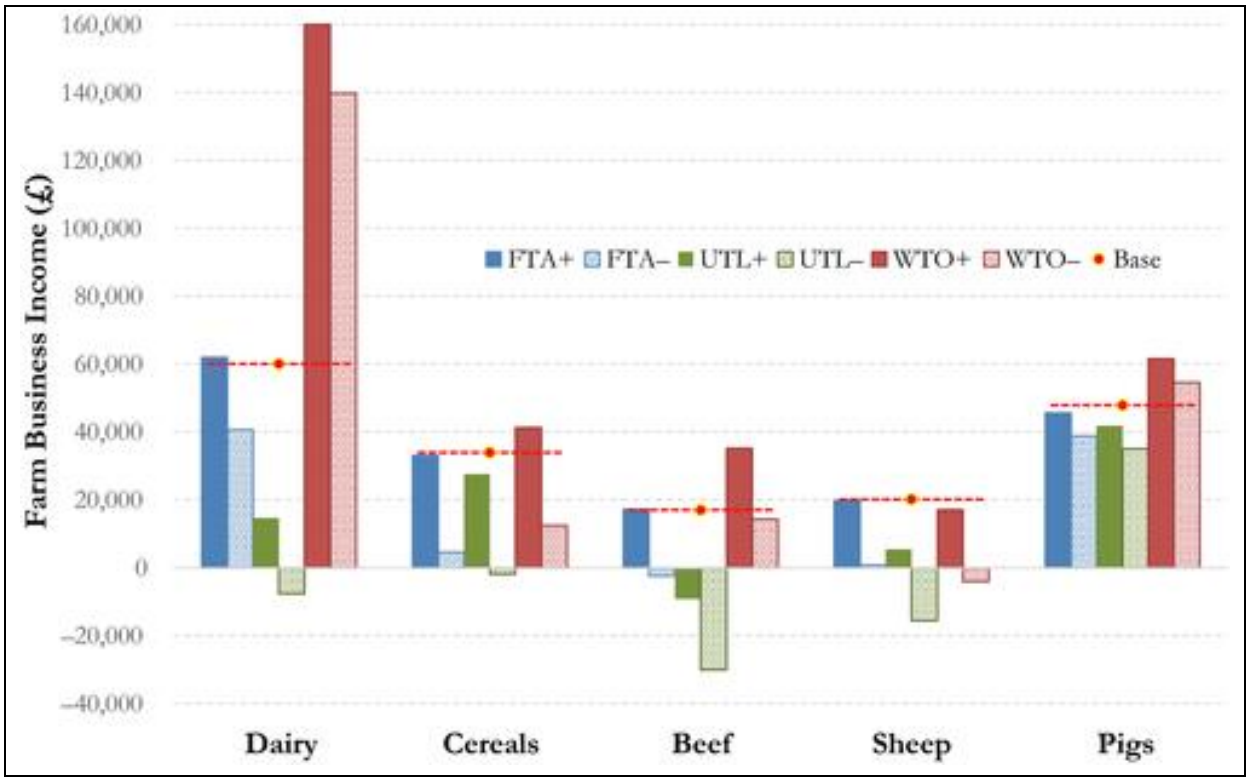



**Figure 3.1: Impact on Farm Business Income by sector (UK)**

Source: Hubbard, et al. (2018).

The extreme free trade scenario leads to some striking results regarding farm income distributions, an analysis only made possible by access to individual farm level data. Whereas 15-20 per cent of the farms were not making any money at all (positive Farm Business Income) even in the baseline scenario, this rises to 45 per cent under the UTL scenario with direct payments still in place (UTL+). The elimination of direct payments further increases this figure to 70 per cent (UTL-) (but recall that this scenario does not assume any recycling of support into Pillar 2-type mechanisms).

In summary, the preliminary results from this source show that Brexit would have significant implications for UK agriculture. Trade scenario effects depend on the net trade position, and/or world prices. Under a Free Trade Agreement (FTA) with the EU, agricultural impacts are relatively modest. By contrast, unilateral removal of import tariffs (UTL) has significant negative impacts on prices, production and incomes. Adoption of the EU's WTO tariff schedule for all imports (including from the EU)

increases the value of output in some net importer sectors (e.g. dairy) and reduces the value of output in sectors with significant exports (e.g. sheep). These trade effects, however, might be overshadowed by exchange rate movements and possible labour market changes and other non-tariff barriers (not addressed in this article).

Given the dependence of many UK farms on direct payments, their removal, predictably, worsens the negative impacts of new trade arrangements and offsets positive impacts. The elimination of direct payments will affect most farm businesses, but the magnitude varies by enterprise and devolved administration. Arable and dairy farms may be relatively unaffected, but many beef and sheep farms would struggle to survive if assessed on farm income alone, as they tend to be much more reliant on direct support.

Despite some differences regarding the relative changes in prices and output across the sector and commodities, the estimates reported in Hubbard, *et al.* (2018) are broadly in line with the studies of van Berkum, *et al.* (2016), Davis, *et al.* (2017) and our previous study for the AHDB (Bradley and Hill (2017)).

Several other reports that have appeared since Bradley and Hill (2017) should be noted.

*Cumulus Consultants (2017)* generated estimates on behalf of the Royal Society for the Protection of Birds (RSPB). The focus was on the potential environmental impacts of Brexit. Two scenarios were used, but also with variations in input and output prices. Trade effects on the markets for agricultural products were discussed (but not independently quantified) and models used to assess the impact of changes in direct payments.

*Dwyer (2018)*, for the Wales Centre for Public Policy, considered the impact on farming in Wales, using four scenarios. Though the impact of trade on prices received by farmers was considered, this was not independently quantified. There was no

modelling of withdrawing direct income payments or of different farm types, though these were mentioned.

Also restricted to considering the impact of Brexit on Welsh agriculture, the summary paper from the Welsh Government's EU exit scenario planning workshops (***Welsh Government, 2018***) used five scenarios and considered trade arrangements (but without making independent assessments) but did not model at the farm level. However, it highlighted the difficulties some sectors would experience and the advantages or opportunities that would present themselves to others. This report drew heavily on the output of Bradley and Hill (2017) and Davis, *et al.* (2017).

***Defra*** published in February 2018 **The Future Farming and Environment Evidence Compendium,** a collection of statistics that, while having a broader coverage, updates many pieces of information that are relevant to Brexit, and in particular considers the importance of the present level and distribution of Basic Payments (Defra, 2018). This Compendium takes a form that is unusual and clearly intended to be reader-friendly, though hidden within its linked pages are many figures and explanatory details that earn it respect as a source of statistics. After the initial summary section, pages 14-45 deal with farm economics and accounts, including farm structure, resource use and contribution to the economy. A later section deals with food and trade. The geographical coverage is the UK or England. Results from the FBS for the three years 2014/15 to 2016/17 are averaged at farm level to show the relationship between direct payments and farm income, and how this varies across farm types. The proportion of farms that make negative incomes before and after direct payments are estimated (16% and 42% respectively) and consideration is given to alternative patterns of their withdrawal. Questions are raised over how some farms can persistently make negative incomes, and explanations for this phenomenon offered, with statistical support. There is a section on how farmers could respond to the removal of direct payments, including by cutting input costs, improved efficiency, making better investments, and by diversification. This compendium has relevance to a following part of this literature review (on structural change) and will be revisited there.

# 4. Methodology

This report has been constructed using the same general approach as in Bradley and Hill (2017). This is set out in detail in Appendix 1. In summary, a micro-economic farm-level model was constructed from the average FBS data for the years 2015/16, 2016/17 and 2017/18, supplemented by data made available by the AHDB and the NFU. This model requires inputs in terms of changes in domestic support, labour costs, the cost of important inputs and the prices received by UK farmers from the domestic market. Prices were estimated using a gravity model which required data on domestic production, net trade and the forecast differential between EU and world prices in 2022.

*The impact of changes to domestic policy* in 2022 involved the reduction of Pillar 1 payments by £150 million and the increase of Pillar 2-type payments by the same amount at the sector level to leave overall support unchanged. It was assumed that the distribution of Pillar 2-type payments would follow the current pattern which implies some redistribution between farm types.

*The restriction of EU labour availability to half of current levels for permanent positions* was estimated to increase the cost of paid labour by approximately 50%. These increases in labour cost were also applied to catching costs in our poultry model. Contract costs were also increased to reflect the additional cost of labour. Following discussions with AHDB experts, contract costs were apportioned 30% to labour and 70% to non-labour charges, so contract costs were increased by 15%. A similar approach was taken to cleaning costs in the poultry model, although here labour costs account for 65% of total catching costs. As with our previous work, we have taken no account of the impact of the National Living Wage which could add 35% to the cost of seasonal wages over the period 2016-2021 (Migration Watch UK, 2016).

*Estimates of domestic market prices of farm commodities for use in the farm level model* were derived using economic logic in conjunction with a gravity model and were validated by AHDB experts. These are shown in Table 4.1. There are many

important caveats around the estimation of prices to which the reader should refer in Appendix 1.

**Table 4.1: Price changes used in the farm-level model**

| | Scenario A: UK-EU FTA | Scenario B: WTO: UK tariffs |
|---|---|---|
| Wheat | +2.27% | +3.59% |
| Barley | -2.00% | -12.10% |
| Oats | +0.09% | -2.98% |
| Oilseed rape | -2.00% | -4.00% |
| Potatoes | +1.79% | +3.58% |
| Carrots | +1.20% | +2.41% |
| Sugarbeet | +0.82% | +1.12% |
| Milk | +2.57% | +3.78% |
| Beef | +4.30% | -6.11% |
| Sheep | -5.00% | -24.97% |
| Pigs | +3.43% | -4.82% |
| Poultry | +1.49% | +2.32% |
| Purchased feed and fodder* | +0.73% | -0.76% |
| Poultry feed+ | +1.28% | +1.12% |

* Purchased feed and fodder is (by value) 63% wheat, 20% barley, 15% OSR, 2% peas and beans.

+ Poultry feed is (by value) 65% wheat, 10% barley, 25% soybean.

*Carcase balancing/market balancing* was undertaken for the poultry, pig, dairy and sheep sectors. The approaches differed according to the specificities of the markets. In each case the market was segmented by cut or product with price changes estimated for each market segment using a combination of economic logic and a gravity model. A weighted average price was then calculated for the market as a whole to take account of market segments for which there is an import requirement and market segments for which there is an exportable surplus. In the case of poultry, a further constraint was added consistent with Bradley (2018b) such that imports of fresh chicken could only come from the EU because the length of the supply chain precludes fresh imports from distant lower cost producers such as Brazil and Thailand.

***Estimations of changes in fertiliser and plant protection product costs*** were made outside of the gravity model due to a lack of suitable data and difficulties in estimating the elasticity of demand. The UK is a major net importer of fertiliser. Assuming that farmers are not able to substantially reduce their use of fertilisers, after Brexit they will have to bear trade friction costs on imports from the EU and pay tariffs (6.5%) where these apply.

The resultant price changes on the UK market were estimated as:

- ***Scenario A: UK-EU FTA:*** +3.92%
- ***Scenario B: WTO: UK tariffs:*** +5.33%

The UK is net exporter of insecticides and fungicides, but is a net importer from the EU of herbicides. This implies that the domestic price paid by farmers for insecticides and fungicides will not be affected post-Brexit while the cost of herbicides is likely to increase. However, the FBS data do not allow a disaggregation of plant protection costs and it is therefore not possible to estimate price changes.

***Separate micro-economic farm-level models for each farming type were built*** for England, Scotland and Wales using the respective last three years of available FBS (or equivalent) data (2015/16, 2016/17 and 2017/18) (results from Scotland and Wales will be presented when domestic policy is known). All data were converted to 2017/18 prices. Other sources were used for the poultry model (data provided by the NFU) and the potato and carrot enterprise models (data provided by the AHDB). Where FBS data were used, sector sub-models were developed to show the impact of the scenarios on different farm sizes (defined by Standard Labour Requirements) and performance levels (defined by the ratio of outputs to inputs). This information formed the baseline against which the impact of the scenarios was compared.

We focus our results on Farm Business Income (FBI). This is defined in the FBS as the financial return to all unpaid labour (farmers and other unpaid partners in the business) and to their capital invested in the farm business, including land and buildings. FBI is equal to:

*Total output – total costs + Profit/(loss) on sale of machinery, glasshouses and permanent crops*

# 5. First-order modelling results

This Chapter sets out the results of our modelling of the scenarios. A brief overview of the initial impact of the scenarios on Farm Business Income (FBI) compared to the baseline position (average of FBS data for 2015/16, 2016/17 and 2017/18) is followed by a more detailed examination of the impact, and the drivers of change, for each farming sector considered. Within the analysis of each sector we consider the sensitivity of key elements of the scenarios and the likely subsequent reaction as the sectors adjust to the new operating environments implied by the scenarios.

Each farm type is broken down by size and performance level. Performance level is defined with reference to the ratio of the value of outputs to the value of inputs (including an imputed figure for unpaid labour provided by the farmer and other family members). Low performers comprise the bottom quartile, high performers the upper quartile with the two middle quartiles defined as medium performers.

## 5.1. England

### 5.1.1. Overview of results

The first-order impact of the scenarios on each of the examined sectors is compared to the baseline in Figure 5.1. Under ***Scenario A: UK-EU FTA***, FBI falls markedly for all farm types, with the exception of the sheep and beef sectors. A key factor in the fall in FBI in 2022 is the projected increase in labour costs. In most cases at the sector level the reduction in Pillar 1 payments is offset to some extent by the reallocation of support under Pillar 2-type schemes; there will be differences by farm size within this, in line with the difference in the relative importance of Pillar 1 and Pillar 2 payments. LFA beef and sheep is the only sector where production revenue declines under Scenario A (see below for further details). Under ***Scenario B: WTO: UK tariffs***, FBI falls further than under Scenario A. This is driven by the same increases in labour costs, but under this scenario, all sectors see falls in production revenue to varying extents as well.

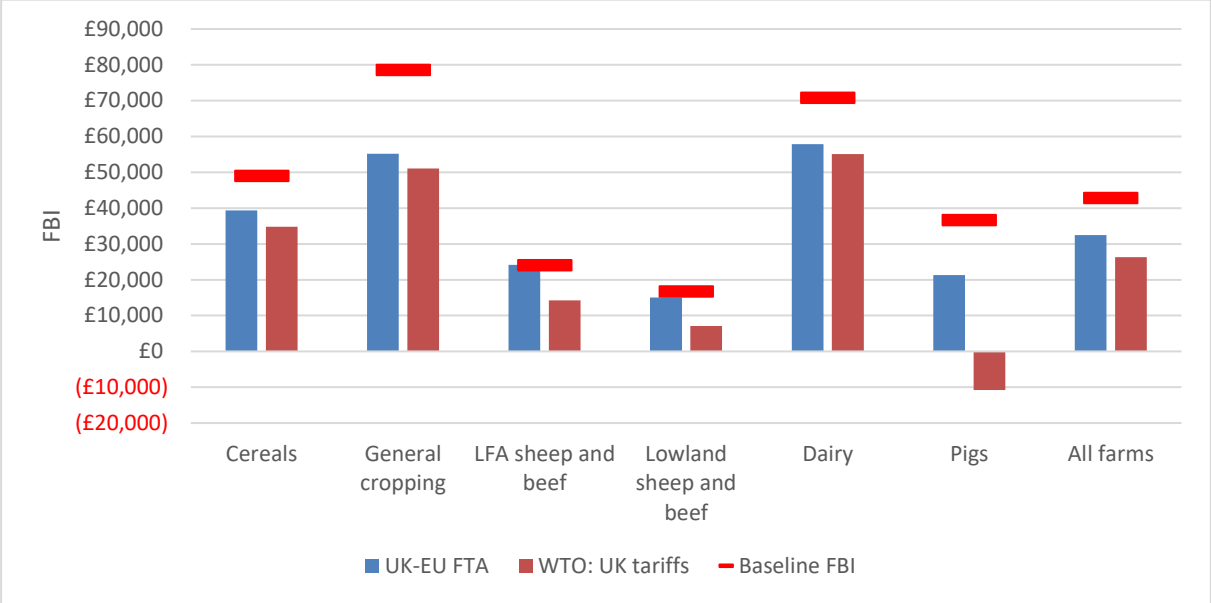



**Figure 5.1: Farm Business Income (2022) for each sector compared to the baseline (England)**

Note: Potatoes, carrot and poultry enterprises not shown due to different y-axis.

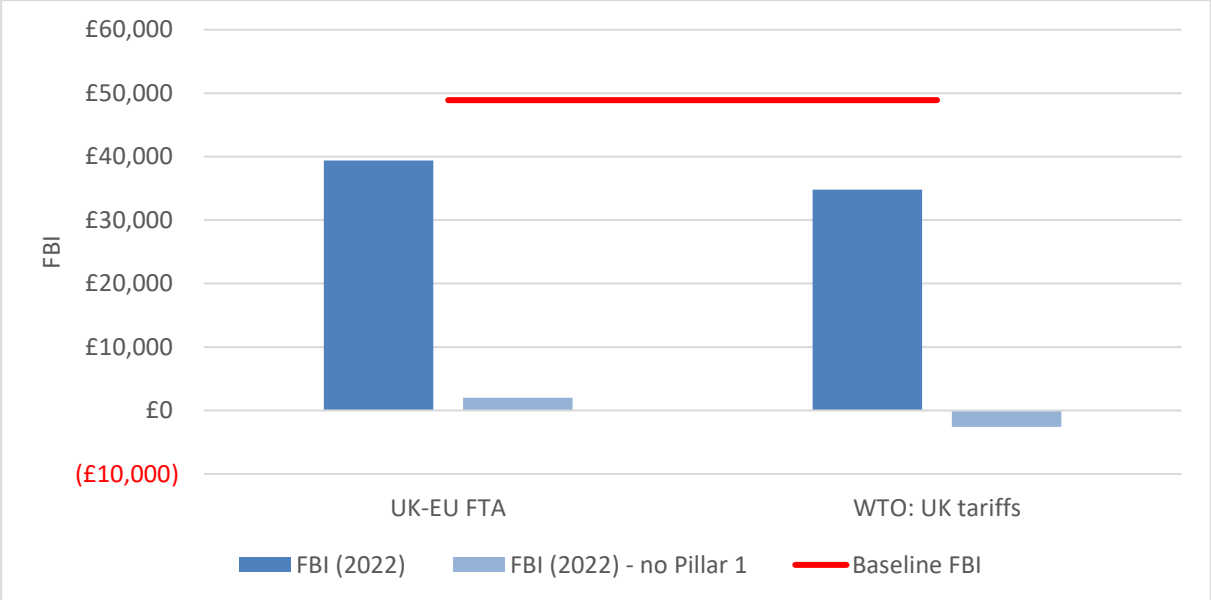
In addition to the impacts on FBI produced by our assessment, there are likely to be long-term impacts on the structure of the industry, as reflected in numbers of farms; changes in farm sizes as some release land (especially by quitting farming) and others attempt to expand; the substitution of capital for hired labour as the latter becomes relatively more expensive; restructuring of the farm business (such as a major change of enterprises); and, the broadening of income sources by on-farm diversification or the development of off-farm jobs and business enterprises. There may also be an impact on land prices. We consider such changes, which go well beyond the scope of our farm-level model, by drawing on the literature and expert opinion. This analysis is presented in Chapter 6.

We turn next to the results of each type of farming in turn.

### 5.1.2. Cereal farms

The baseline FBI for English cereal farms[3] is £48,902 (Figure 5.4). Under ***Scenario A: UK-EU FTA***, this falls by 19% to just over £39,000; under ***Scenario B: WTO: UK tariffs***, FBI falls by 29% to just under £35,000. The importance of Pillar 1 payments can be clearly seen; removing these entirely would reduce FBI to just over £2,000 under ***Scenario A: UK-EU FTA*** and would make FBI negative under ***Scenario B: WTO: UK tariffs***.

It should be noted that the wheat price change used in this exercise is based on the UK being a modest net importer of wheat, as it has been for most of the last five years of official data. In individual years where the UK has an exportable surplus of wheat, prices are likely to come under downward pressure due to decreases in competitiveness as trade friction costs and/or tariffs are applied to UK exports. The impact of this would be to reduce FBI still further given the importance of wheat in production output on cereal farms. This is examined further in the sensitivity analysis below.




[3] Holdings on which cereals, combinable crops and set aside account for more than two-thirds of the total Standard Output (SO) and where set aside alone does not account for more than two-thirds of the total SO.

**Figure 5.2: Impact of the scenarios on 2022 FBI: Cereals (England)**

Figure 5.5 shows the components of FBI for the baseline and each scenario; comparisons between them give the explanation why FBI differs between scenarios. The fall in FBI under ***Scenario A: UK-EU FTA*** is driven by increases in labour costs (manifested as increases in regular labour costs and contracting costs). The reduction in Pillar 1 payments is largely offset by the reallocation to Pillar 2, while production revenue increases by just under £1,000 driven by a small increase in revenue from wheat which outweighs a reduction in revenue from barley and oilseed rape. As farmers seek to adjust to this scenario it is likely that more wheat will be grown at the expense of barley and oilseed rape, subject to agronomic constraints. Of course, if total wheat production results in an exportable surplus, then this would result in decreasing prices and a further round of adjustment.

FBI falls further under ***Scenario B: WTO: UK tariffs***. In addition to the increases in labour costs, fertiliser cost increases are more substantial and, contrary to scenario A, production revenue decreases as the falls in revenue from barley and oilseed rape more than offset the increase in wheat revenue. Under this scenario there would be stronger price pressure to move away from barley in particular as access to EU markets would be closed off by the high tariff (although the UK could switch exports to other destinations, particular those for which there is a low or zero-rate Tariff Rate Quota, the extent that this is possible).

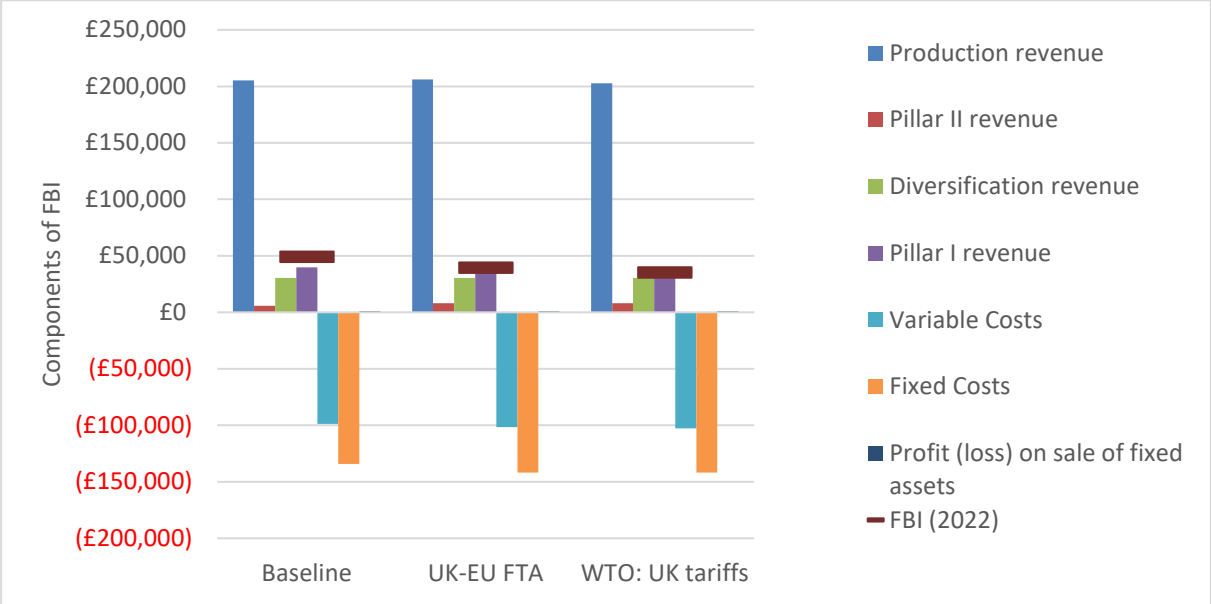



**Figure 5.3: Impact of the scenarios on components of 2022 FBI: Cereals (England)**

The impact of the scenarios disaggregated by farm size and performance level is shown in Figure 5.6. While the pattern of reduction in FBI is evident across the farm sizes, the reduction from the baseline becomes more pronounced as farm size increases due mainly to progressively higher labour costs – because Standard Labour Requirements determine the categorisation of farms by size, this is to be expected. The greater scale of Pillar 1 reductions for farms with higher levels of support is also a factor. There is therefore an incentive for larger farms in particular to seek to reduce labour cost or increase efficiency to the extent possible. This could mean a greater focus on enterprises with a lower labour requirement.

Low performance cereal farms are already making a loss (they are likely to be sustained by off-farm income earned by the farmer, spouse and/or other family members which is not included within the FBI calculation) and this loss is exacerbated under both scenarios. FBI is best protected on high performance farms under both scenarios, partly due to higher revenue from diversified activities and lower permanent labour costs. The prospect of further reductions in Pillar 1 payments is likely to prompt greater consideration of alternative sources of income such as Pillar 2-types schemes, as long as these deliver additional income rather than making payments based on income foregone.

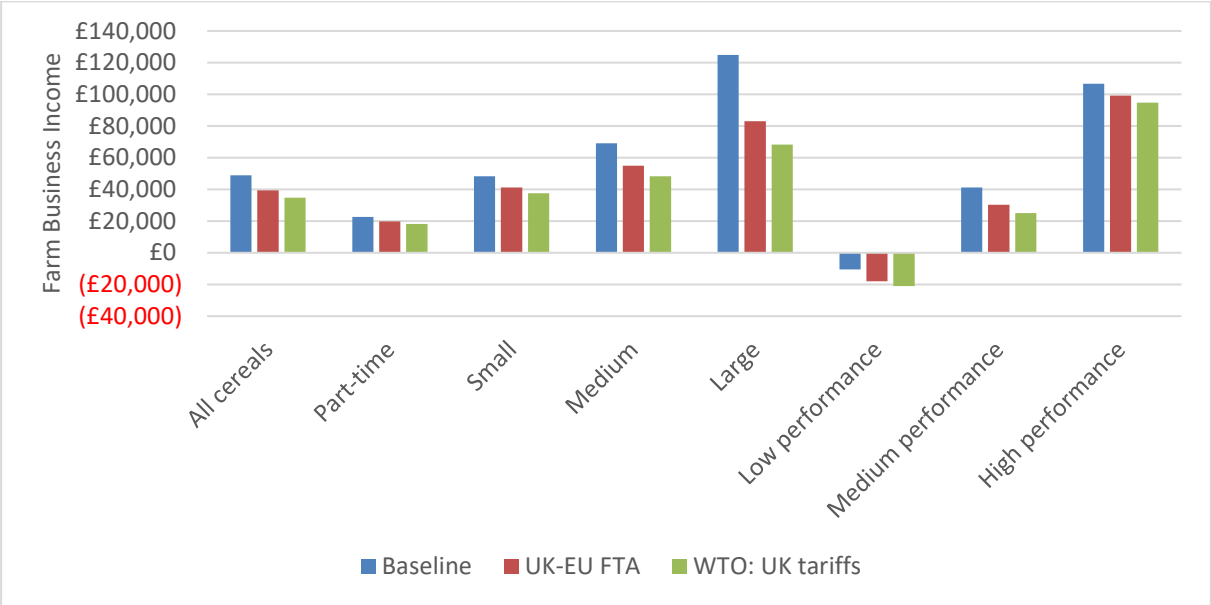



**Figure 5.4: 2022 FBI by farm size and performance level: Cereals (England)**

## Sensitivity analysis

Sensitivity analysis is presented in Appendix 6.

Under ***Scenario A: UK-EU FTA***, a change in labour costs of 10% would result in a change in FBI of ±4.93%. Under ***Scenario B: WTO: UK tariffs***, a 10% change in labour costs would change FBI by ±5.54%.

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 32.6% reduction in FBI. A 10 percentage point depreciation in Sterling would result in an 32.6% increase in FBI. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be ±36.7%.

Our assessment of the impact of leaving the EU on cereal farms assumes that the UK is a net importer of wheat (the situation for the five-year reference period). If the UK were to have an exportable surplus of wheat, such as from a year of unusually high yields, it would not be possible to sell this competitively on the export markets due to the additional trade friction costs and/or tariffs. This would result in further

reductions in FBI. The additional decrease in FBI is most significant under ***Scenario B: WTO: UK tariffs*** where FBI reduces by 40.0% compared to the baseline, some 15.6% lower than when the UK is a net importer.

It should be noted that the wheat and barley markets are differentiated into feed and milling/malting quality and the impact on these market segments might not be the same. For example, within the wheat sector, the UK imports milling quality wheat and there may be an opportunity to replace some imports with domestic production; the impact on the feed wheat sector could be different.

### 5.1.3. General cropping

Figure 5.7 shows that the baseline (*status quo*) FBI for English general cropping farms[4] is £78,478. Under ***Scenario A: UK-EU FTA***, FBI falls to just over £55,000, and falls slightly further to just over £51,000 under ***Scenario B: WTO: UK tariffs***. Removing Pillar 1 support would exacerbate the fall in FBI which would be to approximately £11,500 under ***Scenario A: UK-EU FTA*** and just over £7,000 under ***Scenario B: WTO: UK tariffs***.

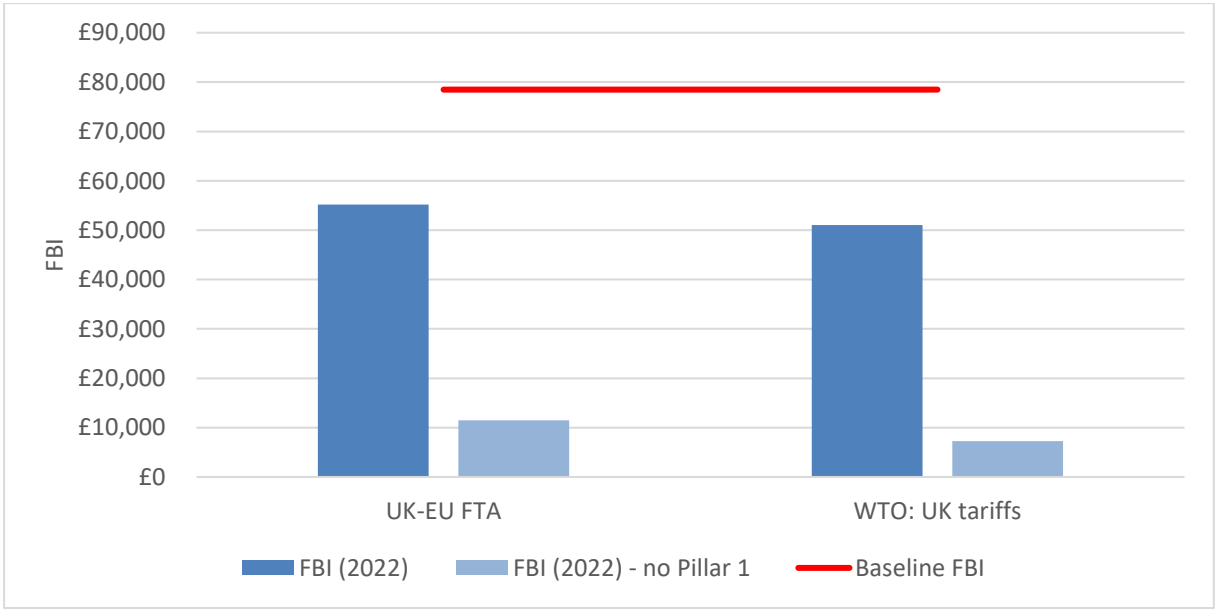



**Figure 5.5: Impact of the scenarios on 2022 FBI: General cropping (England)**

Components of FBI under the baseline (current situation) and two scenarios are shown in Figure 5.8. Regular labour costs under both scenarios increase by almost £22,500. Variable costs rise as a result of increases in contract costs (driven by labour cost) and an increase in fertiliser cost. The transfer of funds from Pillar 1 to Pillar 2 results in a net increase in support of approximately £1,000 in 2022. Under ***Scenario A: UK-EU FTA***, production revenue actually increases by almost £3,000, the main factor

[4] Holdings on which arable crops (including field-scale vegetables) account for more than two-thirds of their total Standard Output (SO) excluding holdings classified as cereals; holdings on which a mixture of arable and horticultural crops account for more than two-thirds of their total SO excluding holdings classified as horticulture and holdings on which arable crops account for more than one-third of their total SO and no other grouping accounts for more than one-third.

being an increase in revenue from the wheat enterprise (which accounts for a fifth of total production revenue). However, under ***Scenario B: WTO: UK tariffs***, production revenue is very marginally lower.

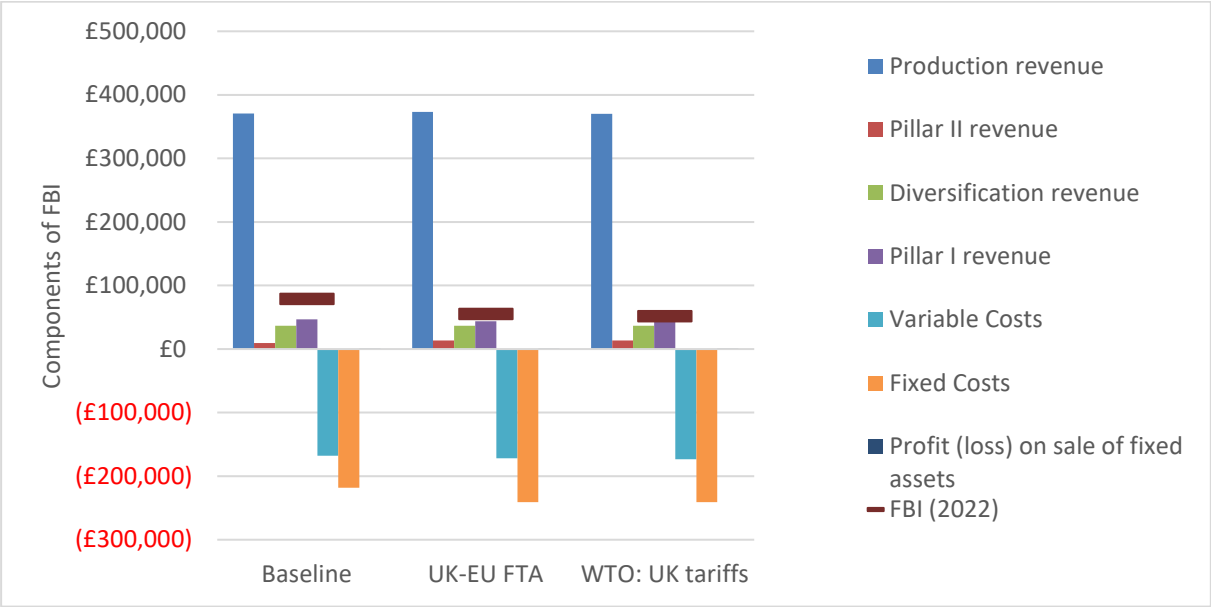



**Figure 5.6: Impact of the scenarios on components of 2022 FBI: General cropping (England)**

The pressures on FBI are likely to lead to adjustments in the cost base where possible to reduce labour costs, or at least maximise the efficiency of labour. This may mean closer examination of the mix of enterprises in favour of those that require lower labour and/or contractor input. There is also likely to be some adjustment in the enterprise mix in favour of enterprises where prices are expected to increase and away from those, such as barley and oilseed rape, where they are expected to decrease. On general cropping farms this could mean an expansion of wheat, potatoes and sugar beet, for example.

Figure 5.9 shows the impact of the scenarios on FBI broken down by farm size and performance level. FBI remains positive for all farm size groupings, although there is a much more noticeable impact on large farms where regular labour costs are very high (almost £134,000 compared to £11,500 on medium sized farms); it is likely that large farms will examine their use of labour with a view to increasing its efficiency.

Pillar 1 payments are also much higher on large farms meaning that the reduction in payments is more substantial, although this is a minor factor compared with labour costs.

In terms of performance groups, for the low performers FBI is negative in the baseline and under both scenarios. While those in the medium performance group see FBI reduced by almost half under ***Scenario A: UK-EU FTA*** and by more than half under ***Scenario B: WTO: UK tariffs***, farms in the high performance group see FBI much better protected under both scenarios. This is a consequence of having more than twice as much revenue from diversified activities and almost three times as much revenue from Pillar 2 schemes. There are lessons here that would benefit farms not in this group.

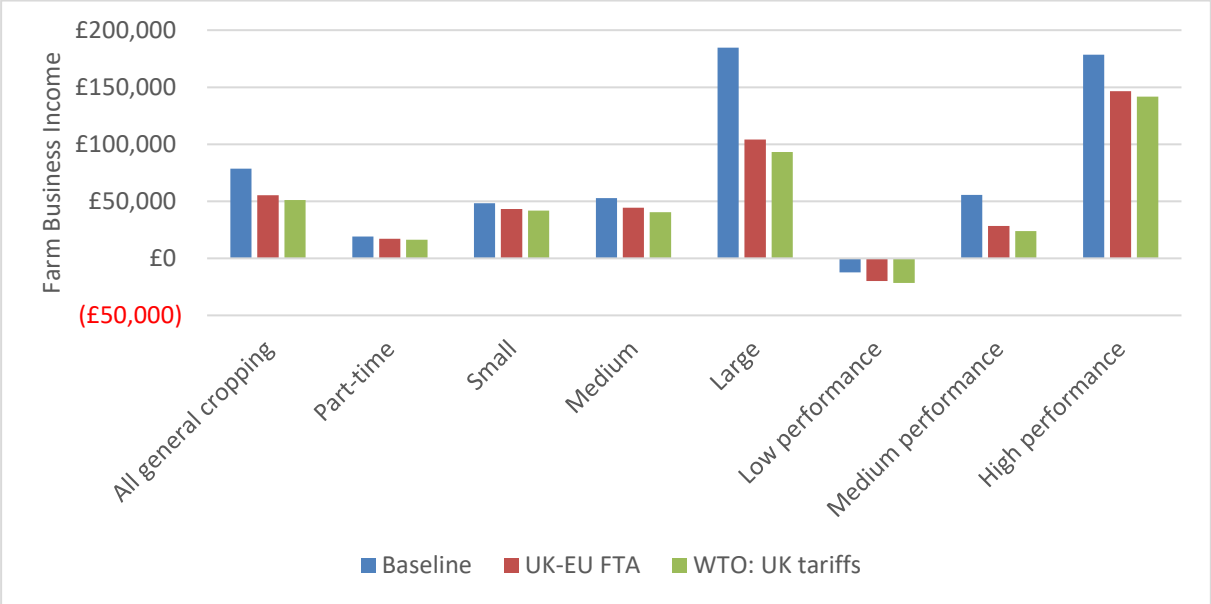



**Figure 5.7: 2022 FBI by farm size and performance level: General cropping (England)**

## Sensitivity analysis

Sensitivity analysis is presented in Appendix 6.

Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±9.40% change in FBI. Under ***Scenario B: WTO: UK tariffs***, a ±10

percentage point change in the labour cost assumption would result in a ±10.13% change in FBI.

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 36.3% reduction in FBI. A 10 percentage point depreciation in Sterling would result in an 36.3% increase in FBI. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be ±39.2%.

### 5.1.4. The processed potato sector

Because potatoes are not well represented within any of the farm types defined by the FBS, and specific "potato farms" is not a recognised group in the published typology, a separate exercise was carried out using data made available by the AHDB for producers in England of potatoes for processing. These data allowed the synthesis of a model on a per hectare basis, i.e. this model differs from the others in that it represents the potato enterprise rather than a specific farm type. Data not in the AHDB source, but necessary to allow the scenarios to be constructed, were estimated using the "general cropping" FBS data:

- **Pillar I and Pillar II payments:** a value for revenue and associated costs per hectare was calculated by dividing total Pillar I/Pillar II payments/cost elements by Utilised Agricultural Area.

The baseline synthesised FBI for potatoes is £1,337 per hectare (Figure 5.10). Under ***Scenario A: UK-EU FTA***, this decreases to just over £900 per hectare. The decrease is less severe under ***Scenario B: WTO: UK tariffs*** with FBI slightly over £1,000 per hectare. FBI would be lower if Pillar 1 payments were removed entirely at just under £750 in ***Scenario A: UK-EU FTA*** and just over £850 under ***Scenario B: WTO: UK tariffs***.

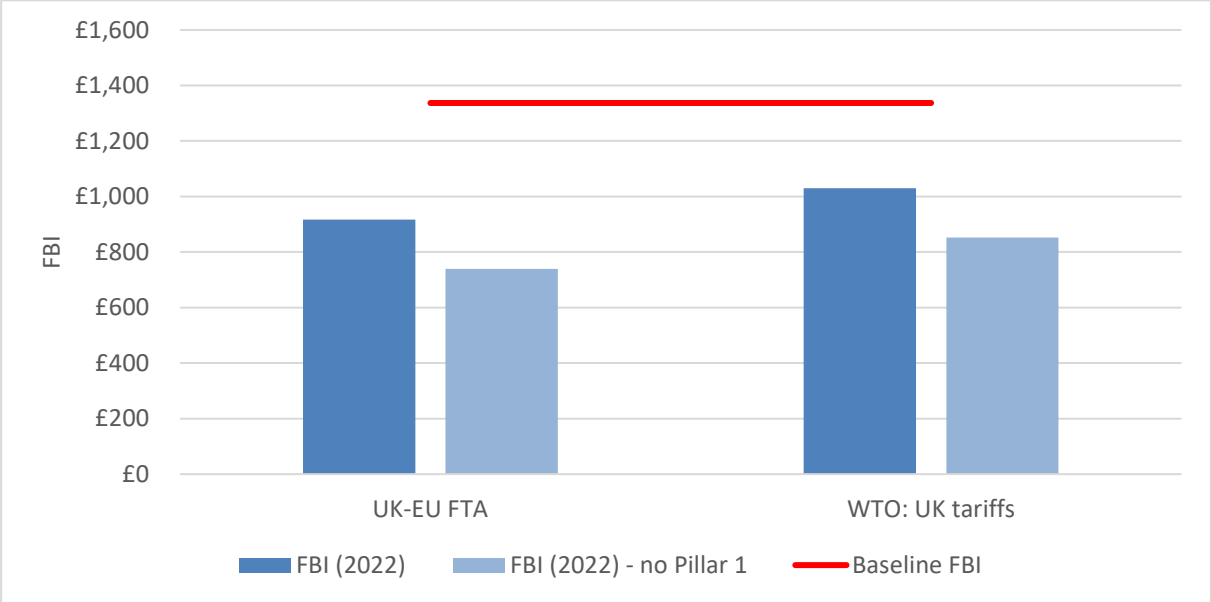



**Figure 5.8: Impact of the scenarios on 2022 FBI: Potatoes (England)**

Figure 5.11 shows the changes in the components of synthesised FBI under the two scenarios. The changes to Pillar 1 and Pillar 2 payments approximately net off each other. There are increases in production revenue under both scenarios as prices increase; this increase is higher under ***Scenario B: WTO: UK tariffs***. However, these increases in production revenue are more than offset by an increase of almost £550 in regular labour cost under both scenarios. There are also increases in fertiliser costs; these are more significant under ***Scenario B: WTO: UK tariffs***. Potato producers will seek to maximise the efficiency of labour use to mitigate the cost increases; given the projected increases in price for processing potatoes under both scenarios, achieving higher yields is likely to be one way in which labour efficiency can be increased.

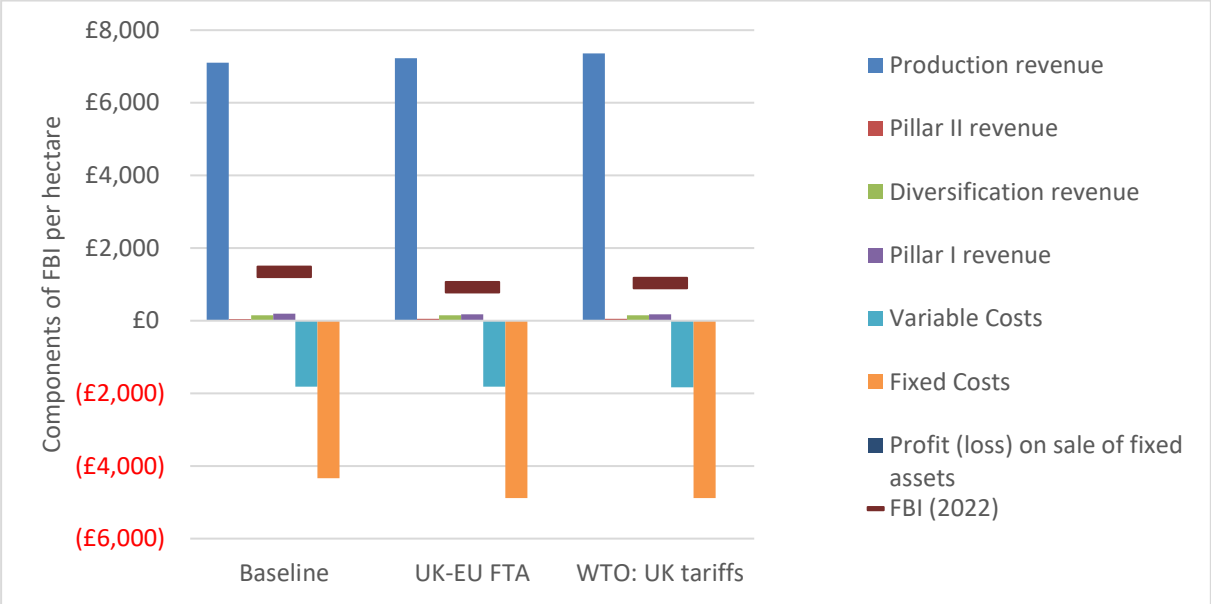



**Figure 5.9: Impact of the scenarios on components of 2022 FBI: Potatoes (England)**

## Sensitivity analysis

Sensitivity analysis is presented in Appendix 6.

Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±11.80% change in income per hectare. Under ***Scenario B: WTO: UK***

***tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±10.50% change in income per hectare.

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 73.6% reduction in FBI. A 10 percentage point depreciation in Sterling would result in an 73.6% increase in FBI. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be ±65.5%.

### 5.1.5. Horticulture (carrots)

The FBS data relating to horticultural businesses encompass a wide range of disparate activities and was not felt to be representative of any specific form of horticulture and thus difficult to interpret. For this reason, it was decided to replace the FBS material by a synthesised per hectare model of carrot production in England using data supplied via the AHDB. The approach taken was the same as for the synthesised potato model, i.e. data not in the AHDB source, but necessary to allow the scenarios to be constructed, were estimated using the "general cropping" FBS data:

- **Pillar I and Pillar II payments:** a value for revenue and associated costs per hectare was calculated by dividing total Pillar I/Pillar II payments/cost elements by Utilised Agricultural Area.

The baseline synthesised FBI for carrots is £1,640 per hectare (Figure 5.12). FBI decreases to around £1,300 under ***Scenario A: UK-EU FTA***, but only to just under £1,450 under ***Scenario B: WTO: UK tariffs***. If Pillar 1 payments were removed entirely, FBI under ***Scenario A: UK-EU FTA*** would fall to just over £1,100, while FBI under ***Scenario B: WTO: UK tariffs*** would fall to just under £1,300.

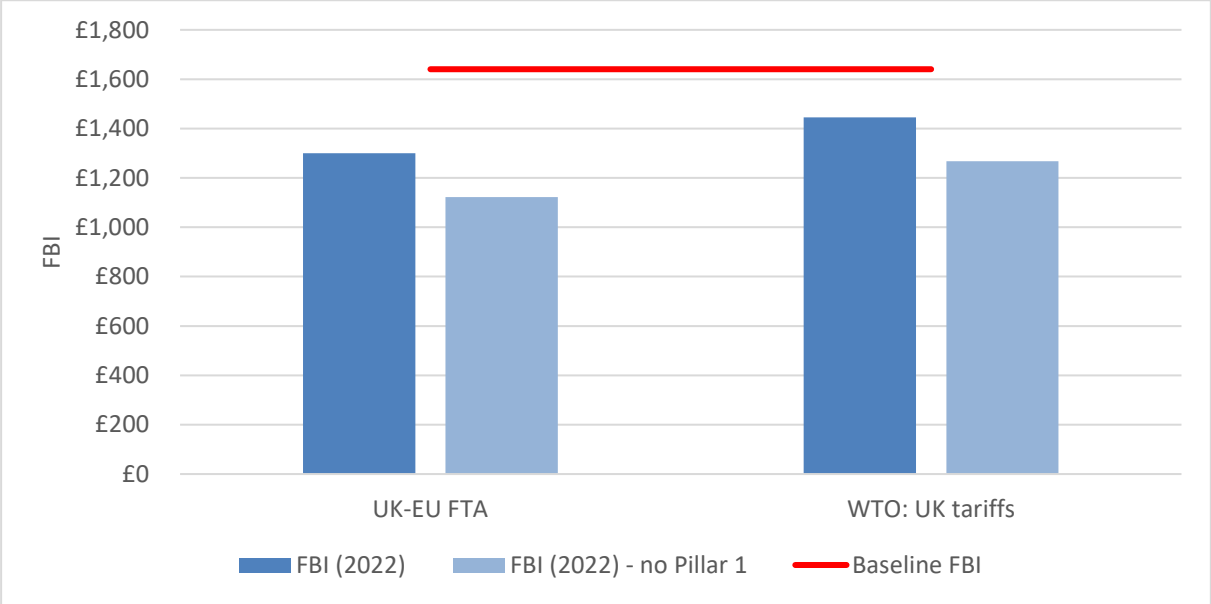



**Figure 5.10: Impact of the scenarios on 2022 FBI: Carrots (England)**

Figure 5.13 shows the components of FBI under the two scenarios and the baseline. The first point to note is that the reduction in Pillar 1 support and the increase in Pillar 2 support more or less nets out. Labour cost increases of almost £500 per hectare offset the increases in production revenue which is higher under ***Scenario B: WTO: UK tariffs***. Fertiliser costs also increase under both scenarios, more so under ***Scenario B: WTO: UK tariffs***. There will be pressure to increase labour efficiency.

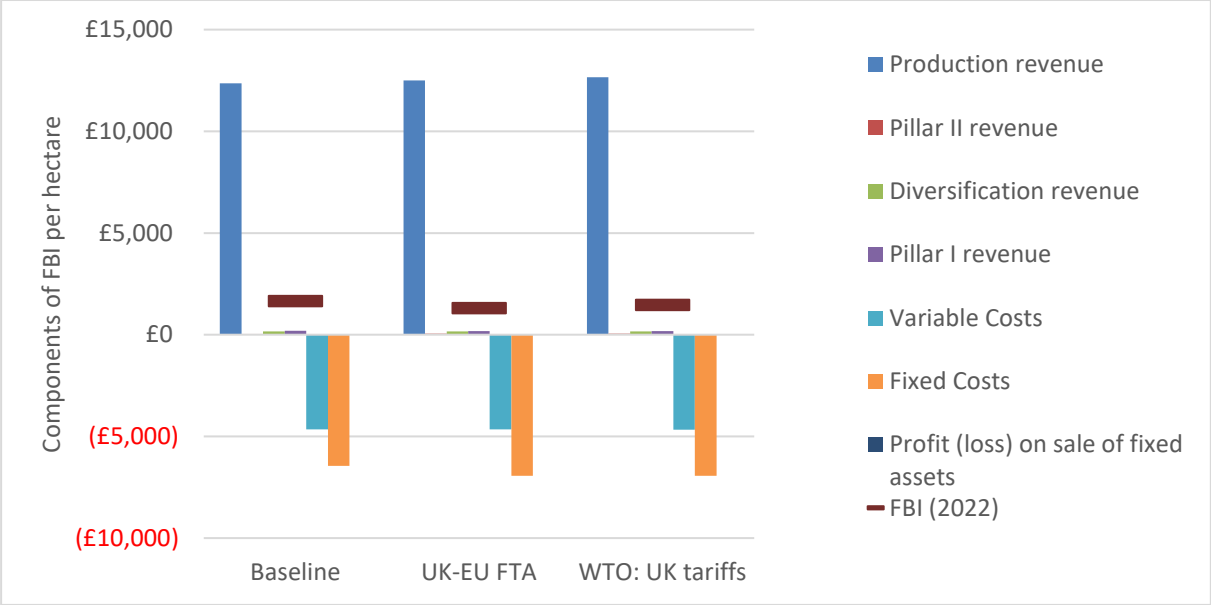



**Figure 5.11: Impact of the scenarios on components of 2022 FBI: Carrots (England)**

## Sensitivity analysis

Sensitivity analysis is presented in Appendix 6.

Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±7.46% change in income per hectare. Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±6.71% change in income per hectare.

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 94.2% reduction in income per hectare. A 10 percentage point depreciation

in Sterling would result in an 94.2% increase in income per hectare. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be ±84.7%.

### 5.1.6. Less Favoured Area sheep and beef

The baseline FBI for English LFA sheep and beef farms[5] is £23,976 (Figure 5.15). FBI is very slightly higher under ***Scenario A: UK-EU FTA***, but falls by almost half under ***Scenario B: WTO: UK tariffs***. However, the picture would be rather different if Pillar 1 payments were to be removed entirely with FBI becoming marginally negative under ***Scenario A: UK-EU FTA*** and substantially negative (more than -£10,000) under ***Scenario B: WTO: UK tariffs***.

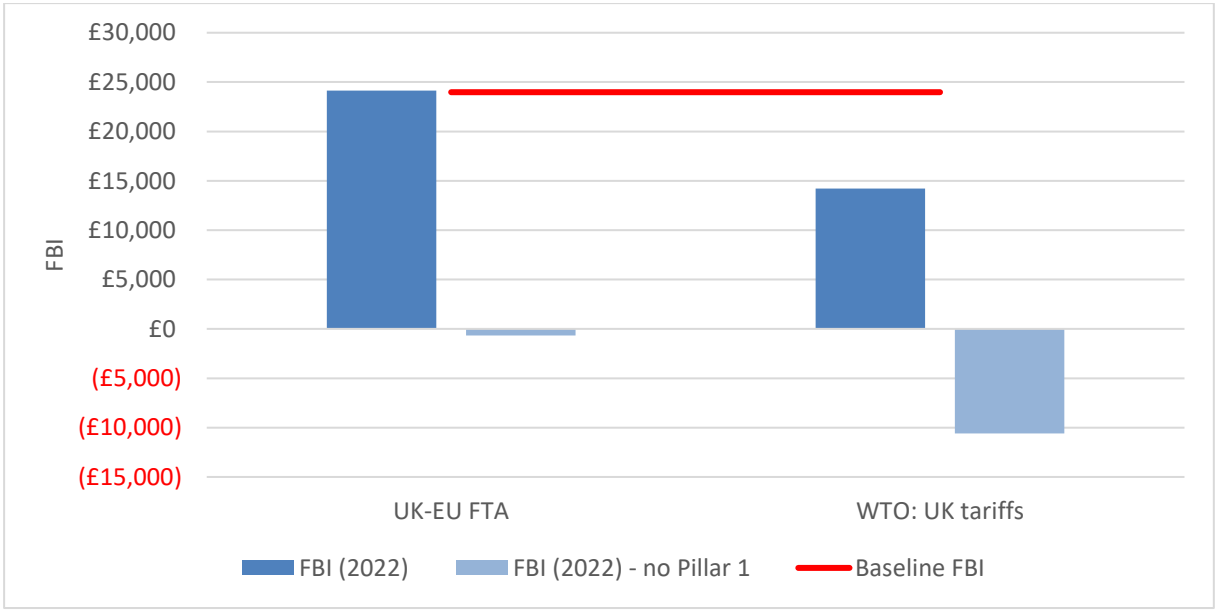



**Figure 5.12: Impact of the scenarios on 2022 FBI: LFA sheep and beef (England)**

Figure 5.16 shows the changes in the composition of FBI under each scenario. Under both scenarios, regular labour costs increase by just under £3,000 and there are relatively minor changes in variable costs; contract costs increasing under both scenarios, but livestock feed costs increase under ***Scenario A: UK-EU FTA*** and decrease under ***Scenario B: WTO: UK tariffs*** due to different movements in the prices of feed ingredients. The reduction in Pillar 1 payments for this farm type is relatively minor, at around £1,300; this is more than offset by the increase in Pillar 2 payments

[5] Holdings on which cattle, sheep and other grazing livestock account for more than two-thirds of their total Standard Output (SO) except holdings classified as dairy. A holding is classified as a Less Favoured Area (LFA) holding if 50% or more of its total area is in the LFA.

(over £5,700). However, production revenue decreases a little (about £500) under ***Scenario A: UK-EU FTA*** but by more than £10,500 under ***Scenario B: WTO: UK tariffs***. This is driven by the mix of sheep and beef on this farm type which means combined revenue from these enterprises is little different under Scenario A, but substantially lower under Scenario B, a result of much smaller revenue for sheep output linked to sharply lower prices.

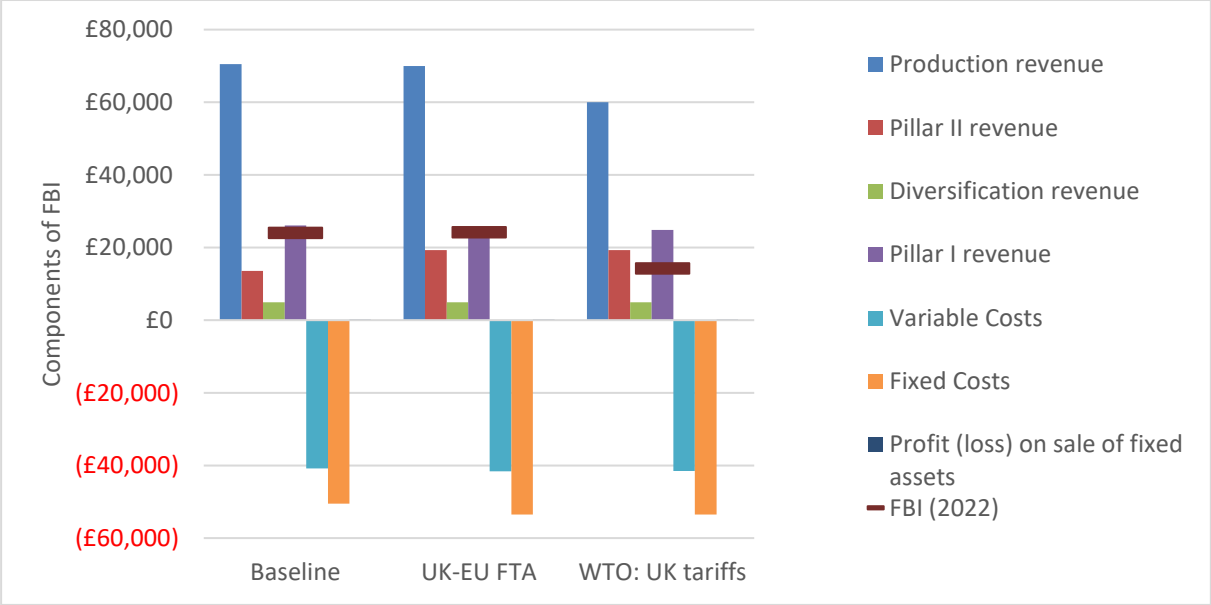



**Figure 5.13: Impact of the scenarios on components of 2022 FBI: LFA sheep and beef (England)**

These estimated shifts in FBI are only a first-round indicator of where financial pressure is likely to be felt. In reality, they will be softened by behavioural responses. The ability of these LFA producers to adapt by rebalancing production away from sheep in favour of beef is likely to be less technically feasible than on lowland farms, where this is already being considered together with switching into dairying (see below). However, LFA sheep and beef producers are well placed to benefit from the reallocation of support into Pillar 2-type schemes under the assumption that they farm in areas where there are relatively more options to deliver public goods. In the longer-term, household income diversification and more substantial structural adjustment will need to be considered.

The impact on FBI by farm size and performance level is shown in Figure 5.17. While under ***Scenario A: UK-EU FTA*** FBI is slightly higher than the baseline at the aggregate level, there are differences in this relationship by farm size. For medium and large farms FBI under Scenario A is lower than the baseline, although fairly marginally so, as a result of their higher labour costs. For low and medium performers FBI is also lower than the baseline under Scenario A, again marginally so. While ***Scenario B: WTO: UK tariffs*** would see FBI fall substantially for all farm sizes and for low and medium performers, FBI falls less substantially for high performers, showing that this group is best protected in all circumstances.

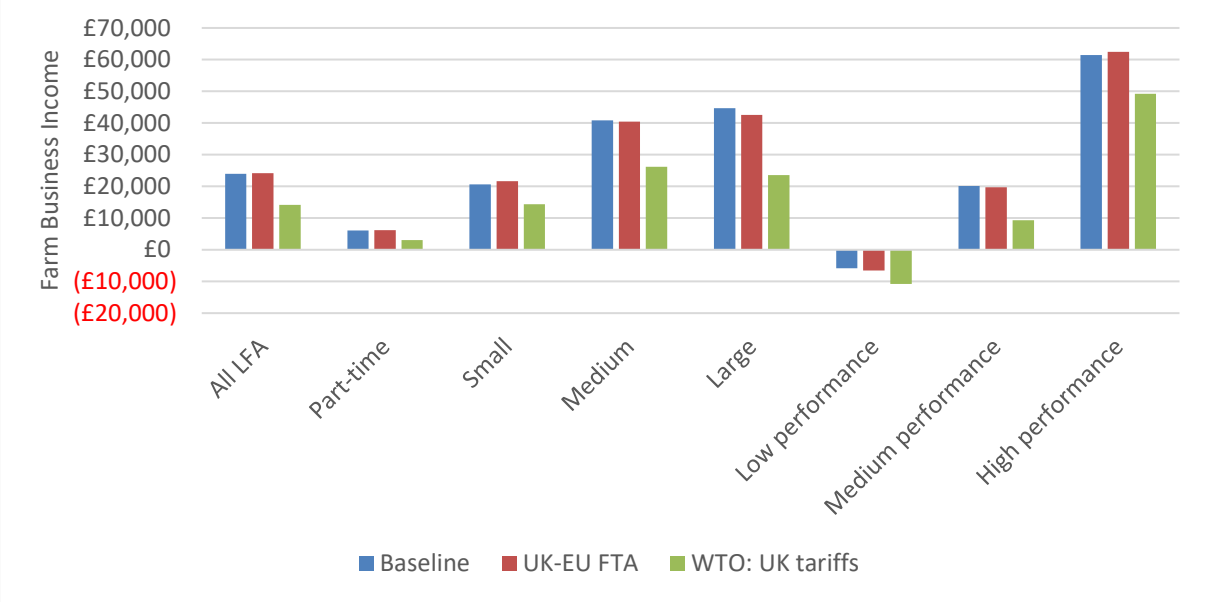



**Figure 5.14: 2022 FBI by farm size and performance level: LFA beef and sheep (England)**

## Sensitivity analysis

Sensitivity analysis is presented in Appendix 6.

Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±1.79% change in FBI. Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±3.82% change in FBI.

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 19.0% reduction in FBI. A 10 percentage point depreciation in Sterling would result in a 19.0% increase in FBI. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be a 32.27% reduction in FBI and a 32.3% increase in FBI.

### 5.1.7. Lowland sheep and beef

Figure 5.18 shows that the baseline (*status quo*) FBI for English lowland beef and sheep farms[6] is £16,683. Under ***Scenario A: UK-EU FTA***, this decreases slightly to just over £15,000. Under ***Scenario B: WTO: UK tariffs*** FBI would fall by just over half to £7,100. Pillar 1 payments are important in this sector – without them, FBI in 2022 would become negative under both scenarios at just under -£1,200 under ***Scenario A: UK-EU FTA*** and just over -£9,000 under ***Scenario B: WTO: UK tariffs***.

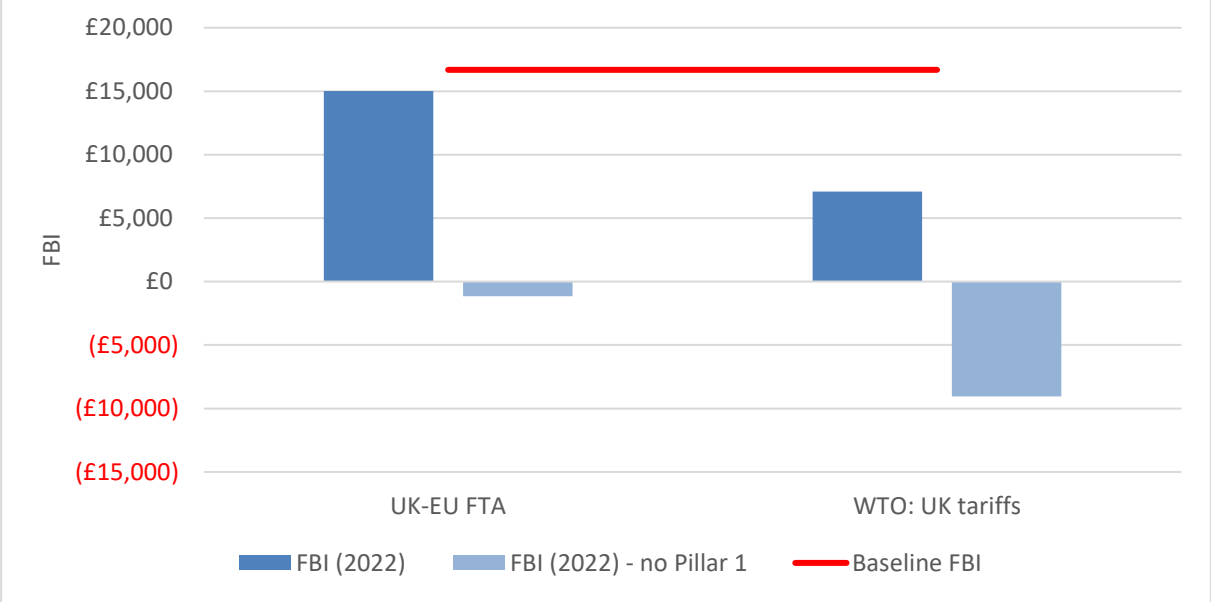



**Figure 5.15: Impact of the scenarios on 2022 FBI: Lowland sheep and beef (England)**

Figure 5.19 presents the change in the components of FBI by scenario. The data behind the Figure show that there is a very marginal increase in production revenue just over (£900) under ***Scenario A: UK-EU FTA***, the result of decreases in output from sheep being countered by a slightly larger increase in output from beef. Under ***Scenario B: WTO: UK tariffs***, production revenue falls by just over £7,000 following the sharp downward move in sheep prices and the (less substantial) reduction in beef prices.

[6] Holdings on which cattle, sheep and other grazing livestock account for more than two-thirds of their total Standard Output (SO) except holdings classified as dairy. A holding is classified as lowland if less than 50% of its total area is in the Less Favoured Area (LFA).

Comparison between the columns (and the underlying data) establishes that the loss of Pillar I payments in 2022 (£850) is more than offset by the increase in Pillar II payments (just under £1,900) for this farm type. The decrease in FBI driven by changes in production revenue is exacerbated by an increase of just over £2,500 in regular labour costs and a smaller increase in contract costs.

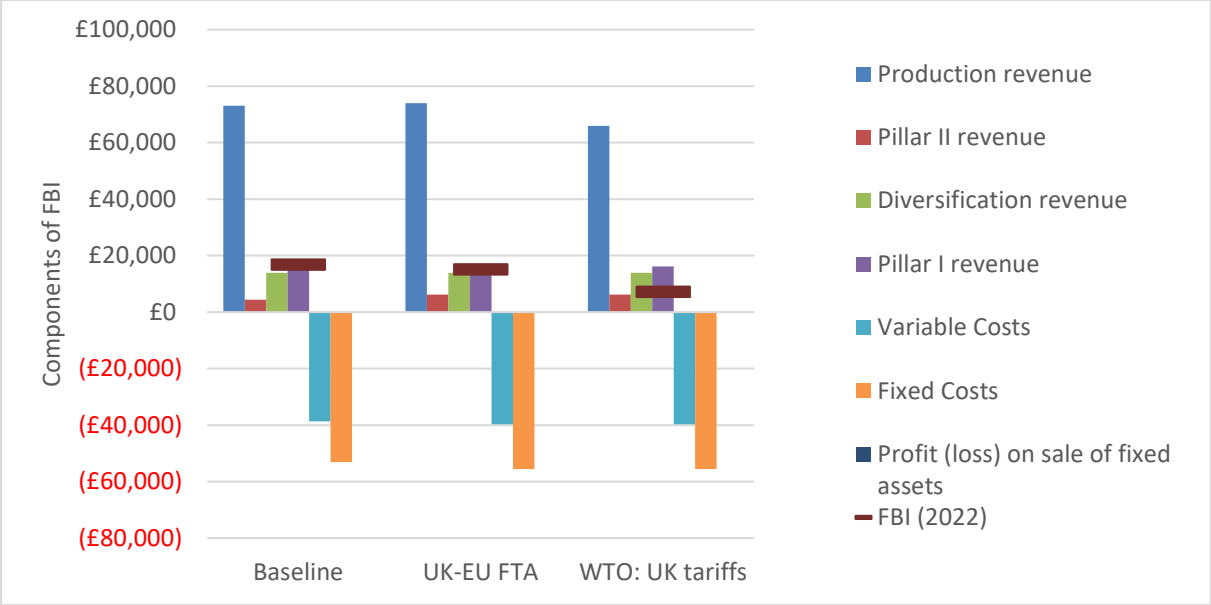



**Figure 5.16: Impact of the scenarios on components of 2022 FBI: Lowland sheep and beef (England)**

It should be recalled that these results are first-order impact only. Because the sheep sector is more negatively affected than the beef sector, it would be expected that producers would seek to expand their beef enterprise at the expense of their sheep enterprise where this is possible. This would make most sense under ***Scenario A: UK-EU FTA*** where beef prices are likely to increase due to trade friction costs; under ***Scenario B: WTO: UK tariffs***, switching from sheep to beef could reduce the fall in production revenue, but other alternatives would be preferable, again, to the extent possible within agronomic constraints. For example, it is known that some sheep producers are considering entering/expanding dairy enterprises because the price outlook is more favourable in this sector.

Figure 5.20 shows the impact of the scenarios by farm size and performance level. Generally, FBI increases with scale under each scenario, although under ***Scenario B: WTO: UK tariffs***, FBI for part-time farms is slightly higher than for small farms because their production revenue falls slightly further as a percentage than it does for part-time farms; small farms also have higher labour use meaning increases in the cost of labour have a greater impact. It is also noticeable that FBI on medium and large farms under ***Scenario B: WTO: UK tariffs*** is similar. This is because production revenue falls by proportionally more for large farms than medium farms while labour use is higher on larger farms meaning that the increase in labour costs is more substantial. FBI on high performance farms is better protected than medium or low performance farms under both scenarios. This is most evident under ***Scenario B: WTO: UK tariffs*** where production revenue falls by a similar amount in absolute terms, but high performance farms draw more revenue from Pillar 1, Pillar 2 and diversified activities making this fall in production revenue less important in overall FBI. In addition, labour use on high performance farms is only slightly higher than on medium performance farms meaning that there is little differential impact here.

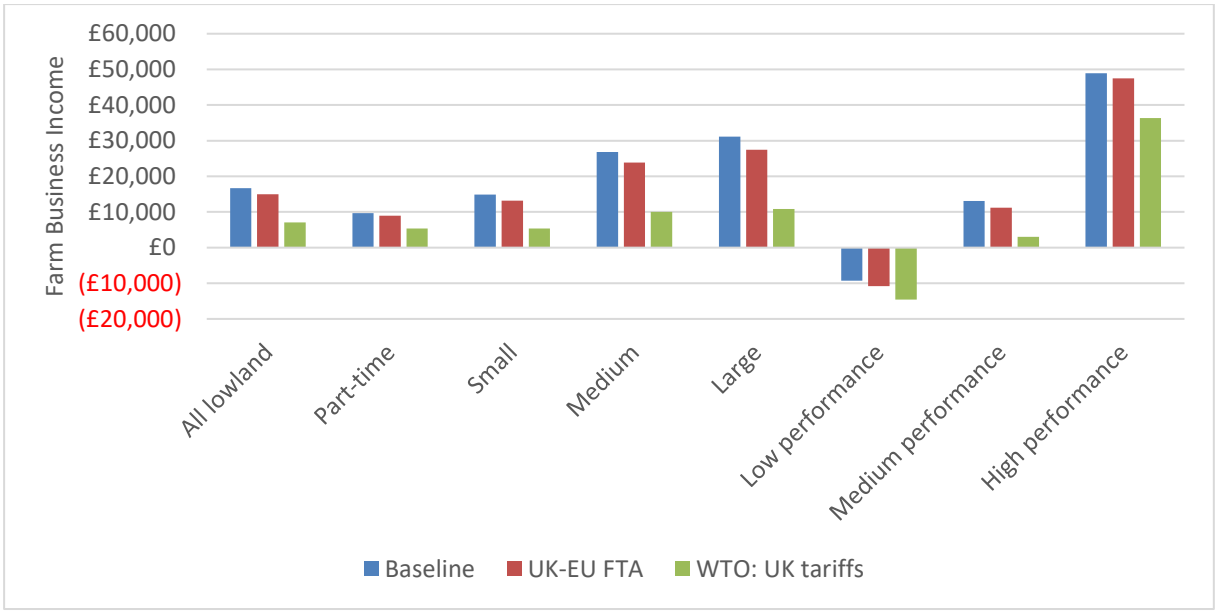



**Figure 5.17: 2022 FBI by farm size and performance level: Lowland sheep and beef (England)**

## Sensitivity analysis

Sensitivity analysis is presented in Appendix 6.

Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±4.31% change in FBI. Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±9.00% change in FBI.

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 30.8% reduction in income per hectare. A 10 percentage point depreciation in Sterling would result in a 30.8% increase in income per hectare. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be ±65.0%.

### 5.1.8. Dairy

The baseline FBI for English dairy farms[7] is £70,694 (Figure 5.21). This decreases to just under £58,000 under ***Scenario A: UK-EU FTA*** and to just over £55,000 under ***Scenario B: WTO: UK tariffs***. The removal of Pillar 1 support would further decrease FBI to almost £32,000 under ***Scenario A: UK-EU FTA*** and to almost £29,000 under ***Scenario B: WTO: UK tariffs***.

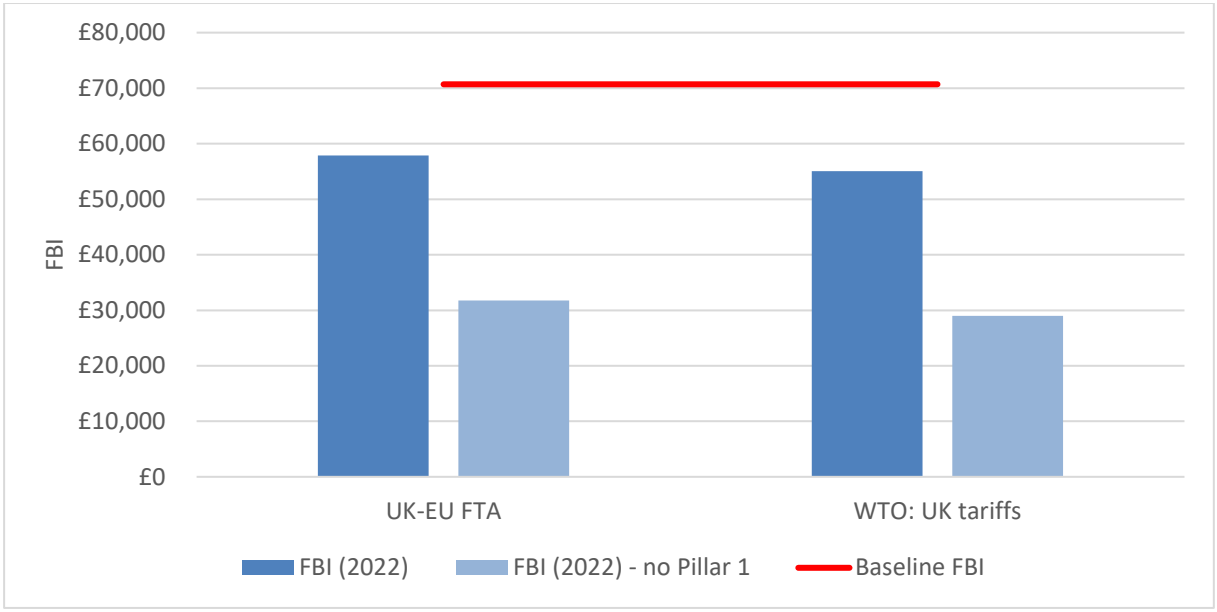



**Figure 5.18: Impact of the scenarios on 2022 FBI: Dairy (England)**

The main driving factor behind the decreases in FBI under both scenarios is an increase in regular labour costs of more than £20,000. This is exacerbated by increases in contract costs. Under ***Scenario A: UK-EU FTA*** the cost of feed increases slightly, whereas under ***Scenario B: WTO: UK tariffs*** the cost of feed is slightly lower (as prices for feed ingredients move in different directions under the different scenarios). The reduction in Pillar 1 payments of just under £1,400 is more than offset by the increase in payments under Pillar 2 (approximately £1,600). FBI under Scenario A is supported to some extent by an increase in production revenue of almost £13,000. Under ***Scenario B: WTO: UK tariffs***, production revenue increases by just under £8,750 (Figure 5.22).

[7] Holdings on which dairy cows account for more than two-thirds of their total Standard Output (SO).

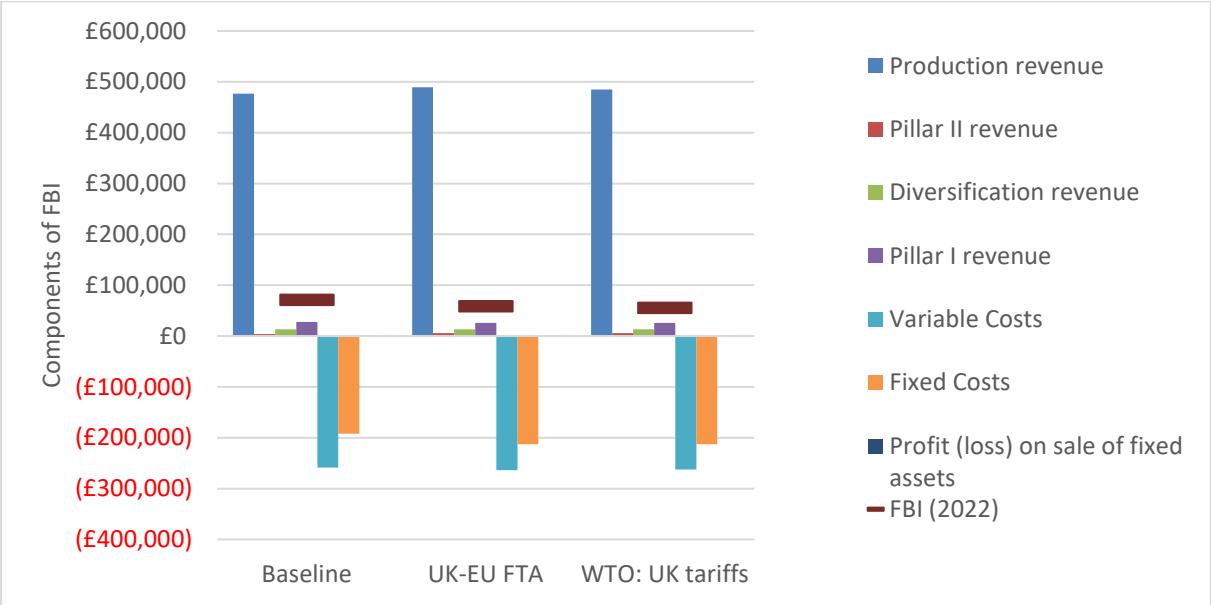



**Figure 5.19: Impact of the scenarios on components of 2022 FBI: Dairy (England)**

The importance of labour costs in dairy production means that there will be pressure to maximise labour efficiency where possible. As the price of raw milk is expected to increase under both scenarios, this could be achieved through an increase in scale. Dairy farms often also have a beef enterprise. Under Scenario A, beef prices are expected to increase, but under Scenario B they are predicted to fall, so there will be pressure to reduce or remove beef enterprises in this case.

The impact of the scenarios on FBI by farm size is noticeably different for small dairy farms and less extreme for medium dairy farms, mainly as a result of the relative importance of labour costs (Figure 5.23). This pattern is not evident when disaggregating dairy farms by performance level. Low performance dairy farms currently make a loss (from the agricultural business) and this is exacerbated under both scenarios. FBI for high performance dairy farms is more protected than for medium performance farms, although this effect is less pronounced than for some other farm types. This is driven by lower regular labour costs and a higher revenue from diversification. Unlike other sectors, high performance dairy farms do not have higher revenue from Pillar 2 support.

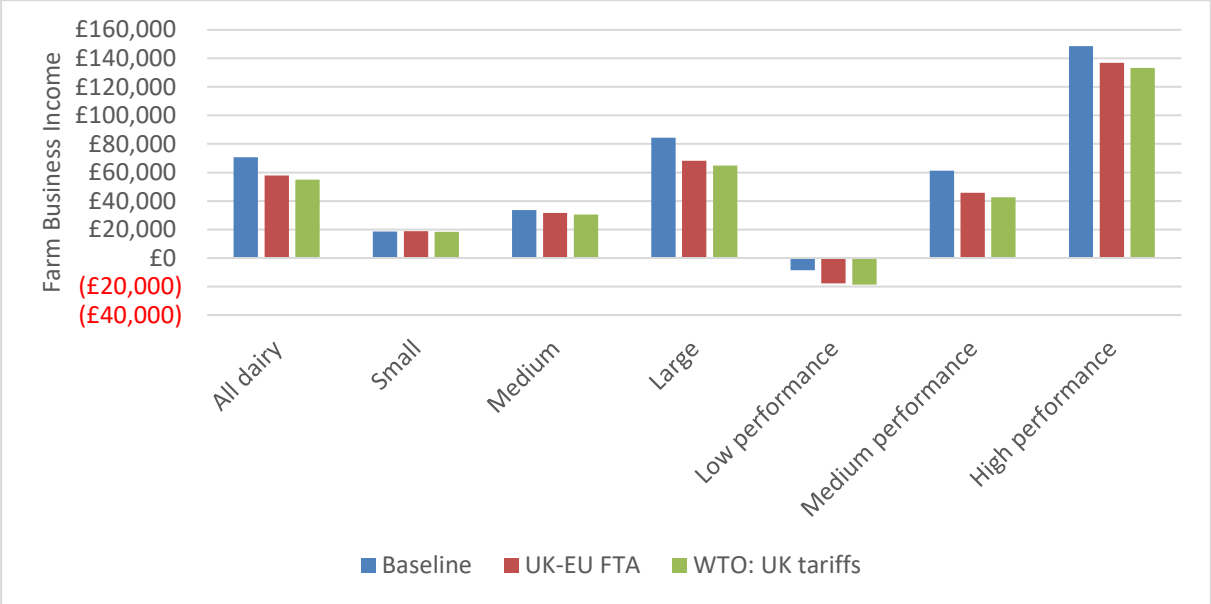



**Figure 5.20: 2022 FBI by farm size and performance level: Dairy (England)**

## Sensitivity analysis

Sensitivity analysis is presented in Appendix 6.

Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±8.57% change in FBI. Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±8.99% change in FBI.

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 56.5% reduction in FBI. A 10 percentage point depreciation in Sterling would result in a 56.5% increase in FBI. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be a 59.3% reduction in FBI and a 56.4% increase in FBI.

### 5.1.9. Pigs

Figure 5.24 shows that the baseline FBI for English pig farms[8] is £36,578. This decreases under both scenarios to just over £21,200 under ***Scenario A: UK-EU FTA***, and becomes negative (a loss of almost £11,000) under ***Scenario B: WTO: UK tariffs***. Despite not typically receiving substantial support under Pillar 1, removing these payments would still leave FBI noticeably lower, at just under £11,000 under Scenario A and at around -£21,000 under Scenario B.

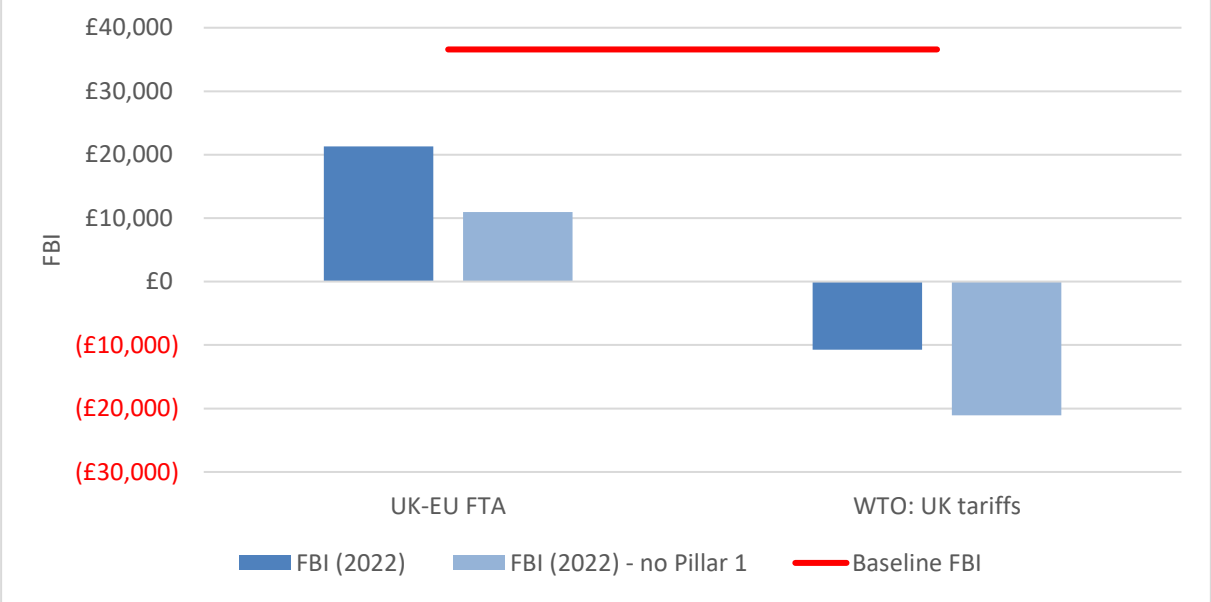



**Figure 5.21: Impact of the scenarios on 2022 FBI: Pigs (England)**

Figure 5.25 shows that the main reason for the decrease in FBI under ***Scenario A: UK-EU FTA*** is the increase in regular labour costs (approximately £26,200). Other cost increases under this scenario result from higher feed costs and increases in contract costs. These increases are though offset to some extent by an increase in production revenue of more than £14,000. Under ***Scenario B: WTO: UK tariffs***, feed costs fall as the prices of feed ingredients fall, but so too does production revenue (by almost £21,000) which, added to the increases in labour and contract costs, results in negative FBI.

[8] Holdings on which pigs account for more than two-thirds of their total Standard Output (SO).

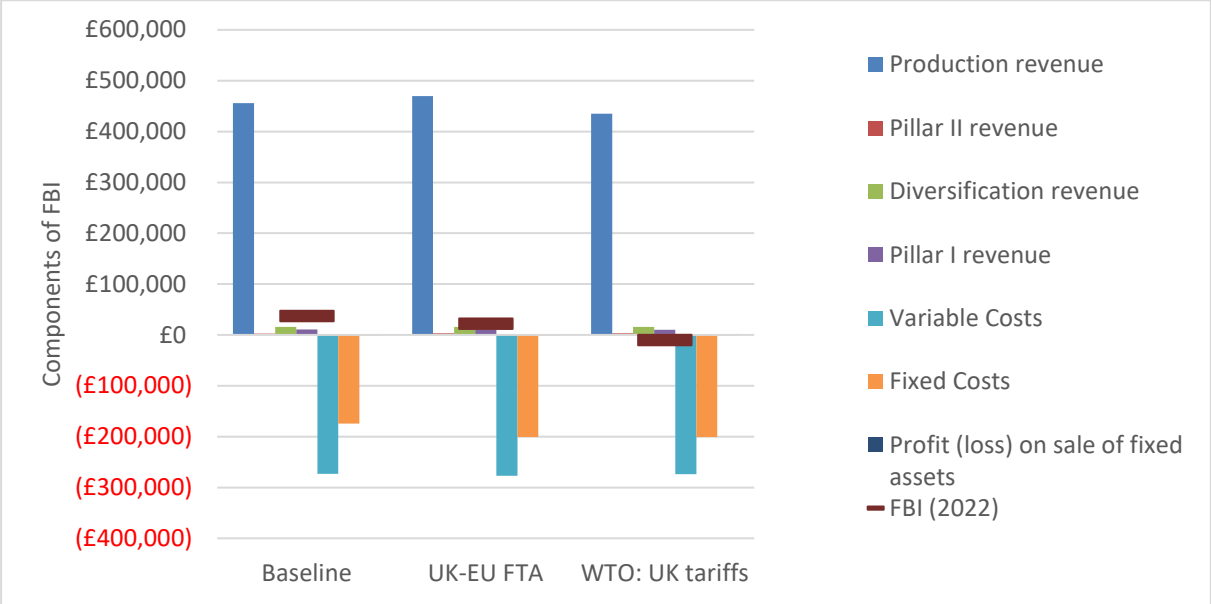



**Figure 5.22: Impact of the scenarios on components of 2022 FBI: Pigs (England)**

Permanent labour costs are high in pig production and so there will be pressure to reduce these or at least to maximise labour efficiency. Under ***Scenario A: UK-EU FTA***, pig prices are expected to increase due to trade friction costs, so increased labour efficiency could be achieved through increases in production. However, under ***Scenario B: WTO: UK tariffs***, pig prices are predicted to fall, so increases in production are not likely. It is possible that pig producers will look to introduce or expand other enterprises, although as pig production is often a landless activity, this will not always be possible.

The FBS data only permit an examination of large pig farms against all pig farms and of only medium and high performers (Figure 5.26). The impact of the scenarios on large pig farms follows the same pattern as for all farms, although the decreases in FBI are more pronounced due to relatively high labour costs. FBI for medium performers becomes negative under both scenarios, more significantly so under ***Scenario B: WTO: UK tariffs***. The FBI of high performers is better protected than all pig farmers under ***Scenario A: UK-EU FTA*** and obviously so under ***Scenario B: WTO: UK tariffs*** where it remains positive. This is driven mainly by significantly lower regular labour costs (£63,000 compared to £117,000 for large pig farmers), although lower contract costs are also a factor.

