OXFORD ECONOMICS

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THE IMPACT OF A GLYPHOSATE BAN ON THE UK ECONOMY

JUNE 2017

Crop Protection Association

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1. INTRODUCTION: A POTENTIAL BAN ON GLYPHOSATE

Arable farming forms a central pillar of the British countryside. Crops ranging from wheat and barley to oilseed rape, potatoes and fruit are grown on some six million hectares of land across the UK. The activity and employment sustained by arable farming represent a major part of the rural economy.

Plant control is important to agriculture. Plants compete with crops for light, water and nutrients. This competition risks compromising yield levels by reducing plant survival and lowering productivity—for example, fewer grains in each ear of wheat, and fewer potatoes on each root.[1] The quality of a crop can also be affected by the presence of weeds, both directly, by depriving it of necessary resources, and indirectly, by harbouring pests and diseases that can affect the main crop.

Glyphosate-based herbicides used for weed management on farms throughout the UK. First marketed in the 1970s, glyphosate's wide applicability and efficacy in controlling weeds for a broad spectrum of plants, as well as its relatively low cost as a treatment option, mean that it has evolved to become a key tool at the disposal of UK farmers. Use of glyphosate facilitates faster preparation of land prior to planting, which increases the number of crop rotations possible. It also affords higher yields than other weed management options.[2] As such, in 2014, 2.2 million hectares of UK farmland—representing a third of arable land—was treated with an average of 0.1g of glyphosate per square metre.[3]

The licence that allows use of glyphosate within the EU is due to expire in 2017. Glyphosate is widely used throughout the EU but there has been some political debate as to whether the licence for its use will be renewed when it expires in 2017. This reflects health concerns from some quarters over the active ingredient, however there is a body of scientific evidence that disputes these.

Failure to renew the license—equivalent to a total ban—will have a negative economic impact on UK agriculture, affecting UK GDP, jobs, and tax revenues. Oxford Economics, with the Andersons Centre, has undertaken research commissioned by the Crop Protection Association that explores the possible impact of a ban on the competitiveness of the UK's agricultural sector. Further analysis extends this theme to model the potential wider impact on UK GDP and employment stemming from altered agricultural practices.

This report presents the findings of this analysis. It is structured as follows:

- chapter two describes the importance of glyphosate-based herbicides to UK agriculture;
- the potential impact of a ban on glyphosate on agricultural practices is explored in chapter three;
- the likely outcome of these changes for farmers is discussed in chapter four;
- chapter five highlights how these changes would affect the wider UK economy; and,
- finally, chapter six concludes.

[1] ADAS, "How valuable is glyphosate to UK agriculture and the environment?", *Outlooks on Pest Management*, December (2010): 280-4.
[2] Ibid.
[3] Food and Environment Research Agency, *Pesticide Usage Survey Report 263: Arable crops in the United Kingdom 2014* (York: Food and Environment Research Agency, 2015).

2. HOW GLYPHOSATE IS USED IN UK AGRICULTURE

2.2 million

Hectares of arable land treated with glyphosate in 2014

Glyphosate is the most widely used herbicide in UK agriculture. According to the most recent Pesticide Usage Survey some 2.2 million hectares of arable land was treated with glyphosate in 2014.[4] While some land will need treatment annually, glyphosate is used more generally to lower the overall weed burden on a rotating basis. For instance, data indicate that in any given year, a third of the land used for growing wheat is treated with the herbicide.[5] This means that, typically, all the land used for growing wheat is treated with glyphosate every three years. Around a third of the land used for growing oilseed rape is treated with the herbicide in any given year.[6] The herbicide is also used to prepare a substantial part the land used for barley (23 percent of planted area), potatoes (36 percent) and sugar beet (52 percent) crops.[7]

The herbicide is used both in preparing fields for planting and to make harvesting easier.

HOW DOES GLYPHOSATE WORK?[8]

Glyphosate blocks a specific metabolic process in plants: the shikimic acid pathway. This pathway is essential for growth and the action of glyphosate causes treated plants to die. All plants contain this pathway. This means that one application can control both grass weeds and broadleaved weeds. Many other herbicides are effective only on certain categories of plants.

The action of glyphosate is *systemic*—the active substance is absorbed through the leaves (and to a lesser extent, the roots), and then moves through the entire plant to the growing points in the shoots and roots. Consequently, the entire plant, including the root system is killed, and not just the foliage above ground. However, the plant must have foliage for glyphosate to be absorbed. Once treated, the weed cannot re-shoot.