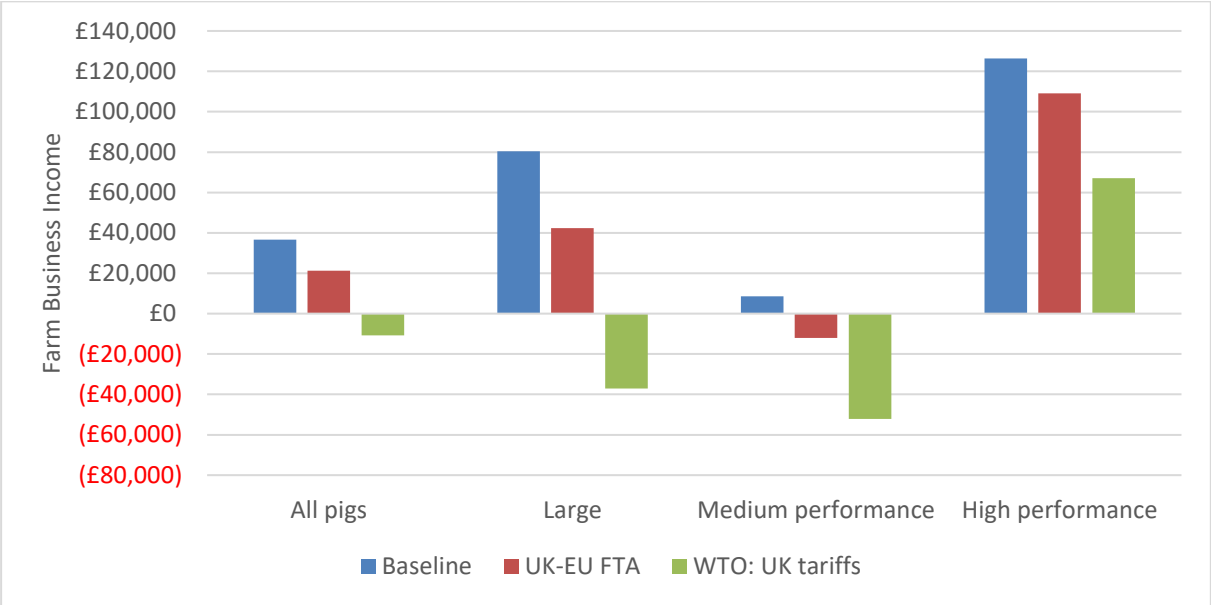



**Figure 5.23: 2022 FBI by farm size and performance level: Pigs (England)**

## Sensitivity analysis

Sensitivity analysis is presented in Appendix 6.

Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±26.72% change in FBI. Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±52.80% change in FBI.

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 111.3% reduction in FBI. A 10 percentage point depreciation in Sterling would result in an 111.0% increase in FBI. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be a 220.3% reduction in FBI and a 219.8% increase in FBI.

### 5.1.10. Poultry

As noted elsewhere, poultry farming is treated in a different way from most of the other sectors, not using FBS data and basing the costs and revenues associated with 1,000 birds on a representative farm, rather than a single business. The baseline income per 1,000 birds for our representative England poultry farm is £30.55 (Figure 5.25). Under ***Scenario A: UK-EU FTA***, this becomes negative at just below -£32.00 per 1,000 birds. Under ***Scenario B: WTO: UK tariffs***, FBI is £0.00 per 1,000 birds (which explains why the bar is not visible).

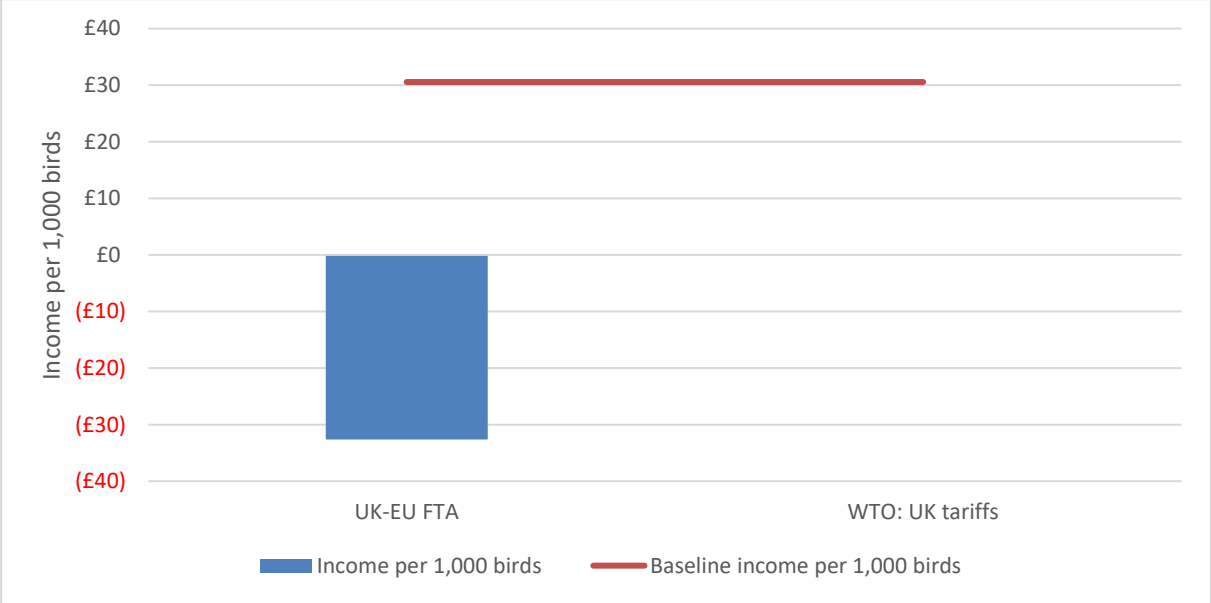



**Figure 5.24: Impact of the scenarios on 2022 income per 1,000 birds: Poultry (England)**

Figure 5.26 shows that the main driver in the reduction in income per 1,000 birds is regular labour cost which increases by £60 per 1,000 birds. This is exacerbated by increases in catching costs, which is another labour cost, and also by increases in cleaning costs which are around two-thirds labour. Under ***Scenario A: UK-EU FTA*** there is an increase of more than £8 per 1,000 birds in production revenue, but this is insufficient to offset the increases in labour costs. Under ***Scenario B: WTO: UK tariffs***, the almost £40 increase in production revenue is enough to prevent income

per 1,000 birds becoming negative, although this is not sufficient to deliver a positive FBI.

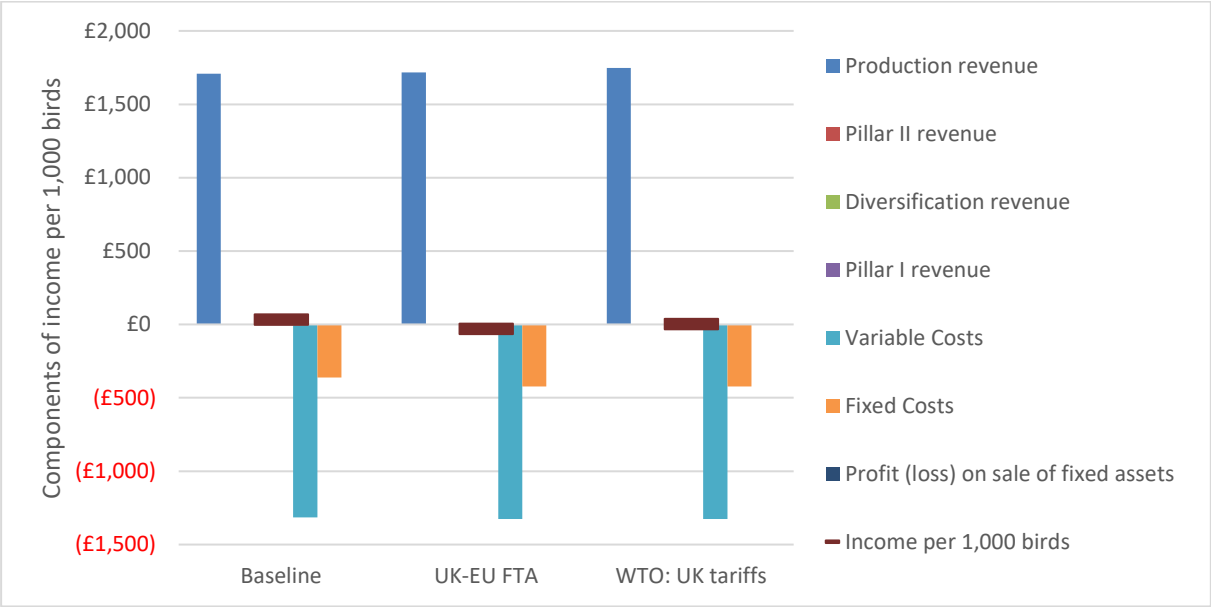



**Figure 5.25: Impact of the scenarios on components of 2022 income per 1,000 bird: Poultry (England)**

The change in FBI on poultry units is largely explained by labour costs so there will be pressure to minimise increases through maximising labour efficiency, possibly through increasing output with the same labour complement. Labour costs are important elements of catching and cleaning costs and so there will be pressure to control these costs too.

## Sensitivity analysis

Sensitivity analysis is presented in Appendix 6.

Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±36.87% change in FBI. The magnitude of change under ***Scenario B: WTO: UK tariffs*** is too large relative to the baseline FBI to comment in percentage terms; in absolute terms, a 10% change in labour costs results in a £5.99 change in FBI.

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 317.8% increase in FBI. A 10 percentage point depreciation in Sterling would result in a 317.8% decrease in FBI. Under ***Scenario B: WTO: UK tariffs*** the changes are from such a low base that citing them in percentage terms is not meaningful; in absolute terms the equivalent changes translate into decreases/increases in income per 1,000 birds of £103.61.

### 5.1.11. All farms

The all-farms assessment reflects the weighted composition of the farming types already described. It is included to provide an industry-wide impression of the impact of the scenarios chosen by the AHDB on business incomes.

The baseline (*status quo*) FBI for all farms in England is £42,754 (Figure 5.27). Under ***Scenario A: UK-EU FTA***, this decreases to just under £32,500, and to just over £26,000 under ***Scenario B: WTO: UK tariffs***. The importance of Pillar 1 support in maintaining FBI can be clearly seen. Removing Pillar 1 payments entirely would leave FBI at just over £5,600 under Scenario A and marginally negative under Scenario B.

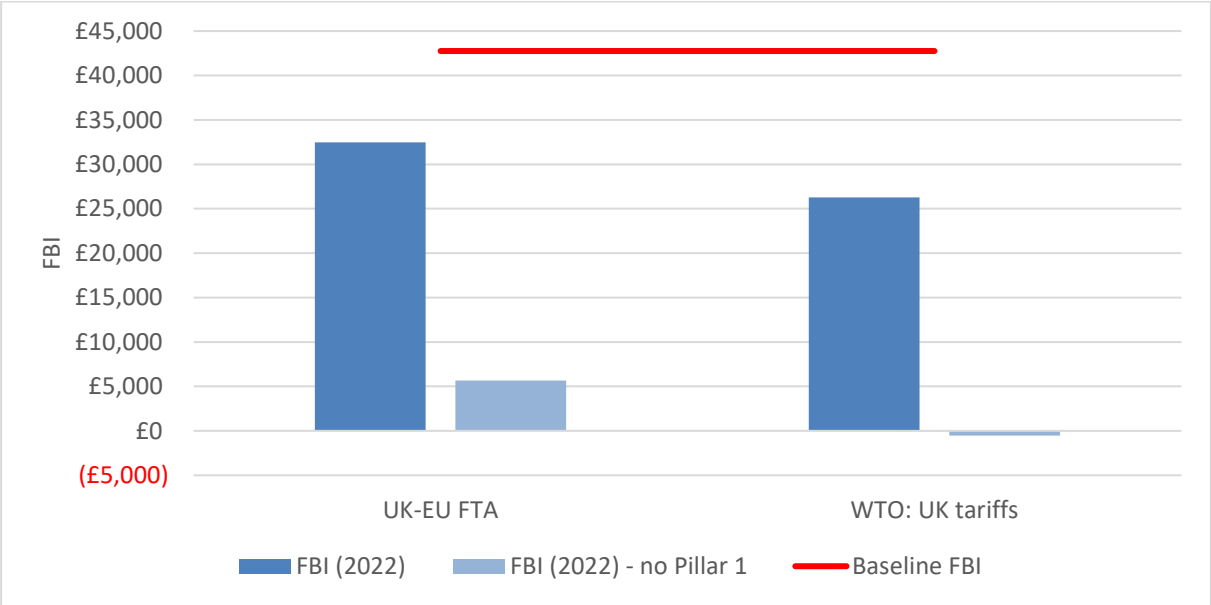



**Figure 5.26: Impact of the scenarios on 2022 FBI: All farms (England)**

Permanent labour costs increase by almost £12,000 and there are also increases in contract costs, of which labour costs are a major component. Together these outweigh the almost £3,000 increase in production revenue under ***Scenario A: UK-EU FTA***. Production revenue falls by almost £3,500 under ***Scenario B: WTO: UK tariffs***, exacerbating the increases in labour costs

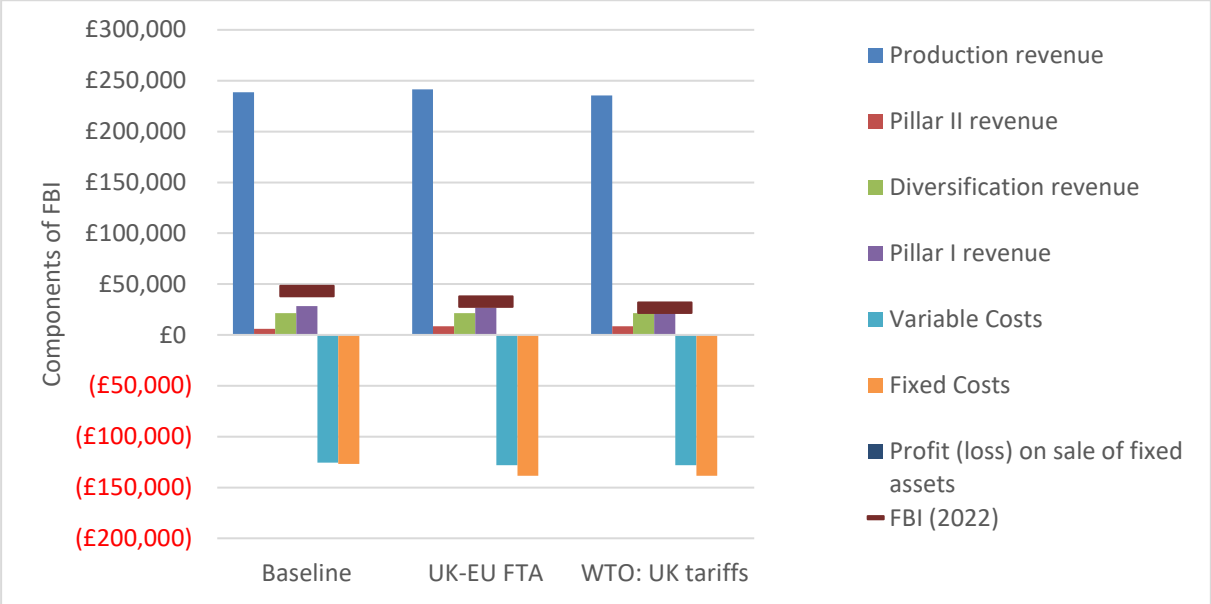



**Figure 5.27: Impact of the scenarios on components of 2022 FBI: All farms (England)**

The impact of the scenarios on FBI by farm size is moderated for part-time and small farms, but is magnified for large farms, mainly as a result of the relative importance of labour costs (Figure 5.29). For the low performance group, FBI is negative for the baseline and under all scenarios. As is generally the case, FBI for high performance farms is better protected than for the other performance groups partly helped by higher revenues from Pillar 2 and from diversified activities and partly helped by similar labour costs compared to the medium performance group; permanent labour costs on high performance farms are less than half those on large farms.

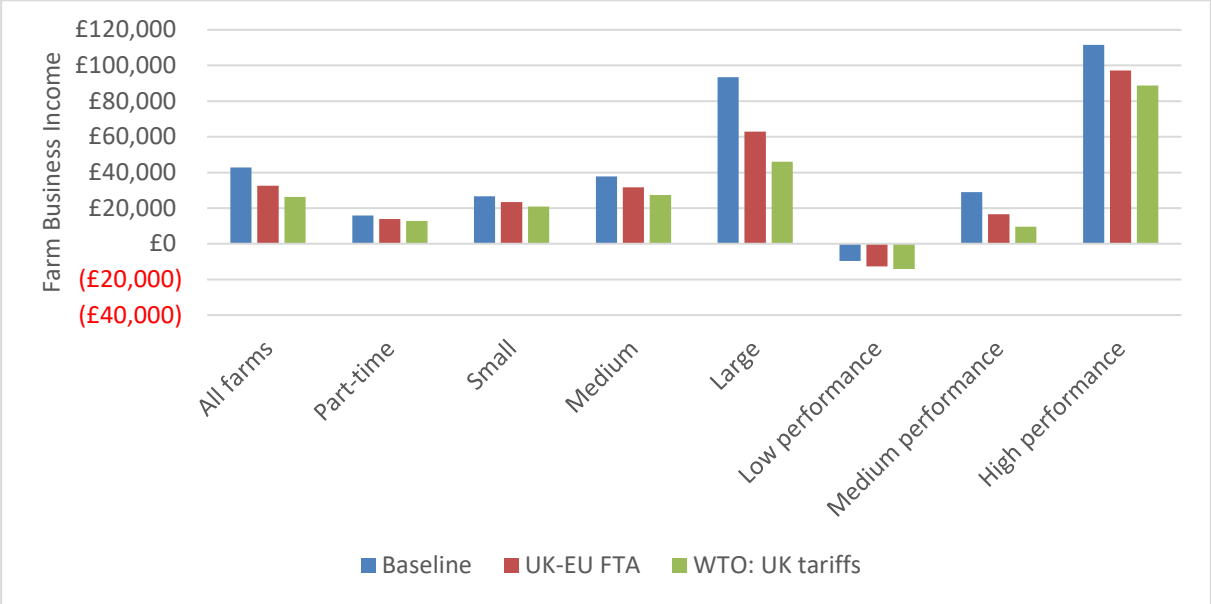



**Figure 5.28: 2022 FBI by farm size and performance level: All farms (England)**

**Sensitivity analysis**

Sensitivity analysis is presented in Appendix 6.

Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±8.37% change in FBI. Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±10.38% change in FBI.

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 38.5% reduction in FBI. A 10 percentage point depreciation in Sterling would result in an 41.6% increase in FBI. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be a 47.3% reduction in FBI and a 52.1% increase in FBI.

### 5.2. Scotland

AHDB plans to work with QMS and the Scottish Government to produce an impact assessment for farm types in Scotland.

### 5.3. Wales

AHDB plans to work with the other HCC and the Welsh Government to produce an impact assessment for farm types in Wales.

# 6. Potential subsequent adjustments

As outlined in earlier sections, the impacts assessed at farm level in 2022 use a static model of the farm business. The revenue and cost structure for each type, size and performance level of business are the average over three years at group level taken from the FBS survey (2015/16 to 2017/18). The impact on Farm Business Income (FBI) of the UK leaving the EU and its Common Agricultural Policy under two different scenarios is assessed by applying, within this structure, changes in individual revenue lines for each major commodity, receipts from subsidies, and some of the cost lines (cost of regular labour, livestock feed, fertiliser and plant protection products). These changes reflect anticipated commodity prices and the pattern of direct income support in 2022. No account is taken of how farm businesses, and the households that operate them, respond to the initial price and income signal (first round impacts), as they almost certainly will.

In order to stimulate thinking about the way in which farms will respond, a literature review was undertaken on adjustment in farming. This covered the basic economics of adjustment, a review of studies of past examples of how farmers are known to have responded, and of drivers of various forms of structural change (such as farm size adjustment, entry and exit decisions, substitution of capital for labour, innovation and investment, and on-farm and off-farm diversification. A generic approach was taken, with the changes not specific to farm types. This review is provided as Annex 3 of this Report, with a summary given below. These longer-term responses were discussed at separate workshops involving AHDB specialists and industry representatives for each of six sectors (cereals and oilseeds, potatoes, horticulture, dairying, beef and sheep, pigs) at which the first-round price and income impacts formed the basis of an assessment of the longer-term likely responses. This literature review and workshops were an alternative to the approach taken for the 2017 Report, when experts from an external, farm-level consultancy were asked to comment on longer-term responses (given for each farming type in that Report).

### 6.1. Short-term impacts and resilience

Brexit carries implications for ***farmer incomes and viability***, though these vary with the scenario chosen and between types of farming. For some, there could be substantial financial pressure, whereas for other the effects are far smaller, or in some cases, even positive. This raised the point in our workshops that, for some, the short-term impacts of Brexit and policy changes might be within the bounds of normal inter-year volatility of prices and incomes that farmers expect and have learned to live with; it might not be reasonable to expect any response to changes experienced in some sectors by 2022. This is why several of the workshops felt it important that longer-term income movements brought about by the phasing out of Basic Payments by 2027 should be made apparent to farm businesses at an early stage, as adaptation by then would become more urgent. This is in line with the finding from the literature review that, while a substantial proportion of farmers may not intend to adapt initially, a higher proportion will take remedial actions once they become convinced that the signals they receive are persistent and reliable. This also accords with another view from the workshops that sometimes a decision not to respond is a positive and rational one; enough information needs to be accumulated, because a premature reaction based on inadequate information may be as risky as one which is too tardy.

There is a difference between a farm's ***resilience*** in the face of short-term adverse shifts in the conditions in which it operates and its ability to adapt to more permanent change. Despite definitional differences between writers, it is clear that ***farm managements should bear in mind both their shorter and longer-term abilities to respond to change signals***. They are likely to experience both. From our workshops the point was made that for adaptation to be relevant it is necessary for short-term resilience to be present to allow businesses to cope in the very short-term with income shocks. Concern was expressed that in some sectors (such as horticulture) margins, especially among small producers, were so small that resilience was threatened.

Farms will vary in their resilience and adaptability, linked to a host of economic, external, internal and social factors that shape farmer behaviour. Policy makers need

to consider elements in the external environment in which farms operate that can facilitate adaptation/adjustment, including the availability of policy tools to facilitate change. A review of international examples leads to the conclusion that ***policy makers often underestimate the ability of farmers to adapt***.

### 6.2. Optimising marginal relationships

Economic theory suggests that in the ***short-term farmers can be expected to respond to changes in product prices (and input costs) in ways that are in line with optimising marginal relationships to maximise profits/minimising losses***. Where there are currently inefficiencies in production, we would expect farmers to seek opportunities to improve the balance between marginal costs and marginal revenues (assuming of course that farmers have the information to enable them to do this). Cost reduction would be looked for, especially in paring away fixed costs. Analysis of enterprise profitability would be expected to lead to rebalancing towards the more profitable and the cutting back or elimination of unprofitable ones, subject to technical constraints such as appropriate land, the need for break crops, etc. and to balance risk. In our workshops we were told of examples of sheep farmers, a sector where indications are that Brexit will lead to severe income reductions, already moving towards switching into dairying where they have suitable land to do so. Such rebalancing could, however, run into a problem of inadequate capacity to process this milk, with perhaps downward pressure on milk prices; decisions among processing firms to invest in additional capacity are driven by purely commercial factors, and there is a disjuncture between decisions at farm level and at sector level; this in turn could prompt vertical integration with milk producers considering adding processing to their activities. Enterprise substitution was also mention on farms that produce both beef and sheep, with the former likely to increase in relative importance where this is possible.

Rebalancing enterprises was also mentioned in our workshops in connection with sugarbeet (where expansion also encounters processing capacity issues) and potatoes, both of which can form a break-crop (with peas and beans) in cereal

farming. The fixed costs of specialised machinery may present a barrier to those not currently producing these crops.

### 6.3. Labour use

A particular issue was how farmers were expecting to cope with reduced availability and higher costs of *labour* after Brexit. Most workshops anticipated rises in the cost of permanent labour in line with the model used in estimating cost changes to 2022 (a rise of 50% in the cost of permanent labour). Some sectors had already experienced increases compatible with this, though among cereal and oilseeds farms it was felt that this increase was too steep by that date. A distinction between the costs of family labour which was paid and of hired, non-family labour could be drawn; the point was made in a workshop that the cost of family labour might not rise as rapidly as for workers where there was no familial link. However, unpaid labour is not included as a cost in the derivation of Farm Business Income and therefore this is not a relevant concern in the output from our modelling work.

Also related to labour, interest in the substitution of capital for labour was mentioned in several workshops, with technical development leading to processes previously undertaken manually being automised (planting of leeks, certain picking operations, potato grading, etc.). This seemed to be a reflection of a mix of rising labour costs and uncertainty over availability; there was a lack of clarity at present in the workshops about the adequacy of SAWS-like provision to supply adequate quantities of casual seasonal labour from EU-27 and a probable reduction in the willingness of regular EU-27 workers already resident in the UK to stay (for financial and other reasons) after the UK leaves the EU.

### 6.4. Expanding economic capacity

All the above are generally within the existing framework of the firm's fixed inputs and costs (such as land area). In the longer-term, more inputs become variable. In particular, ***when there is downward pressure on incomes operators will seek to change farm size so that economies of scale are obtained***. In farming there is strong evidence that farms that are too small experience higher average costs through their inability

to spread their fixed costs, especially family labour, over a sufficient volume of output. However, ***there are alternative ways of expanding economic capacity and income generation, such as diversification or off-farm activities***. Our workshops made clear that the level and importance of pluriactivity and other income sources is often under-estimated (see also below).

Retrospective studies of actual responses to past financial pressures reveal a variety of ways of coping, some of which move in opposing directions (such as expanding or cutting back output). These suggest ***different types of management behaviour among farmers***, details of which vary between authors. This diversity of behaviours underlines the need to take into account the ***heterogeneity of likely response to any change***, such as is represented by Brexit. This could be assisted by developing a typology of farmers using variables that have been shown to influence adaptation. However, to operationalise them by placing farmers in the England FBS sample (used to model the income implications of Brexit scenarios by each of the major quantitative studies currently available) into categories/groups as a way of exploring the longer-term responses of the industry and its sub-sectors would require much more information than is routinely collected and is available on the farm and farm business. It would require personal details (such as education, family status, how the farm was acquired, etc.), histories of past responses, and value statements in response to prompts on issues such as attitude to risk and retirement/succession plans. While it would not be impossible for additional data of these types to be collected in the future, this might not reflect Defra priorities for coverage in the regular FBS or its periodic modules. Nevertheless, appreciation of the typologies may permit some qualitative discussion of the range of responses likely to Brexit.

### 6.5. Structural change

As a response to Brexit, ***structural change is likely to take many forms***, though attention is often given primarily to the size distribution of businesses. The long-established picture of structural change in the UK has been one of a rise in the numbers of large farms and falls among smaller commercial ones, though this is complicated by rising numbers among very small units that are primarily residential

or hobby in nature and not primarily dependent on farming to generate the occupier's household income. Size adjustment can be achieved in various ways, and Farm Business Tenancies play a part in this. In our workshops it was made evident that, for the potato crop, a diversity of tenure arrangements are found, and these are used by specialist growers to have access to suitable land (the key technical requirement); thus specialist potato growers have a relatively flexible approach to enlarging the size of their businesses, and enterprises have been becoming larger, though technical capacity of machinery makes this 'lumpy', with discrete points beyond which only large further growth steps are possible. Ways of arranging production ownership in the pig sector (such as 'bed and breakfast') means that the risks and rewards are split in different ways from simple ownership. However, for the generality of farm types, ***most past adjustments have been studied in times of relative economic stability and gradual structural change; radical shifts in incomes, such as might accompany some forms of Brexit, could present rather different sets of drivers***.

### 6.6. Exit and entry

Exit of existing farmers and entrants of new entrepreneurial talent represents one form of structural change. ***Assessing the impact of Brexit on decisions to exit should not rely in a simple way on what may happen to incomes from agricultural activity***, though anticipated future incomes and income security will play a significant part in shaping exit decisions. The literature demonstrates that the process of leaving the industry is a complex one, affected by many factors both within the farm household as well as external conditions. ***Diversity of income sources, retirement opportunities, taxation, assets held outside the farm and net worth play important roles***. In our workshops we were told that multiple income sources are common, even among large farmers, and are often under-estimated by the industry's commentators.

Exit from farming does not necessarily imply the sale of farmland, even among owner-occupiers. Many of these shapers of exit decisions are not directly affected by Brexit and the changing fortunes of agriculture (for example, inheritance taxation). However, there are several pointers to the importance of expectations of future income levels and to uncertainty (associated with Brexit) as being influences. Several

workshops heard that those most likely to exit tended to be the more able businessmen, as they had the greater opportunities in other industries and the foresight to see where future problems lay in agriculture; they also typically had skill sets that many farmers lacked. Similarly, for entrants, many determinants of the rate of joining the farming industry seem to be not directly affected by Brexit, though the willingness of successors to join the family business, already compromised on farms where profitability is low, is likely to suffer if the future offers only lower incomes or less secure rewards. New entrants need not be full-time in farming; attention was drawn to the significant contribution to output of beef in USA and Canada of farmers who are life-style/hobby farmers.

### 6.7. Innovation and investment

When considering the potential impact on innovation and investment, ***Brexit seems unlikely to affect factors that determine the spread of information that is critical to the awareness that farmers have of innovations***. However, their abilities to implement changes seem susceptible where adoption requires investment. Periods of negative incomes and increased risks, though not universal throughout the industry in Brexit scenarios, are likely to impede innovation and the investments necessary to bring them into use. As usual, the heterogeneity of farms must be borne in mind. In our workshops we were told that, in some sectors such as horticulture, greater mechanisation of processes was underway; the literature shows that the major horticultural growers have for a long time had a close relationship with the science community, with innovations rapidly put into practice. Furthermore, business operators are already taking an international approach to investment, with decisions to set up production in EU-27 for reasons such as access to labour.

### 6.8. Diversification and off-farm income

***Farm diversification and taking of off-farm jobs (or self-employment in non-agricultural businesses) is a possible strategy for farmer households facing income problems from Brexit***. However, a simplistic view should be avoided, as the drivers of existing levels of these phenomena are complex and extend to many factors that are unlikely to be impacted by Brexit, at least in the short and medium-terms.

Countering income pressures in agriculture is only one such driver. However, our workshops found examples where, over time, the number of people working full-time on farms had been greatly reduced as family members progressively made their living primarily outside agriculture. This did not necessarily mean a reduction in the number of farms, or even in the numbers living on them, but represented a decline in the amount of labour resource and thus a form of structural change.

### 6.9. Land prices and rents

Turning to land prices and rents, changes in these would impact on the farming industry in several ways, though at farm business level there would be wide variation due to individual circumstances (including indebtedness). ***Brexit is likely to impact directly on some of the factors that are known to determine agricultural land prices***, though others are more affected by what happens in the broader economy or by changes in legislation that governments may choose to implement. While the directions of change for individual determinants can be foreseen with some confidence, the magnitudes remain uncertain, especially as what has happened in the past is not necessarily a reliable guide to future changes post-Brexit. Furthermore, it is quite likely that individual factors will work in opposite directions (such as downward pressure on farm incomes and flight into land purchase by investors worried by returns in other industries). In this milieu, a clear assessment of what will happen to land prices (or rents) is difficult to assess ex-ante with any degree of precision.

# 7. Conclusions

## 7.1. Estimates of FBI in 2022 for the two scenarios

### 7.1.1. England

The output from the process takes the form of estimates of FBI per farm in 2022 for the two scenarios, (***Scenario A: UK-EU FTA*** and ***Scenario B: WTO, UK tariffs***) and compares them with the baseline of the FBI average of the years 2015/16, 2016/17 and 2017/18.

The general picture for England is that under ***Scenario A: UK-EU FTA***, compared with the baseline, FBI falls markedly in 2022 for the all-farms average and for each individual type of farming, with the exception of the sheep and beef sectors where they remain at close to the baseline level. A key factor in the income drop is the projected increase in labour costs. In most cases at the sector level the reduction in Pillar 1 payments is offset to some extent by the reallocation of support under Pillar 2-type schemes; there will be differences by farm size within this, in line with the difference in the relative importance of Pillar 1 and Pillar 2 payments. LFA beef and sheep is the only sector where production revenue declines under Scenario A. Under ***Scenario B: WTO: UK tariffs***, FBI falls further than under Scenario A. This is driven by the same increases in labour costs, but under this scenario, all sectors see falls in production revenue to varying extents as well.

Attention is drawn to the importance of the contribution to FBI in 2022 of the remaining Pillar 1 payments (mainly under the CAP's Basic Payments Scheme). These Payments are scheduled to be phased out in England by 2027, though the precise pattern has not been announced, nor has what may happen the resources they represent beyond 2022 (the first year of scaling down, when the implication is that the savings will be reallocated to Pillar 2-like schemes). The hypothetical removal of these payments would have a major impact on the remaining income of businesses.

Consideration is given to the causes of the change is estimated FBI (income per hectare for our synthesized potato and carrot enterprises and income per 1,000 birds for our poultry farm) in each farming type. The causal changes are linked to elements of revenue (from the market, from diversified activities, from Pillar 1-type and Pillar 2-type subsidies, etc.) and from variable costs (including feed, fertiliser, casual labour and contracting) and fixed costs (including that of regular labour).

Though in most farming types the FBI under ***Scenario A: UK-EU FTA*** is lower than the baseline, there are variations between types in the size of this gap and its underlying causes. This also applies to the further gap to the FBI under ***Scenario B: WTO: UK tariffs***. A prominent cause of the fall below the baseline in both is the higher costs of regular hired labour, a factor that is independent of the trade relationship, though these are more important in some types of farming than in others because of the different quantities per business that they employ. Consideration is also given at farm-type level to the contribution in 2022 of direct payments due to be phased out by 2027; the implications are more significant for some types that currently receive higher levels of these payments (such as LFA cattle and sheep farms) than those which receive relatively little (such as pig farms).

Despite these variations between farming types, there are some common features within each type. This applies to the analysis by size, where larger farms generally have larger FBIs than smaller ones even under ***Scenario B: WTO: UK tariffs***. But, in particular, analysis by performance level (ratio of the value of output to the value of inputs) sees a consistent pattern in which low-performing farms have lower FBIs that are often negative in both the baseline and in the two scenarios. However, high-performing farms have higher FBIs that are always positive even in ***Scenario B: WTO: UK tariffs*** where incomes are generally lower than in the baseline or Scenario A. The message for businesses is therefore clear; to be most resilient to what might otherwise be adverse economic conditions, they should adapt in ways that enable the business to achieve a relatively good ratio between output and input values.

#### 7.1.2. Scotland

AHDB plans to work with QMS and the Scottish Government to produce an impact assessment for farm types in Scotland.

#### 7.1.3. Wales

AHDB plans to work with HCC and the Welsh Government to produce an impact assessment for farm types in Wales.

### 7.2. Longer-term adaptations

The farm-level model generates estimates of first-order indications of the impact on current income by 2022; it does not take into account the responses that farm operators may make in the face of such signals as they adjust longer-term enterprise mixes, cost structures and embrace more fundamental structural changes, including scale, investment and labour-saving innovation, and exit decisions. These are the subject of a further step in our analysis. A literature review of the wide variety of responses to past income crises ('no-change' being the conscious choice of a substantial number) was discussed with AHDB experts and board members, themselves farmers, with the intention of encouraging a broader consideration of how the farming industry may develop. While the direction of change is usually discernible from the literature, and fleshed out in the discussions, turning these into quantified estimates of structural change is beyond the scope of the present project.

### 7.3. Other comments

Our analysis of the impacts of the scenarios, as with any study of this sort, inevitably involves assumptions and simplifications. As in our 2017 Report to the AHDB, we have attempted to make clear our assumptions and the implications they entail, not least by the use of sensitivity analysis where appropriate (such as changes in exchange rates, in the costs of labour, and shifts in production caused by factors such as weather that can change the UK from being a net importer to a net exporter of a particular commodity). However, it follows that our results in terms of shifts in incomes (FBI) should be regarded primarily as indications of where the greatest economic pressures are likely to be felt within the agricultural industry and the

predominant causes of these changes. It should be remembered that FBI does not include off-farm income earned by farmers and/or other family members, pensions, or interest on (non-farm) investments, etc. Incomes from such non-agricultural sources may enable farms to be sustainable even in the face of negative FBIs, as often applies currently under the baseline for low performing farms and will be the case for some farms when FBI becomes negative under some scenarios. Similarly, capital gains (and losses) are not covered. Nevertheless, anticipated falls in FBI can be a useful indicator of where the AHDB and other organisations tasked with supporting the agricultural industry can best deploy their resources and focus their attention.

### 7.4. Final thoughts

The results in terms of the implications at the farm level for the various scenarios chosen by the AHDB carry lessons for both farmers and for organisations such as the AHDB that support the agricultural industry. As expected, there are substantial impacts on projected levels of FBI. Though these should not be interpreted as precise predictions (see methodology) they are reasoned indications of where the greatest levels of financial pressure on farms will be felt, and to which farmers can be expected to respond by longer-term adjustments, such as structural change (including exiting the sector).

There are significant expected impacts from moving from the present situation to the scenario that involves not only a trading situation that is little different (apart from higher trading costs) but also changes in the pattern of domestic support and higher costs of regular labour (***Scenario A: UK-EU FTA***). The impacts are generally more pronounced when moving to the more extreme scenario that also includes reductions in UK tariffs on imports (***Scenario B: WTO, UK tariffs***). Though for the industry as a whole incomes can be expected to fall in these situations, there are differences between farming types. Trade issues are relevant for all types (sometimes in different directions) and critical for a few. So too is the way that greater restrictions on migrant labour can be expected to affect regular labour costs, with the impact felt most on those types of farming and sizes which employ greater amounts of regular labour.

For most farming types, and thus the industry as a whole, the postulated removal of direct income payments would have a substantial impact on incomes.

Two general findings from our 2017 report can be underlined by this 2019 work. First, the opportunities to influence outcomes or to mitigate them vary, with the ability of farmers, even acting collectively, to influence the outcome of the final trading relationship between the UK and EU likely to be limited, though there are grounds for thinking that the projected impact of an extreme liberal approach to tariff removal contributed to the design of national tariffs that afforded some protection to vulnerable sectors (such as sheep). However, the nature of domestic support in the UK's agricultural policy will be decided at national level (UK or devolved administrations) and can be expected to be more responsive to evidence and proposals. Awareness of the importance of the postulated removal of direct income payments will be useful to the AHDB and to governments, not least in their design of Pillar 2-type schemes that are commonly seen as being easily justified (on public-goods arguments) and pragmatically useful in partially compensating for the withdrawal of Basic Payments. Similarly, a demonstration of the impact of increased labour costs resulting from restrictions on migrant labour should assist with the design of targeted measures to ease this specific problem. Already concession in the restrictions on migrant seasonal labour have been won, though it remains to be seen whether they are adequate to avoid poor availability and higher labour costs (for the purpose of our modelling we have assumed that the measures taken will be adequate). Given that higher regular labour costs contribute in a major way to falling incomes in many farming types by 2022, this is another issue on which a case for a targeted relaxation of restrictions could help the farming sector, though there would be an administrative problem of preventing transfer of workers to other sectors suffering from reduced labour availability.

There are also important messages to be conveyed to the agricultural industry by the AHDB and other organisations that support farmers. Perhaps the most significant is that, according to the evidence, high performing farms (in terms of their output/input ratios) are shown to be in a far stronger position to cope with the changes associated

with the scenarios. This should focus attention on farmers knowing their relative performance (such as by using benchmarking) and on pursuing practical ways of improving output and containing costs. High performance is not necessarily associated with larger farms, and there is the possibility of improving performance across the size spectrum. Another general lesson is the importance of adaptation; the literature points to the proven ability of UK farmers as a group to absorb and adjust to shocks and pressures. Again, support organisations and governments could promote this ability by identifying and tackling constraints; knowledge transfer and skills training are likely to play prominent parts in the assistance provided to farmers.

### 7.5. Proposal for filling information gaps

This review of literature points to the desirability of a number of 'next steps', based on the responses in terms of current production activity, changes to farm size and other structural shifts, exit and entrance decisions, innovation and investments.

Some aspects of Brexit could pose short-term downward pressures on incomes among certain types and sizes of farms, while others might see enhanced prices and incomes, though the speed of onset will be shaped by the transitional arrangements eventually agreed between the UK and EU. Consideration of farmers' past behaviour to combat pressures underlines the heterogeneity. Explaining likely response to any Brexit-induced change needs to embrace both the anticipated (and unanticipated) behavioural adjustment and a typology to explain disparities between farms. This heterogeneity applies to responses in terms of current activities within the general framework of the business (such as cost cutting, rebalancing enterprises, innovation and marginal investments in modernisation), on-farm diversification, development off-farm activities, and exit and succession. In particular, exiting is a complex process which may or may not involve disposing of land.

However, to operationalise the exploration of this wide range of responses would require much more information than is routinely collected by the FBS. It would require personal details (such as education, family status, how the farm was acquired, etc.), histories of past responses, and value statements to prompts on issues such as

attitude to risk and retirement/succession plans. While it would not be impossible for additional data of these types to be collected in the future, this might not reflect Defra priorities for coverage in the regular FBS or its periodic modules.

*We therefore invite AHDB to consider a parallel approach in which a sample of its levy payers could be asked to express their intentions for adjustments to current practice, diversification, innovation, farm expansion, etc.*, though it must be recalled that the literature suggests that intentions do not necessarily translate into action. Past studies provide multiple examples of the sorts of responses that might be explored. Because responses to historic periods of income pressure have been found to be a reliable guide to future intentions, it would be helpful to include questions on past behaviour. But it would also be desirable to collect sufficient socio-economic data to enable a meaningful typology to be used. Again, past studies can be a good guide, and would be expected to include variables such as the composition of the entrepreneurial group on the farm, basic biographical data, education and skills training, other gainful activities, succession plans, attitude to risk and so on. A major element in any such approach would be the refining of methodology, including the stripping down of variables to the minimum required to generate meaningful results.

While a telephone survey is commonly used to gather these sorts of data, other approaches are feasible, with various degrees of personal or impersonal communication, which might be tailored to particular areas or issues. Focus groups could also be employed or, at the other extreme, an online questionnaire. The matter of methodological detail is, however, an issue that follows from the consideration by the AHDB of whether it wishes to commission further work of this nature.

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# Appendix 1: Methodology

The methodology used in constructing this report is essentially the same as used previously in Bradley and Hill (2017). The approach taken is set out below.

## A1.1. Estimation of the impact of policy changes for use in the farm model

Our approach here was different for England, Scotland and Wales reflecting what is known about policy intentions at the time of writing.

### England

All scenarios feature the policy framework which is known for 2022. This entails the first year of reduction in Pillar I support payments which will be removed completely over a seven-year period. This reduction in total Pillar 1 support of £150 million will be disbursed through Pillar 2-type schemes leaving total payments unchanged from the present level. Figures for total support under Pillar I and Pillar II was taken from Agriculture in the United Kingdom[9] for 2015, 2016 and 2017.

Pillar 1 payments were reduced for each farm type group average (and size and performance level within this) by the appropriate amount depending on the baseline payments as shown in Table A1.1Table 2.2.

**Table A1.1: Reduction schedule for Pillar 1 payments**

| Direct Payment band | Reduction percentage |
|---|---|
| Up to £30,000 | 5% |
| £30,000 - £50,000 | 10% |
| £50,000 - £150,000 | 20% |
| £150,000 or more | 25% |

Total Pillar 1 support (for the three years 2015/16-2017/18) was reduced by £150 million and total Pillar 2 support increased by £150 million. The percentage change

[9] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/741062/AUK-2017-18sep18.pdf

in Pillar 2 payments that this entailed (142.2%) each was then applied to Pillar 2 payments for each farm type. The underlying assumption is therefore that the distribution of Pillar II funds will remain as it is currently, although the total disbursed will increase. In increasing support under Pillar II, it is assumed that the infrastructure exists to enable additional funds to be disbursed at the farm level. This implies a combination of more being channelled through existing schemes and the introduction of new ones (such as perhaps payments to farmers under agreements related to animal welfare).

Some important simplifying assumptions should be noted. First, despite Pillar I payments being nominally decoupled, the literature finds some evidence that there may be some links with decisions on production (Howley, *et al.*, 2012; Davis, *et al.*, 2017). However, any impact of reducing Pillar I payments on levels of production and hence on market prices and revenues are ignored in this study. Second, it is assumed that Pillar II payments can be treated as additional income rather than as compensation for income forgone. It should be noted that much of the payments under EU-supported Rural Development Programme (RDP) agri-environment schemes is intended by design only to compensate for any income forgone or higher costs incurred by following prescribed actions; this is set out in the underlying Regulation. If this principle were to be maintained post-Brexit, expansion of Pillar II-type funds would, if strictly applied, leave farm incomes unchanged, which is not the understanding generally given by commentators when this issue is discussed in the media; Alan Swinbank, speaking at a Defra-AES one-day conference (Swinbank, 2018) indicated that, even if interpreted as additions to income and thus not in alignment with WTO rules, there would be a strong likelihood that such payments through agri-environment payments could still go ahead without serious challenge. For simplicity, we have assumed that the expanded Pillar 2-type payments are in effect, a form of area payment for providing public goods.

<u>Scotland</u>

The agricultural policy environment in Scotland remains unknown at this stage, so analysis has been held back until information emerges.

**Wales**

The agricultural policy environment in Wales remains unknown at this stage, so analysis has been held back until information emerges.