[4,5,6,7] Food and Environment Research Agency, *Pesticide Usage Survey Report 263: Arable crops in the United Kingdom 2014* (York: Food and Environment Research Agency, 2015).

[8] National Pesticide Information Centre, "Glyphosate: General Fact Sheet", in National Pesticide Information Centre <http://npic.orst.edu/factsheets/glyphogen.html> [accessed 15 March 2017], World Health Organisation, "Environmental Health Criteria 159: Glyphosate", in International Programme on Chemical Safety <http://www.inchem.org/documents/ehc/ehc/ehc159.htm> [accessed 21 March 2017], and ADAS, "How valuable is glyphosate to UK agriculture and the environment?", Outlooks on Pest Management, December (2010): 280-4.

2.1 PRE-PLANTING USE

The aim of pre-planting glyphosate use is to create a clean seedbed, free from both annual and perennial weeds, and free from '*volunteers*'—self-set plants from a previous crop.[9] This enables the establishment of the next crop. Glyphosate is also used pre-planting to remove the *green bridge*—green cover on a field between crops that enables pests such as virus-carrying aphids, fungi and slugs to transfer to the next crop.

Traditionally, plough-based inversion cultivation systems were used at the pre-planting stage in order turn over the soil and thereby to bury weeds and volunteers, and to break the green bridge. The availability of glyphosate meant more efficient crop cultivation practices could be established instead. By killing competitor plants through pre-planting use, glyphosate enabled reduced cultivation practices to be implemented.[10] For example, rather than full plough-based inversion cultivation to bury weeds, cultivations could to simply loosen and mix the top portion of the soil, or even avoid the need for cultivation altogether, with seed is drilled directly into existing stubble instead. These reduced systems of cultivation are quicker (and usually cheaper) than traditional inversion ploughing.[11] They allow more land to be planted in the limited planting window and less fuel is required to establish crops, meaning CO_2 emissions are reduced. In agronomic terms, not ploughing the land helps retain moisture and nutrients: soil structure and organic matter is improved and the number of beneficial invertebrates, such as worms, rises.[12]

Finally, the pre-planting timeframe can also include applications of glyphosate that are *post-planting, pre-emergence*. This is the brief period after the seeds have been put in the ground, but before they emerge from the soil; however, only a narrow range of crops are treated this way.

2.2 PRE-HARVEST USE

Glyphosate is also used immediately before harvest, when the crop is desiccated to aid harvesting (although glyphosate is not a true desiccant as this refers to a product that simply burns-off the foliage).[13] The benefit of desiccating a crop is that it reduces the quantity of green material going through the harvester, both from the crop itself (particularly when ripening has been uneven), and from any weeds present in the crop. This speeds up the harvesting operation, reduces costs and increases yields. However, this treatment is only suitable for a relatively narrow range of crops including cereals, oilseed rape, dry peas, field beans, mustard and linseed.

[9] These are self-set plants from a previous crop that are equivalent to weeds as they are unwanted in the current crop. As well as the usual issues with weeds in that they compete with the crop for resources, such volunteers can also reduce the crop quality as their grain appears in the harvested crop.
[10] ADAS, "How valuable is glyphosate to UK agriculture and the environment?", *Outlooks on Pest Management*, December (2010): 280-4.
[11] John Nix, *Farm Management Handbook 2017* (Melton Mowbray: The Pocketbook, 2017).
[12,13] ADAS, "How valuable is glyphosate to UK agriculture and the environment?", *Outlooks on Pest Management*, December (2010): 280-4.

3. CHANGES TO FARMING AFTER A BAN

To gauge the effect of the loss of the glyphosate on UK farming practices and production, the Andersons Centre created a model of likely effects. The model explores the cost changes that can be anticipated alongside changes in yields and cropping. The assumptions and implications of this model are set out in the chapter, which represents the Andersons Centre's assessment of the changes UK agriculture would have to make in the wake of a glyphosate ban.

3.1 ALTERNATIVES TO GLYPHOSATE IN AGRICULTURE EXIST

The Andersons Centre's assessment is that glyphosate's characteristics mean there is no like-for-like replacement. If the herbicide is banned in the EU, no single alternative chemical or cultivation practice would be suitable to replace glyphosate wholesale. Instead, a range of approaches are likely to be adopted by the farming industry to mitigate its loss.