### A1.2. Estimation of labour costs for use in the farm level model

Our 2017 literature review found considerable evidence suggesting that labour costs would increase if migrant labour is restricted post-EU exit, though no precise estimates of the magnitude of expected increase were identified. However, an examination of the difference between wages in the construction and manufacturing sectors (ONS data) and the agricultural sector (FBS data) showed that a 52% increase in agricultural wages would be necessary to achieve parity between the sectors. Such an increase would be required before UK labour could be attracted into agriculture from these sectors (perhaps more given the disparities in working conditions) or, put another way, labour in agriculture would need to be pay an increase of this magnitude if it was to retain workers in competition with demand for labour in construction and manufacturing where the firms were facing labour shortages because of EU workers wishing to return home after Brexit.

British Summer Fruits (2017) reported that it expects that prices for strawberries and raspberries will rise by between 35% and 50% as a result of restrictions in access to migrant labour. Working this range through the cost structure of production in our 2017 horticultural model, we estimated that such a price increase would be produced if labour costs increased by around 50%. Based on both these approaches, we therefore assume that limiting the supply of migrant permanent labour under all scenarios will result in an increase in the respective labour costs of 50% as employers need to offer higher wages to attract workers from other sectors to replace lost migrant workers. This assumption was tested in workshops with AHDB experts who found it plausible. While in some sectors it was felt that this full increase would take some time to work through, and may not be fully evident by 2022, other sectors felt that employment costs are already well on the way towards this sort of increase.

Our assumption is that it would be possible to attract the required levels of labour in this way in what in reality is a tight labour market. In practice, a premium might be required to compensate for what are sometimes seen as difficult working conditions.

Discussions with AHDB experts revealed that approximately 30% of contract costs would typically comprise labour. Contract costs were therefore increased by 15% to reflect this on the basis that contract labour is typically employed (by the contractor) on a permanent rather than seasonal basis. A similar approach was taken to cleaning costs in the poultry model, although here labour costs account for 65% of total catching costs.

As with our previous work, we have taken no account of the impact of the National Living Wage which could add 35% to the cost of seasonal wages over the period 2016-2021 (Migration Watch UK, 2016).

### A1.3. Estimation of prices for use in the farm level model

Changes to domestic UK prices of commodities produced by farmers under the original three scenarios were estimated using a gravity model followed by validation by AHDB experts. There is generally a high degree of conformity with the prices derived by other researchers, including Davis, *et al.* (2017) and subsequent, as yet unpublished, updates, although these authors had access to a more sophisticated trade model. Following the reduction from three to two scenarios, our FTA scenario (***Scenario A: UK-EU FTA***) remained the same. Economic logic was used to determine the basis for prices under ***Scenario B: WTO: UK tariffs***. In some cases these prices followed the logic for ***Scenario A: UK-EU FTA***, but with a different (higher) trade friction cost; for example cases were tariffs are set at 0%. In others the logic more closely resembled that under our original WTO scenario, i.e. there are tariffs, but at a lower level than the EU MFN schedule.

It should be noted that there is a great deal of uncertainty around the information made available to allow the estimation of prices under ***Scenario B: WTO: UK tariffs***. For example, the schedule is meant to apply only for one year, after which it is

assumed it will be revised, but with no indication of how. We have had to assume that this schedule remains in place until 2022 in order to estimate price changes for this year. In addition, the EU has questioned the legality of the UK tariff schedule – we have assumed that it would be put into effect. Finally, HM Treasury has indicated that all imports from Ireland would be able to enter Northern Ireland without tariff. This though is at odds with the tariff schedule. If this approach were possible, then it is hard to see how goods imported into Ireland from the rest of the EU could then be prevented from entering the UK without tariff. We have had to ignore this issue in our analysis.

EU and world prices for 2022 were taken from the European Commission's EU Agricultural Outlook: Prospects for EU agricultural markets and income 2018-2030, December 2018 edition.[10] Domestic production, consumption and net trade data were taken from Defra statistics.[11] An average of the 2013-2017 period was used to smooth out annual volatility.

In order to calculate the impact on UK domestic prices it was necessary to select appropriate tariff lines. We used the EU's WTO MFN bound tariffs for UK exports and the UK tariff schedule released on 13 March 2019 for imports. In some cases, this was straightforward (commodity crops), but for the beef sector a trade weighted average was used (this was constructed with the assistance of AHDB sector experts and reflected the composition of imports to the UK). A specific solution to the carcase balancing issue was developed (see below).[12]

The impact of the two trade variants was calculated for each commodity. In terms of trade friction, in 2017 we assumed a cost of 5% under an FTA and 8% outside such an arrangement, in line with the literature (Berkum, *et al.* (2016) and Davis, *et al.* (2017)

[10] https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/medium-term-outlook-2018-report_en.pdf

[11] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/741062/AUK-2017-18sep18.pdf

[12] Davis, *et al.* (2017) select specific tariffs rather than using a trade weighted average.

used the same percentages to reflect trade friction costs). However, for this 2019 research we adopted the more sophisticated trade friction costs used in the updated FAPRI work; this applied different trade friction costs for crops and livestock products, reflecting the higher costs associated with trade in livestock products. The trade friction costs used are shown in Table A1.2 .

**Table A1.2: Trade friction costs used**

| | Crops | Livestock products |
|---|---|---|
| Scenario A: UK-EU FTA | 2% | 5% |
| Scenario B: WTO: UK tariffs | 4% | 8% |

Some adaptations were required for commodities (and market segments) where the UK is a net exporter (barley and oilseed rape). Here the assumption was that additional transaction costs and tariffs (a weighted average of the tariffs in the UK's main export markets by commodity), would effectively lower the price at which UK exporters could sell on the world market, and UK prices were reduced accordingly. In these cases, the world price also provided a floor below which UK domestic prices could not fall, as at this price point, commodities would be exported rather than sold at a lower price within the UK (under the assumption that a market is available) (see also below).

In the case of imports, in all cases the lower of the EU and RoW adjusted price was used to estimate the impact of the scenarios in the gravity model reflecting the fact that, *ceteris paribus*, imports will be drawn from the lowest cost producers. In reality the situation is more complex, with the logistics chain, established supplier relationships and any standards on imports potentially ruling out access to imports from some markets.

The gravity model requires a number of assumptions which do not necessarily reflect reality and, for this reason, the prices produced were discussed with AHDB experts to validate them. First, trade is net and assumes product homogeneity. This means that no account is taken of trading complexities such as an import requirement for bread wheat and an exportable surplus of feed wheat; market segmentation also results in

different prices for what are, in effect, different commodities. The situation in relation to livestock products is more complicated and required consideration of carcass/market balancing (see below). It is, though, not possible to take account of the carousel trade (where product is exported and then reimported after processing). The gravity model also assumes that there is always product available to be imported and that this product is homogenous in its characteristics. These simplifying assumptions are common to all but the most sophisticated trade models.

The gravity model requires the selection of values for supply elasticity and for price elasticity of demand.

- *Supply elasticity:* this reflects the ability of the agricultural sector to increase or decrease the quantity supplied over a given period in response to price signals. The value can range from 0 (no ability to respond; completely inelastic) to infinity (completely elastic). In practice, the supply elasticity in agriculture in response to rising prices is effectively 0 in the short-term (as once a crop is planted and inputs applied, there is nothing that can be done by farmers to expand output until next season) with elasticity increasing as the time period under consideration is lengthened. An elapsed time of several years may be required to make fundamental changes such as switching between dissimilar enterprises. Responses to falling prices may show a different elasticity; crops may be ploughed in and breeding animals slaughtered, though there will be a reluctance to reduce capacity if there is a prospect of price recovery. Supply elasticities are notoriously difficult to estimate and come with significant caveats. The limited literature available suggests that supply elasticities are relatively low in agriculture and we have used a value of 0.5 which means that a 10% change in price would induce a 5% response in supply.
- *Price elasticity of demand:* this reflects the change in quantity demanded per time period as prices increase/decrease. For 'normal' goods, as price increases, demand decreases and *vice versa*, coefficients are negative. As a general principle, essential goods and those that are relatively inexpensive have a lower price elasticity of demand than higher priced 'luxury' goods. The availability (and price) of substitute goods is also a determining factor. Demand elasticities

assessed at the farm gate will differ from those at retail level (where measurement usually takes place), being generally lower. However, there is little guidance from the literature which is directly relevant here; Andreyeva, *et al.* (2010) found that studies reporting price elasticities for food products in the US between 1938 and 2007 placed these in a range between -0.27 and -0.81, depending on the product with values for staple products tending to be lower. Price elasticity is likely to have changed over time as levels of disposable income have changed and as the availability and price of alternatives have moved; it does not follow that elasticities in this time period in the US shed much light on price elasticities in the UK post-exiting the EU. We have assumed a price elasticity of demand of -0.5, which means that if prices increase by 10%, demand falls by 5%.

Estimates of prices on the domestic market are sensitive to changes in both the elasticities used. Increases (decreases) in the price elasticity of demand or in the supply elasticity result in lower (higher) price changes. Sensitivity analysis on the prices used is carried out in Appendix 6.

### A1.3.1. Carcase balancing

Estimating price changes in the livestock product sector is complicated due to the complexity of trade. The first complexity is created by the ***carcase balance trade***. IMTA (2013) explains that profitability in the meat sector requires the matching of demand to all parts of the carcase. For example, the three-quarters of the chicken carcase which is left after removing the breasts is less valuable, but still has to be valorised or disposed of at a cost. There is high UK demand for chicken breasts, but relatively low demand for other cuts including dark meat and feet. This means that the net trade position can mask considerable inflows and outflows of specific cuts such as imports of breast meat and exports of legs, wings and feet. IMTA (2016) estimates that UK production would need to increase by 124% to meet the demand for breast meat; this would leave an additional 1.3 million tonnes of non-breast meat which would need to be exported or otherwise disposed of.

There are similar issues in the pigmeat sector where there is an import requirement of some specific cuts and an exportable surplus of others. In the dairy sector the issue relates to trade balances for butter, cheddar cheese and milk powder; this is a *market balance issue*. The situation in the sheep sector is slightly different; here the issue is one of high domestic demand for lowland sheep, met in part by imports from New Zealand, and an exportable surplus of upland sheep, again a form of market balance issue.

The addition of extra costs in the form of tariffs and/or trade friction costs would act on both imports and exports, rather than simply net trade. This is a level of sophistication which it is difficult to cater for, even in sophisticated models. For example, Berkum, *et al.* (2016) explain that their price change calculations within the AGMEMOD model are based on net trade. Davis, *et al.* (2017) explain that the imposition of WTO MFN tariffs on low value cuts which are exported from the UK to the EU would lead to the collapse of this market. These authors explain that since these cuts are valued more highly outside of the EU, it is assumed that the UK is able to find markets in the rest of the world and total export levels can therefore be maintained at the current level. However, this is a contentious assumption and in many cases world prices are certainly lower than those in the EU where UK exports currently incur no trade friction costs and no tariffs. We have used a more sophisticated approach that tackles the carcase balance/market segmentation issue directly.

In all cases the market was segmented by cut or product to create a disaggregated balance sheet. For items for which the UK is an importer, the gravity model was used to estimate price changes for each market segment. For items in which the UK is an exporter, prices were determined by the market to which they were sent. The price changes were then combined in a weighted average to reflect the composition of the entire market. Thus, the impact of prices in market segments where the UK is an exporter were also taken into account. The help of the AHDB in establishing the disaggregated market segments is gratefully acknowledged.

One further consideration was taken into account in establishing the change in poultry prices. In line with our initial work for the NFU on the structure of the UK broiler market, it was decided to consider fresh and cooked/processed meat as effectively two disconnected markets. Only the fresh chicken market was considered when estimating price changes to use under the scenarios. It was further decided not to allow the gravity model to source fresh chicken imports from outside the EU to reflect the fact that it is considered unlikely that fresh chicken can be supplied from low cost producers such as Brazil and Thailand because of the length of the supply chain.

### A1.3.2. Input prices

As noted above, account is taken of changes in labour costs as this is a key variable within the scenarios. However, Bradley and Hill (2017) took no account of the other major input costs, fertilisers and plant protection products beyond a reduction in regulatory compliance costs under one of the examined scenarios; this analysis has not been included here. In recognition that Brexit could impact the price of these inputs it was decided to assess whether this could be taken into account across all three scenarios.

**Fertilisers**

***Estimations of changes in fertiliser costs*** were made outside of the gravity model due to a lack of suitable data and difficulties in estimating the elasticity of demand. Over the five-year period 2014-2018, the UK has been a major net importer of fertiliser as shown in Table A1.3.

**Table A1.3: UK trade in fertiliser 2014-2018 (tonnes)**

| | 2014 | 2015 | 2016 | 2017 | 2018 | Average |
|---|---|---|---|---|---|---|
| **Urea** | | | | | | |
| Imports | 865,737 | 936,216 | 1,121,946 | 875,719 | 316,220 | 823,168 |
| Exports | 21,184 | 34,556 | 40,699 | 33,170 | 6,488 | 27,219 |
| **Urea Ammonium Nitrate** | | | | | | |
| Imports | 258,418 | 289,697 | 340,919 | 361,978 | 84,432 | 267,089 |
| Exports | 394 | 466 | 197 | 903 | 943 | 581 |
| **Liquid Ammonium Nitrate** | | | | | | |
| Imports | 53 | 34 | 246 | 33 | 28 | 79 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Exports | 2,405 | 1,670 | 2,142 | 2,003 | 155 | 1,675 |
| **Ammonium Nitrate** | | | | | | |
| Imports | 57,832 | 57,832 | 57,832 | 57,832 | 57,832 | 57,832 |
| Exports | 87,783 | 140,524 | 74,303 | 182,225 | 2,921 | 97,551 |
| **Combined** | | | | | | |
| Imports | 1,182,041 | 1,283,779 | 1,520,943 | 1,295,563 | 458,512 | 1,148,167 |
| Exports | 111,767 | 177,217 | 117,341 | 218,301 | 10,508 | 127,027 |

Source: HMRC.

Assuming that farmers are not able to substantially reduce their use of fertilisers, after Brexit they will have to bear trade friction costs on imports from the EU and pay the 6.5% tariff set out in the UK no trade deal tariff schedule. An average of 46% of imports are from the EU over the period examined. To estimate the increase in fertiliser costs, trade friction costs were applied to the proportion of imports coming from the EU (in line with the FAPRI work these are 2% and 4% for Scenarios A and B respectively). The tariff of 6.5% was then also applied to this proportion of imports under Scenario B. It was assumed that there would be no change in costs for the proportion of fertilisers imported from outside the EU as there is no reason for this to change as a result of Brexit. The resultant price changes on the UK market were estimated as:

- *Scenario A: UK-EU FTA:* +0.92%
- *Scenario B: WTO: UK tariffs:* +4.86%

Plant protection products

The classification of plant protection products for trade purposes is very complicated. In addition to products categorised as insecticide, herbicide, etc., specific chemicals used in plant protection products are also separately categorised. An analysis at the 4-digit HS code level (3808) shows that the UK is a net exporter of these products. This implies that while there may well be an impact on the UK's plant protection product sector post-Brexit, when the 54% of these exports which currently go to the EU face trade friction costs and possibly tariffs or have to find alternative markets, there should be no impact on the prices faced by UK farmers. However, drilling down into the detail shows that while the UK is a net exporter of insecticides and fungicides,

it is a net importer from the EU of herbicides (it is a net exporter outside the EU). In theory, it would therefore be possible to segment the market to allow an estimation of price impact post-Brexit to be derived. Unfortunately, the FBS data do not split plant protection products by type and therefore assumptions would be necessary which would be likely to differ by farm type. These data problems meant that it was not possible to estimate price changes for plant protection products.

### A1.3.3. Price estimates

The changes to domestic prices produced by the gravity model, and validated by the AHDB experts, are shown in Table A1.4. It should be borne in mind that this is a considerable simplification of reality (see above). The economic logic underpinning the price changes for each commodity is as follows:

- **Wheat.** The UK has a relatively small import requirement for wheat. As trade friction costs are applied to imports from the EU, the cost of imports increases. This allows UK domestic prices to rise to replace some of these imports. Because the import requirement is small, only a small price increase takes place before imports cease. If the import requirement were larger, the price response would be more substantial. The difference in price increase between the two scenarios reflects the different trade friction costs; no tariff would be placed on imports of wheat under the UK's published tariff schedule.
- **Barley.** The UK is an exporter of barley. The imposition of trade facilitation costs and tariffs (by importing countries) will make UK exports more expensive abroad, thus reducing the UK's ability to export. There is therefore greater availability on the UK domestic market which depresses prices. Under ***Scenario A: UK-EU FTA***, the UK price will fall (because of the additional costs faced by EU importers) but cannot fall far before exports become economically viable once more. Under ***Scenario B: WTO: UK tariff***, UK exports to the EU would be faced with a tariff of €93 per tonne and this would make UK exports uncompetitive. The main global importers of barley are China and Saudi Arabia. China imposes a tariff of 3%, while exports to Saudi Arabia are tariff-free. Our assumption is that UK exports could take place to these markets with an import-weighted tariff of 1.6% plus

trade friction costs. These additional costs mean that the price fall is larger than under Scenario A.

- **Oats.** The UK has a very small net import requirement for oats. Although there would be no tariff on oats under the UK's published tariff schedule, trade friction costs would result in very small price increases (higher under scenario B).
- **Oilseed rape.** The logic behind the price changes for oilseed rape is the same as for barley, but it should be noted that the EU imposes no tariff on imports of oilseeds as there is a structural deficit in vegetable protein. This means that the only difference in price impact between the two scenarios derives from the higher trade friction costs under ***Scenario B: WTO: UK tariffs***.
- **Potatoes.** Potatoes are largely traded in processed form and the UK has a substantial import requirement. Under both scenarios, imports become more expensive due to the costs of trade friction (higher under Scenario B); the UK tariff schedule shows that no tariffs would be applied to imports. The trade friction costs would allow UK domestic prices to increase.
- **Carrots.** The UK has a small import requirement for carrots (5.5% of total consumption). Three-quarters of these imports are drawn from the EU and this proportion of imports would be subject to additional trade friction costs under both scenarios (higher under Scenario B); there would be no tariff on carrots under the UK's tariff schedule.
- **Sugarbeet.** The sugar sector is complicated. The UK has a net import requirement which is met through a combination of raw sugar imports under various EU trade agreements and imports of white sugar from the EU, the proportion of which has increased following the removal of sugar quota. Under ***Scenario A: UK-EU FTA***, EU sugar imports would be subject to trade friction costs which would increase the price of imports slightly; there would be no change in access from outside the EU. However, under ***Scenario B: WTO: UK tariffs***, imports from the EU would be subject to a tariff of €150 per tonne which would make the EU an uncompetitive supplier. The UK has negotiated a range of bilateral agreements which provide for preferential access at 0% tariff for raw sugar. A series of TRQs has also been set up at a tariff rate of €98 per tonne with various specific countries. This means that countries eligible to supply the UK at 0% tariff are able to increase prices

above world prices up to this tariff barrier without fear of competition. In practice it is expected that the combination of this tariff protection and the limited competition between suppliers at 0% tariff will result in raw sugar being supplied to the UK at a small premium, around €50 per tonne, to the world price. Because the EU is currently able to supply the UK with sugar at world prices, this implies a small increase in import prices under this scenario.

- **Milk.** There is virtually no trade in liquid milk. With the help of the AHDB, the market was segmented into the main traded commodities: butter, cheddar cheese and milk powder. Price changes were estimated for each under both scenarios (the UK is a net importer of butter and cheddar cheese, but has an exportable surplus of milk powder). The UK tariff schedule shows tariffs of €605 per tonne for butter and €221 per tonne for cheddar cheese under a no EU trade deal exit; trade friction costs also apply. The estimations showed increases in prices for cheese and butter under both scenarios and a fall in prices for milk powder as UK exports to the EU are diverted to Pakistan. A weighted average price change for raw milk was constructed using the AHDB's AMPE and MCVE coefficients which relate changes in the price of milk products back to farmgate milk prices (Milk Market value).[13] This suggested small increases in domestic UK prices.
- **Beef.** As a net importer of beef, under ***Scenario A: UK-EU FTA***, trade friction costs would allow UK beef prices to increase slightly as the EU would remain the key supplier; cheaper beef from South America would remain uncompetitive on the UK market due to the high EU MFN tariff. However, if a trade agreement is not reached with the EU, the UK government would introduce a Tariff Rate Quota approximately equal to two-thirds of current beef imports. The logic behind this is that around a third of UK beef imports are made up of the carousel trade under which UK beef carcases are exported to the EU for further processing and then reimported as, for example, mince. In recognising that this trade would no longer be economically viable if exports were subject to tariffs (even if the following

[13] The Milk Market Value (MMV) is a weighted average of AMPE and MCVE on a 20:80 basis. The AHDB has found this to be the best predictor of movements in farmgate prices based on historical data (the analysis was done excluding prices paid on retailer-aligned contracts). Further information can be found here: https://dairy.ahdb.org.uk/market-information/milk-prices-contracts/market-indicators/projected-farmgate-price-movements/#.XI9pUMn7Tct.

imports were not), the government is assuming that this beef would in future be processed within the UK (this would be subject to processing capacity). The TRQ would allow the UK's import requirement to enter at 0% tariff. However, this TRQ would be open to all exporters and therefore EU supply would come under competition from lower cost suppliers. Allowing for this, under ***Scenario B: WTO: UK tariffs***, our gravity model estimated that there would be a decrease in UK beef prices.

- **Sheep.** Under ***Scenario A: UK-EU FTA***, it is assumed that the TRQs currently in place are retained and that UK exports to the EU are also maintained at the current level, through with a small decrease in UK price resulting from additional trade friction costs. In the event of failing to agree a trade deal with the EU (Scenario B), the UK government will retain the EU MFN tariff and, we assume, the New Zealand TRQ in an effort to protect the sheep sector from the serious consequences of competition from cheaper imports. However, UK exports to the EU would become subject to tariffs and trade friction costs resulting in a severe loss of competitiveness which would force exports to look elsewhere at world prices thus depressing domestic UK prices. Under this scenario UK sheep prices fall considerably.
- **Pigs.** The UK has a large import requirement for certain pig meat cuts, but an exportable surplus of other market segments, most notably whole and half-carcases of cull sows. With the help of the AHDB, the pigmeat market was segmented into a number of fresh and frozen cuts and whole and half-carcases. Market balances were developed for each and price changes estimated using the gravity model for imported cuts, taking into account the UK tariff schedule in the event of a failure to agree a trade deal with the EU; for exported cuts the price in destination markets was adopted, adjusted for tariffs and trade friction costs. These price changes were then used to produce a weighted average price change for the farm-gate pig price which reflects carcase/market balancing. The end result was a small increase in pig prices under ***Scenario A: UK-EU FTA*** and a decrease in prices under ***Scenario B: WTO: no tariffs***.
- **Poultry.** In line with Bradley (2018) and Davis, *et al.* (2017), only the market for fresh chicken was considered. This was segmented in to whole birds, chicken

breast and dark meat. Under ***Scenario A: UK-EU FTA***, imports from the EU are subject to trade friction costs which increases the price of the whole bird and breast markets. However, the trade friction costs imposed on the UK's exports of dark meat lead to a decrease in domestic UK price for this segment of the market. In the event of failing to agree a trade deal with the EU, the UK government would open a TRQ to allow imports of fresh chicken to continue with the intention that prices would remain more or less unaffected. Unlike the beef market, it is not likely that lower cost fresh product would enter the UK from outside the EU because fresh chicken has a short shelf-life (Bradley, 2018). We therefore assumed that the only impact on the cost of imports under Scenario B would be additional trade friction costs. A weighted average by carcase value was used to produce a final UK price change for poultry reflecting the increases in price of whole birds and breast meat and the decrease in value achievable for dark meat.

**Table A1.4: Price changes on the domestic market used in the farm-level model**

| | Scenario A: UK-EU FTA | Scenario B: WTO: UK tariffs |
|---|---|---|
| Wheat | +2.27% | +3.59% |
| Barley | -2.00% | -12.10% |
| Oats | +0.09% | -2.98% |
| Oilseed rape | -2.00% | -4.00% |
| Potatoes | +1.79% | +3.58% |
| Carrots | +1.20% | +2.41% |
| Sugarbeet | +0.82% | +1.12% |
| Milk | +2.57% | +3.78% |
| Beef | +4.30% | -6.11% |
| Sheep | -5.00% | -24.97% |
| Pigs | +3.43% | -4.82% |
| Poultry | +1.49% | +2.32% |
| Purchased feed and fodder* | +0.73% | -0.76% |
| Poultry feed+ | +1.28% | +1.12% |

* Purchased feed and fodder is (by value) 63% wheat, 20% barley, 15% OSR, 2% peas and beans.

+ Poultry feed is (by value) 65% wheat, 10% barley, 25% soybean.

## A1.4. The farm level model

While the process described above enables estimates of changes in support payments, labour costs and commodity prices to be generated, these need to be translated to change in Farm Business Income (FBI) to assess the impact at farm level. A series of micro-economic models were built using Farm Business Survey (FBS) data drawn from England, Scotland and Wales. In order to assess the impact of the scenarios on Farm Business Income (defined as total output minus total costs)[14], output was sub-divided into:

- Revenue from production output
- Revenue from Pillar I subsidies
- Revenue from Pillar II schemes
- Revenue from diversification activities

For the same purpose, total costs were sub-divided into fixed and variable costs. Fixed costs were identified as:

- Regular labour (paid)
- Machinery running costs
- Machinery depreciation
- Depreciation of glasshouses & permanent crops
- Bank charges & professional fees
- Water, electricity and other general costs
- Share of net interest payments
- Write-off of bad debts
- Rent paid
- Maintenance, repairs and insurance
- Depreciation of buildings and works
- Miscellaneous fixed costs (including for work done on other farms)

Variable costs were identified as:

- Seeds
- Fertilisers

[14] Further expressions of profitability are also used by the FBS which go beyond FBI to include, for example, changes in the value of breeding livestock, land, etc.

- Crop protection
- Other crop costs
- Purchased feed & fodder
- Home grown feed & fodder
- Veterinary fees & medicines
- Other livestock costs
- Casual labour

Averages of three years' data were used to smooth out annual variations which could otherwise present a misleading picture. The latest data available allowed the inclusion of data from 2015/16, 2016/17 and 2017/18. All data were converted to 2017/18 prices.

### A1.4.1. Model construction

The base for each sector model used in our study was the average farm of that type within the FBS sample. Defra publishes FBS data for all farms classified as, for example, dairy, in which the activities undertaken are summed and then divided by the number in the sample. The average dairy farm therefore has a certain number of dairy cows, certain areas of specific crops, etc.[15] Sub-sector models were produced within each farm type for part-time (in effect, very small), small, medium and large farms, and also for low, medium and high performance farms, using published Defra FBS statistics as the base (some breakdowns were not available for some sectors for disclosure reasons) (see Box A1.1 for the basis of categorisation).

**Box A1.1: FBS categorisation of farms by type, size and performance**

Details of how the FBS classifies businesses by type and size are reported by Defra[16]. Classification of Farm Businesses by type is based on the contribution of different enterprises to Standard Output. For example, to be classified as a dairy farm, two-thirds of the Standard Output must come from dairy cows.

[15] The composition of the different farm types can be accessed from: https://www.gov.uk/government/statistics/farm-accounts-in-england

[16] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/365564/fbs-uk-farmclassification-2014-21oct14.pdf

Standard Labour Requirements (SLRs) are used to provide an estimate of the total amount of standard labour used on the farm based on a calculation by livestock and crop types. The use of SLR (rather than actual labour requirements) means that account is taken of different levels of mechanisation. Farms are then classified according to the number of full-time equivalent (FTE) workers. For example, part-time farms are those where the labour requirement is between 0.5 and 1 FTE (it does not mean that in practice the farm is operated part-time); a medium sized farm has a labour requirement between 2 and 3 FTEs.

Farms in England and Wales are allocated to performance bands according to the ratio of total farm output divided by total farm costs. Total costs for this calculation include an adjustment for unpaid manual labour. The farms are then ranked with the bottom quartile making up the low performance group and the top quartile the high performance group; the remaining farms in the middle make up the medium performance group. This ranking is independent of farm type, so it is possible that certain farm types are over/under represented in specific performance groups.

In order to produce a model to be used to address the AHDB scenarios it was necessary to deconstruct published FBS data, such as output from production, into its component parts so that elements could be varied to represent the scenarios.[17] The model was validated by comparing the values produced to the original data; there are some minor differences due to rounding, but all modelled values were within less than 0.5% of the original data, and most were within 0.1%.

The sub-sector models (farm size and performance level) had to be constructed differently to the main sector models because some data are not available at the necessary level of disaggregation. For example, financial output for individual crops is available for the main farm types, but for different farm sizes and performance levels within farm type, output is only published for all cropping enterprises and all

[17] The FBS does not permit access to farm-level raw data by which this might be done directly.

livestock enterprises. To counter this, the contribution of different enterprises to total cropping output/livestock output for all farms was used as a key to distribute total output for the different farm sizes and performance levels by enterprise. This approach means that the total crop and livestock financial outputs match the FBS data for specific farm types and performance levels, but the financial outputs for individual enterprises are estimates. The same approach was used to distribute fixed and variable costs. These sub-sector models were validated in the same way as the main models.

Before turning to the results, it is necessary to reflect on how they should be interpreted. The price changes at the market level, shown in Table A1.4. above, are used as input to our farm-level model to assess their implication for Farm Business Incomes for businesses of various types of farming, economic size and performance level. This two-stage approach is common in this sort of work, including Berkum, *et al.* (2016) and Hubbard, *et al.* (2018). However, it must be recognised that some supply response from the industry as a whole to changing prices resulting from the imposition of tariffs has already been incorporated into the commodity price movement through the elasticity of supply coefficient adopted.

Furthermore, the impact at farm level of shifts in labour costs, regulatory costs and product prices assumes that the production structure remains fixed, so that changes in these elements translate directly into changes in FBI without farmers making adjustments to optimise the new marginal relationships (though the model does incorporate allowances for changes in costs of feed for livestock associated with changing cereal/oilseed prices and for changes in fertiliser prices). These short-term adjustments could be expected to soften the drops in income that emerge from our farm-level models and increase the positives.

In reality, farmers would also be expected to make further rounds of adjustments (scale, enterprise substitution, etc.) that would impact on their incomes; we take these into account in Chapter 6, with the relevant literature covered in Appendix 5. As indicated previously, the upshot is that the implications for FBI produced by the

assessment process are best regarded only as indicators of where financial pressures resulting from the scenarios are likely to be most severe (types of farming, levels of performance, etc.).

# Appendix 2: Key points from the 2017 literature review

The full literature review was given as Appendix 2 to the 2017 Technical Report to the AHDB (Bradley and Hill, 2017). This showed that, in terms of considering the impacts arising from the chosen scenarios, the literature was characterised by a small number of studies that were of direct relevance (most pertinently Davis, *et al.* (2017) and Berkum, *et al.* (2016)) and a long tail of publications that were marginal.

The key points which emerged from the literature review are set out in the sub-sections below. The overall conclusion was that the (then) existing literature could, to varying extents, throw light onto the impacts of the scenarios chosen by the AHDB as the basis for the 2017 study. However, none were sufficiently close to avoid the necessity of taking an independent approach.

## A2.1. General points

- Sector-level models (as used by some of the prominent studies, such as that by LEI for the NFU (Berkum *et al.*, 2016 and Davis, *et al.*, 2017) are dependent on the assumptions and coefficients built into them. Policy scenarios that represent large shifts (such as are represented by some of the scenarios put forward by the AHDB) and contain the potential to trigger structural changes are less suitable for modelling, and any results should be interpreted with caution. Davis, *et al.* (2017) make the point that some of the projected price changes go beyond the range of variation on which the FAPRI model is calibrated and note that this adds some uncertainty to their projections.
- Static analysis at the farm level to changes in policy, prices and/or costs ignores the behavioural responses by farmers, including by both short-term adjustments and longer-term structural change, investment and innovation. These could be considerable. Again, first round impacts should not be interpreted as the final adjusted position.

## A2.2. Support under UK domestic agricultural policy

- It is widely assumed in the literature that Pillar I payments to UK farmers will be reduced or terminated post-exiting the EU (though assurances by the Conservative government indicate that the total level of support will be maintained to 2022).
- It is also widely assumed that Pillar II payments, encompassing agri-environment and other payments under the Rural Development Programme, will be at least continued post-exit from the EU.
- Both forms of support will be/are devolved responsibilities, and different patterns and levels may emerge in the constituent countries of the UK.
- Static analysis can easily show that removing or scaling back Pillar I payments would have significant impacts on Farm Business Income, and would be particularly damaging for certain farming types (such as LFA livestock farms). However, it is also pointed out that farmers have a history of adaptation and adjustment, so in the longer-term the impacts could be very different.
- Defra's analysis on the initial impact of cutting the level of Pillar I payments on income distributions, based on averaging figures on individual farms over five years, shows a predictable shift towards lower incomes.
- There is evidence that there is a wide variety of responses at the farm level to economic shocks. However, the proportion of farmers who intend to 'carry on as before' in the face of economic signals declines with greater persistence of these signals, and more fundamental changes are explored.
- Policymakers have in the past frequently under-estimated the ability of farmers and their households, as a group, to adjust to economic shocks. Given adequate notice, transitional arrangements, which may be advocated on economic, welfare or political economy grounds, may be unnecessary. However, experience in New Zealand points to the contribution that can be made by an exit package, financial advice and support to household consumption.
- Though Pillar I payments are nominally decoupled from production decisions, there are links that impinge on production decisions, so that removal of such payments could be expected to impact on output. Though more likely to affect sectors that are relatively large recipients of such payments, the extent of this output link in the UK is not well established.

### A2.3. Labour costs

- Several studies have considered the implications of leaving the EU for the supply of labour to the UK agricultural industry, and specifically the way that the supply of migrant labour will be affected.
- It is widely assumed that restricting access to migrant labour will cause difficulties for agriculture and the wider supply chain, with the greatest impact likely to be seen in the horticulture sector. The impact of these restrictions is assumed to be reflected in the labour costs faced by agricultural businesses.
- Wages are not the only factor in attracting labour. A lack of available UK labour and the perception of difficult working conditions are likely to exacerbate the difficulties in replacing migrant labour by UK employees.
- Some prominent studies have omitted any consideration of labour costs. The NFU-LEI research project on the UK's exit from the EU (Berkum *et al.*, 2016), with its modelling of commodity prices and trade, did not include any movement of labour costs, an important gap especially with the horticulture sector. Labour cost changes were also beyond the scope of the FAPRI analysis (Davis, *et al.*, 2017).
- There is no direct evidence on the magnitude of the likely increase in labour costs associated with leaving the EU. However, there is evidence on the impact of higher labour costs on output prices, which can be used to estimate the implied increase in labour costs.

### A2.4. Trade arrangements

- Leaving the EU Single Market (even though remaining in a Customs Union or Free Trade Area with the EU) will incur additional costs to trading, in the form of more border controls, checks on regulatory compliance, etc. For commodities that the UK imports, this will lead to a rise in market prices for UK farmers. *Ceteris paribus* this will lead to greater domestic production (replacing imports), and farm incomes will increase. (The quantity demanded in the UK will also be reduced by the rise in market prices.)
- Trading relationships that involve placing import taxes on trade coming into the UK from the EU will take this increase in market price a stage further, resulting in

higher prices and higher incomes for UK farmers, further expansion in domestic production and reduced imports. A similar effect will come from raising existing tariff levels. (Note: this effect on prices will cease once imports have been reduced to zero.)

- Trading relationships that open the UK market for commodities that UK agriculture produces to low-cost suppliers will lower the market price received by British farmers, cause them to supply less, and put downward pressure on their incomes.
- Where the UK exports farm output to the EU, more impediments (border checks, etc.) or tariffs (if applied by the EU on goods from the UK) are likely to depress the prices received by UK farmers.
- Only the NFU/LEI study (Berkum, *et al.*, 2016) and Davis, *et al.* (2017) quantify price shifts in these scenarios, and they do so for a range of commodities. However, there is a lack of clarity in the information available on the NFU/LEI methodology that suggests alternative approaches should also be employed, such as the use of a range of possible price shifts or sensitivity analysis.
- Real markets are often far more complex than can be assumed in trade models, and additional factors (such as consumer preferences for credence attributes like place of origin) need to be considered. Similarly, many commodities are not homogeneous, for example, lamb which can be differentiated by age, cuts, specification and seasonality.
- Currency exchange rates, as between £ Sterling and the Euro, influence competitiveness. A change here can easily outweigh any cost advantage arising from comparative advantage.
- Some costs of production in the UK will be affected by trading relationships and can influence farmers' supply decisions and farm incomes.

# Appendix 3: Recent studies of the impact of Brexit on UK agriculture

The Technical Report of the project by Agra CEAS Consulting (Bradley and Hill, 2017) for the AHDB included a review of the 20 or so studies and reports of the anticipated impact of Brexit then available, and to which the Technical Report itself constituted a major additional analysis. The studies and reports displayed a diversity of approaches and generated a range of results. They differed in a number of ways.

(i) ***Coverage of impact factors.*** In the studies, four main factors were seen to be at work: (a) *The shape of possible domestic agricultural policy*, and in particular what may happen to the levels of Direct Payments (in particular, Basic Payments); (b) *The outcome of trade negotiations in the Brexit process that will impact on market prices received by UK farmers*, and which carry implications for trade with the rest of the world; (c) *The availability and cost of migrant labour*; and, (d) any change in the *regulatory burden* on farmers as a result of leaving the EU. Not many studies dealt with them all (though Bradley and Hill (2017) did so).

(ii) ***Detailed specification of impact factors.*** Each of the impact factors is capable of alternative specification, for example, the assumptions about tariff rates, world prices, etc. when considering impacts on trade.

(iii) ***Use of scenarios.*** Many studies use scenarios to explore the post-Brexit situation. However, these differ in the number of factors considered and what the scenario is intended to represent.

(iv) ***Sophistication of approach*** in modelling prices at national levels and farm-level impact on income.

(v) ***Sector coverage.*** Some studies do not differentiate by sector. Where a sector approach is used, coverage differs between studies.

(vi) ***Geographical coverage.*** Some studies are at the UK level, others differentiate England, Scotland, Wales and (less commonly) Northern Ireland.

The Bradley and Hill (2017) Technical Report on the anticipated impact of various Brexit scenarios formed the basis of an AHDB Horizon Market Intelligence publication

dealing with the same issues (AHDB, 2017). The farm-level model used to estimate income changes was developed using data from the FBS that related only to England. Following the publication of Bradley and Hill (2017) the same basic methodology was used to present analysis for Wales and Scotland (Bradley, 2017), i.e. market price changes were taken from the same gravity model and farm-level income estimation based on models developed from data taken from regional farm account surveys. Findings were published in separate Horizon Market Intelligence reports. A geographically specific report for the grazing farms of England's Lake District National Park was also produced (Bradley, 2018a). A modified approach was used at enterprise level to generate income estimates for the poultry and egg industry (Bradley, 2018b) using data supplied through the NFU.

Independent of this work from Agra CEAS Consulting, a small number of studies have been published.

*Cumulus Consultants (2017)* generated estimates on behalf of the Royal Society for the Protection of Birds (RSPB). The focus was on the potential environmental impacts of Brexit. Two scenarios were used, but also with variations in input and output prices. Trade effects on the markets for agricultural products were discussed (but not independently quantified) and models used to assess the impact of changes in direct payments.

*Dwyer (2018)*, for the Wales Centre for Public Policy, considered the impact on farming in Wales, using four scenarios. Though the impact of trade on prices received by farmers was considered, this was not independently quantified. There was no modelling of withdrawing direct income payments or of different farm types, though these were mentioned.

Also restricted to considering the impact of Brexit on Welsh agriculture, the summary paper from the Welsh Government's EU exit scenario planning workshops (*Welsh Government, 2018*) used five scenarios and considered trade arrangements (but

without making independent assessments) but did not model at the farm level. However, it highlighted the difficulties some sectors would experience and the advantages or opportunities that would present themselves to others.

The most significant publication to appear since Bradley and Hill (2017) is that arising from ESRC-Newcastle University's research (***Hubbard,* et al.*, 2018***) that formed part of the ESRC-funded project *How might UK Agriculture Thrive or Survive*. It builds on the aggregate models reported in Davis, *et al.*, (2017) and covered in the literature review in Bradley and Hill (2017). These comprise an agriculture-specific variant of the Global Trade Analysis multi-region computable general equilibrium CGE model to assess the impact of Brexit scenarios on the macro-economy and factor markets, and the FAPRI-UK partial-equilibrium model to make projections for prices, production and trade flows. The later work reported here takes the analysis down to the impact at farm level. The full report is anticipated in December 2018, though a summary has appeared in EuroChoices (Hubbard, *et al.*, 2018).

Rather than having to rely on group averages within classes of farm size and farming types to build farm-level models (as used by other studies, including Bradley and Hill (2017)), this Newcastle work has had access to individual farm data in the FBS in England and the equivalent surveys in the other parts of the UK; this followed because of the sponsorship of the research by the four devolved agricultural government departments, though this access has been severely restricted to the research in hand. It did, however, enable several forms of analysis not available to other Brexit studies, such as averaging results over a run of years at the individual farm level, the consideration of income distributions, and analysis of the impact on farm household incomes (arguably more significant for assessing farm viability than the income from farming alone as shown in Farm Business Income). This last analysis has yet to be made public.

It should be noted that, while the aggregate models projected changes in product prices and factor costs to specific future dates (2026 represented the end of the

period of adjustment) the farm-level modelling is only static, in that it assumes the cost structure of the base period to which the farm accounts data relate (a historic three-year average) and makes income estimates on this basis. It does not take into consideration the way that farmers react to the changed prices by altering their production patterns, constraints on production at the farm level, or structural change.

Scenarios were chosen to represent a broad range of feasible options for two main factors (out of the four identified in other studies): ***trade relations*** with the EU and the Rest of World, and the shape of ***domestic UK policy and support for farmers***. However, in addition, sensitivity analysis (not reported in the EuroChoices summary) was undertaken with regards to two other factors affecting the impact:

(iii) restrictions on migrant labour (a factor explicitly covered in Bradley and Hill (2017)); and,

(iv) the sterling exchange rate, both with the Euro and with the US dollar.

However, the effect of changing the regulatory burden (also covered in Bradley and Hill (2017) and several other studies) was not explored.

The three selected trade policy scenarios were designed to cover the range of likely outcomes of the UK-EU negotiations:

(iv) a UK-EU Free Trade Agreement (***FTA***);

(v) Unilateral Trade Liberalisation (***UTL***); and,

(vi) return to World Trade Organisation tariffs (EU Tariffs Schedule - ***WTO***).

For domestic agricultural policy, two options were selected:

(iii) direct payments retained as currently under the CAP, and,

(iv) a gradual elimination of direct payments over a five-year period (2020-2025). It was also assumed that Pillar 2-type payments would continue after Brexit at current levels.

Turning to the results, the impacts on the general economy that arise from the Brexit scenarios are relatively small. However, at the sector level there are potential impacts on farm production and market prices, confirmed by both the CGE and FAPRI models. As noted in other studies, the impact depends on the status of the sub-sector concerned (e.g. beef, sheep, dairy, pigs, poultry, wheat and barley) and whether the UK is a net importer or net exporter of specific commodities.

The farm modelling showed interesting results regarding the distribution of farm business incomes across the devolved administrations and by farm type and the importance of retaining or eliminating direct payments (see Figure 3.1, in which + or - corresponds with the treatment of direct payments). The negative impact on farm business income of removing direct payments is reflected across all trade scenarios, especially UTL with or without direct payments (DPs). Average farm income varies significantly across the devolved administrations and by farm type, with most farms worse off (relative to the baseline) under all scenarios but one, (WTO+). Noticeably, under this scenario dairy farms particularly benefit as their average farm income could almost triple compared to the baseline scenario. Beef and sheep farms will be the most affected under UTL-.

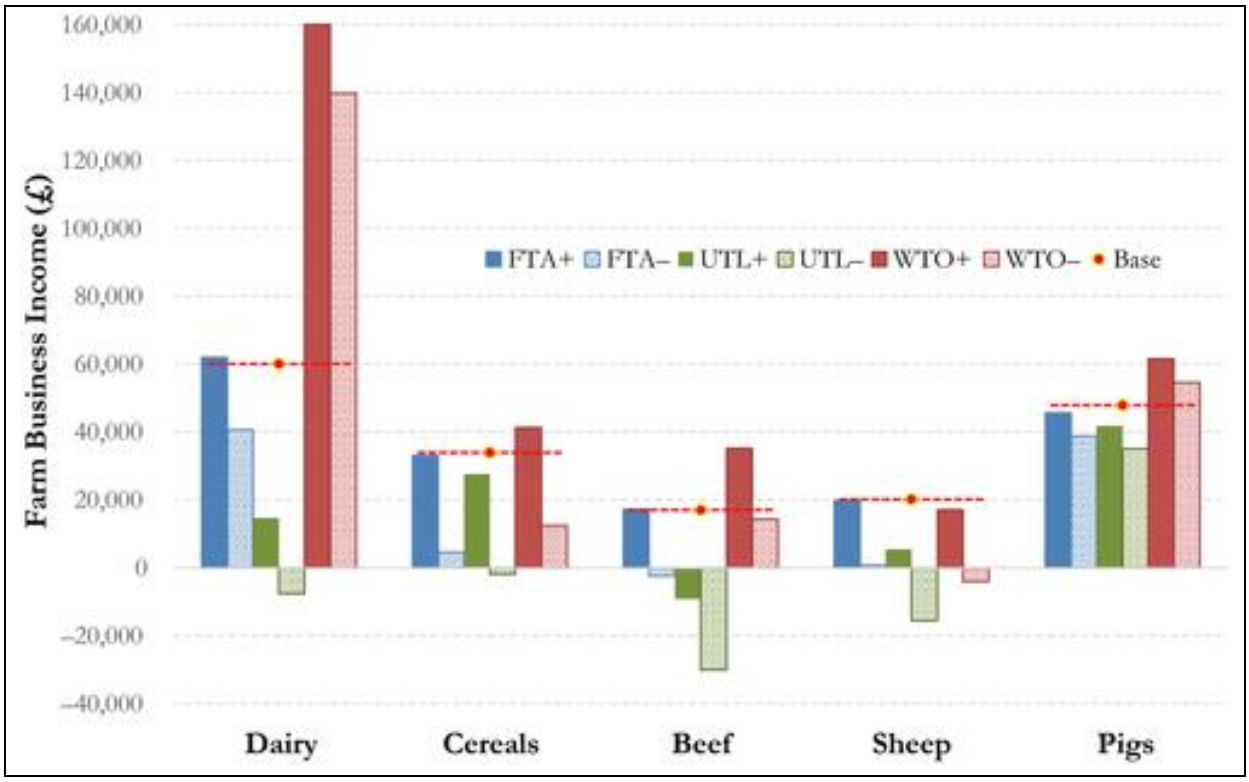


**Figure A3.1: Impact on Farm Business Income by sector (UK)**

Source: Hubbard, et al. (2018).

The extreme free trade scenario leads to some striking results regarding farm income distributions, an analysis only made possible by access to individual farm level data. Whereas 15-20 per cent of the farms were not making any money at all (positive Farm Business Income) even in the baseline scenario, this rises to 45 per cent under the UTL scenario with direct payments still in place (UTL+). The elimination of direct payments further increases this figure to 70 per cent (UTL-).

In summary, the preliminary results from this source show that Brexit would have significant implications for UK agriculture. Trade scenario effects depend on the net trade position, and/or world prices. Under a Free Trade Agreement (FTA) with the EU, agricultural impacts are relatively modest. By contrast, unilateral removal of import tariffs (UTL) has significant negative impacts on prices, production and incomes. Adoption of the EU's WTO tariff schedule for all imports (including from the EU) favours some net importer sectors (e.g. dairy) and harms exporter sectors (e.g.

sheep). These trade effects, however, might be overshadowed by the exchange rate and possible labour market changes and other non-tariff barriers (not addressed in this article).

Given the dependence of many UK farms on direct payments, their removal, predictably, worsens the negative impacts of new trade arrangements and offsets positive impacts. The elimination of direct payments will affect most farm businesses, but the magnitude varies by enterprise and devolved administration. Arable and dairy farms may be relatively unaffected, but many beef and sheep farms would struggle to survive if assessed on farm income alone, as they tend to be much more reliant on direct support.

Despite some differences regarding the relative changes in prices and output across the sector and commodities, the estimates reported in Hubbard, *et al.* (2018) are broadly in line with the studies of van Berkum, *et al.* (2016), Davis, *et al.* (2017) and Bradley and Hill (2017). The full report was expected in December 2018, but has so far failed to materialise.

***Defra*** published in February 2018 a compendium of statistics that, while having a broader coverage, updates many pieces of information that are relevant to Brexit, and in particular considers the importance of the present level and distribution of Basic Payments (Defra, 2018). The Future Farming and Environment Evidence Compendium takes a form that is unusual and clearly intended to be reader-friendly, though hidden within its linked pages are many figures and explanatory details that earn it respect as a source of statistics. After the initial summary section, pages 14-45 deal with farm economics and accounts, including farm structure, resource use and contribution to the economy. A later section deals with food and trade. The geographical coverage is the UK or England. Results from the FBS for the three years 2014/15 to 2016/17 are averaged at farm level to show the relationship between direct payments and farm income, and how this varies across farm types. The proportion of farms that make negative incomes before and after direct payments are

considered (16% and 42% respectively) and consideration is given to alternative patterns of their withdrawal. Questions are raised over how some farms can persistently make negative incomes, and explanations for this phenomenon offered, with statistical support. There is a section on how farmers could respond to the removal of direct payments, including by cutting input costs, improved efficiency, making better investments and by diversification. This compendium has relevance to a following part of this literature review (on structural change) and will be revisited there.

# Appendix 4: Changes of production output from agriculture

Economic logic dictates that where domestic UK prices of agricultural commodities increase as a result of higher priced imports, the quantity demanded by consumers will fall, the extent depending on factors such as the availability of substitutes, and being reflected in the elasticity of demand. It is also to be expected that domestic production will increase to some extent, to replace more expensive imports. It is therefore possible to see contemporaneous decreases in domestic consumption, and increases in domestic production. Where domestic UK prices decrease as a result of access to cheaper imports, consumer demand will increase, but domestic supply is likely to contract as these cheaper imports both meet new demand and also replace some (higher priced) domestic production.

Although the gravity model that we have used to determine price changes on the UK market does also produce estimates of changes in domestic production, these are simplistic because the model examines one commodity at a time and so there is no account of cross effects between different commodities. A further complication is that in many sectors we have attempted to address carcase and/or market balancing issues which creates problems in trying to estimate production changes at the sector level. Finally, we have not used the gravity model to estimate prices in sectors/market segments where the UK is a net exporter.

However, the AHDB has expressed interest in more information on the impact of Brexit scenarios on aggregate production. For this reason we have reviewed the literature on the sophisticated modelling exercises that are in the public domain to draw out what they have concluded on the likely impacts of Brexit on agricultural production output.

Two studies are available that explicitly estimate the impacts on aggregate production, Berkum, *et al.*, (2016), for the NFU, and Davis, *et al.* (2017), funded by the devolved government agriculture departments in the UK. Both were described in

some detail in the literature review of Bradley and Hill (2017). They both operate in two stages; the first is aggregate modelling to assess market shifts by a future date (2025 or 2026) and a second stage (not considered here) of farm-level models to estimate the impacts of price movements on farm incomes. They use similar sets of three scenarios which are compared with the *status quo* as a baseline (the three are a UK-EU trade agreement, no such agreement but unilateral free trade adopted by the UK, and no agreement but the UK trading on WTO terms), but these have detailed differences in their specification. These studies build on historic data to estimate the commodity prices and aggregate supply responses over a specified period, though such exercises become hazardous when the Brexit scenarios take situations beyond what has been experienced in the past (Davis, *et al.*, 2017).

Berkum, *et al.*, (2016), working from the LEI in the Netherlands for the British National Farmers' Union, explore their scenarios at industry level using the AGMEMOD model. This is a dynamic, multi-country, multi-market, partial equilibrium model, and was developed by an extensive network of economists collaborating across the EU. The model has been largely econometrically estimated at the individual Member State level. Each country model is based on a database of annual time series, covering, when possible, a period from 1973 to the latest available year. AGMEMOD's database includes balance sheets for all primary agricultural commodities and most food processing commodities, generally including prices, production, imports and exports, opening and ending stocks as well as food, feed and other consumption. Country experts have collected and validated data from various sources, e.g. national statistics, Eurostat and the FAO. The represented agricultural sectors differ across countries depending on their importance in the respective country. For each commodity in each country agricultural production as well as supply, demand, trade, stocks and domestic prices are determined in equations with econometrically estimated or calibrated parameters. For the UK horticulture was not modelled in detail because of data problems; rather, estimates were made to price changes based on the postulated impact of trade facilitating costs. Changes in labour costs resulting from restrictions on migrants were not taken into consideration. Additional

reservations about the methodology were set out in the review in Bradley and Hill (2017).

Nevertheless, it is worth noting the changes in aggregate production emerging for the various scenarios in the following three tables, taken directly from Berkum, *et al.*, (2016) with the original table numbering.

Table 5.2

*Percentage difference in price, production, consumption and trade in Scenario 1 (FTA, 5% trade facilitation costs and a 3% negative price wedge for sheep meat) a) compared to the baseline scenario, 2025*

| | Soft wheat | Barley | Rapeseeds | Sugar | beef | pork | Poultry | Eggs | Sheep | Raw milk | Butter | cheese | SMP | WMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Price | 5.0 | 5.0 | 5.0 | 4.9 | 4.6 | 4.9 | 4.9 | 4.5 | 2.3 | 4.3 | 5.0 | 5.0 | 4.9 | 5.5 |
| Production | 1.2 | 1.2 | 0.1 | 1.1 | 1.1 | 0.7 | 1.5 | -0.8 | 1.1 | 1.1 | 0.1 | 0.1 | 18.9 | 7.8 |
| Use | 1.2 | 0.4 | 1.8 | 0.0 | -0.1 | -0.4 | 0.0 | -0 | 2.2 | | -0.2 | -1.1 | 0.0 | 0.0 |
| Net exports b) | | 9.5 | -7.4 | | | | | | -48.7 | | | | 1333 | |
| Net imports b) | 1.6 | | | -0.6 | -17.9 | -2.1 | -18.2 | 0.4 | | | -0.6 | -2.5 | | -62.3 |

a) See Section 5.2.1 for explanation; b) net exports stands for a positive trade balance. A positive sign means an increase (exports increase) and a negative sign means a decline of the positive trade balance. Net imports stands for a negative trade balance. A positive signs means the negative trade balance becomes more negative, and a negative sign means the negative trade balance becomes less negative (imports decline).

Source: own calculations, based on AGMEMOD

Table 5.3

*Percentage difference in price, production, consumption and trade in Scenario 2 (WTO default, 8% trade facilitation costs, UK loses access to the EU's preferential import regimes) compared to the baseline scenario, 2025*

| | Soft wheat | Barley | Rapeseeds | Sugar | beef | pork | poultry | Eggs | Sheep | Raw milk | Butter | cheese | SMP | WMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Price | 8.0 | 8.0 | 8.0 | 11.5 | 7.4 | 7.8 | 8.1 | 7.1 | 8.8 | 7.2 | 8.8 | 8.3 | 7.8 | 9.3 |
| Production | 2.0 | 2.0 | 0.2 | 2.9 | 1.5 | 1.2 | 2.5 | -1.3 | 6.8 | 2.0 | 0.4 | -0.2 | 32.5 | 13.5 |
| Use | 2.1 | 0.6 | 2.9 | -0.1 | -0.1 | -0.6 | 0.2 | -0 | -0.8 | | -0.4 | -1.9 | 0.0 | 0.0 |
| Net exports a) | | 16.6 | -12.4 | | | | | | 326 | | | | 2285 | |
| Net imports a) | 2.4 | | | -1.5 | -26.4 | -3.5 | -28.9 | 0.6 | | | -1.4 | -4.1 | | -107 |

a) Net exports stands for a positive trade balance. A positive sign means an increase (exports increase) and a negative sign means a decline of the positive trade balance. Net imports stands for a negative trade balance. A positive signs means the negative trade balance becomes more negative, and a negative sign means the negative trade balance becomes less negative (imports decline)

Source: own calculations, based on AGMEMOD.

Table 5.5

*The impact of a UK Trade liberalisation scenario (50% border tariff reduction and 8% trade facilitation costs), in percentage difference in price, production, consumption and trade compared to the baseline scenario, 2025*

| | Soft wheat | Barley | Rapeseeds | Sugar | beef | Pork | poultry | Eggs | Sheep | Raw milk | Butter | Cheese | SMP | WMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Price | 7.9 | 8.0 | 8.0 | -4.6 | -14.9 | -3.3 | -6.6 | 8.7 | -4.7 | 2.2 | -0.6 | 3.9 | 8.0 | 3.8 |
| Production | 1.3 | 1.3 | 0.5 | -1.9 | -6.6 | -1.9 | -2.5 | -1.2 | -6.6 | -0.7 | -1.9 | 0.5 | -2.6 | -1.7 |
| Use | -2.3 | 0.4 | 2.9 | 0.0 | 0.6 | -1.7 | 0.1 | -0 | -1.8 | | 0.1 | -0.9 | 0.0 | 0.0 |
| Net exports a) | | 10.8 | -10.0 | | | | | | -206 | | | | -181 | |
| Net imports a) | -17.2 | | | 1.0 | 106 | -1.3 | 29.0 | 0.5 | | | 2.2 | -2.7 | | 13.5 |

a) Net exports stands for a positive trade balance. A positive sign means an increase (exports increase) and a negative sign means a decline of the positive trade balance. Net imports stands for a negative trade balance. A positive signs means the negative trade balance becomes more negative, and a negative sign means the negative trade balance becomes less negative (imports decline).

Source: own calculations, based on AGMEMOD.

The alternative source of explicit estimates of production output changes is the FAPRI work reported in Davis, *et al.* (2017), and which formed an input to the farm-level study reported above (Hubbard, *et al.* (2018)). The FAPRI-UK model captures the dynamic inter-relationships among the variables affecting supply and demand in the main agricultural sectors of England, Wales, Scotland and Northern Ireland, with sub-

models 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) model run by FAPRI at the University of Missouri. The commodity sub-models were solved at the European level by ensuring EU-28 excess supply equalled EU-28 excess demand in all markets. The key price in each model was adjusted until equilibrium was attained at the end of the study period (2025). The iterative equilibrating process continued until all product markets in all years were in equilibrium. Thus, within this traditional modelling system, projected UK commodity prices were determined by equilibrium at the EU-28 level and tracked continental EU prices closely. However, for the FAPRI analysis reported in Davis, *et al.* (2017), the FAPRI-UK model was updated to allow for the fact that after Brexit the UK and EU markets would no longer be fully integrated. Market clearing under this updating is thus at the UK level.

Again, the three trade scenarios depict a UK-EU free trade agreement, a WTO default without such an agreement, and no agreement but unilateral trade liberalisation by the UK. Separate analyses are presented for the entire UK, and for each constituent country (not reported here). Output estimates for 2025 (the end of the projection period) are reported in the summary table, given below, and within the more detailed tables that follow.

**Table A4.1: Executive Summary Table: Percentage Change in UK Commodity Prices, Production and Value of Output under Three Alternative Trade Scenarios Compared to the Baseline at the End of the Projection Period (2025)**

| | Bespoke Free Trade Agreement with the EU | WTO Default | Unilateral Trade Liberalisation |
|---|---|---|---|
| Scenario definitions: | • UK retains tariff and quota free access to the EU and EU retains tariff and quota | • MFN tariffs applied to imports from the EU<br>• TRQs from 3rd countries retained | • Zero tariffs applied on imports to the UK from both the EU and the rest of the world |

| | | Bespoke Free Trade Agreement with the EU | WTO Default | Unilateral Trade Liberalisation |
|---|---|---|---|---|
| | | free access to the UK<br>• UK maintains EU tariff structure to rest of the world<br>• 5% trade facilitation costs on UK-EU27 trade | • MFN tariffs applied to UK exports destined for the EU<br>• No change in tariff structure for exports to the rest of the world<br>• 8% trade facilitation costs on UK-EU27 trade | • MFN tariffs applied to UK exports destined for the EU<br>• No change in tariff structure for exports to the rest of the world<br>• 8% trade facilitation costs on UK-EU27 trade |
| **Commodity** | | | | |
| Beef | Price | +3% | +17% | -45% |
| | Production | 0% | +10% | -10% |
| | Output value | +3% | +29% | -50% |
| Sheep | Price | -1% | -30% | -29% |
| | Production | 0% | -11% | -11% |
| | Output value | -1% | -38% | -36% |
| Pigs | Price | 0% | +18% | -12% |
| | Production | +1% | +22% | -6% |
| | Output value | +1% | +44% | -17% |
| Poultry | Price | 0% | +15% | -9% |
| | Production | 0% | +11% | -3% |
| | Output value | 0% | +28% | -12% |
| Milk and dairy | Price | +1% | +30% | -10% |
| | Production | 0% | +7% | -2% |
| | Output value | +2% | +37% | -12% |
| Wheat | Price | -1% | -4% | -5% |
| | Production | 0% | -1% | -1% |
| | Output value | -1% | -4% | -6% |
| Barley | Price | -1% | -5% | -7% |
| | Production | 0% | -1% | -2% |
| | Output value | -2% | -6% | -8% |

Source: Davis, et al. (2017).

**Table A4.2: Projected Changes in the Livestock Sectors in the UK, Percentage Difference in 2025 Compared to the Baseline**

| | S1 | S2 | S3 |
|---|---|---|---|
| | **Bespoke agreement** | **WTO trade** | **Unilateral free trade** |
| **Cattle** | | | |
| Beef cows | +1% | +18% | -42% |
| Dairy cows | 0% | +6% | -2% |
| Total Cattle | 0% | +11% | -17% |
| **Beef** | | | |
| ***Production*** | ***0%*** | ***+10%*** | ***-10%*** |
| Domestic use | -1% | -3% | +18% |
| Exports | -2% | -100% | -100% |
| Exports from UK to EU-27 | -2% | -100% | -100% |
| Exports from UK to Non-EU | -2% | -100% | -100% |
| Imports | -3% | -70% | +38% |
| Imports from EU-27 to UK | -3% | -92% | -100% |
| Imports from Non-EU to UK | -3% | +94% | +1103% |
| Cattle price | +3% | +17% | -45% |
| **Sheep** | | | |
| Ewes | 0% | -13% | -12% |
| Total sheep | 0% | -12% | -12% |
| **Sheepmeat** | | | |
| ***Production*** | ***0%*** | ***-11%*** | ***-11%*** |
| Domestic use | 0% | +9% | +16% |
| Exports | 0% | -73% | -86% |
| Exports from UK to EU-27 | -1% | -83% | -84% |
| Exports from UK to Non-EU | 0% | -23% | -100% |
| Imports | 0% | -17% | -15% |
| Imports from EU-27 to UK | -1% | -100% | -100% |
| Imports from Non-EU to UK | 0% | -7% | -5% |
| Sheepmeat price | -1% | -30% | -29% |
| **Pigs** | | | |
| Sows | +1% | +21% | -8% |
| Total pigs | +1% | +23% | -8% |
| **Pigmeat** | | | |
| ***Production*** | ***+1%*** | ***+22%*** | ***-6%*** |

| | S1 | S2 | S3 |
|---|---|---|---|
| | **Bespoke agreement** | **WTO trade** | **Unilateral free trade** |
| Domestic use | 0% | -6% | +5% |
| Exports | 0% | -100% | -100% |
| Exports from UK to EU-27 | -1% | -100% | -100% |
| Exports from UK to Non-EU | 0% | -100% | -100% |
| Imports | -1% | -56% | -9% |
| Imports from EU-27 to UK | -1% | -57% | -31% |
| Imports from Non-EU to UK | 0% | 0% | +7811% |
| Pigmeat reference price | 0% | +18% | -12% |
| **Poultry** | | | |
| ***Production*** | ***0%*** | ***+11%*** | ***-3%*** |
| Domestic use | 0% | -2% | +1% |
| Exports | -2% | 0% | -43% |
| Exports from UK to EU-27 | -2% | -100% | -100% |
| Exports from UK to Non-EU | 0% | +408% | +189% |
| Imports | -1$ | -40% | -8% |
| Imports from EU-27 to UK | -1% | -81% | -100% |
| Imports from Non-EU to UK | 0% | +676% | +1603% |
| Chicken price | 0% | +15% | -9% |

Source: Davis, *et al.* (2017).

## Table A4.3: Projected Changes in the Dairy Sectors in the UK, Percentage Difference in 2025 Compared to the Baseline

| | S1 | S2 | S3 |
|---|---|---|---|
| | **Bespoke agreement** | **WTO trade** | **Unilateral free trade** |
| **Cattle** | | | |
| Cow's milk Production | 0% | +7% | -2% |
| Liquid consumption | 0% | -3% | +1% |
| Manufacturing use | +1% | +18% | -6% |
| ***Prices*** | | | |
| Producer milk price | +1% | +30% | -10% |
| Cheese price | +1% | +29% | -11% |
| Butter price | 0% | +43% | -11% |
| WMP price | 0% | 0% | 0% |
| SMP price | 0% | 0% | 0% |
| **Cheese** | | | |

| | S1 | S2 | S3 |
|---|---|---|---|
| | **Bespoke agreement** | **WTO trade** | **Unilateral free trade** |
| ***Production*** | ***+1%*** | ***+19%*** | ***-4%*** |
| Domestic use | 0% | -4% | +2% |
| Export | -2% | -100% | -88% |
| Exports from UK to EU-27 | -3% | -100% | -100% |
| Exports from UK to Non-EU | 0% | -100% | -27% |
| Import | -2% | -54% | -20% |
| Imports from EU-27 to UK | -2% | -55% | -28% |
| Imports from Non-EU to UK | -13% | -23% | +380% |
| **Butter** | | | |
| ***Production*** | ***0%*** | ***+25%*** | ***-2%*** |
| Domestic use | 0% | -11% | +4% |
| Export | -4% | -100% | -100% |
| Exports from UK to EU-27 | -5% | -100% | -100% |
| Exports from UK to Non-EU | +1% | -100% | -100% |
| Import | -2% | -97% | -26% |
| Imports from EU-27 to UK | -2% | -100% | -100% |
| Imports from Non-EU to UK | -1% | -7% | +2558% |

Source: Davis, et al. (2017).

## Table A4.4: Projected Changes in the Crop Sectors in the UK, Percentage Difference in 2025 Compared to the Baseline

| | S1 | S2 | S3 |
|---|---|---|---|
| | **Bespoke agreement** | **WTO trade** | **Unilateral free trade** |
| **Wheat** | | | |
| ***Production*** | ***0%*** | ***-1%*** | ***-1%*** |
| Domestic use | 0% | +6% | -2% |
| Export | -3% | -77% | -34% |
| Exports from UK to EU-27 | -4% | -100% | -100% |
| Exports from UK to Non-EU | -1% | -25% | +116% |
| Import | -1% | -66% | -62% |
| Imports from EU-27 to UK | -1% | -93% | -96% |
| Imports from Non-EU to UK | -1% | -20% | -6% |
| **Barley** | | | |
| ***Production*** | ***0%*** | ***-1%*** | ***-2%*** |
| Domestic use | 0% | +7% | -2% |

| | | | |
|---|---|---|---|
| Export | -3% | -42% | -8% |
| Exports from UK to EU-27 | -5% | -78% | -78% |
| Exports from UK to Non-EU | 0% | +12% | +97% |
| Import | -3% | -100% | -100% |
| Imports from EU-27 to UK | -3% | -100% | -100% |
| Imports from Non-EU to UK | -2% | -100% | -100% |
| **Area** | | | |
| Wheat | 0% | -1% | -1% |
| Barley | 0% | -1% | -1% |
| **Prices** | | | |
| Wheat | -1% | -4% | -5% |
| Barley | -1% | -5% | -7% |

Source: Davis, et al. (2017).

Comparison between these two modelling exercises finds both similarities and differences in the estimates of production. Both are generally in line with expectations based on economic principles, for example that impediments to imports (trading costs, tariffs, etc.) can be expected to raise prices on the domestic market, and similar impediments on UK exports entering markets abroad will lower prices received by UK suppliers.

For the scenario of a bespoke free trade agreement between the UK and EU, in the FAPRI work Davis, *et al.*, (2017) show zero change in production (apart from pigs where it is +1%) whereas the LEI work shows small positive changes of between 0.7% (pigs) and 1.5% (poultry). For the WTO scenario there are more marked differences, for example beef (+1.5% LEI, +10% FAPRI) and milk (+2.0% LEI; +7% FAPRI). The biggest difference is seen with sheep, where LEI estimates +6.8% and FAPRI -11%. In the scenario of UK unilateral trade liberalisation, the two sources are in closer general agreement, at least in the direction of change, though reductions in beef and sheep production (both -6.6% in LEI) become rather larger in FAPRI's results (-10% and -11% respectively). For both wheat and barley, the small increase in production in the LEI estimates (+1.3%) become small negatives (-1% wheat, -2% barley) in the FAPRI work.

Explaining the differences would require a forensic analysis of differences in the details of scenarios, data sources, treatments of Tariff Rate Quotas (TRQs) and factors such as assumptions and simplifications within the modelling process. In particular, the very different production estimates for sheep in the LEI results (which also assume an 8.8% rise in price, in contrast with the 30% fall in FAPRI) seems to arise from a mis-specification by LEI of the markets for sheep and a failure to recognise their heterogeneity, with exported and imported sheepmeat being in reality virtually separate commodities. Bradley and Hill (2017) argue that the FAPRI position (on prices) is the more realistic, given the segmentation of the market for sheepmeat in which animals from UK hill areas are mainly exported to the EU, and that this channel of disposal would be substantially penalised if the EU applied WTO-agreed tariffs. However, such a forensic analysis, if carried out in an exhaustive way to explain each difference, is outside the bounds of this project's literature review.

# Appendix 5: Longer-term responses and structural change

## A5.1. Implications for responses by individual farmers

The three main estimates of quantitative impacts of Brexit on UK farms (Berkum, *et al.* (2016), Bradley and Hill (2017) and Hubbard, *et al.* (2018)) each use estimates of the impact on prices on UK agricultural farm commodity markets as an intermediate step to assess changes in farm incomes (Hubbard uses the aggregate level findings of Davis, *et al.* (2017)). As noted above, in their models, production responses are estimated from historic sector-level data, not by summing the observed or modelled responses of individual farmers. The income movements shown in the various scenarios adopted involve not only the effect on prices resulting from trade arrangements but also revisions in domestic agricultural policy.

Each source uses a static farm-level model to translate changes in prices of commodities on domestic markets into changes in farm incomes. Berkum, *et al.* (2016) are quite specific about the limitations of this approach, pointing out that this static tool, while it may indicate the pressure on farmers, does not include farmers' behavioural responses to changes in prices (or other payments). It follows that, in the case of price rises the positive impact on farm income and farm viability might be underestimated as a likely increase in production is not modelled (though prices may be eroded subsequently by the impact of increased production on markets). Similarly, the negative impact of price falls may be overstated, as farmers can be expected to make mitigating adjustments.

We first consider here the likely farmer responses within the framework of the existing industry structure, then later consider longer-term responses in the form of structural change (e.g. changes in farm size, farm exit, outflow of family labour, substitution of capital for labour) or issues such as the land market (land price). This part of the literature review is intended to help to frame our assessment of how farmers might respond to the changes in farm income implied by changes in the four key variables:

- prices and costs associated with the trading position of the UK, with special attention to the UK-EU arrangements;
- domestic agricultural policy, especially direct income payments;
- the availability and cost of migrant labour, with the knock-on effect on costs of UK labour; and,
- the regulatory environment.

#### A5.1.1. Resilience and adaptation

In making this assessment it is useful to bear in mind the difference between responses that form part of a farm's ***resilience***, in the sense that its operators are in a position to withstand shocks and periods of depressed incomes, and its responses that form part of its ***adaptation*** to what appears to its operators to be a permanent change in the economic, technical or regulatory conditions in which it operates. Not all writers make this distinction. For example, Darnhofer (2014) uses the term resilience to encompass buffer, adaptive and transformative capability. There seem to be different sets of factors at work in resilience and adaptation. For example, resilience would be affected by the farm operator's degree of income dependence on the farm's income generating ability, with those with substantial off-farm income and treating their farms primarily as hobby farms (or mainly as residences providing a lifestyle) being largely insulated from the economics of agricultural production and therefore distanced from Brexit's impact on farm incomes. Similarly, large financial reserves or easy access to credit could provide a buffer. In contrast, farms with no other sources of income or access to reserves, or where heavy debt servicing costs have to be met, would be far more sensitive to changes in the profitability of farming.

Factors associated with the longer-term process of adapting would include the ability to secure (or release) land, the education and skills of the farmer and family members (human capital), access to advice (both technical and on risk management) necessary to make enterprise changes or other major investments, and access to capital for investment. Additional factors outside the farm itself would include business and employment opportunities in the broader economy when considering partial or

complete exit from farming (Goetz and Debertin, 2001; Errington & Tranter (1991)). Darnhofer, *et al.* (2016) point to necessity of social capital in the form of relationships (networks) that contribute to the smooth operation of farming and marketing actions and assist adjustment in the local economy.

The importance of recognising both internal and external factors in understanding change is a key point emerging from the review by Pike (2008) when explaining farmers' behaviour, together with an appreciation of the diversity found within the sector and the necessity of recognising this heterogeneity when trying to explain behaviour and when designing policy interventions. In a similar vein, for farmers in Scotland, Hallam, *et al.* (2012) identified various categories of factors determining behaviour for the population in general, which will be expected to apply to farmers:

- external factors (financial costs and effort);
- internal factors (habit, personal capacity, etc.); and,
- social factors (personal and societal values, social commitment, etc).

For agriculture the following are identified specifically (abbreviated here):

- *Economic factors* influencing farmer behaviours relating to market dynamics such as present and future levels of market prices, operating costs and subsidies; the nature of economic motivation; quality assurance issues; issues relating to non-profitable farming systems.
- *External factors* that create the context in which farmer behaviours can, or cannot, be influenced. These include: capacity to change (some environmental behaviours are just not possible within certain farm environments); size and type of farm, farmer demographics.
- *Internal factors*, such as attitudes, values and beliefs. Farmers tend to be cautious by nature, and they work to long timescales so, once they commit to decisions, they are often tied into specific actions for years. However, there are specific "moments of change" when it is easier to make alterations to farm management practices.

- ***Social factors*** include ways in which farmers are influenced by the views and behaviours of family members, peers and neighbours. The farming community contains a diverse range of decision makers who respond to policy levers and economic influences in different ways. It is also important to consider who is responsible for making decisions on the farm. If the farmer is not acting alone, how might the characteristics of others affect farm business decisions?

To sum up, Brexit carries implications for farmer incomes and viability, though these vary with the scenario chosen and between types of farming. For some, there could be substantial financial pressure. There is a difference between a farm's resilience in the face of short-term adverse shifts in the conditions in which it operates and its ability to adapt. Despite definitional differences between writers, it is clear that farm managements should bear in mind both their shorter and longer-term abilities to respond to change signals. They are likely to experience both. Farms will vary in their resilience and adaptability, linked to a host of economic, external, internal and social factors that shape farmer behaviour. Policy-makers need to consider, in addition, elements in the external environment in which farms operate that can facilitate adaptation/adjustment, including the availability of policy tools to facilitate change (Blandford and Hill, 2006). These authors also point out that, after reviewing international examples, policy-makers often underestimate the ability of farmers to adapt.

### A5.2. The economics of short-term and longer-term responses to price changes

The two exercises (LEI and FAPRI) that use sophisticated aggregate modelling techniques indicate that, if the UK negotiates a bespoke Free Trade Agreement with the EU, by 2025/2026 prices of farm commodities will be unchanged or a very little higher than before Brexit (LEI) or some 4% to 5% higher, reflecting the increased costs of trading (FAPRI) (Berkum, *et al.*, 2016; Davis, *et al.* 2017). However, the other scenarios see far larger price shifts, especially in the livestock sector. For example, FAPRI shows a +17% rise in the beef price under a WTO default but a -45% fall if the

UK operated unilateral trade liberalisation (equivalent figures from LEI were +7.4% and -14.9%). Milk and dairy prices are estimated by FAPRI to be +30% higher than the baseline under the WTO scenario and -10% lower under unilateral trade liberalisation (LEI figures were +7.2% and +2.2% respectively). Cereal price changes were smaller (-7% or less in either of these two scenarios). It is also worth noting that these aggregate modelling approaches make some assumptions that ignore practical issues. For example, it is assumed that appropriate supply can be obtained; this might not be possible (at least at world prices) due to competition from larger and less demanding markets (China). There are also logistical issues such as shelf life and the chill-chain which means fresh chicken will not be coming in from very far away (ResPublica, 2018). It is beyond our brief in the literature review to consider the practicalities of importing specific products, although the AHDB may wish to consider this issue.

It is appropriate at this point to consider the literature about how farm businesses can be expected to respond to these price changes that emerge from sector-level models.

Working at this high level ignores some practical considerations through the assumptions used. Economic theory is quite settled on how in the short-term changes in product prices shape the pattern of production in terms of the use of variable inputs and the balance between outputs in a multi-product farm firm (for a summary and overview see Chavas, 2001 or Hill, 2014). Higher product prices are likely to encourage an increase in output in pursuit of profit maximisation, with an increase in the use of variable inputs to achieve the equilibrium between the marginal revenue (the revenue arising from one additional unit of output) to the marginal cost of that unit (the increase in costs arising from that unit of output), with a reverse shift if prices fall. Where several products are possible within the firm's production possibility boundary (which for family farms would include not only the agricultural outputs but also their other diversified activities, including the provision of environmental services in return for incentives), shifts in relative prices would involve

an adjustment in the pattern of output towards the products with the increased prices; at this optimum, the ratio of prices will be equal to the inverse of the marginal rate of (technical) substitution between products. It is worth noting that this discussion does not extend to economic externalities from agricultural production (environmental or social) that have not been internalised in the form of payment schemes for farmers to deliver them.

Discussions of such responses for farm-firms usually assume that some factors of production are variable (such as, typically, fertilisers for crops, and animal feed) while others are fixed (such as stock of land, machinery, regular labour). The distinction reflects the length of the time horizon being used, and in the long-term all inputs are capable of being varied. Bundles of these fixed inputs are what determine the scale of operation. At each scale, average variable costs (AVC) first fall then rise with increasing output, for reasons of technical aspects of production (such as crop response to additional units of fertiliser, or responses to feed by animals). Average fixed costs (AFC) fall progressively with increased output. Average total costs (ATC), being the sum of these two, also first fall but then rise with output as the increases in variable costs more than exceed the dilution of fixed costs. The marginal cost (MC) curve reflects the profit-maximising production at a range of output prices, and is in effect the firm's supply curve in a market that approximates to perfect competition.

For any particular scale (combination of fixed inputs) there will be a minimum commodity price that can be accepted in the short-term (where only variable costs are covered), and a minimum acceptable in the long-term (where both variable and fixed costs are covered) (see Figure A3.1).

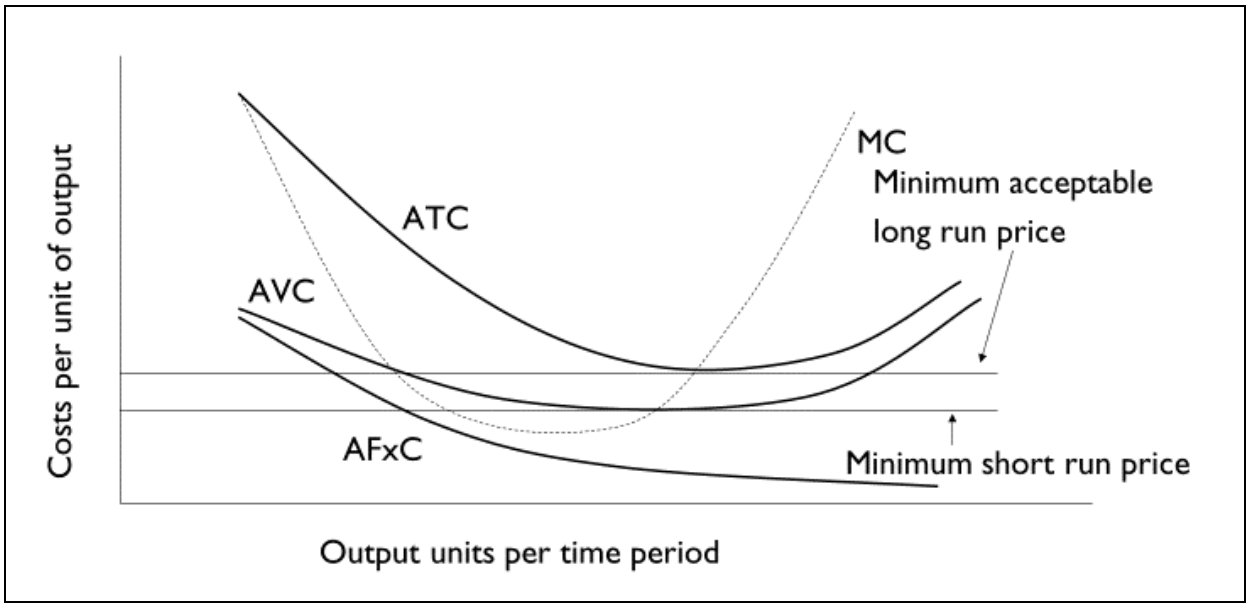


**Figure A5.1: Acceptable minimum short and long-run prices**

Source: Hill (2014), Figure 5.22.

When considering land as the fixed input, responding to product prices will be seen in the form of using increasing or reducing the density of variable inputs per hectare (extending or retracting the intensive margin, which may carry environmental implications) and also, if land quality is not uniform, bringing into cultivation or releasing from cultivation land of marginal quality (adjusting the extensive margin of cultivation, again with environmental connotations). Similar phenomena could be described for fixed labour or machinery usage.

Different scales of operation will have different levels of ATC associated with them. Figure A3.2 illustrates a stylised set of average (total) cost curves for three different sizes of dairy herd, assumed to correspond to three set combinations of land, capital and labour. The long-run average cost curve (LRAC) shows the minimum cost of producing each level of output; where intermediate scales of production are possible, this LRAC curve will be smoother.

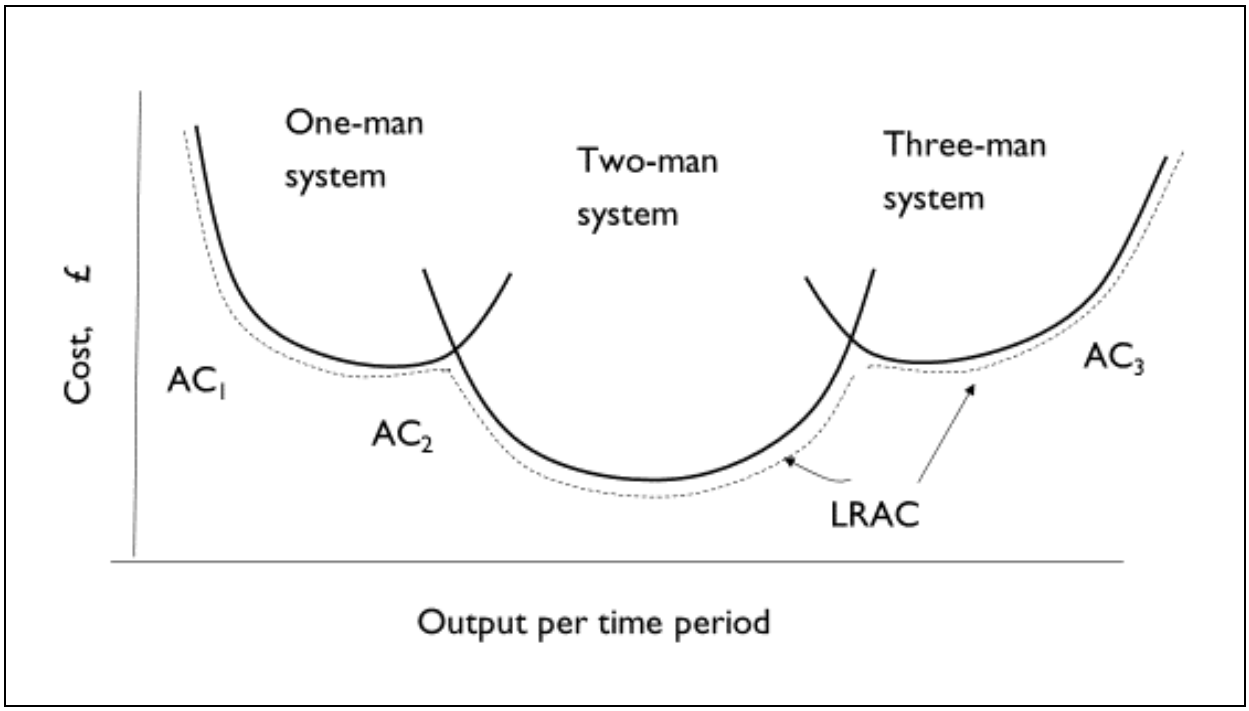


**Figure A5.2: Stylised set of average (total) cost curves for three different sizes of dairy herd**

Source: Hill (2014).

The term "economies of scale" is applied to the fall in (the lowest possible) costs as production scale is expanded, and "diseconomies of scale" to the rise in lowest possible costs as it is further extended as shown in Figure A3.3. (A strict interpretation of this term refers to the changes in average costs when all inputs are changed in the same proportion, and "economies of size" used where this condition does not apply, though in reality the two are often used interchangeably.) In a competitive industry with unhindered entry and exit it is expected that firm sizes will settle at the point where the LRAC is at its lowest, as both larger and smaller firms will not be earning 'normal' profits and will eventually transfer their resource elsewhere.

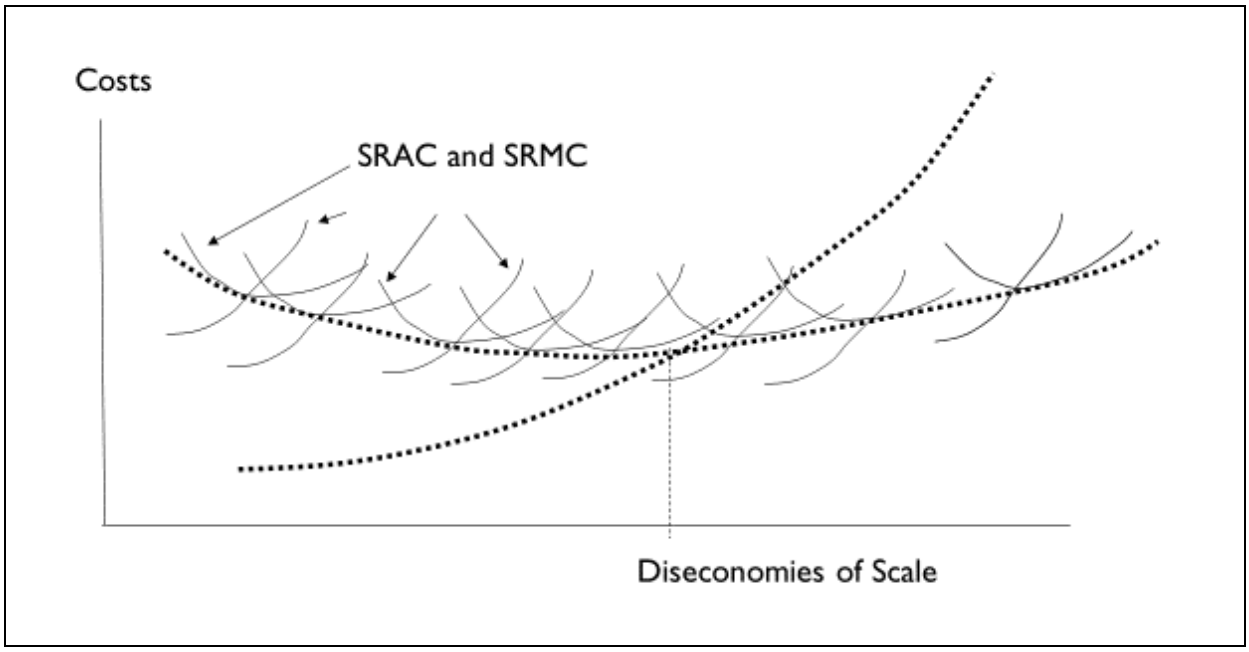


**Figure A5.3: Economies and diseconomies of scale**

Source: Hill (2014).

In practice, in agriculture the LRAC seems to be L-shaped (Britton and Hill, 1975), with a clear cost advantage of moving away from the smallest farms, but no obvious advantage from moving from the medium to the largest ones (though lack of data in surveys for the largest farms is a statistical problem). A similar pattern was produced with alternative measures of size (Power and Watson, 1983). This seems to be a common finding in developed countries and is well represented in the literature (reviewed in OECD, 2011). Under these circumstances a range of farm sizes can be competitive. Of course, a shift in technology can be expected to affect the level of this curve, advances generally serving to lower this LRAC curve, and perhaps the modify its shape. Often new technology results in the optimum scale of operations becoming larger; history suggests that without this enlargement new forms of machinery may hold no cost advantages.

Finally, in this section on economic theory we look at the reasons why scale of operations affects costs of production. Economies of scale arise from a range of sources, some of which are more relevant to farming than others. They are:

1. Economies in the use of ***land***.
2. Greater efficiency in the use of ***labour*** (through specialisation, skill development, greater mechanisation so that labour can do more).
3. Economies in the use of ***capital***. Larger machines and buildings are usually cheaper in relation to what they can do than smaller ones. Some units of capital are expensive and indivisible and are only justified by large-scale enterprises. There are also possibilities of better matching units of equipment, again maximising capacities.
4. Economies of ***administration***. Increasing the scale of production does not necessarily need a proportional increase in administrative staff.
5. Economies of ***material***. The waste product of a large firm may often be turned profitably into a saleable by-product.
6. Economies of ***marketing***.
7. Economies of ***finance***. Large firms can often borrow more easily and at preferential rates.
8. Other economies, such as research and development; knowledge transfer; staff training and retention.