In summary, the model assumes that following a ban farmers would need to adopt more mechanical and labour-intensive means to control weeds. This will require more cultivations of the soil. For example, this might mean a shift to full inversion cultivation on land that previously underwent minimal ploughing (see chapter two). The model also assumes that a ban on glyphosate will require extra cultivation passes, and mowing of fallow and orchards prior to harvesting to control weeds. Each of these processes is both time- and labour-intensive, and the model therefore assumes additional costs for farmers. Even where different herbicides—such as pelargonic acid—can be used in the absence of glyphosate, additional spray passes will be needed to achieve effective weed control due to lower efficacy.[14]

The rest of this chapter explores the assumptions and implications of the Andersons Centre model.

The cost implications of growing crops for farmers of a glyphosate ban fall into two categories: additional operations, and additional chemical costs. We now explore each in turn.

[14] ADAS, "How valuable is glyphosate to UK agriculture and the environment?", *Outlooks on Pest Management*, December (2010): 280-4.

MODELLING CHANGES IN AGRICULTURAL PRACTICES

To gauge the effect of the loss of the glyphosate, the Andersons Centre created a spreadsheet model to study the likely effects. This model explores both the monetary loss, and also changes in yields and cropping.

The model is based on the aggregate UK farming accounts as compiled by DEFRA, published annually in Agriculture in the UK. From these accounts a measure of profitability for UK agriculture known as *Total Income from Farming* (TIFF) is derived. This is the aggregate return to all the entrepreneurs in UK agriculture and horticulture for their management, labour and their own capit al in their businesses. Note that the use of the term 'Income' can be confusing—what is essentially being shown is the profit of the farming industry.

To provide a more-detailed analysis, the financial data comprised in the TIFF accounts is supplemented in the model by physical data for each crop, including planted area, yields and prices. These are all reconciled to produce a financial output figure. The sources of these data are the UK June Agricultural Survey[15] and the Basic Horticultural Statistics publication.[16]

In all cases, for both financial and physical data, five year averages for the years 2011 to 2015 (inclusive) have been used (2015 is the latest data available). Farming is an inherently volatile industry so the use of a five-year average means that the base figures are not distorted by unusual yearly events, such as weather events.

The Andersons Centre's model creates a post-ban scenario from this baseline by applying the changes to operations, yields and prices described in this section. The model illustrates the implications of a long-term build-up of the weed burden following a glyphosate ban. The comparison of the baseline with the post-ban scenario assumes all other conditions remain constant. Therefore, the analysis is undertaken at today's prices (and premiums) and cost levels. In this way, the effect of the loss of glyphosate can be seen in isolation.

The Andersons Centre's model is an attempt to simplify the real world, and in the process of building it many assumptions are made. In a scenario such as the loss of glyphosate, it is necessary to model a counter-factual situation. Inevitably some of the consequences of a ban are unknown and unknowable. The assumptions made draw from existing literature and the Andersons Centre's expertise in this area. It would be possible to argue a different outcome for any of the individual assumptions. However, as the model is made up of numerous calculations any individual figure is not crucial to the overall outcome.

The model draws on the data published in the Pesticides Usage Survey (PUS)[17] for statistics on areas being treated by glyphosate. However, the manufacturers of glyphosate suggest that the quantities (and thus areas) reported in this survey do not always reconcile to the quantities of product that they know have been sold. There may be some methodological issues that mean the full use of glyphosate on UK farms is not being picked up. By using the PUS figures this report is erring on the side of caution, and therefore any losses calculated are likely to be at the lower end of the possible range.

[15] Department for Environment, Food and Rural Affairs, "Structure of the agricultural industry in England and the UK at June", in Gov.uk <https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june> [accessed 27 February 2017]

[16] Department for Environment, Food and Rural Affairs, "Basic horticultural statistics 2013", in Gov.uk <https://www.gov.uk/government/statistics/basic-horticultural-statistics> [accessed 27 February 2017]

[17] Food and Environment Research Agency, Pesticide Usage Survey Report 263: Arable crops in the United Kingdom 2014 (York: Food and Environment Research Agency, 2015).

3.2 ADDITIONAL OPERATION COSTS FOLLOWING A BAN

With glyphosate no longer available, farming operations would have to change. The major change would the additional cultivations that would be required to control weeds, with a focus on mechanical rather than chemical means. These alternative practices are likely to impact on farm costs (in the form of labour, fuel, repairs, finance, and depreciation) in several ways.