As pointed out above, in agriculture, long-run average cost curves appear in general to be L-shaped. The relatively high ATCs of small farms stem primarily from their inability to utilise fully the entrepreneurial family labour found on them (a common finding in UK studies that use cross-sectional data from surveys of farm accounts, such as Britton and Hill (1975)). On small farms this labour may not be fully utilised, thus presenting a cost penalty per unit of output, yet, because of ***indivisibility***, it may not be possible to have less labour on the farm. Growth in business size which takes up this spare capacity can result in considerable economies; this growth may be in farming or in diversified activities on or off the farm premises. Taking other gainful activities (whether in self-employment or in employment) off the farm is another way of countering this cost disadvantage, though there may be technical reasons (distance from alternative activities, need to be constantly available on the farm in case of emergencies) why this may not be used. The development of pluriactivity is a well-

documented strategy for farms under income pressure (see for example Bryden, *et al.*, 1993; Gasson, 1986) though there are other explanations for its increase. A similar case can be made with respect to essential and indivisible capital equipment, such as field machinery.

The drive to spread fixed costs is not restricted to small farms. Whenever indivisible fixed factors of production, typically in the form of capital assets or labour, are being used at less than full capacity a potential exists for a greater level of output to reduce average costs. This helps explain the dominance of the land market by medium and larger farmers expanding their land areas; in doing so their rewards are the gross margins from production (the value of output minus variable costs) as there are no additional fixed costs. This allows them to outbid potential purchasers who would need also to incur more fixed costs. This helps explain why land in the UK has historically usually appeared to have a high market price compared to the income (after all costs) that on average can be derived from it, and the rate of current return on investment in it low compared with alternatives.

In summary, economic theory suggests that in the short-term farmers can be expected to respond to changes in product prices (and input costs) in ways that are in line with optimising marginal relationships to maximise profits/minimise losses. These are generally within the existing framework of the firm's fixed inputs and costs (such as land area). In the longer-term, more inputs become variable. In particular, when there is downward pressure on incomes, operators will seek to change farm size so that economies of scale are obtained. In farming there is strong evidence that farms that are too small experience higher average costs through their inability to spread their fixed costs, especially family labour, over a sufficient volume of output. However, there are alternative ways of expanding economic capacity and income generation, such as diversification or off-farm activities.

### A5.3. Evidence of actual responses in the face of major financial pressure

There are a few studies that indicate the sort of responses that could be expected from UK farmers if Brexit resulted in downward pressure on their incomes (though these are clearly inappropriate for sectors where increased profitability may result). In particular there is a series of studies from the Centre for Agricultural Strategy (CAS) at the University of Reading (Errington and Tranter (1991), Giles, (1990), Harrison and Tranter (1989), Harrison and Tranter (1994), Gasson, *et al.* (1998). These involved surveys of English farmers carried out in 1986, 1990 and 1997.

The first of this series (Harrison and Tranter, 1989) related to the responses at the farm level in 1986/87 to a financial crisis affecting agriculture caused not by a cut in direct payments (which were not part of policy at the time), but by reduced market returns. It used a large postal survey (n=1,276) and demonstrated that:

- actual responses can differ from ones that are reported as intended;
- responses at the farm level differed widely;
- non-response ('carry on as before') was a characteristic of a large minority of planned reactions (29%);
- planned expansion of output as a way of coping with the income crisis was the intention of almost half of respondents (in contrast with what might be expected from simple economic theory);
- between a third and a quarter had reduced the amounts of inputs used, reduced machinery costs and reduced labour costs;
- few farmers were planning to retire or to take up some form of part-time farming; and,
- one in five was planning to expand the farmed area.

Harrison and Tranter point out that the survey revealed a remarkable lack of large-scale disruptive restructuring in either broad management or more narrowly financial terms.

Errington and Tranter (1991) could be seen as an updating and extension of the Harrison and Tranter study with a subsequent survey (1990) that corresponded to a

later stage in the financial crisis affecting agriculture (in terms of aggregate income this reached its lowest point in 1991, followed by a rapid recovery). By this stage, many farmers had progressed from the initial adjustments to more radical actions. Though the types of responses were very similar to that found in the earlier work, the share of farmers that intended to 'carry on as before' was much lower (3.5% in contrast to 28.6%); this indicates that the greater persistence of the signal that change is necessary will increase the perception that farm-level adjustment should be made.

Gasson, *et al.* (1989) found that responses to the financial uncertainties and fluctuating farm incomes of the 1990s were very much in line with those to the recessions of the 1980s, which strengthened confidence in the earlier findings. Nearly half the respondents claimed to be just carrying on as before, and this applied to the farmers judged to be under high financial pressure, where 44% stated they were carrying on as before. Among the rest, commonest responses were to:

- increase output from existing enterprises;
- cut out less profitable enterprises;
- reduce inputs and machinery and labour costs;
- increase the area farmed in order to spread costs; and,
- to take financial advice.

Thus, farmers were more inclined to improve the productivity of existing enterprises than to attempt the more radical steps of introducing new enterprises, diversifying the farm business or looking for alternative employment (this may be related to skill sets and the availability of necessary land types, machinery, etc.). Farmers increasing output, cutting labour and machinery costs, enlarging their farms and taking financial advice in the 1990s tended to be the younger and better qualified operators with the larger businesses. Having the farmer or another family member take off-farm employment was associated with smaller farms and younger, better qualified farmers. Perhaps surprisingly, little difference was found among most of the responses between those judged to be under high or low financial pressure. Though those under high pressure were more likely to reduce inputs or cut machinery costs, they were no

more likely to cut labour costs, expand production from existing enterprises, cut out unprofitable enterprises, or start a non-agricultural enterprise. Detailed explanations were not explored in Gasson, *et al.* (1989), but maybe the key was that the former type of cost reductions seem to be relatively easy to implement whereas the latter actions might encounter more substantial constraints. For example, shedding a worker could incur social costs where there was a close personal relationship with the farmer, enterprise adjustment might run into technical problems of crop rotation or resource occupational mobility, and diversification could expose skills gaps within the farm family. Those under high financial pressure were more likely to extend the repayment period on loans and to have family members (but not themselves) take other employment, though they were no more likely to have sold assets (including land) to reduce debts.

It is instructive to look at the responses that farmers made to the collapse in their incomes resulting from the Foot and Mouth Disease (FMD) crisis in 2001. Franks, *et al.* (2003) report on a survey of farm households in Cumbria which showed that FMD caused a 60% fall in revenue from traditional farm enterprises, a 17% reduction in earnings from diversified activities and a 15% fall in salaries from off-farm employment. Costs also fell by 32%, leaving a net shortfall of £41,840. When analysed by farms which had had stock culled and those that had not, the net shortfall was £51,516 and £15,235, respectively. (There were also psychological and social costs, detailed in other research (for example, Scottish Government, 2003), especially associated with the slaughter of livestock and sense of isolation resulting from movement restrictions.) Despite these losses, all but one farmer in the Cumbria sample intended to continue farming and restock, an important finding in the present context and signalling short-term resilience. However, many also recognised the need to rebalance, declaring intentions to carry fewer stock and more enrolment in agri-environment schemes, more diversified enterprises and more work off-farm (though the last was less popular than on-farm diversification despite being less affected by FMD).

Whether these intentions were reflected in actions was beyond the scope of the research. The authors noted that an increasing proportion of farm households would benefit from any switch in agricultural subsidies to support rural development and the provision of public-good benefits and the countryside—upon which so much of Cumbria's service sector depended. Though the income impact of FMD was probably recognised as a hiatus rather than a permanent shift (unlike Brexit), the dominance of carrying on as before is clear, though where a need to adjust was recognised it was in the general direction that economic theory would indicate.

Lobley, *et al.*, (2005) looked at changes in six locations in England, spread across upland and lowland farming and arable, and in remote and less remote regions. The context was the reformed system of the CAP and, in particular, the introduction of the Single Payment System. Farms visited as part of a 2002 report were revisited; this earlier report (Lobley, *et al.*, 2002) introduced the concept of the ***restructuring spectrum*** in order to capture the variety of ways in which farmers were deploying and re-deploying the assets at their disposal, encompassing a number of categories of restructuring response, ranging from those making little or no change (minor change and static businesses) through to those diversifying their income base (agricultural integrators, on-farm diversifiers, off-farm diversifiers) and those surviving by consuming capital assets (capital consumers). The main impression from the 2005 survey was one of consolidation of existing trends rather than the development of any significant new trends or the shake-out of farmers or land. That said, there was a continuing, marginal decline in the number of dairy farms (falling from 21% to 17% of the same sample of farms between 2001/02 and 2005) and an increase in the proportion of very small lifestyle farms (rising from 17% to 20%). At an aggregate level, the trend of labour shedding had continued and there had been some substitution of salaried non-family labour for family labour.

The position of the 2005 sample of farmers on the restructuring spectrum was analysed to give an illustration of the types of restructuring undertaken in the recent past (previous five years) and intentions for the near future (next five years). The

dominant type of restructuring in the recent past continued to be farm focused, traditional restructuring (cost cutting, expansion, switches between agricultural enterprises), accounting for 37% of all recorded instances of restructuring (compared to 46% of the 2002 sample). A significant minority of farmers (25%) were re-orientating their business through up/down stream integration with the wider agricultural sector or through on- or off-farm diversification. Overall, there was little sense of significant movement between categories of restructuring, with 50% of the 2005 sample following the same trajectory as in 2001/02. Where there had been movement between categories it was largely between traditional restructuring and the minor change or static categories. Thus, the picture was one of relative stability at the individual farm level, and avoidance of radical change in the trajectory of the farm business. This seems a reasonable assumption in terms of response to (then) future pressure for change, though Lobley, *et al.* (2005) felt it likely that there would be a small increase in the numbers of on- and off-farm diversifiers and a proportionally similar increase in the number of 'static' businesses attempting to absorb market trends or policy changes by 'standing still', typically by reducing household consumption and accepting a declining standard of living.

Where disengagement from mainstream agriculture was taking place, this proceeded along a number of pathways and, at the time of the research, seemed rarely to lead to complete farm businesses being given up. Alongside a continuing, if unspectacular, move to diversify the income streams coming into the farm household, the increasing incidence of retirement and lifestyle holdings meant that a growing proportion of agricultural land was no longer being farmed by those who actually occupied it. The rise of contract farming and other land rental and letting arrangements, was partly explained by reluctance on the part of many disengaging and retiring farmers to actually give up their farms, even in the face of declining returns and policy uncertainty. Lobley, *et al.* comment that the effect of the then uncertainty surrounding the SPS and market conditions more generally had been to delay widespread change rather than hasten its implementation. So far as farmers themselves were concerned, few appeared to be planning to leave the industry in the

next five years, with 60% reporting that they still expected to be managing their current farms in five years' time (this proportion rose to 76% if those planning to retire in favour of a successor were included). Only 6% currently planned to sell their farm, while a further 6% planned to retire or semi-retire and let their land. There were hints that this strategy sometimes carried high personal costs.

More recently Lobley and Butler (2010) analysed the response to CAP reform amongst farmers in the South West and suggested that there may be a relationship between strategic plans for the future and farm size. They identified a number of distinct groupings of farmers (expanders, withdrawers, managerialists, consolidators and disillusionists). The largest group – consolidators – were characterised by a high dependency on agricultural income, small farm size and a low incidence of diversification. The consolidators were less active than the expanders and managerialists and appeared to be attempting to absorb the impacts of CAP reform without making significant changes to their farming practices. Many of the farmers in this group were older and comparatively least satisfied with their lives. Lobley and Butler (2010) suggested that this is where much of the movement of land occupancy would occur in the longer-term. Winter and Lobley (2016), with a focus on the ability of the small farm to survive, commented that, broadly speaking, farmers faced with declining economic fortunes can either focus on a farming solution, combined with tightening their belts, or redeploy resources away from agricultural production, which may involve leaving farming altogether by selling or letting their land. In reality, farmers may vacillate between periods of off-farm work (generating income) interspersed with a focus on the farm.

The notion of a typology of farmers making different responses was also used by Shucksmith and Herrmann (2002), who also pointed to the need, when explaining farmer behaviour, to move beyond the simple business model and embrace all the other factors that influence farm households. Farmers' and farm households' actions may be viewed as the outcome of interplay between the individual's own "disposition-to-act" (the product of socialisation and interaction), the farm household's material

resources (size of farm, capital, labour skills, cultural capital, position in the life cycle, tenure) and external structures (relative prices, policy, labour market opportunities, social and cultural norms, etc).

Building on the Europe-wide programme on "Rural Change in Europe: Farm Households and Pluriactivity", coordinated by the Arkleton Trust (see Bryden, *et al.* 1993), a typology of response patterns was identified by Shucksmith and Herrmann that specifically related to a sample in the Cairngorms, a mountainous LFA region. The types revealed by clustering techniques were 'hobby farmers', (8%), 'pluriactive successors' (15%), 'struggling monoactives' (31%), 'contented monoactives' (26%), 'potential diversifiers' (17%) and 'agribusinessmen' (5%). Each had behaved differently in the past and, moreover, might be expected to diverge increasingly in their future behaviour. For example, the struggling monoactives did not wish their children to succeed them and most would give up the 'struggle' of farming themselves if their returns fell far enough. In contrast, contented monoactives indicated that they would seek to expand their farm businesses in order to survive, while potential diversifiers would explore new options instead. If these expectations are realistic, then it is possible to discuss how structural change might proceed if agricultural support is reduced and returns from farming fall. But in the context of Brexit, it is clear that a diversity of responses is likely among the farming community.

Pike (2008), reviewing segmentation research for Defra, describes alternative typologies which are useful in the context of potential responses to Brexit. Research for Defra by the University of Reading (Garforth and Rehman, 2004), using factors extracted from 25 objective and 26 value statements, clustered farm respondents into five farmer types:

1. family orientation;
2. business / entrepreneur;
3. enthusiast / hobbyist;
4. lifestyler; and,
5. independent / small.

Each had certain characteristics which can affect likely responses in respect of a policy change. A second study (by Continental Research for Defra and not available independently) built on the Reading work and, in a similar way to the first study, used factors (seven) from environmental issues to technology as a basis for the segments. In very broad terms, the five segments, identified through descriptions rather than labels, lay within a rainbow. Groups 1 ('custodians') and 2 ('lifestyle choice') may respond more to emotive issues where inclusion and partnership working / mutual benefits are key. Groups 4 ('modern family business') and 5 ('challenged enterprises') are more economically rational and pragmatic – they can be focused on the bottom-line. Group 3 ('pragmatists') which are mainstream, traditional, family types, are a mixture of the two.

The heterogeneity of strategic responses to the need for change among UK farmers seems to be part of an EU pattern, and probably a universal one in OECD countries. Weltin, *et al.* (2017) used a survey of 2,154 farms from eleven European regions to identify responses to two scenarios; a continuation ('baseline') and the removal of any market intervention ('No CAP'). The focus was on the willingness to diversify. A factor and cluster analysis found six farm types, a typology that proved valid across all case studies, though single types occurred more frequently under specific site conditions. The six farm types showed strong variations in the stated future diversification behaviour. Young farm households with organic production were most likely to diversify activities, particularly on-farm, whereas intensive livestock farms, those already diversified, and part-time farm households were least likely to apply this strategy. Results further showed that, under hypothetical conditions of termination of CAP support, an increasing share of farmers – across all types – would apply income diversification, mainly off-farm, as a survival strategy.

Finally, there is evidence (Barnes, |*et al.*, 2016) of a strong link at farm level between past responses to policy reform and intentions with regard to future ones (though, as noted above, intentions may not be borne out in reality). This suggests that a

typology based on past behaviour would be a useful tool in assessing how farmers could be expected to react to the shift in conditions associated with Brexit. Working with a survey of 1,764 livestock-based holdings in Scotland, it was found that the majority of farmers sought no changes in their business up to 2020, though intentions were more sensitive to reductions in direct payments than to possible increases. Under a payment decrease scenario, intentions were in line with economic expectations; the number of farmers stating they would exit the industry more than doubled from 4% to 9% and around half the respondents stated they would decrease both herd size and intensity if payments were to decrease. Response to past reform was found to be a significant predictor of intention to change. So too was the identification of a successor within the farm household. The authors concluded that future studies of farmer intentions should include some of these variables (such as past responses, presence of a successor) to explain change.

To sum up, retrospective study on actual responses to past financial pressures reveal a variety of ways of coping, some of which move in opposing directions (such as expanding or cutting back output). These suggest different types of management behaviour among farmers, details of which vary between authors. This diversity of behaviours underlines the need to take into account the heterogeneity of likely response to any change, such as is represented by Brexit. However, to operationalise them by placing farmers in the England FBS sample (used to model the income implications of Brexit scenarios by each of the major quantitative studies currently available) into categories/groups as a way of exploring the longer-term responses of the industry and its sub-sectors would require much more information than is routinely collected and is available on farm size and type. It would require personal details (such as education, family status, how the farm was acquired, etc.), histories of past responses, and value statements in response to prompts on issues such as attitude to risk and retirement/succession plans. While it would not be impossible for additional data of these types to be collected in the future, this might not reflect Defra priorities for coverage in the regular FBS or its periodic modules. Nevertheless,

appreciation of the typologies may permit some qualitative discussion of the range of responses likely to Brexit.

### A5.4. Structural change in UK agriculture

In the longer-term, structural change is likely to follow any shift in the economic and technical environment brought about by Brexit. While economic theory can provide useful insights, reality is more complex than the simple economic model just outlined in at least the following respects.

- At any one scale individual farms will display a range of costs because of factors such as quality of management (the diversity of farm performance, has been the subject of a recent AHDB-funded research project).
- Change is primarily driven not by the ***ratio*** of outputs to inputs (often taken as a metric of economic performance and of competitiveness) which determine average costs in the simple economic model and in which costs are imputed to the factors owned by the operator, including land which may have been inherited or bought at historic low costs and the value of their entrepreneurial labour. Rather, at least in the short-term there will be more potent factors, such as the level of current income (the value of output ***minus*** the paid costs of its production) and whether that is adequate to meet the consumption expenditure of the households involved. Anticipated future income and risk factors associated with it will be important (as with any investment decision), together with the resilience in the face of falls in income (anticipated or unanticipated) and coping strategies (such as access to credit).
- As farms are typically run by households rather than by impersonal corporations (and even most farms organised as companies for taxation convenience are family-owned and operated), the dynamics of the family are important to the functioning and development pattern of the farm-firm. This applies in particular to what happens at points of succession, where decisions can impact on both the farm's land holding and its environmental character (Potter and Lobley, 1996a and 1996b).

- Change is not a frictionless process, and there will be costs that will have to be overcome.
- Structural change can be asymmetric, in the sense that a move in one direction (e.g. abandoning an enterprise) may be easier than establishing such an enterprise; sunk costs may not be recovered.

The structure of UK agriculture can be described in many ways (pattern of output, input use, land use, marketing channel, business form, land tenure, labour force and its characteristics, etc.). Changes in structure are seen as a necessary part both of responses to long-term economic pressures and to shorter-term revisions in agricultural and related policies (Blandford and Hill, 2006). National governments and the EU have often provided assistance to such adjustments (Cahill and Hill, 2006) on grounds of economic efficiency, equity, and political economy, or combinations of these. Here the focus of interest is on those changes in structure that are (a) likely to be accelerated or retarded by Brexit-induced changes in income in the short term; and, (b) are likely to carry implications for the UK agricultural industry, as seen by the AHDB. Of course, in the longer-term, structural changes can themselves be expected to impact on incomes and rewards. The most likely candidates for further study appear to at least include the following structural changes, which tend to be linked with each other:

- the pattern of farm sizes and pressures to change size;
- farmer exit decisions and entry opportunities, and pluriactivity of family labour;
- adoption of technical change, and the investment in new technology; and,
- farm diversification and development of diverse income sources.

From a policy standpoint it should be noted that structural change is likely to have an impact on non-market output, in the form of environmental and social externalities. Though these, by definition, are not factors that are taken into account by farm operators in their management decisions, they can be the basis of intervention by governments, and these (such as payments for environmental services) can impact on the revenue stream of the business.

In summary, structural change can take many forms, though attention is often given primarily to the size distribution of businesses.

### A5.5. The pattern of farm sizes and pressures to change size

Agricultural statistics for the UK over many decades clearly show a long-term pattern in the numbers and size distribution of farms (Marks and Britton, 1989), one that differs only little according to whether physical area, estimated labour input or economic size is being considered. The general picture is one in which the numbers of farms in small size classes diminishes over the years, but at a declining rate up to a 'breakeven' point at which number are steady. Above this size the number of farms increases with increasing farm size. Over time this 'breakeven' size tends to rise. This general pattern is driven by the long-term downward pressure on incomes that results from the treadmill of technical advance expanding supply in the face of relatively static demand and the associated decline in real product prices.

In the UK this general pattern when size is expressed in physical area may be primarily a feature of change in the post-Second World War period. Allanson (1990, 1992) argues that average holding size was either stable or slowly declining between 1875 and 1939, and that constant growth in holding size since 1951 is a novel phenomenon rather than a continuation of previously established trends. Similarly, according to Grigg (1989), between the 1880s and 1930s large holdings (in terms of area) were in decline but the number of holdings of less than 120 hectares was increasing. Notwithstanding the general pattern, in recent decades the numbers of very small holdings has risen, this being explained by them being operated on a part-time or hobby basis and their households not being solely dependent on income generated from agriculture. Thus, the overall pattern of changes in size distributions measured in physical area is better described as one of 'hollowing out', with declining middle sizes but increasing numbers of large farms (where agriculture is capable of generating a satisfactory income) and of very small ones (whose incomes primarily come from non-farming activities or property sources such as investments and

pensions). Declining numbers are associated with farms that are too small to generate a satisfactory income for operators and their families from farming, yet which are too large to be operated on a part-time basis and allow family labour to engage in off-farm gainful activities. This 'disappearing middle' is also seen elsewhere, for example Weiss (1999) in Austria, where the survival of farms has been found to be associated with age and schooling of the operators, their family's size, off-farm earning status, and the initial size of farm.

According to Neuenfeldt, *et al.*, (2017), a multitude of theoretical hypotheses are put forward to explain farm structural change within Europe. Important drivers identified in the literature include, among others, technology (economies of scale) and productivity growth (Harrington and Reinsel, 1995), farm household and path dependency (Balmann, *et al.*, 2006; Zimmermann and Heckelei, 2012), input and output prices as well as macroeconomic drivers (e.g. unemployment rate) (Zimmermann and Heckelei, 2012), regional characteristics, agricultural policies (Chau and de Gorter, 2005; Ben Arfa, *et al.*, 2015), and competitive pressures from non-agricultural sectors for resources (Alvarez-Cuadrado and Poschke, 2009). Higher land prices will impact differentially on different categories of farmer, harming some (existing farmers who wish to expand and potential new entrants) and increasing the economic status of others, with lower prices having opposite affects.

A key distinction between the studies that attempt to assess the importance of drivers on structural change in agriculture are those that use either macro or micro data. Studies using data at the macro level exploit the information of farm structure (e.g. number of farms) at the regional or country level to explain its dynamics (entry and exit of farms) and drivers over time (Breustedt and Glauben, 2007; Goetz and Debertin, 2001). The studies based on micro data explore farm level information to explain farm structural change/growth models (Bremmer, *et al.*, 2004; Weiss, 1999 and Sumner and Leiby, 1987). Some studies combine micro and macro data to make better use of the information when identifying significant drivers and performing projections (Storm, *et al.* 2015a, 2016).

It should be emphasised that findings from cross-sectional analyses should not be interpreted as what happens on individual farms over time; this would imply a 'false' long-run production function in which small farms when they enlarge take on the characteristics of present large ones; in reality large farms, especially very large ones, may be the product of unusual circumstances, not least in the quality of their management teams, that are not replicated when small farms grow (Britton and Hill, 1975). The dynamics of structural change have to be considered. For example, small farms do not generally merge to become large farms. The pattern is more likely to be that medium and large farms absorb small ones (because of the economic rationale for enlargement by spreading fixed costs, as already described). Adjacent land is clearly more attractive than more distant land, as the spreading of fixed costs is easier; Storm, *et al.* (2015b) has shown for Norway the significance of spatial issues to farm survival, including the direct payments that neighbouring farms receive.

Acquisition of land may be by purchase or renting/leasing, and this may shift the existing tenure balance. Hill and Gasson (1985) explained that the superior economic performance of mixed tenure farms in the FBS of England and Wales was likely to have resulted from the growth of well-managed businesses taking on more land, irrespective of tenure (with owner-occupiers renting additional land or, less often, tenants purchasing land) rather than any attribute linked to tenure itself. Expansion by renting land has become a lot easier since the change in tenure legislation in 1995 (that brought in Farm Business Tenancies) enabled farmers wishing to reduce their area farmed to let it to other farmers without losing control of it for an extended period, as would happen under full agricultural tenancies.[18] The retiring farmer could still live in the farm house without responsibility for farming the entire area owned. Small farms are likely to result from the dismembering of existing farms in which

[18] Agricultural tenancies agreed before 1 September 1995 are known as 1986 Act Tenancies. They are also sometimes referred to as Full Agricultural Tenancies (FATs) or Agricultural Holdings Act tenancies (AHAs). These tenancies usually have lifetime security of tenure and those granted before 12 July 1984 also carry statutory succession rights, on death or retirement. This means a close relative of a deceased tenant can apply for succession to the tenancy within three months of the tenant's death.

most of the land is taken by larger farms, leaving a rump that includes a farmhouse that can be sold for residential purposes.

Changes in farm size structure using aggregate data have attracted studies using Markov chain analysis to track the probability of movement of individuals between size groups, with Zimmermann and Heckelei (2014) reviewing the literature and regional differences in such probabilities in the EU. Piet (2011) has proposed a superior parametric Markov Chaim Model (MCM) and applied it in the EU and USA, while Saint-Cyr and Piet (2015) have tried a mover-stayer model as an alternative. Interesting as these may be, they seem to be more relevant to economic and technical conditions that are relatively stable, or slow moving. There are examples of studies that look at the structural changes in farming associated with the substantial shock that was represented by the accession of countries in central and eastern Europe to the EU (such as Buchenrieder and Möllers (2009) or Karwat-Woźniak, *et al.* (2015) explicitly for Poland) but the conditions are probably so different from those of the UK, not least in the pattern of landownership, that they hold little relevance for what may happen here after Brexit.

To summarise, the long-established picture of structural change in the UK has been one of a rise in the numbers of large farms and falls among smaller commercial ones, though this is complicated by rising numbers among very small units that are primarily residential or hobby in nature and not primarily dependent on farming to generate the occupier's household income. Size adjustment can be achieved in various ways, and Farm Business Tenancies play a part in this. However, most past adjustments have been studied in time of relative economic stability and gradual structural change; radical shifts in incomes, such as might accompany some forms of Brexit, could present rather different sets of drivers.

### A5.6. Exit and entry decisions

Here we are concerned with the potential impact of Brexit on the rate of exit and entrance, and what these mean for the agricultural industry. The general situation

was reviewed by ADAS, *et al.* (2004) and Williams (2006). Farm businesses in the UK are most usually run as household-firms (usually unincorporated businesses or companies owned by families), so commercial decisions are overlaid by stages in the family cycle, and these (aging, retirement, succession, etc.) can be crucial to the survival of the business (Chavas, 2001; Gasson, *et al.*, 1988; Gasson and Errington, 1993). Major structural and environment changes are commonly associated with transfer of control of farms (Potter and Lobley, 1996a, 1996b). Though land reallocation can be achieved at any stage, where retirement takes place decisions on lifestyle often trigger the release of land, which can then be absorbed by other farms and can thus result in structural change. Therefore, it is appropriate to consider how exits, entries and inter-generational transfers may be affected by Brexit.

Perrier Cornet, *et al.* (1991) noted that the process of replication/take-over is a complex one that necessarily involves the ownership and/or access to land. Within the (then) EEC though in many countries family inheritance was dominant, there was wide variation in the legal environment and social norms concerning landownership and inter-generational transfers. The authors comment that in the UK, farm entrance, farmer retirement and renewal (together) are not considered to represent a major social issue in general, though it is of greater concern in less-favoured areas and in regions with a size structure with more small farms.

The size of UK farms in general is such that several generations can often cooperate, with (according to these authors) the young receiving 'good incomes', and the collaboration eases intergenerational transfer. The legal situation enables many to succeed to land without having to purchase it, and thus without debt and interest charges associated with entry by purchase (a situation in sharp contrast with, for example, Denmark where purchase by successors is the norm using special forms of credit, a situation that is manifest in exceptionally high interest charges in official accounts for farm income – see Eurostat, 2002). This, and the relatively small numbers of entrants to tenanted farms, is one contributing factor the authors believe lies behind the relatively low economic performance of farms in the UK. They point

out that policy has always favoured the disappearance of small farms and the increase of medium and large ones, whatever the farmer's age. Land abandonment due to the collapse of farming activity 'is not considered as a fear haunting British minds'. Bearing in mind this report, it is hard to see how Brexit could be expected to impact on the legal framework involved in exit and entrance to farming or the social norms of inheritance and succession. However, there could be an impact via changes in farm income if sufficient farms were caused to become unviable, or fragmented.

The complexity of the transfer process between generations (though not all the judgements of Perrier Cornet, *et al.* on their implications) is also noted by many UK authors, including Gasson, *et al.* (1988, 1989) and Gasson and Errington (1993). When successors are present, passing responsibility for part of the business, with or without changes to its formal organisation, seems common. It follows that in such circumstances, exit is not a simple and clearly identified step, being more of a process.

Raggi, *et al.* (2013) drew an important distinction between the decision to exit from farming and the separate decision to sell land. A survey of stated intentions (as distinct from actual responses) under two extreme CAP scenarios was carried out in nine EU countries at the beginning of 2009. The numbers of farm households signalling their intentions to exit from agriculture increased sharply under the scenario characterised by the removal of the CAP. The statistically significant determinants (mostly consistent with previous studies) differed between, on the one hand, the exit decision and, on the other, the willingness to sell the farm. The results seemed to reinforce the notion that the current CAP direct payments were important for staying in/exiting farming activities. However, the land reallocation process was clearly different, suggesting more attention was needed to transfer mechanisms other than land sale, such as renting or alternative land tenure solutions.

This leads on to the issue of whether changes in farm incomes could be expected to lead to some sectors, or sizes, becoming unviable and thus forcing exit. Zeddies

(1991) looked at the issue of farm viability for the European Commission and found it definitionally complex; furthermore, it reflected factors additional to current income from farming, including the household's consumption habits, capital position and presence of other gainful activities. Nevertheless, a number of levels of risk to viability could be established using data on profitability, ability to build capital, and liquidity taken from farm accounts as supplied to EU-FADN; these include the relationship between, on the one hand, spending on capital formation and, on the other, depreciation estimates incorporated in income calculations.

Chau and de Gorter (2005) identify the impacts of infra-marginal production subsidies on the farmers' decision to exit the industry or stay in business, and perhaps even expand output. There could be parallels in the post-Brexit scaling back or removal of direct payments. Isik, *et al.* (2005) point to the importance of uncertainty and irreversibility in decisions at the farm firm level, making an options-value model a useful tool. Not making a decision preserves the opportunity of making a better decision later. Reluctance to abandon an investment may be explained because there is an option value of keeping the operation alive. There is an obvious parallel in the uncertainty that the UK's Brexit process has generated, which could be expected to delay decisions on exit and entry, as well as investments (see below).

Defra (2016) used data from the FBS for England to show the potential impact of removing CAP direct payments (excluding agri-environmental schemes) on the numbers of farms making zero or negative incomes from agriculture, implying that they were likely candidates for exit. This static analysis was based on a five-year matched dataset sample (1,294 farms) (2010/11 to 2014/15) and results were weighted to reflect the 2014/15 FBS population. The average Farm Business Income (FBI) was calculated for each farm over five years, together with the average payment from the Single Payment Scheme (SPS). Distributions of farms were generated (by farm type). There was a predictable shift in the distribution when SPS payments were halved or eliminated; in the latter case the numbers of farms with a negative FBI

increased by a factor of more than three (from 5,900 out of a population of 57,600, to 10,700 if payments were halved and to 20,600 if they were totally eliminated).

Defra pointed out that these relationships do not make allowances for the adjustments and adaptations that farms would almost certainly make if these cuts were made and were continued at a sustained level. Blandford and Hill (2006), using evidence from many countries, established that the ability of farmers to adapt and adjust is often under-valued by policy-makers; this helps explain phenomena such as the very muted impact on the rate of exit in New Zealand (estimated at only 1%) of the sudden removal of subsidies there (evidence to the House of Lords, 2016). As noted above, many authors (including Shucksmith and Herrmann, 2002; Gasson, *et al.*, 1988, 1989; Gasson and Errington, 1993; Barnes, *et al.*, 2016) writing about the UK point to the importance of wider personal and social factors in shaping actual responses by farms.

Elsewhere, in its Brexit evidence compendium, Defra identified additional factors that undermine the simplistic assumption that negative incomes from farming activity, even persistent ones, will lead to exist from the industry (Defra, 2018). These include that evidence (for England) shows that:

- Almost two-thirds of farm engage in diversified (non-agricultural) activities by using their farm's resources (e.g. generating solar energy, letting buildings for non-farming uses, sport and recreation), generating an average income from such sources of £17,100 per farm.
- Other gainful activities provide income generated off the farm for many farm households, and for 40% of principal farmer households the income received from non-farming sources exceeds the income from the farm business.
- For many farmers profits are not their main motivation and, in a survey conducted for Defra in 2008, 93% agreed that the farming lifestyle was what they really enjoyed. This is supported by a raft of further evidence cited in Defra (2018) and in Pike (2008). While an ability to meet basic living costs is a prerequisite (though these can be lower than for non-farming households because of the close mix

between business and household), this motivational characteristic helps explain why simple accounting cannot satisfactorily explain exit behaviour. Gasson (1973) was seminal in this area and established the strength of an intrinsic orientation among farmers, which help explained subsequent muted responses to retirement schemes that, while compensating for losses of monetary income, did not replace the non-monetary rewards. It also explained the unanticipated enthusiastic take-up of farm modernisation schemes that helped farmers do things which they were predisposed to value.

- Many farmers are asset-rich, especially if they own land, and have received substantial capital gains in recent years. According to Defra (2018), 53% of farm holdings are owner-occupied, and a further 21% is of mixed tenure but mainly owner-occupied (they were also larger). In the first group the average net worth was £1.9 million in 2016/17 and had increased by 28%, or £422,000, since 2013/14. For the second group the average was £2.5 million and its gain was 18%. Because of this asset position, and the gains that have accrued, downturns in current income may be both endurable and the continuation in farming/landowning rational, especially in light of favourable taxation treatment of these assets.

In explaining the slowness of farmers to exit, ADAS, *et al.* (2004) note that older farmers choose to remain in agriculture because they like the lifestyle and have an attachment to a home which may have been in the family for many generations. Lack of affordable and suitable housing may be a pressing problem for retiring tenants. Inadequate pension provision has long been identified as a problem in agriculture, making it more difficult to retire from farming without liquidating business assets to supplement pension income. Retention of property assets, appreciating in value and capable of generating cash income, may be viewed as the optimal strategy for later life.

Attention to the problems of entrance has acknowledged that the principle traditional way into the industry has been by membership of farming families that already control

land or have the wealth to do so; in other circumstances it is far harder, though not impossible, to establish oneself as an independent farmer. Even within farming families the process of succession is not without its frictions, especially when farms are small (Hastings, 1983). According to Williams (2006), anecdotal evidence suggests the means by which this takes place has adjusted, with the next generation farming independently at a much later stage in the family cycle.

Industry commentators suggest that there is an increase in the relative numbers of new entrants from other sectors, particularly in agricultural areas in close proximity to large centres of population. Income derived elsewhere coupled with lifestyle considerations, fuels an argument that some new entrants may be less pre-disposed towards operating a competitive farm business and are 'hobbyist' in their approach (thus denying others the opportunity). Another school of thought is that capital investment in the industry is beneficial and opportunities are afforded for mutually beneficial contract arrangements with other farmers. ADAS (2004) point out that some residential purchases by non-farmers leads to increased availability of bare land for short-term tenancy or separate purchase. On the other hand, a new entrant buying a farm with a house may be obliged to contemplate a price which reflects the consumption of residential services which would be valued extremely highly by other potential purchasers. Finally, new entrants via the 'agricultural ladder' (starting as a hired labourer, progressing to a tenancy, with perhaps later purchase) are now perceived to be a rare occurrence, the economic barriers facing this group (high start-up costs with low expected rates of return) being insurmountable.

There is a debate in the literature about whether the rate of farms with a successor has been changing, and whether this represents a 'crisis', with methodological differences between studies (such as disparities between the exact wording of survey question, clouding the picture (see Burton and Fischer, 2015); Lobley, 2010; and, Lobley, *et al.*, 2010). What is clear, from a number of studies on the family nature of farm businesses in the UK, is that the presence of a successor is key to a lot of behaviour by the existing cohort of farmers. This includes not only decisions about

when to retire and pass control to the next generation but also to investment decisions, farming operations and farm growth. It is worth noting that successors are not always present, because of an absence of children or their reluctance to enter the farm business and preference for other careers. Researchers (including Errington, Gasson, and Harrison) point to the relatively low frequency of successors on farms that are economically marginal, with young people apparently unwilling to commit themselves to a future of low incomes if they can earn more in other occupations, even though there may be non-monetary rewards from a farming lifestyle. Such low-income problems disappear among larger farms, where inheritance as a means of entry seems to have been historically high (for example, see Newby, *et al.* (1978, 1980)).

Summing up, assessing the impact of Brexit on decisions to exit should not rely in a simple way on what may happen to incomes from agricultural activity, though anticipated future incomes and income security will play a significant part in shaping exit decisions. The process of leaving the industry is a complex one, affected by many factors both within the farm household as well as external conditions. Diversity of income sources, retirement opportunities, taxation, assets held outside the farm and net worth play important roles. Exit from farming does not necessarily imply the sale of farmland, even among owner-occupiers. Many of these shapers of exit decisions are not directly affected by Brexit and the changing fortunes of agriculture. However, there are several pointers to the importance of expectations of future income levels and to uncertainty (associated with Brexit) as being influences. Similarly, for entrants many determinants of the rate of joining the farming industry seem to be not directly affected by Brexit, though the willingness of successors to join the family business, already compromised on farms where profitability is low, is likely to suffer if the future seems to offer only lower incomes or less secure rewards.

### A5.7. Innovation and investment

Innovation and investment at farm level are key to ensuring the longer-term viability of individual businesses, though heavy borrowing to make investment possible may

lead to vulnerability if economic conditions deteriorate (such as rising interest rates). Thus, it is useful to review the factors associated with innovation and investment, and how they could be impacted by Brexit.

As part of a study commissioned by the Ministry of Agriculture, Fisheries and Food (MAFF) on the factors determining on-farm innovation in UK agriculture (Gasson and Hill, 1996) a thorough review of the extant literature was carried out by Gasson. This study reflected a concern within MAFF that the scientific information that was being generated by public spending on the research community was not being reflected in developments at farm level, and that this was a particular problem in certain sectors. Following the literature review, case studies were examined of the process of innovation in various policy areas important to MAFF; these were the beef and sheep sector (where poor innovation seemed endemic), arable crops, horticulture (where there was particularly good exchange of knowledge between scientists and prominent farmers and growers), environmental protection and animal welfare. Several of these are directly relevant to the activities of the AHDB. Since Gasson's work there have been other reviews of the literature as part of research projects (e.g. CCRI/Macaulay, 2007; Wilson, *et al.*, 2013), but the prime features are robust and enduring.

In brief, several key observations may be made:

- The process of innovation at the farm level has a number of recognised stages, the names of which may differ between studies. These correspond with (a) awareness of problems and of the existence of possible solutions; and, (b) mental acceptance of these innovations; and, (c) actual adoption (implementation). These stages spread through the farming industry in sequence over time and follow a pattern that is approximately sigmoid, though the delay between the stages, the precise shape of the curves and how long they extend over time reflects a number of factors, mentioned below.
- Awareness by farm operators of innovations generated by the science and development community (or by fellow farmers) is impacted on by the 'knowledge exchange' system (a better term than "Knowledge Transfer" as this implies a one-

way directional process whereas the science community often needs information from farmers about the issues that require technical solutions). Many channels of communication contribute to farmer awareness through knowledge exchange (including impersonal mass media, advertising, shows and demonstrations, public and commercial advisory services, consultants, fellow farmers, family, etc.).

- For adoption to take place there must be a perceived benefit (such as increased income, more stable income, reduced managerial load, better working conditions, etc.) and the "bottom line" will be influential in shaping uptake. It may be that awareness of some innovations is never turned into adoption, at least for some farmers, or economic circumstances may need to change before this happens (such as a rise in labour costs triggering innovations that substitute capital for labour). Non-adoption is not necessarily indicative of failure to make farmers aware of innovations or of misjudgements of the opportunities that they offer. Vanclay and Lawrence (1994) conclude that most "barriers" have a rational basis and can be categorised as: conflicting information; risk; implementation costs and capital outlay; intellectual outlay; loss of flexibility; complexity; and, incompatibility with other aspects of farm management and farm and personal objectives. It follows that such factors have to be taken on board by advisory services (such as clarity of message, where this is appropriate, and assisting farmers to balance conflicting objectives when devising development plans).
- The rate of adoption (though not necessarily of awareness) will reflect the characteristics of the innovation, in particular, the demands on capital and management skills and their risk characteristics. For example, those that are cost-reducing or require little extra capital will tend to be adopted more quickly than those that represent a major investment. A new variety of cereal will not require much extra management skill (maybe less), in contrast with the replacement of extensive grazing for livestock with an intensive housed system which may carry high vulnerability to disease risks unless matched by suitable management skills.
- Farm operators differ widely in their rates of awareness, mental acceptance and adoption of innovations. This reflects (a) the circumstances of the farm business,

which in turn depends on characteristics including farming system, level of indebtedness, level of profitability, farm size (larger ones typically being able to absorb more easily the additional risks of innovation); and, (b) the personal characteristics of the farm decision-makers, including psychological factors such as attitude to risk, willingness to network, personal aims and objectives and values, stage of family cycle, age, degree of formal education and so on. Knickel, *et al.* (2009) draw attention to the need for advisory services to be aware of such personal factors; furthermore, the advisory institutions can themselves become barriers to innovation if they fail to recognise that the needs of farmers and of society change over time.

- Consequently, at any one time farmers will display a distribution of innovation behaviour that approximates to a normal distribution, with innovators and early adopters at one extremity, and laggards at the other, separated by the majority who can also be divided into earlier and later adopters, i.e. early majority and late majority.[19] There is usually a degree of consistency in innovative behaviour across a range of innovations (it is unlikely that an individual operator will be an innovator for some and a laggard for others), so that farmers may be stratified (segmented) according to their general response to innovations.
- It has been long recognised by studies that different persistent behaviour patterns at the farm operator level are associated with particular sets of socio-economic characteristics. For example, Jones (1972) drew on several British studies to associate the spectrum from innovators to laggards with three variables: personal characteristics; salient values; and, personal relationships and communication behaviour. To take only the extremes, innovators' typical personal characteristics were: high social status; largest and most specialist operation; wealthy; often young; well educated; and, often experienced in non-farming environments. In terms of their values and relationships, innovators were typically: venturesome and willing to accept risk. In contrast, laggards had lowest social status; smallest operations; lowest income; and were often oldest. Their values were "traditional";

[19] Laggards can be defined as those falling behind the mean adoption time by 1 Standard Deviation in the distribution, early adopters anticipating it by 1 SD, and innovators anticipating it by 2 SD.

orientated towards the past; avoid risks; little if any opinion leadership; and almost isolated socially.

- Of particular relevance to organisations (such as the AHDB) whose remit includes making farmers aware of the potential to innovate, is the finding on communications behaviour. It is worth presenting Jones' full spectrum on this characteristic:
  - *Innovators* – Closest contact with scientific information sources; interaction with other innovators; relatively greatest use of impersonal information.
  - *Early adopters* – Greatest contact with local change agents (including extension or advisory services, commercial technical advisors, etc.); competent users of mass media.
  - *Early majority* – Considerable contact with change agents and early adopters; receive mass media.
  - *Late majority* – Interaction with peers who are mainly early or late majority; less use of mass media.
  - *Laggards* – Neighbours, friends and relatives with similar values are main information source; suspicious of change agents.
- Though the studies that formed the basis of Jones' work were carried out long before the internet was developed, his analysis underlines the importance of the general principle of choosing the appropriate channel of communication. For example, if the target group comprises farmers who might be characterised as "laggards", impersonal methods of communication are unlikely to impact on them; personal communication using trusted sources (typically neighbours, friends and relatives) are more likely to be successful.
- Within the agricultural industry there are several "agri-cultures" which are likely to overlap the typology described above. Each will have its own concept of "good farming", and attempts to influence behaviour will need to target not only the individuals but their culture too (Hallam, *et al.*, 2012). Segmentation models (such as that of Garforth and Rehman (2006) developed for Defra (Wilson, *et al.*, 2013) can be helpful in focusing on which agri-cultures are of particular interest to policy-makers and on whom communications are to be concentrated.

- While not disputing the importance of farmer-to-farmer communications, especially for certain target groups, Gasson's 1996 review of innovation literature warns against reliance on the "trickle down" effect, whereby progressive farmers are assumed to act as exemplars to others. "*The "trickle-down" effect assumes a homogeneous population, whereas farming populations are likely to be heterogeneous in respect to access to resources, group norms, stage of life cycle, etc. It assumes that the message is transmitted more-or-less intact, whereas in practice it is likely to be distorted in its passage. The adoption process also assumes that the innovation is equally applicable to all farming situations and will benefit potential adopters, overlooking the need to adapt innovations to individual circumstances*".
- From the pattern of awareness, acceptance and adoption described above, it follows that, at any one time, some farmers will be well behind the leaders in terms of the adoption of innovation. An OECD study has drawn attention to this gap as a cause of the disparities of economic performance that characterises farming in many countries: "*It implies that promoting the adoption of existing best practice and improving the resource allocation can lead to a significant improvement in the sector performance…*" (Kimura and Le Thi, 2013). Consequently, it may be possible to make a case that public funds should be used to provide interventions that shorten the length of the whole process, of which knowledge transfer activities and advisory schemes could be part (as could financial inducements to invest and other instruments). Because of the dynamic nature of the system, the gap between innovators and the rest is likely to persist, and thus a permanent system of intervention may be justified.

Considering the impact of Brexit on innovation and investment requires the identification of those factors mentioned above that are likely to be changed and those that are not. At least in the short-term, it is unlikely that the personal characteristics of farmers will be affected, or the flow of new knowledge, or the channels of communication in use or the preferences of various types of farmer. No specific mention has been made of scaling back public support for knowledge

exchange; if anything, the government has provided assurances over support to agriculture (at UK level) and the possible switching of more funds into rural development measures (which includes KT activities under existing EU Regulations). On this basis, it seems reasonable to assume that the ***awareness*** stage of the innovation process will not be seriously affected.

There may be an impact on the second stage in the innovation process (***acceptance*** that change is necessary), but that will depend on the particular form that Brexit takes. Only if migrant labour becomes recognisably less accessible and more expensive are farmers likely to accept that the substitution of capital for labour is a desirable move or relocation to where labour supply is unconstrained (both would represent innovations at the single farm level). Similarly, sharp changes in the profitability of particular enterprises could be expected to sharpen a farmer's resolve that change is necessary or desirable. It could be expected that anticipated levels of income and concerns over their certainty could impact on the acceptance that innovation could be needed.

However, the ***adoption*** phase is more likely to be affected. Among the barriers identified above are implementation costs, capital outlay and risk, with the implication that higher costs, outlays and increased riskiness will lower the rate of farms adopting innovations and making investments, or at least delaying them. The need to take action may become more apparent, but the ability to implement a response may be curtailed. The ability of farm households to bear these costs will be affected directly by its present and future capacity to make profits and indirectly by the size of its financial reserves and access to credit. Though, as noted above, farms will vary widely in their dependency on agriculture for their income and asset position and their ability to withstand additional risk, and thus in their sensitivity to negative changes in these brought about by Brexit, nevertheless the general direction of adjustment is clear. Of course, for those types of farm where Brexit is likely to result in an improved level of income, the rationale is reversed, with less pressure to innovate, but a greater ability to do so. And factors that increase risk are still likely to dampen investment.

To sum up, while Brexit seems unlikely to affect factors that determine the spread of information that is critical to the awareness that farmers have of innovations, their abilities to implement changes seem susceptible where adoption requires investment. Periods of negative income and increased risks, though not universal throughout the industry in Brexit scenarios, are likely to impede innovation and the investments necessary to bring them into use. As usual, the heterogeneity of farms must be borne in mind.

### A5.8. Farm diversification and development of diverse income sources

Many aspects of this form of structural change have already been covered. In conventional terminology, as used by Defra, farm diversification means non-agricultural work of an entrepreneurial nature, on or off the farm, but utilising farm resources (Defra, 2018). Ilbery (1991) saw diversification (in a study area of the England Midlands) as a relatively recent phenomenon driven by income pressures, but this seems to be at least in part the result of definitions; for example, contracting in a formal or informal way between farmers, a form of diversification in most studies, has long historical roots. What is more certain is that diversification, defined in Defra's way, has become normal. In 2016-17 64% of farm businesses (FBS) engaged in such activities (up from 51% in 2009/10) earning an average of £17,000 (among those with these activities). There is little reason to separate such activities from the more conventional production classified as agricultural, as management decisions clearly embrace them. (It should be noted that the aggregate measure of agricultural income, in the Economic Accounts for Agriculture, exclude such non-agricultural activities unless they cannot be separated in the source data.) However, this treatment of diversification seems to create an artificial barrier, in that all the resources of a farming household will be treated as within the same boundary when it comes to responding to change; imposing a 'farm resources' boundary has been criticised as arbitrary (Hill, 2012).

A more holistic view would embrace all the resources at the command of the household-firm, which would include non-agricultural businesses owned by the household members and income flowing from its complete labour force wherever used in economic activity, with income measurement including earnings by the farmer and household members in employment and self-employment. Pluriactivity in the UK has a long history (Harrison, 1975; Gasson, 1986; Hill, 2012); and can be considered the long-term norm, with mono-activity (a focus on farming) largely the product of post-war agricultural policy in the UK. Certainly, there is evidence as long ago as the Royal Commission into the hardship caused by the 1879-96 agricultural depression that families that combined farming, even small-holding, with some other occupation (ranging from mining and fishing to the professions) could remain 'extremely profitable'. Thus, responses by farm households to Brexit are likely to include decisions not only about diversification, but also on the allocation of labour of the farmer and household to off-farm, non-agricultural employment. Indeed, taking a non-farm job or expanding existing non-farming activities could be a strategy enabling many smaller farms to survive. Morris, *et al.* (2017) have explored the different adjustments in these directions by farmers in upland Wales and has found that four strategic stances can be identified: resource maximisation, core farm-focused, lifestyle and passive. These reflect attitudes towards on- and off-farm income generation and on stated stance towards current and future policy grant streams.

However, it is clear that in the UK the development of an off-farm job as a response to income pressure in agriculture is only one way in which pluriactivity originates, and probably only a minor one in recent history among farmers and spouses (Bryden, *et al.*, 1993; Gasson, 1986, 1988). Other ways include non-farmers buying their way into agriculture for investment or lifestyle purposes, inheritance while in another established career, and, for farmers, the desire to develop business interests and social contacts beyond those available in the farming community. Nor should part-time farming be assumed to be a transitional state to complete exit or full-time farming; for many farmers and their spouses it is a permanent arrangement that

accords with their personal preferences. As noted above, for family members who are potential successors, an off-farm job may be desirable both for financial and career purposes, but these are also likely candidates for return as part-time farmers when inheritance takes place.

In short, farm diversification and taking of off-farm jobs (or self-employment in non-agricultural businesses) is a possible strategy for farmer households facing income problems from Brexit. However, a simplistic view should be avoided, as the drivers of existing levels of these phenomena are complex and extend to many factors that are unlikely to be impacted by Brexit, at least in the short and medium-terms.

### A5.9. Expectations of the impact on land prices and rents

Much of the material covered in this section of the literature review has focused on the expected responses of farm operators to changes associated with Brexit to items in their current accounts, in particular market returns and direct payments, and thus on their residual incomes. However, there is also interest in the impact on land values and rents paid. Agricultural land prices have been on an upward trend since 2001, reached a peak in 2015 in England and Wales and have subsequently seen a decline (Savills, 2018), the uncertainty associated with Brexit being cited as an explanation (Roberts, 2018).

Land price changes will affect the balance sheets of farm businesses that have owner-occupied land, an important determinant of their viability (in that rising net-worth can incentivise a business to continue to hold land in the face of negative current income). They will also impact on the costs of farm expansion using owner-occupation and make entry by this means more expensive. For farmers who rent land, changes in prices of tenanted land (which loosely mirror those of owner-occupied land but in a far smaller market) can be expected to be reflected in the annual rent payments seen in their current accounts and thus in residual incomes.

The price of agricultural land is determined in a marginal market, in that only a small proportion of the total stock (recently less than 1% with Defra (2018) citing 0.25% for 2016) changes hand each year (like used cars or houses, but unlike most farm products). Previously it has been noted that this market in the UK for many decades has been dominated by existing farmers expanding their farms and capable of paying prices that reflect the absence of additional fixed costs. Savills (2018) also underline the importance of farm expansion but, in addition, point to the major share of recent buyers that it describes as 'lifestyle' purchasers of land; in recent years lifestyle purchasers in Savills' transactions have accounted for about the same number of transactions as have farmers (with a further small proportion, about 10%, being institutions or corporations). By definition, lifestyle purchasers will have motives that reflect factors other than the returns obtainable from agricultural production (house, amenities, location, etc.) and will tend to represent smaller areas of land (though this is not analysed in Savills (2018)).

As a factor of production, the demand for agricultural land is a derived demand, being dependent on the demand for consumption items (such as food, housing services or recreation). Advances in agricultural technology typically make land less scarce, but this does not appear to have a major downward influence on the demand for land (partly due to rising global populations and increased demand for food). The supply on the factor market can only come from holders of the existing stock releasing land to the market as, by definition, additional land cannot be created (except in the most exceptional circumstances, such as land reclamation or changes of use from virgin forest, scrubland, etc.). Although lifecycle circumstances, such as death and retirement, plus sales to relocate elsewhere, remain the main reasons why farmland is put on the market, about one fifth is driven by debt, a factor that has grown in the last decade and is likely to increase as the costs of servicing borrowings rise in line with expectations in the post-Brexit period (Savills, 2018).

The agricultural economics literature has a long history of concern with land prices, monitoring them and explaining movement (for example Ward, 1953; Peters, 1966;

Lund and Slater 1979, Maddison, 2000; Jadevicius, *et al.*, 2015 and 2016). Land price models have also been developed, using historic data. The first serious attempt in the UK was Traill (1979) which, as a pioneer, was relatively unchallenged. However, Lloyd (1992) offered a critique and detailed some of the its shortcomings, drawing on the extensive modelling activities in the US literature (see also Lloyd and Rayner, 1990 and Lloyd, *et al.*, 1991). In the present context a qualitative approach is thought more appropriate.

In brief, the price of agricultural land (with vacant possession) can be expected from the literature to be influenced by the following (summarised in Hill and Ray, 1987):

- Present and anticipated earning from the land in agricultural use (net of any special tax treatments). Income streams from land will be capitalised into its market value.
- Present and anticipated variability/risks in these earnings.
- Present and anticipated earnings from alternative uses of agricultural land, and their associated variability/risks. (This would include not only those such as forestry where farmers are free to choose, but also for development where planning permission needs to be gained.)
- Anticipated movements in land prices (these have often proved to be self-fulfilling, at least in the short-term).
- Current and anticipated rewards and anticipated movements in the prices of alternative assets that holders of agricultural land have made/could make.
- Current and capital taxes applied to agricultural land compared with that on other assets.
- Costs of borrowing for land purchase.
- Any non-monetary benefits or penalties associated with landownership (such as privacy and the ability to control one's environment, recreational opportunities, or social connotations of landownership).

Some of these factors are likely to be impacted by Brexit. The most obvious is the impact on the net incomes of farms, with downward pressure on land values among

those types of farming suffering declining incomes and rising land values where incomes rise. Greater income instability can be expected to depress land prices. If Brexit appears to threaten the returns available in other parts of the economy, then it can be anticipated that there may be a flight into land by investors who see it as a safe haven, something that appears to have been a factor explaining the very sharp (but short-lived) rise in land prices between 1971 and 1973 when the UK joined the (then) EEC.

While the direction of change of each of these factors is clear, the magnitudes are not. Furthermore, factors may bring opposing influences. Traill (1979 and 1982) found that for the UK for the period 1950-77 a 1% rise in product prices was associated with an eventual 10% increase in land values. However, conditions may have changed so that this relationship no longer holds, and it may be asymmetric with respect to rising or falling prosperity. More recently, Cianian, *et al.* (2018) concluded from an extensive review of international literature, that empirical findings indicate a lower degree of capitalisation into land prices than theory suggests, and that this was particularly true of area-based subsidies (such as the Basic Payments Scheme). Several factors are cited for this disparity; the type of support, imperfections in factor markets, the structure of competition, and transactions costs.

Academic literature on rental values also goes back more than a century (for example, Thomson, 1907). Rents paid for tenanted land in recent years have provided a low gross return (between 1.2% and 1.6%), with capital appreciation appearing to be the main interest of investors (Savills, 2018). Traill (1982) had found a stronger historical relationship between rises in agricultural product prices and rents than with land prices (30% rise compared with 10% rise). A sensitive issue since area-based direct payments were introduced is the proportion that has been reflected in rents and hence has benefitted landlords (rather than the farmers renting the land), including as higher values of rented land. Defra (2018) used international literature to conclude that, for England, perhaps 30% to 50% of direct payments were reflected in the level of rent

payments. Consequently, the withdrawal of such payments could be expected to be followed by rent falls, which would lower the costs of tenanted land.

As noted above, since 1995, Farm Business Tenancies have provided a flexible way of passing the use of the land without loss of control for extended periods. There is a premium to this, with FBTs having a long-term premium of about 30% over full agricultural tenancies. Nevertheless, during the past ten years, according to this source, average rents increased by just over 4.5% per annum (compound annual growth). Farm business tenancies (FBTs) recorded greater growth, closer to 5.5%, yet underperformed traditional tenancies (AHA) during 2016 and 2017. However, it must be recalled that rents are set by periodic negotiations. Savills (2018) noted the reduced numbers of reviews taking place, as well as an increase in the number of 'no change' and downward revisions. The authors recommended that, should the agricultural sector's position weaken post Brexit, there would be material benefit in landlords engaging with tenants to assess rents in relation to the realisable earning capacity of both the farming operation and the land utilised. While this could lead to rents commanding a larger share of cash flow, scarcity of supply should offer protection for newer, shorter-terms tenancies.

In summary, changes in land values and rents would impact on the farming industry in several ways, though at farm business level there would be wide variation due to individual circumstances (including indebtedness). Brexit is likely to impact directly on some of the factors that are known to determine agricultural land prices, though others are more affected by what happens in the broader economy or by changes in legislation that governments may choose to implement. While the directions of change for individual determinants can be foreseen with some confidence, the magnitudes remain uncertain, especially as what has happened in the past is not necessarily a reliable guide to future changes in the post-Brexit environment. Furthermore, it is quite likely that individual factors will work in opposite directions (such as downward pressure on farm incomes and flight into land purchase by investors worried by returns in other industries). In this milieu, a clear assessment of

what will happen to land prices (or rents) is difficult to assess *ex ante* with any degree of precision.

## A5.10. Summary, implications of the main findings of the literature review, and proposal for filling information gaps

### A5.10.1. Summary and implications of the main findings

Brexit carries implications for ***farmer incomes and viability***, though these vary with the scenario chosen and between types of farming. For some, there could be substantial financial pressure. There is a difference between a farm's resilience in the face of short-term adverse shifts in the condition in which it operates and its ability to adapt to more permanent change. Despite definitional differences between writers, it is clear that ***farm managements should bear in mind both their shorter and longer-term abilities to respond to change signals***. They are likely to experience both.

Farms will vary in their resilience and adaptability, linked to a host of economic, external, internal and social factors that shape farmer behaviour. Policy makers need to consider elements in the external environment in which farms operate that can facilitate adaptation/adjustment, including the availability of policy tools to facilitate change. A review of international examples leads to the conclusion that ***policy makers often underestimate the ability of farmers to adapt***.

Economic theory suggests that ***in the short-term farmers can be expected to respond to changes in product prices (and input costs) in ways that are in line with optimising marginal relationships to maximise profits/minimising losses***. These are generally within the existing framework of the firm's fixed inputs and costs (such as land area). In the longer-term, more inputs become variable. In particular, ***when there is downward pressure on incomes operators will seek to change farm size so that economies of scale are obtained***. In farming there is strong evidence that farms that are too small experience higher average costs through their inability to spread their fixed costs, especially family labour, over a sufficient volume of output. However, ***there are alternative ways of expanding economic capacity and income generation, such as diversification or off-farm activities***.

Retrospective study of actual responses to past financial pressures reveal a variety of ways of coping, some of which move in opposing directions (such as expanding or cutting back output). These suggest ***different types of management behaviour among farmers***, details of which vary between authors. This diversity of behaviours underlines the need to take into account the ***heterogeneity of likely response to any change***, such as is represented by Brexit. However, to operationalise them by placing farmers in the England FBS sample (used to model the income implications of Brexit scenarios by each of the major quantitative studies currently available) into categories/groups as a way of exploring the longer-term responses of the industry and its sub-sectors would require much more information than is routinely collected and is available on the farm and farm business. It would require personal details (such as education, family status, how the farm was acquired, etc.), histories of past responses, and value statements in response to prompts on issues such as attitude to risk and retirement/succession plans. While it would not be impossible for additional data of these types to be collected in the future, this might not reflect Defra priorities for coverage in the regular FBS or its periodic modules. Nevertheless, appreciation of the typologies may permit some qualitative discussion of the range of responses likely to Brexit.

As a response to Brexit, ***structural change is likely to take many forms***, though attention is often given primarily to the size distribution of businesses. The long-established picture of structural change in the UK has been one of a rise in the numbers of large farms and falls among smaller commercial ones, though this is complicated by rising numbers among very small units that are primarily residential or hobby in nature and not primarily dependent on farming to generate the occupier's household income. Size adjustment can be achieved in various ways, and Farm Business Tenancies play a part in this. However, ***most past adjustments have been studied in time of relative economic stability and gradual structural change; radical shifts in incomes, such as might accompany some forms of Brexit, could present rather different sets of drivers***.

Exit of existing farmers and entrants of new entrepreneurial talent represents one form of structural change. ***Assessing the impact of Brexit on decisions to exit should not rely in a simple way on what may happen to incomes from agricultural activity***, though anticipated future incomes and income security will play a significant part in shaping exit decisions. The process of leaving the industry is a complex one, affected by many factors both within the farm household as well as external conditions. ***Diversity of income sources, retirement opportunities, taxation, assets held outside the farm and net worth play important roles***. Exit from farming does not necessarily imply the sale of farmland, even among owner-occupiers. Many of these shapers of exit decisions are not directly affected by Brexit and the changing fortunes of agriculture. However, there are several pointers to the importance of expectations of future income levels and to uncertainty (associated with Brexit) as being influences. Similarly, for entrants, many determinants of the rate of joining the farming industry seem to be not directly affected by Brexit, though the willingness of successors to join the family business, already compromised on farms where profitability is low, is likely to suffer if the future seems to offer only lower incomes or less secure rewards.

When considering the potential impact on innovation and investment, ***Brexit seems unlikely to affect factors that determine the spread of information that is critical to the awareness that farmers have of innovations***. However, their ***abilities to implement changes seem susceptible where adoption requires investment***. Periods of negative incomes and increased risks, though not universal throughout the industry in Brexit scenarios, are likely to impede innovation and the investments necessary to bring them into use. As usual, the heterogeneity of farms must be borne in mind.

***Farm diversification and taking of off-farm jobs (or self-employment in non-agricultural businesses) is a possible strategy for farmer households facing income problems from Brexit***. However, a simplistic view should be avoided, as the drivers of existing levels of these phenomena are complex and extend to many factors that are unlikely to be impacted by Brexit, at least in the short and medium-terms.

Turning to land prices and rents, changes in these would impact on the farming industry in several ways, though at farm business level there would be wide variation due to individual circumstances (including indebtedness). ***Brexit is likely to impact directly on some of the factors that are known to determine agricultural land prices***, though others are more affected by what happens in the broader economy or by changes in legislation that governments may choose to implement. While the directions of change for individual determinants can be foreseen with some confidence, the magnitudes remain uncertain, especially as what has happened in the past is not necessarily a reliable guide to future changes post-Brexit. Furthermore, it is quite likely that individual factors will work in opposite directions (such as downward pressure on farm incomes and flight into land purchase by investors worried by returns in other industries). In this milieu, a clear assessment of what will happen to land prices (or rents) is difficult to assess *ex-ante* with any degree of precision.

### A5.10.2. Proposal for filling information gaps

This review of literature points to the desirability of a number of 'next steps', based on the responses in terms of current production activity, changes to farm size and other structural shifts, exit and entrance decisions, innovation and investments

Some aspects of Brexit could pose short-term downward pressures on incomes among certain types and sizes of farms, while others might see enhanced prices and incomes, though the speed of onset will be shaped by the transitional arrangements eventually agreed between the UK and EU. Consideration of farmers' past behaviour to combat pressures underlines the heterogeneity. Explaining likely response to any Brexit-induced change needs to embrace both the anticipated (and unanticipated) behavioural adjustment and a typology to explain disparities between farms. This heterogeneity applies to responses in terms of current activities within the general framework of the business (such as cost cutting, rebalancing enterprises, innovation and marginal investments in modernisation), on-farm diversification, development off-farm activities, and exit and succession. In particular, exiting is a complex process which may or may not involve disposing of land.

However, to operationalise the exploration of this wide range of responses would require much more information than is routinely collected by the FBS. It would require personal details (such as education, family status, how the farm was acquired, etc.), histories of past responses, and value statements to prompts on issues such as attitude to risk and retirement/succession plans. While it would not be impossible for additional data of these types to be collected in the future, this might not reflect Defra priorities for coverage in the regular FBS or its periodic modules.

*We therefore invite AHDB to consider a parallel approach in which a sample of its levy payers could be asked to express their intentions for adjustments to current practice, diversification, innovation, farm expansion, etc.*, though it must be recalled that the literature suggests that intentions do not necessarily translate into action. Past studies provide multiple examples of the sorts of responses that might be explored. Because responses to historic periods of income pressure have been found to be a reliable guide to future intentions, it would be helpful to include questions on past behaviour. But it would also be desirable to collect sufficient socio-economic data to enable a meaningful typology to be used. Again, past studies can be a good guide, and would be expected to include variables such as the composition of the entrepreneurial group on the farm, basic biographical data, education and skills training, other gainful activities, succession plans, attitude to risk and so on. A major element in any such approach would be the refining of methodology, including the stripping down of variables to the minimum required to generate meaningful results.

While a telephone survey is commonly used to gather these sorts of data, other approaches are feasible, with various degrees of personal or impersonal communication, which might be tailored to particular areas or issues. Focus groups could also be employed or, at the other extreme, an online questionnaire. The matter of methodological detail is, however, an issue that follows from the consideration by the AHDB of whether it wishes to commission further work of this nature.

# Appendix 6: Sensitivity analysis

This Appendix presents some sensitivity analysis for the key elements of the scenarios around which there is uncertainty, principally additional labour costs and currency exchange rates (which would influence price changes by making imports cheaper or more expensive and exports more or less competitive). The impact of the UK being a net exporter of wheat is also examined.

Each sensitivity analysis is dealt with in isolation, i.e. only one variable is investigated at a time, all other variables being held constant within the scenarios.

- **Labour cost sensitivity.** Our scenarios assume that the cost of regular labour would increase by 50% as restrictions on migrant labour are imposed. Our sensitivity analysis considers the impact of varying this labour cost increase on FBI. Higher labour costs are associated with lower FBIs, and *vice versa*.

- **Exchange rates.** Firstly, it is important to keep in mind that exchange rates shift for all sorts of reasons, among which Brexit will be only one, and will reflect developments in many markets in addition to those of agricultural commodities. Changes may also only be short-term.

  When Sterling appreciates, imports become cheaper for purchasers in the UK while UK exports become less competitive on non-UK markets. In both cases, downward pressure is exerted on domestic UK prices. Sectors/market segments in which the UK is a net importer come under threat from lower priced non-UK competition, while UK exports must accept a lower Sterling price in order to remain competitive in foreign currency terms. Conversely, when Sterling depreciates, imports become more expensive for purchasers in the UK while UK exports become more competitive on non-UK markets. In both cases upward pressure is exerted on domestic UK prices as sectors/market segments in which the UK is a net importer are given more protection from now higher priced non-UK competition, and sectors/market segments in which the UK is a net exporter

benefit from being able to maintain prices in foreign currency which is now worth more in Sterling.

Our sensitivity analysis considers the impact on FBI of Sterling strengthening/weakening under both scenarios by ±5, ±10 and ±15 percentage point increments. In essence, we have incorporated changes in the value of Sterling by changing the Sterling value of imports (including fertiliser costs) which has a corresponding impact on UK domestic prices. For exports we assume the foreign currency price remains the same, but the Sterling value changes.

For example, we have assumed that beef prices increase by 4.30% under ***Scenario A: UK-EU FTA***. A 10% appreciation in Sterling means a price change of -5.70% while a 10% depreciation of Sterling means a price change of +14.73%. It should be noted that there are in practice many reasons why a change in the value of Sterling is not manifested in its entirety in farm-gate prices such as the use of forward contracts, a reluctance to continually alter supply chains, different market power at different stages of the supply chain, etc. It is also not necessarily the case that products with the desired characteristics are available for import. For example, the UK imports only a small volume of carrots and it would not necessarily be possible to source imports to replace domestic production meaning that there would be less downward pressure on domestic prices should Sterling appreciate in value.

## A6.1. England: Cereals

### A6.1.1. Labour cost sensitivity

The impact of varying the assumption on the additional cost of labour is examined below. The change in labour costs is the same under both scenarios, but the percentage changes differ because the starting position is different. Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±4.9% change in FBI (higher labour costs being associated with lower FBI and *vice*

*versa*). Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±5.5% change in FBI.

**Table A6.1: Sensitivity analysis of labour costs on FBI: England Cereals**

| | 35% | 40% | 45% | Cost used (50%) | 55% | 60% | 65% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £42,241 | £41,270 | £40,300 | £39,329 | £38,359 | £37,389 | £36,418 |
| **WTO: UK tariffs** | £37,946 | £36,975 | £36,005 | £35,034 | £34,064 | £33,094 | £32,123 |

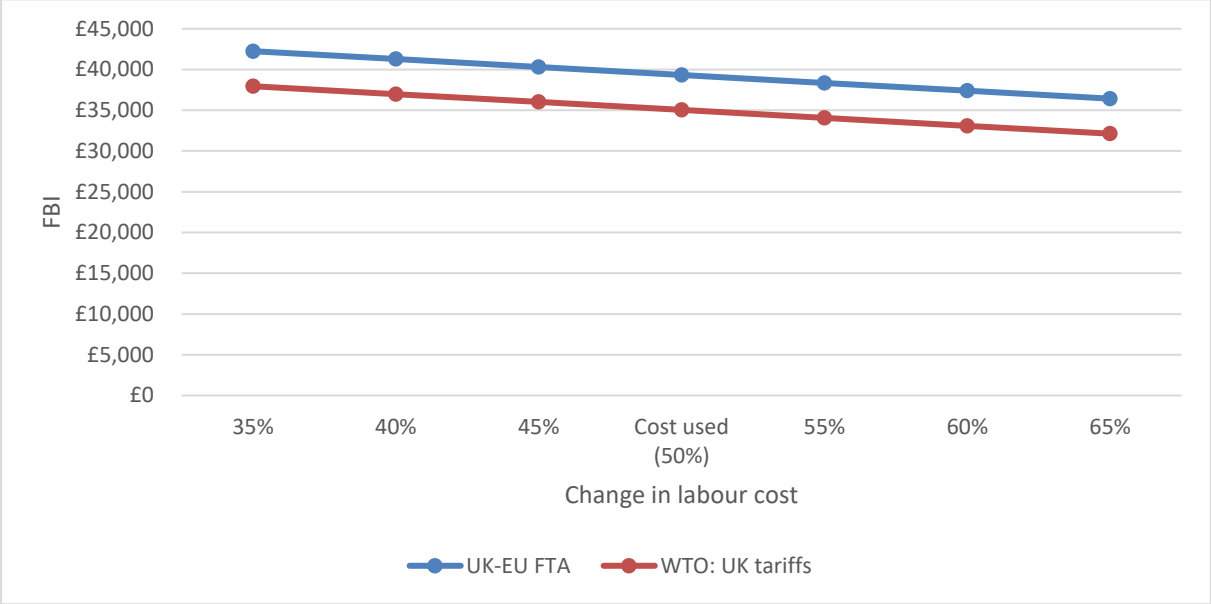


**Figure A6.1: Sensitivity analysis of labour costs on FBI: England Cereals**

### A6.1.2. Exchange rate sensitivity

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 32.6% reduction in FBI. A 10 percentage point depreciation in Sterling would result in an 32.6% increase in FBI. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be ±36.7%.

**Table A6.2: Sensitivity analysis of exchange rates on FBI: England Cereals**

| | -15% | -10% | -5% | Prices used | +5% | +10% | +15% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £58,587 | £52,168 | £45,749 | £39,329 | £32,910 | £26,491 | £20,072 |
| **WTO: UK tariffs** | £54,292 | £47,873 | £41,454 | £35,034 | £28,615 | £22,196 | £15,777 |

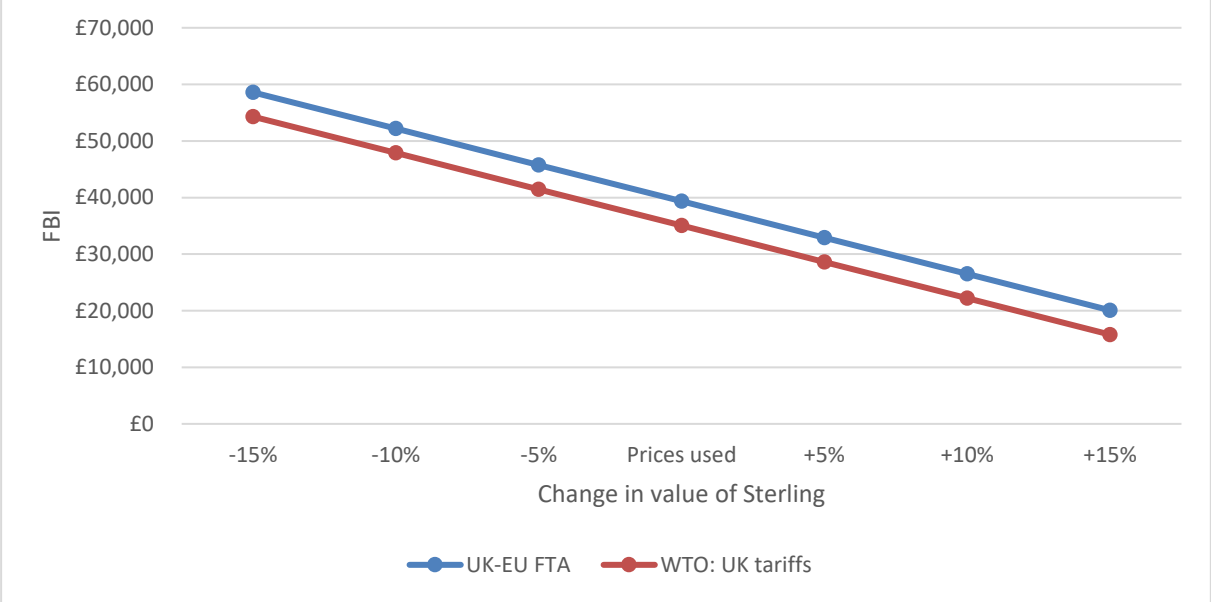


**Figure A6.2: Sensitivity analysis of exchange rates on FBI: England Cereals**

### A6.1.3. Impact of UK having an exportable surplus of wheat

Although a five-year period was used to determine the average balance sheet for wheat, and this showed a small import requirement (equivalent to 3.5% of domestic use), the AHDB felt that situations in which the UK was a net exporter in wheat are likely to arise. To assess the impact of this situation, the model was run under the assumption that wheat production increased by 1 million tonnes resulting in an exportable surplus. Under both scenarios the imposing of trade friction costs and/or WTO tariffs, would make UK-produced wheat less competitive on export markets, leading to a reduction in domestic price for the sector as a whole of -3.17% (a higher volume of exportable surplus would result in a greater decrease in price to enable the surplus to be absorbed by domestic consumption).

The data below shows that an inability to access export markets would reduce FBI for the sector as a whole under both scenarios. The additional decrease in FBI is most significant under ***Scenario B: WTO: UK tariffs*** where FBI reduces by 40.0% compared to the baseline, some 15.6% lower than when the UK is a net importer.

**Table A6.3: Impact of UK having an exportable surplus of wheat on FBI: England Cereals**

| | FBI wheat import requirement | FBI wheat exportable surplus |
|---|---|---|
| **Baseline** | £48,902 | £48,902 |
| **UK-EU FTA** | £39,393 | £34,764 |
| **WTO: UK tariffs** | £34,797 | £29,361 |

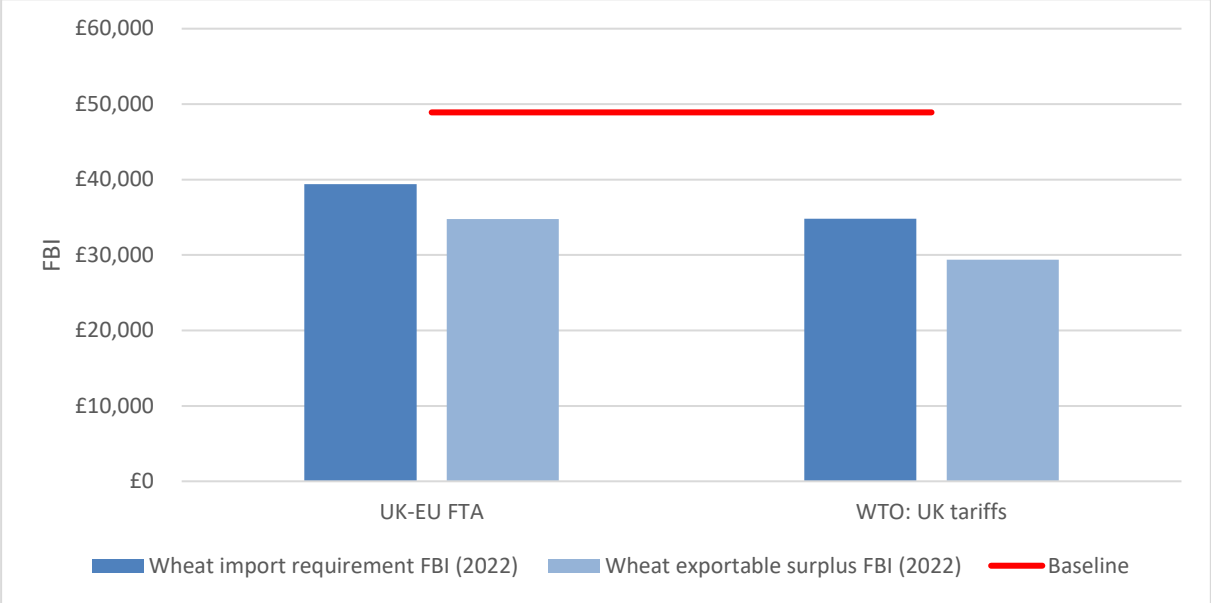


**Figure A6.3: Impact of UK having an exportable surplus of wheat on FBI: Cereals**

## A6.2. England: General cropping

### A6.2.1. Labour cost sensitivity

The impact of varying the assumption on the additional cost of labour is examined below. The change in labour costs is the same under both scenarios, but the percentage changes differ because the starting position is different. Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±9.4% change in FBI. Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±10.1% change in FBI.

**Table A6.4: Sensitivity analysis of labour costs on FBI: England General cropping**

| | 35% | 40% | 45% | Cost used (50%) | 55% | 60% | 65% |
|---|---|---|---|---|---|---|---|
| UK-EU FTA | £62,796 | £60,210 | £57,624 | £55,037 | £52,451 | £49,865 | £47,279 |
| WTO: UK tariffs | £58,826 | £56,240 | £53,653 | £51,067 | £48,481 | £45,895 | £43,309 |

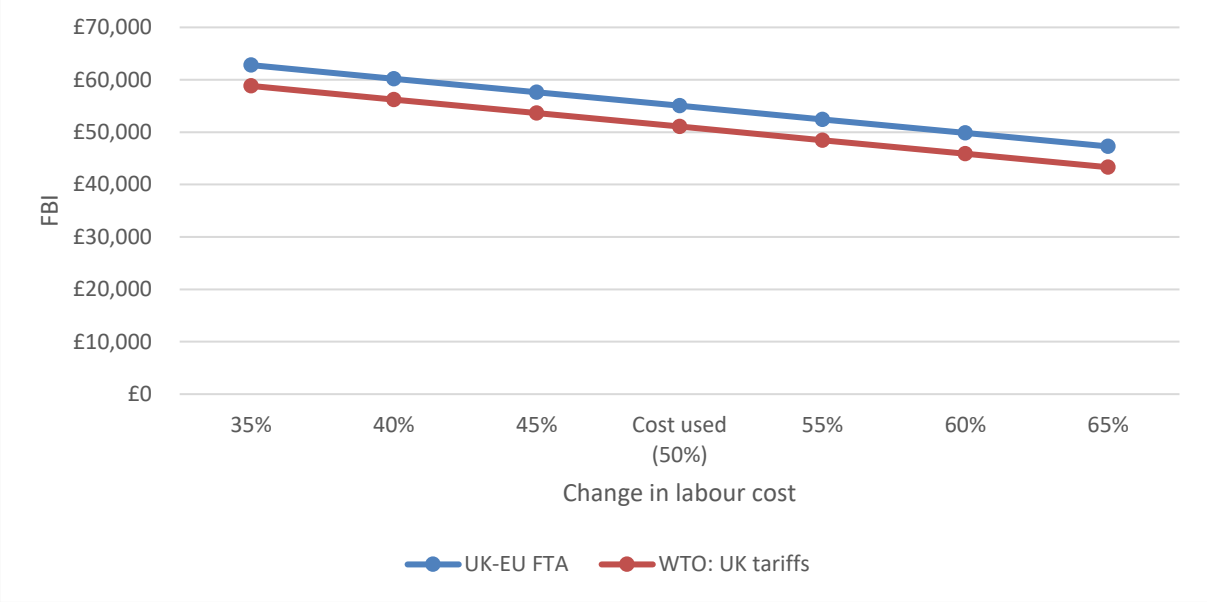


**Figure A6.4: Sensitivity analysis of labour costs on FBI: England General cropping**

### A6.2.2. Exchange rate sensitivity

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 36.3% reduction in FBI. A 10 percentage point depreciation in Sterling would result in an 36.3% increase in FBI. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be ±39.2%.

**Table A6.5: Sensitivity analysis of exchange rates on FBI: England General cropping**

| | -15% | -10% | -5% | Prices used | +5% | +10% | +15% |
|---|---|---|---|---|---|---|---|
| UK-EU FTA | £85,029 | £75,032 | £65,035 | £55,037 | £45,040 | £35,043 | £25,046 |
| WTO: UK tariffs | £81,059 | £71,062 | £61,064 | £51,067 | £41,070 | £31,073 | £21,075 |

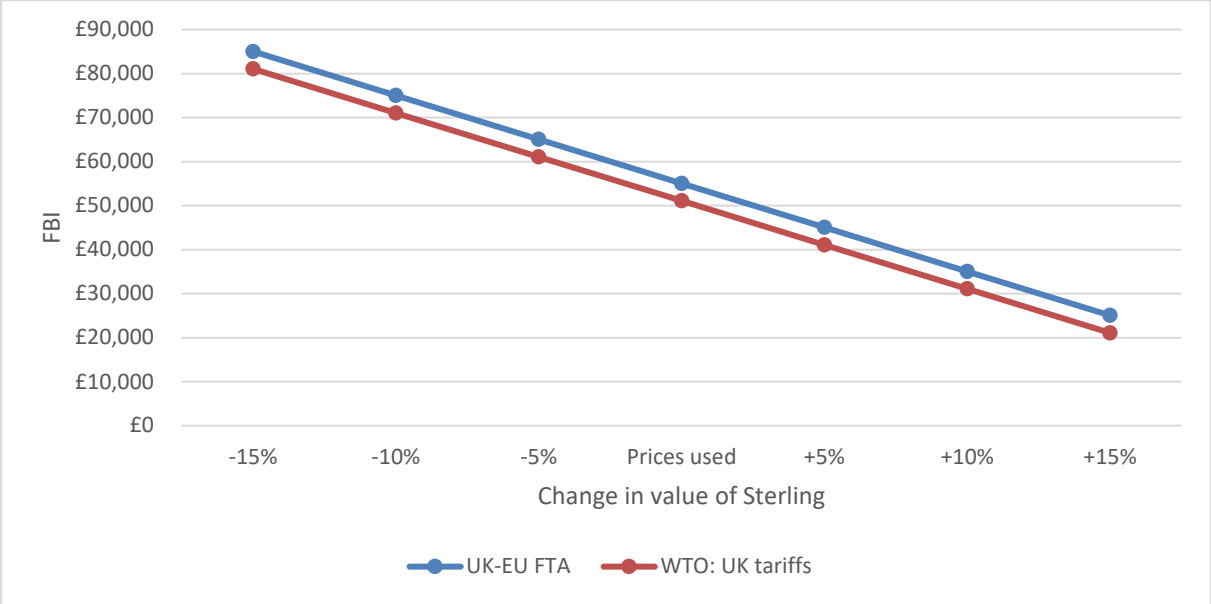


**Figure A6.5: Sensitivity analysis of exchange rates on FBI: England General cropping**

## A6.3. England: Potatoes

### A6.3.1. Labour cost sensitivity

The impact of varying the assumption on the additional cost of labour is examined below. The change in labour costs is the same under both scenarios, but the percentage changes differ because the starting position is different. Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±11.8% change in income per hectare. Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±10.5% change in income per hectare.

**Table A6.6: Sensitivity analysis of labour costs on income per hectare: England Potatoes**

| | 35% | 40% | 45% | Cost used (50%) | 55% | 60% | 65% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £1,079 | £1,025 | £971 | £917 | £863 | £809 | £755 |
| **WTO: UK tariffs** | £1,193 | £1,138 | £1,084 | £1,030 | £976 | £922 | £868 |

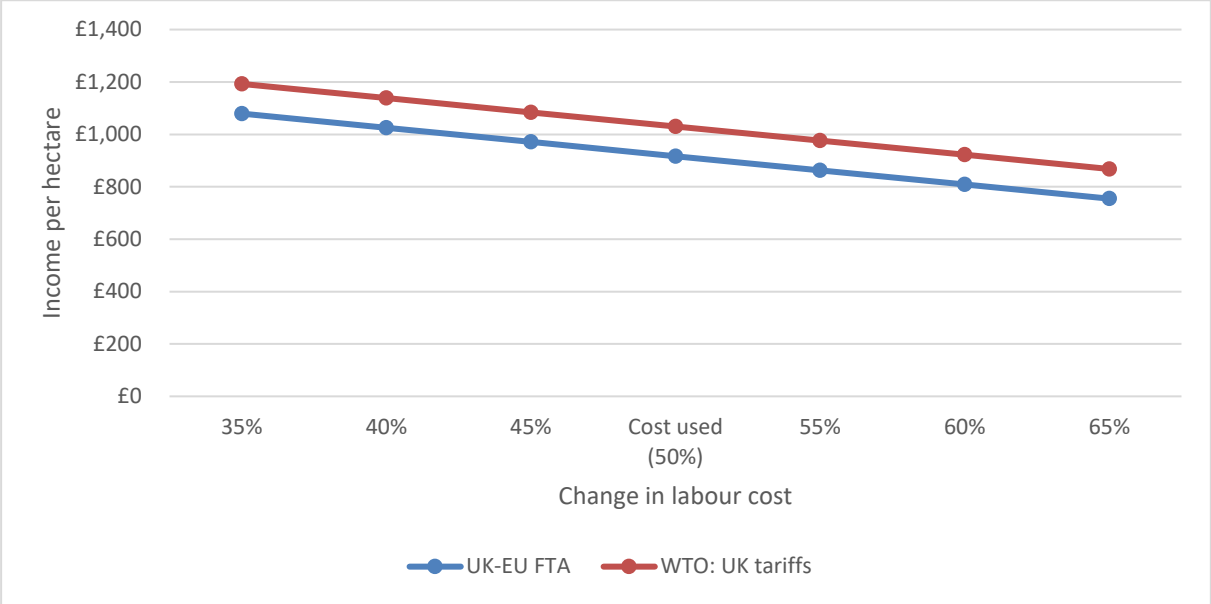


**Figure A6.6: Sensitivity analysis of labour costs on income per hectare: England Potatoes**

### A6.3.2. Exchange rate sensitivity

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 73.6% reduction in FBI. A 10 percentage point depreciation in Sterling would result in an 73.6% increase in FBI. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be ±65.5%.

**Table A6.7: Sensitivity analysis of exchange rates on income per hectare: England Potatoes**

| | -15% | -10% | -5% | Prices used | +5% | +10% | +15% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £1,930 | £1,592 | £1,254 | £917 | £579 | £242 | -£96 |
| **WTO: UK tariffs** | £2,043 | £1,705 | £1,368 | £1,030 | £693 | £355 | £18 |

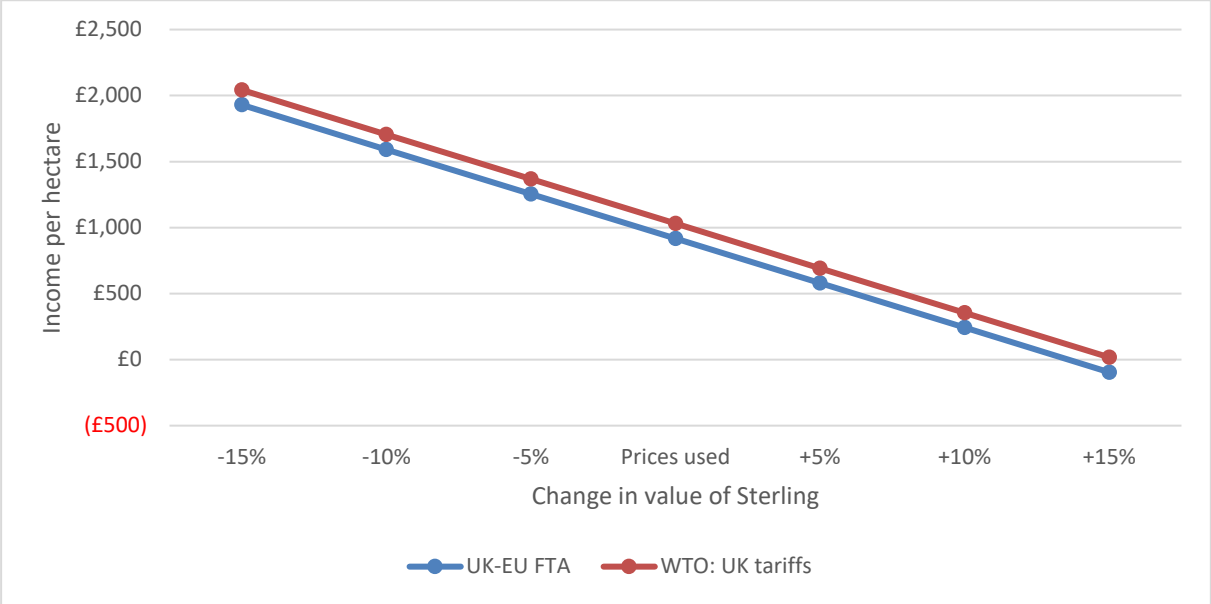


**Figure A6.7: Sensitivity analysis of exchange rates on FBI: England Potatoes**

## A6.4. England: Carrots

### A6.4.1. Labour cost sensitivity

The impact of varying the assumption on the additional cost of labour is examined below. The change in labour costs is the same under both scenarios, but the percentage changes differ because the starting position is different. Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±7.5% change in income per hectare. Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±6.7% change in income per hectare.

**Table A6.8: Sensitivity analysis of labour costs on income per hectare: England Carrots**

| | 35% | 40% | 45% | Cost used (50%) | 55% | 60% | 65% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £1,445 | £1,397 | £1,348 | £1,300 | £1,251 | £1,203 | £1,154 |
| **WTO: UK tariffs** | £1,590 | £1,542 | £1,493 | £1,445 | £1,396 | £1,348 | £1,299 |

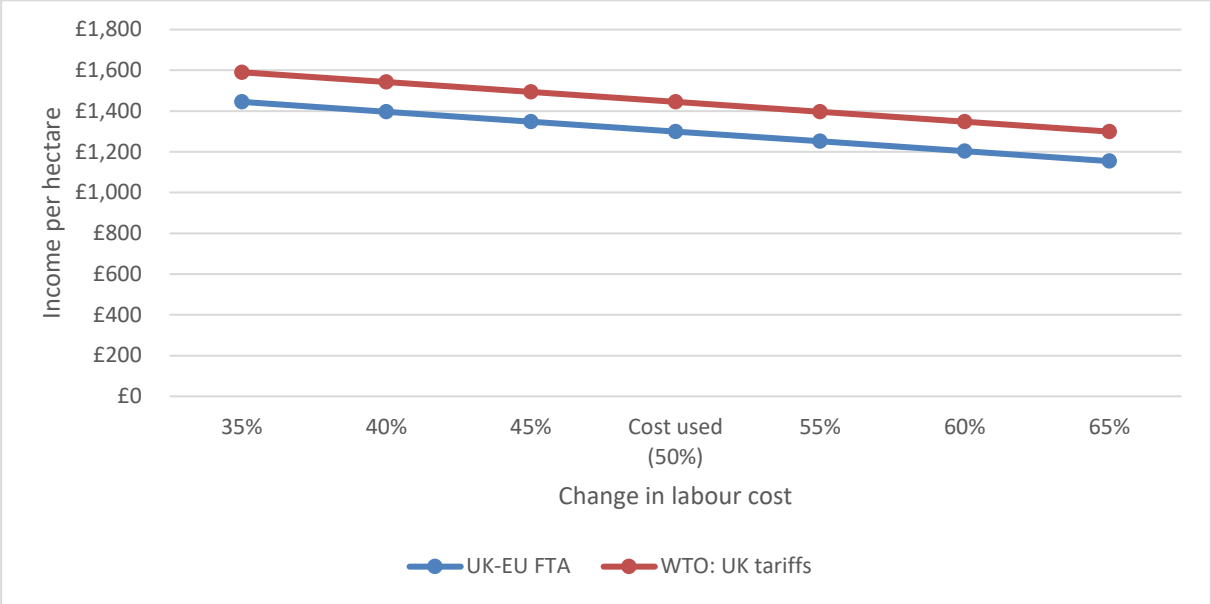


**Figure A6.8: Sensitivity analysis of labour costs on income per hectare: England Carrots**

### A6.4.2. Exchange rate sensitivity

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 94.2% reduction in income per hectare. A 10 percentage point depreciation in Sterling would result in an 94.2% increase in income per hectare. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be ±84.7%.

**Table A6.9: Sensitivity analysis of exchange rates on income per hectare: England Carrots**

| | -15% | -10% | -5% | Prices used | +5% | +10% | +15% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £3,136 | £2,524 | £1,912 | £1,300 | £688 | £75 | -£537 |
| **WTO: UK tariffs** | £3,282 | £2,669 | £2,057 | £1,445 | £833 | £221 | -£392 |

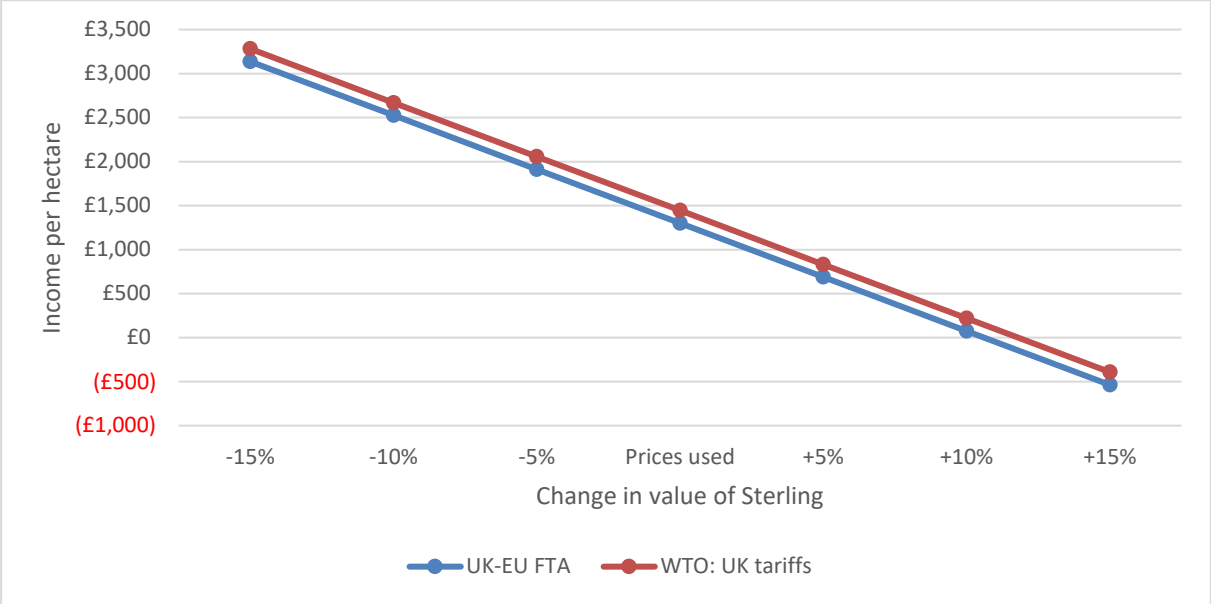


**Figure A6.9: Sensitivity analysis of exchange rates on income per hectare: England Carrots**

## A6.5. England: Less Favoured Area sheep and beef

### A6.5.1. Labour cost sensitivity

The impact of varying the assumption on the additional cost of labour is examined below. The change in labour costs is the same under both scenarios, but the percentage changes differ because the starting position is different. Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±1.8% change in FBI. Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±3.8% change in FBI.

**Table A6.10: Sensitivity analysis of labour costs on FBI: England LFA sheep and beef**

| | 35% | 40% | 45% | Cost used (50%) | 55% | 60% | 65% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £24,780 | £24,565 | £24,350 | £24,139 | £23,921 | £23,706 | £23,492 |
| **WTO: UK tariffs** | £15,025 | £14,752 | £14,480 | £14,205 | £13,936 | £13,663 | £13,391 |

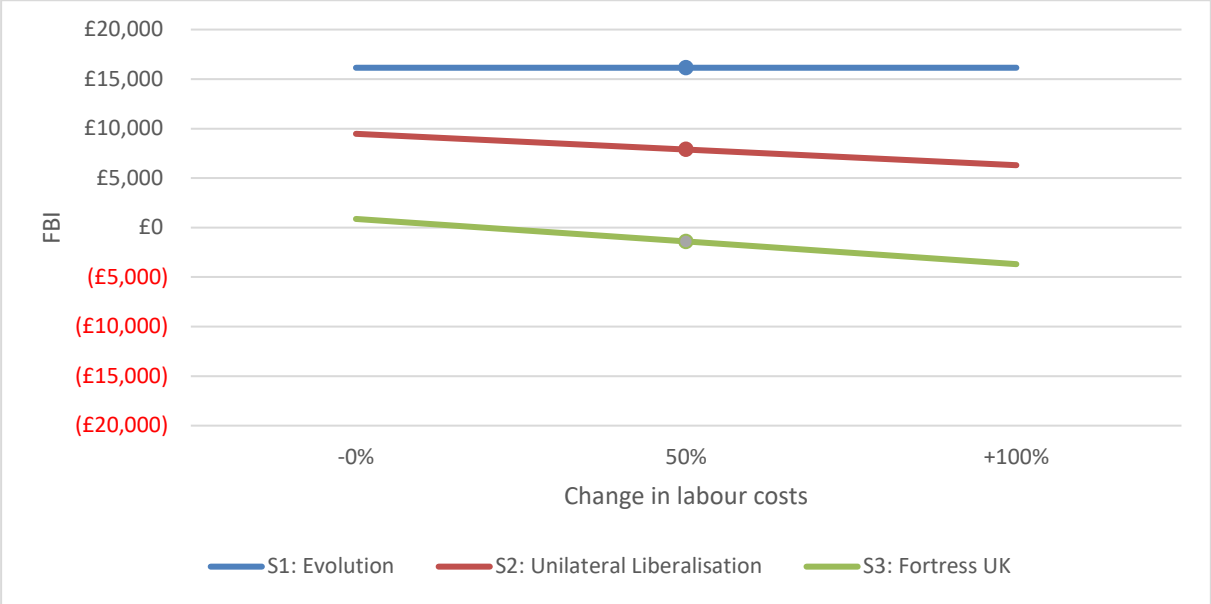


**Figure A6.10: Sensitivity analysis of labour costs on FBI: England LFA sheep and beef**

### A6.5.2. Exchange rate sensitivity

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 19.0% reduction in FBI. A 10 percentage point depreciation in Sterling would result in a 19.0% increase in FBI. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be a 32.27% reduction in FBI and a 32.3% increase in FBI.

**Table A6.11: Sensitivity analysis of exchange rates on FBI: England LFA sheep and beef**

| | -15% | -10% | -5% | Prices used | +5% | +10% | +15% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £31,009 | £28,718 | £26,427 | £24,139 | £21,845 | £19,554 | £17,263 |
| **WTO: UK tariffs** | £21,081 | £18,790 | £16,499 | £14,205 | £11,917 | £9,626 | £7,335 |

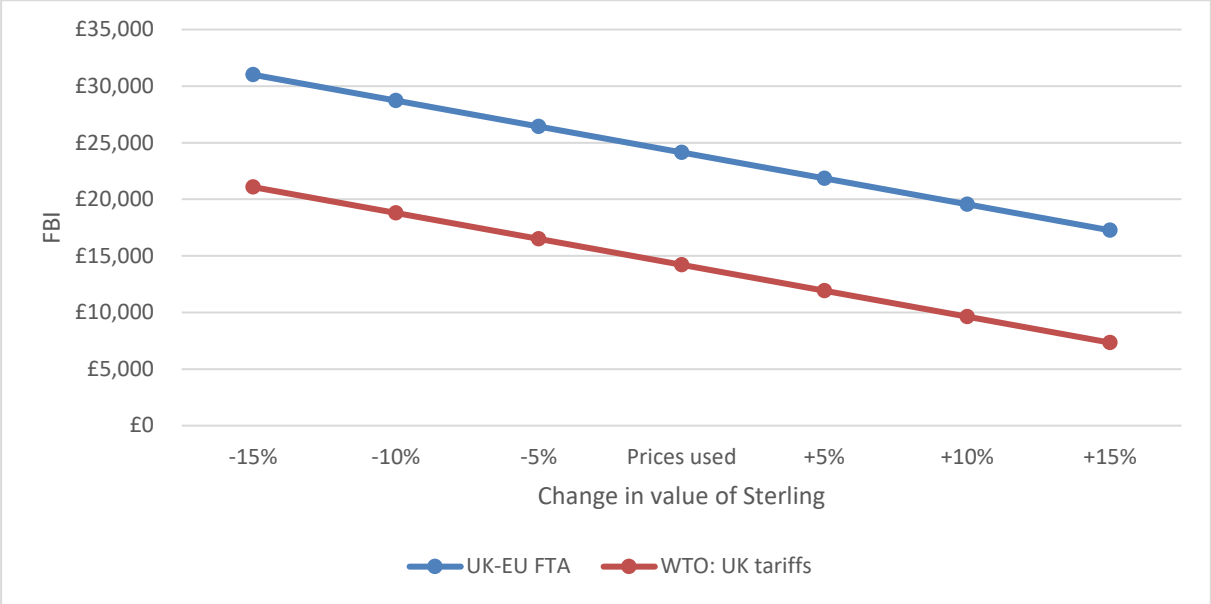


**Figure A6.11: Sensitivity analysis of exchange rates on FBI: England LFA sheep and beef**

## A6.6. England: Lowland sheep and beef

### A6.6.1. Labour cost sensitivity

The impact of varying the assumption on the additional cost of labour is examined below. The change in labour costs is the same under both scenarios, but the percentage changes differ because the starting position is different. Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±4.3% change in FBI. Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±9.0% change in FBI.

**Table A6.12: Sensitivity analysis of labour costs on FBI: England Lowland sheep and beef**

| | 35% | 40% | 45% | Cost used (50%) | 55% | 60% | 65% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £15,941 | £15,626 | £15,312 | £15,015 | £14,682 | £14,368 | £14,053 |
| **WTO: UK tariffs** | £8,034 | £7,720 | £7,405 | £7,100 | £6,776 | £6,461 | £6,146 |

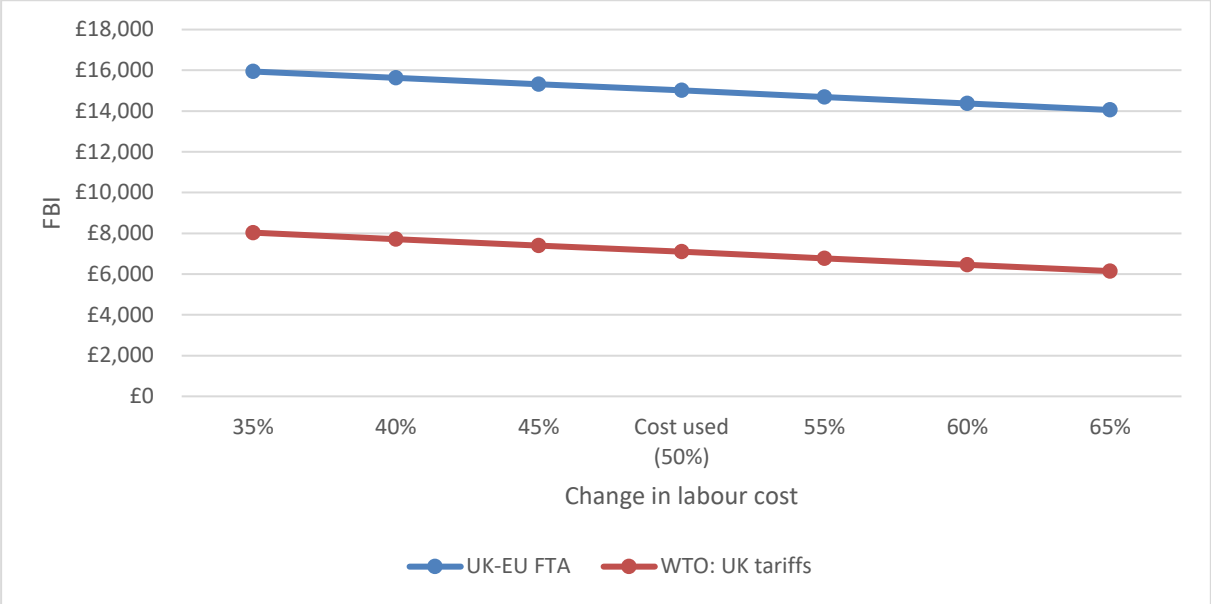


**Figure A6.12: Sensitivity analysis of labour costs on FBI: England Lowland sheep and beef**

### A6.6.2. Exchange rate sensitivity

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 30.8% reduction in income per hectare. A 10 percentage point depreciation in Sterling would result in a 30.8% increase in income per hectare. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be ±65.0%.

**Table A6.13: Sensitivity analysis of exchange rates on FBI: England Lowland sheep and beef**

| | -15% | -10% | -5% | Prices used | +5% | +10% | +15% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £21,917 | £19,610 | £17,304 | £15,015 | £12,690 | £10,384 | £8,077 |
| **WTO: UK tariffs** | £14,010 | £11,704 | £9,397 | £7,100 | £4,784 | £2,477 | £171 |

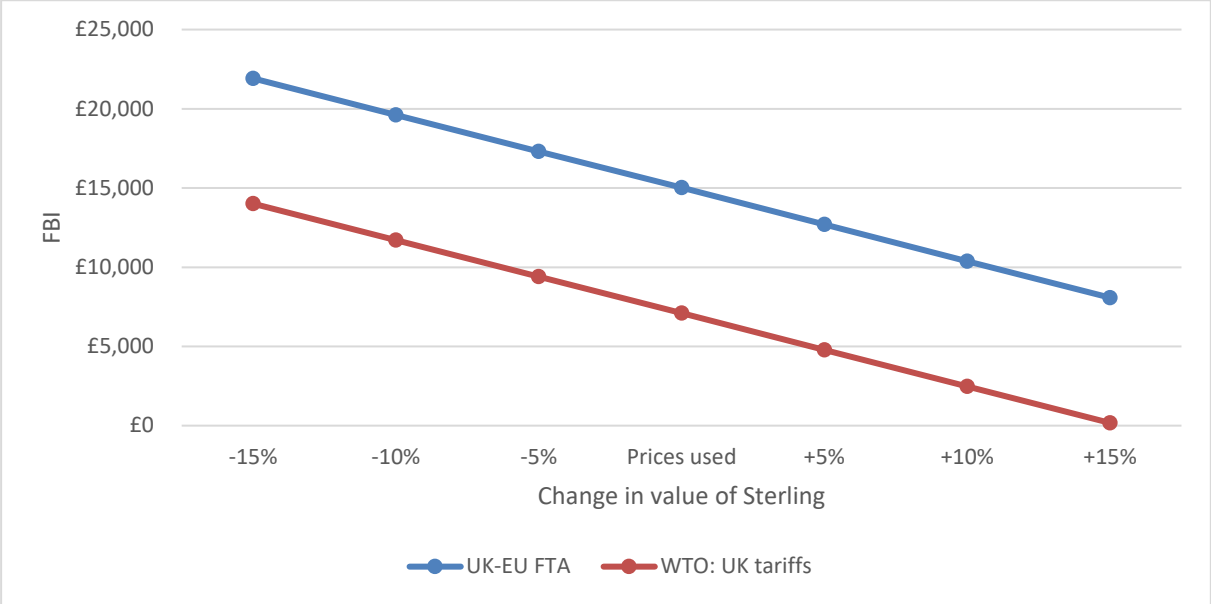


**Figure A6.13: Sensitivity analysis of exchange rates on FBI: England Lowland sheep and beef**

## A6.7. England: Dairy

### A6.7.1. Labour cost sensitivity

The impact of varying the assumption on the additional cost of labour is examined below. The change in labour costs is the same under both scenarios, but the percentage changes differ because the starting position is different. Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±8.6% change in FBI. Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±9.0 change in FBI.

**Table A6.14: Sensitivity analysis of labour costs on FBI: England Dairy**

| | 35% | 40% | 45% | Cost used (50%) | 55% | 60% | 65% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £65,218 | £62,755 | £60,292 | £57,860 | £55,366 | £52,902 | £50,439 |
| **WTO: UK tariffs** | £62,407 | £59,944 | £57,481 | £55,042 | £52,554 | £50,091 | £47,628 |

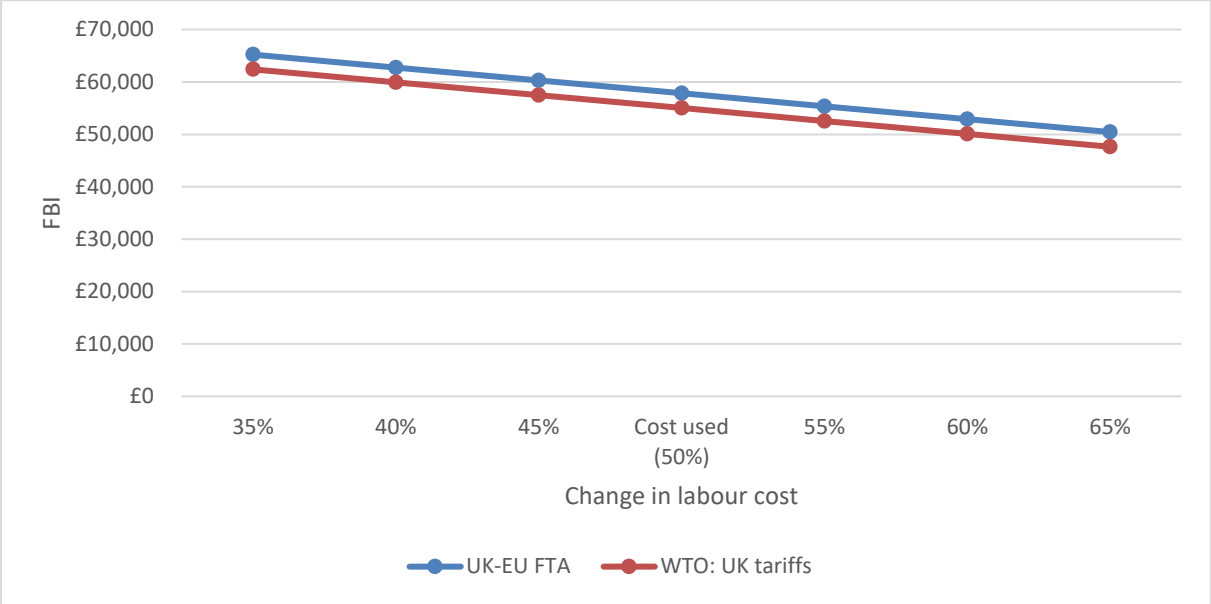


**Figure A6.14: Sensitivity analysis of labour costs on FBI: England Dairy**

### A6.7.2. Exchange rate sensitivity

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 56.5% reduction in FBI. A 10 percentage point depreciation in Sterling would result in a 56.5% increase in FBI. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be a 59.3% reduction in FBI and a 56.4% increase in FBI.

**Table A6.15: Sensitivity analysis of exchange rates on FBI: England Dairy**

| | -15% | -10% | -5% | Prices used | +5% | +10% | +15% |
|---|---|---|---|---|---|---|---|
| UK-EU FTA | £106,807 | £90,481 | £74,155 | £57,860 | £41,503 | £25,177 | £8,851 |
| WTO: UK tariffs | £103,995 | £87,669 | £71,343 | £55,042 | £38,692 | £22,366 | £6,040 |

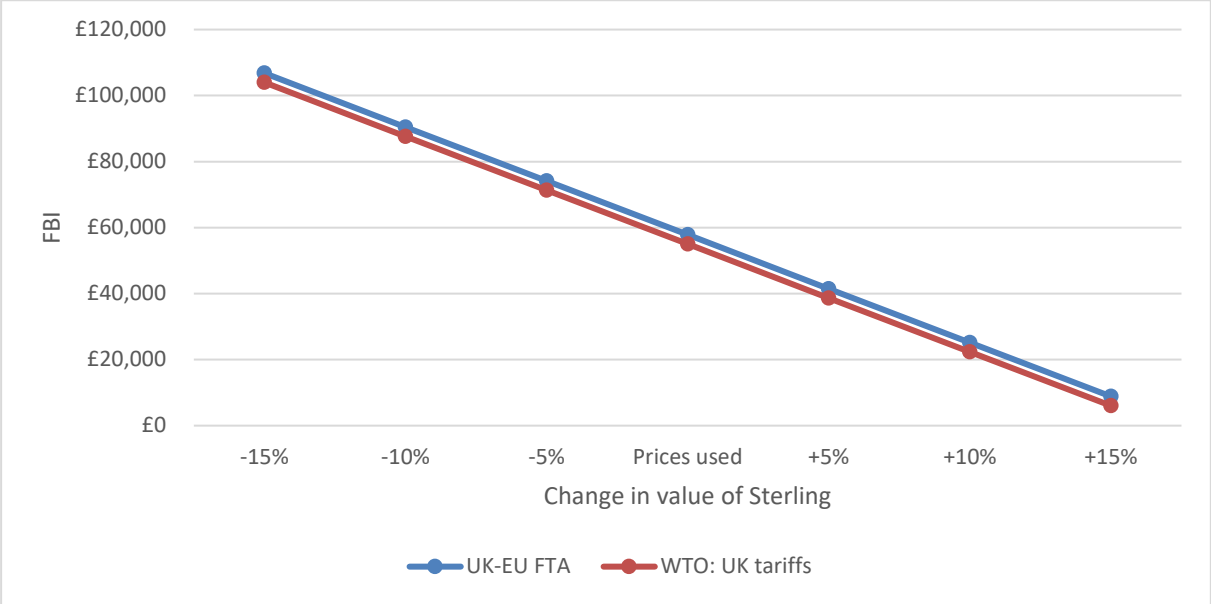


**Figure A6.15: Sensitivity analysis of exchange rates on FBI: England Dairy**

## A6.8. England: Pigs

### A6.8.1. Labour cost sensitivity

The impact of varying the assumption on the additional cost of labour is examined below. The change in labour costs is the same under both scenarios, but the percentage changes differ because the starting position is different. Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±26.7% change in FBI. Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±52.8% change in FBI.

**Table A6.16: Sensitivity analysis of labour costs on FBI: Pigs**

| | 35% | 40% | 45% | Cost used (50%) | 55% | 60% | 65% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £29,692 | £26,871 | £24,051 | £21,273 | £18,409 | £15,588 | £12,767 |
| **WTO: UK tariffs** | -£2,307 | -£5,128 | -£7,949 | -£10,741 | -£13,591 | -£16,412 | -£19,232 |

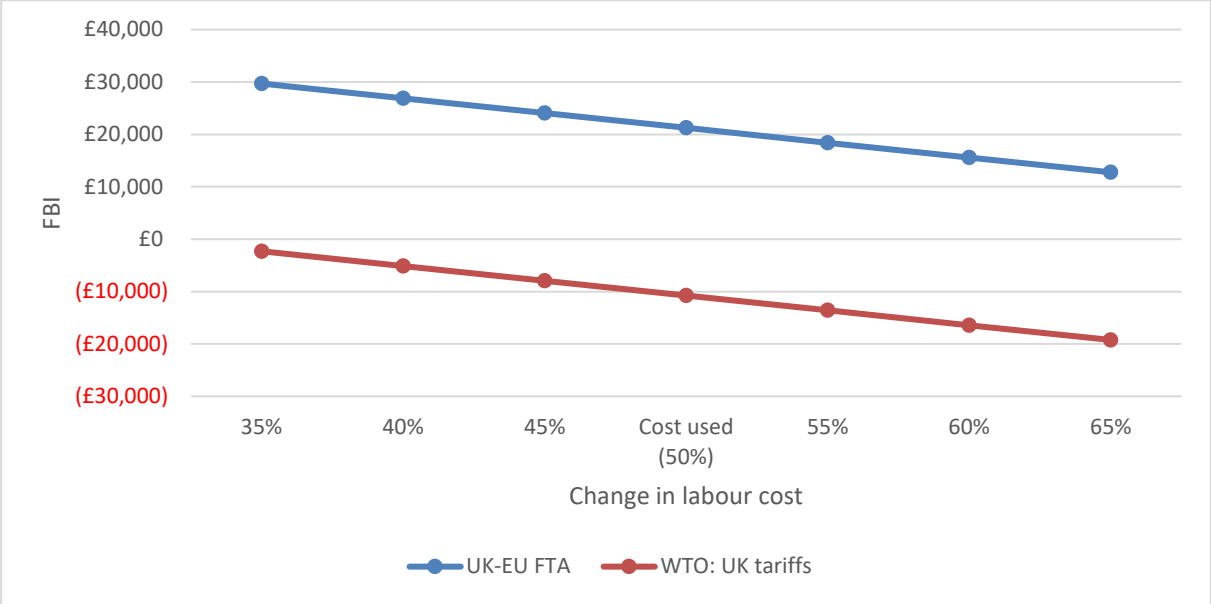


**Figure A6.16: Sensitivity analysis of labour costs on FBI: Pigs**

### A6.8.2. Price sensitivity

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 111.3% reduction in FBI. A 10 percentage point depreciation in Sterling would result in an 111.0% increase in FBI. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be a 220.3% reduction in FBI and a 219.8% increase in FBI.

**Table A6.17: Sensitivity analysis of exchange rates on FBI: Pigs**

| | -15% | -10% | -5% | Prices used | +5% | +10% | +15% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £56,682 | £44,865 | £33,047 | £21,273 | £9,412 | -£2,405 | -£14,223 |
| **WTO: UK tariffs** | £24,683 | £12,865 | £1,048 | -£10,741 | -£22,587 | -£34,405 | -£46,222 |

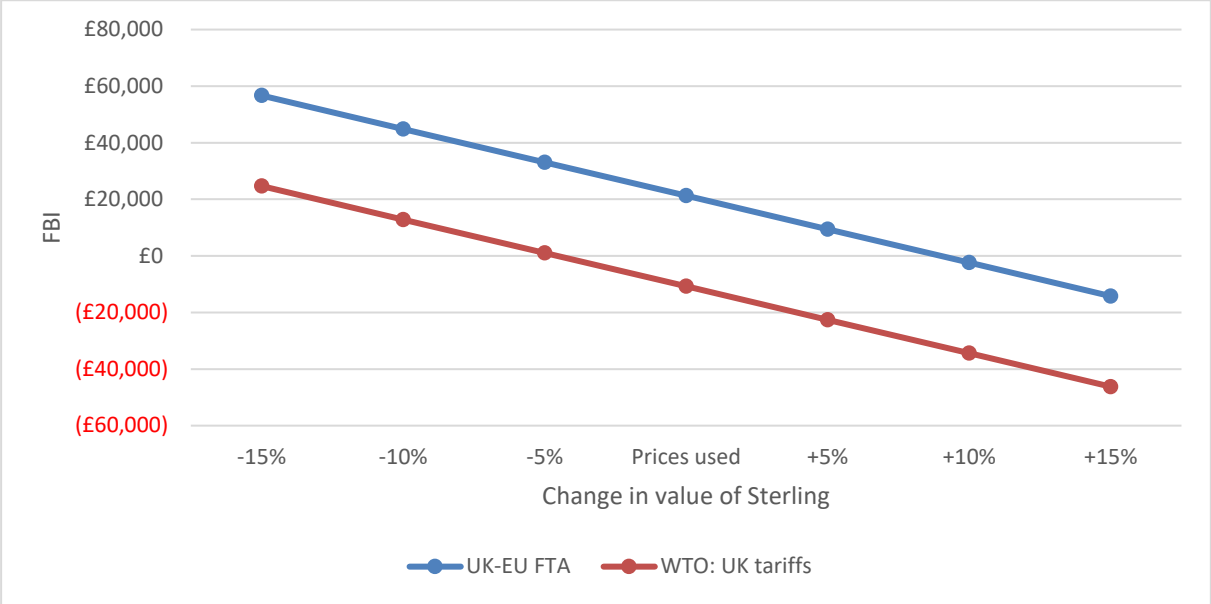


**Figure A6.17: Sensitivity analysis of exchange rates on FBI: Pigs**

## A6.9. England: Poultry

### A6.9.1. Labour cost sensitivity

The impact of varying the assumption on the additional cost of labour is examined below. The change in labour costs is the same under both scenarios, but the percentage changes differ because the starting position is different. Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±36.9% change in FBI. The magnitude of change under ***Scenario B: WTO: UK tariffs*** is too large relative to the baseline FBI to comment in percentage terms; in absolute terms, a 10% change in labour costs results in a £5.99 change in FBI.

**Table A6.18: Sensitivity analysis of labour costs on FBI: Poultry**

| | 35% | 40% | 45% | Cost used (50%) | 55% | 60% | 65% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | -£14.57 | -£20.58 | -£26.59 | -£32.60 | -£38.61 | -£44.62 | -£50.63 |
| **WTO: UK tariffs** | £18.04 | £12.03 | £6.02 | £0.01 | -£6.00 | -£12.01 | -£18.02 |

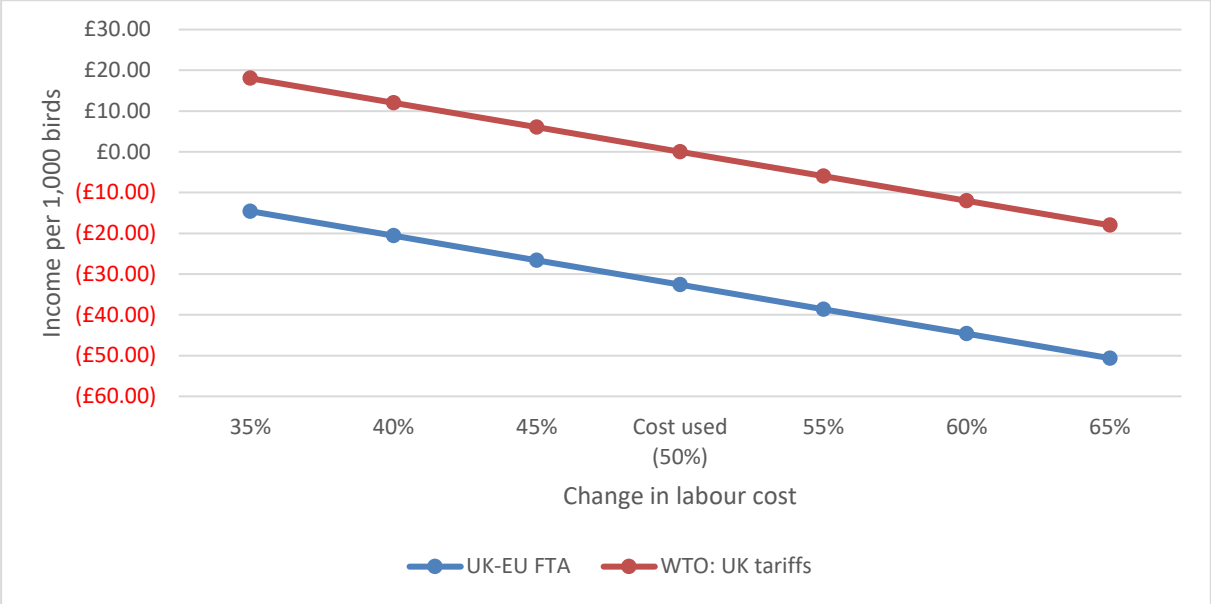


**Figure A6.18: Sensitivity analysis of labour costs on FBI: Poultry**

### A6.9.2. Exchange rate sensitivity

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 317.8% increase in FBI. A 10 percentage point depreciation in Sterling would result in a 317.8% decrease in FBI. Under ***Scenario B: WTO: UK tariffs*** the changes are from such a low base that citing them in percentage terms is not meaningful; in absolute terms the equivalent changes translate into decreases/increases in income per 1,000 birds of £103.61.

**Table A6.19: Sensitivity analysis exchange rates on FBI: Poultry**

| | -15% | -10% | -5% | Prices used | +5% | +10% | +15% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £122.81 | £71.01 | £19.20 | -£32.60 | -£84.41 | -£136.21 | -£188.01 |
| **WTO: UK tariffs** | £155.42 | £103.62 | £51.81 | £0.01 | -£51.79 | -£103.60 | -£155.40 |

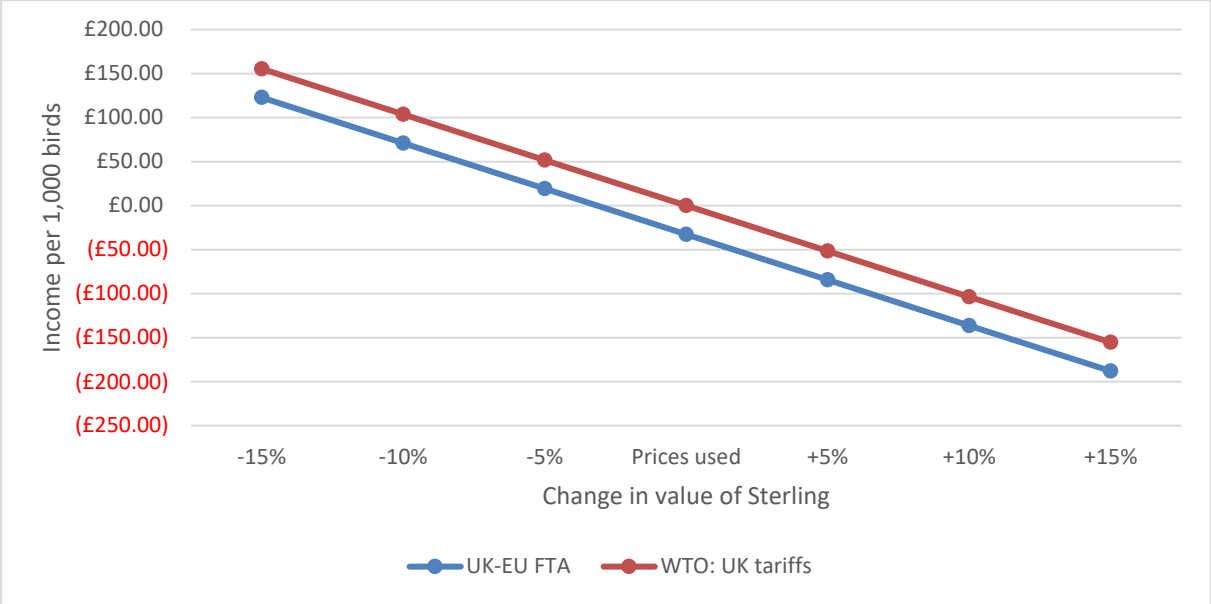


**Figure A6.19: Sensitivity analysis of exchange rates on FBI: Poultry**

## A6.10. England: All farms

### A6.10.1. Labour cost sensitivity

The impact of varying the assumption on the additional cost of labour is examined below. The change in labour costs is the same under both scenarios, but the percentage changes differ because the starting position is different. Under ***Scenario A: UK-EU FTA***, a ±10 percentage point change in the cost of labour would result in a ±8.4% change in FBI. Under ***Scenario B: WTO: UK tariffs***, a ±10 percentage point change in the labour cost assumption would result in a ±10.4% change in FBI.

**Table A6.20: Sensitivity analysis of labour costs on FBI: England All farms**

| | 35% | 40% | 45% | Cost used (50%) | 55% | 60% | 65% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £35,954 | £34,617 | £33,281 | £31,945 | £30,608 | £29,272 | £27,936 |
| **WTO: UK tariffs** | £29,764 | £28,428 | £27,092 | £25,755 | £24,419 | £23,083 | £21,747 |

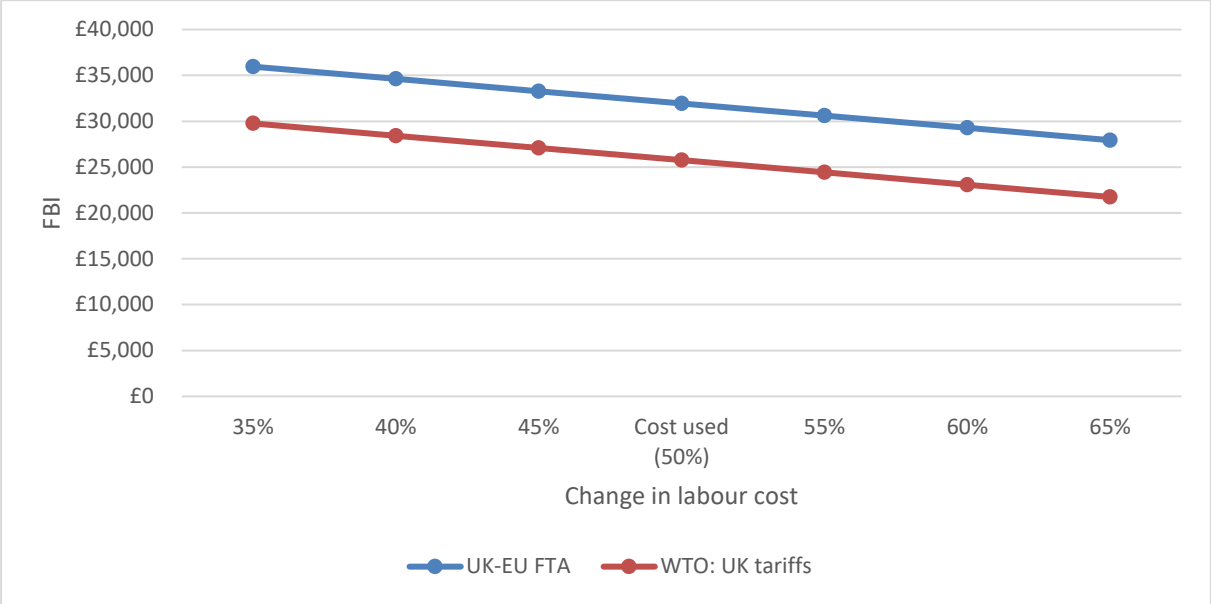


**Figure A6.20: Sensitivity analysis of labour costs on FBI: England All farms**

### A6.10.2. Exchange rate sensitivity

Under ***Scenario A: UK-EU FTA***, a 10 percentage point appreciation in Sterling would result in a 38.5% reduction in FBI. A 10 percentage point depreciation in Sterling would result in an 41.6% increase in FBI. Under ***Scenario B: WTO: UK tariffs*** the equivalent changes would be a 47.3% reduction in FBI and a 52.1% increase in FBI.

**Table A6.21: Sensitivity analysis of exchange rates on FBI: England All farms**

| | -15% | -10% | -5% | Prices used | +5% | +10% | +15% |
|---|---|---|---|---|---|---|---|
| **UK-EU FTA** | £51,626 | £45,230 | £38,833 | £31,945 | £26,040 | £19,644 | £13,248 |
| **WTO: UK tariffs** | £45,557 | £39,160 | £32,764 | £25,755 | £19,971 | £13,574 | £7,178 |

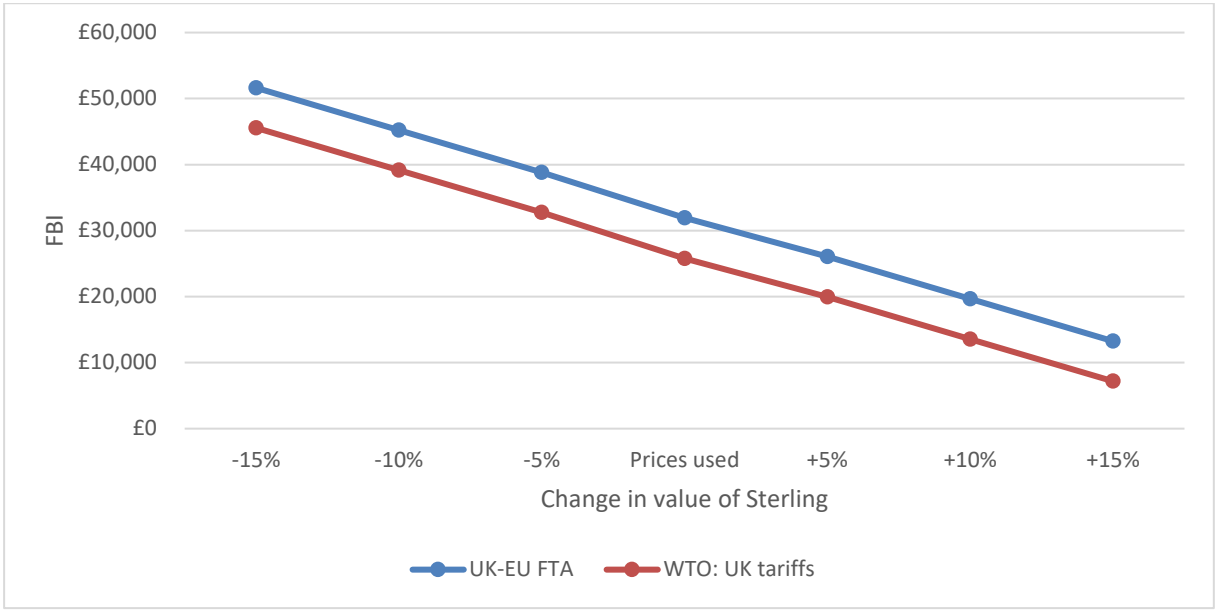


**Figure A6.21: Sensitivity analysis of exchange rates on FBI: England All farms**