3.2.1 A shift to full inversion tilling

Without glyphosate to control weeds, more intensive cultivation (mainly plough-based) can be expected to be required on areas previously cultivated with minimal tilling. Unfortunately, no reliable statistics on areas cultivated under different systems exist for the UK. However, it can be assumed that land currently being treated with glyphosate has a heavy weed burden, and therefore, the model assumes that a ban on glyphosate would require a return to inversion cultivation on this land to control weeds sufficiently in the future.

The evidence suggests that switching from minimal to intensive tilling incurs considerable additional cost for farmers. Data from the Farm Management Pocketbook indicate that it costs £47 to undertake a one-pass, minimal cultivation of a hectare. By contrast, full inversion cultivation costs £54 more (£101 in total) for the same area.[18]

3.2.2 The need for extra cultivations

In addition, without glyphosate, a need for extra cultivation processes prior to planting can be anticipated, mainly of spring-sown crops, with attendant costs. These cultivations encourage weed seeds to chit (grow) so that weed plants can then be destroyed in subsequent cultivations. In the model, post-ban, extra cultivation passes have been assumed to take place, from the autumn through to the spring planting period, at a cost of £33 per hectare. Also included in this category are several other operations, including mowing/topping of fallow and also of orchards, costing £20 per hectare.[19]

Different crops will require a different number of additional cultivations and mowing/topping passes. The table below sets out the Andersons Centre's assumptions for each crop type.

[18,19] John Nix, *Farm Management Handbook 2017* (Melton Mowbray: The Pocketbook, 2017).

Fig. 1: Extra cultivations required post-ban, by crop

Crop	Number of extra cultivations
Spring Barley	2
Other Cereals	2
Peas	2
Beans	2
Other Oilseeds	2
Sugar Beet	2
Potatoes	2
Maize	2
Other Forage	1
Root Vegetables	2
Other Vegetables	2
Top Fruit	3
Soft Fruit	2
Temporary Grass	2

Source: The Andersons Centre

3.2.3 The need for additional spray passes

The final portion of additional operations costs comes from additional spray passes. As set out in the next section, without the availability of glyphosate the model assumes a greater need for in-crop post-emergent herbicide applications. Whilst there will be a saving from the discontinued glyphosate applications, overall, additional sprayings will be required.

The Andersons Centre assumes that one additional spray pass will be required for wheat, winter barley, potatoes, sugar beet, root and other vegetables, and temporary grass. Per the Farm Management Pocketbook, the cost of an additional spray pass is £11 per hectare.

3.3 ADDITIONAL CHEMICAL COSTS FOLLOWING A BAN

In the absence of glyphosate, the model assumes there to be a greater reliance on post-emergent herbicides to control weeds. There are significant issues about the future availability and efficacy of these for UK agriculture (see separate report on the wider issue of plant protection products).[20] It is not within the scope of this study to forecast the extent of the future agro-chemical toolkit available to UK arable farmers. Therefore, it is assumed that current products remain available and have the same level of efficacy as at present. As with other assumptions in this study, this is likely to underestimate the problems faced by producers as the number of active substances available, and their usefulness, is likely to decline in the future.

The cost of these treatments is included in the Andersons Centre's model. The model assumes crops will require between one and three post-emergence treatments. The per hectare cost of such treatments depends on the type of crop: the cost for combinable crops, maize and grass is £25 per hectare, and £45 for fruit and vegetables. Finally, the savings in cost of not applying

As discussed above, glyphosate is also widely used as a desiccant. For several land uses (notably oilseed rape, fallow, grassland) it is assumed that there will still be a requirement to desiccate the existing green cover, either prior to harvest, or ahead of cultivations for the next crop. In the absence of glyphosate, farmers can be expected to turn to a costlier alternative (most likely to be Reglone (diquat)).[21] The Andersons Centre model assumes that the cost of Reglone exceeds glyphosate by £9 per hectare.

Fig. 2: Number of extra herbicide treatments required post-ban, by crop

Crop	Number of extra treatments
Combinable crops	
Wheat	2
Winter barley	2
Oats	1
Oilseed rape	1
Other forage	1
Temp grass	1
Fruit and vegetables	
Sugar beet	2
Potatoes	2
Root vegetables	2
Other vegetables	2
Top fruit	3
Soft fruit	2

Source: The Andersons Centre

[20] The Andersons Centre, *The Future Availability and Efficacy of Plant Protection Products: potential on-farm implications* (Melton Mowbray: The Andersons Centre, 2016).

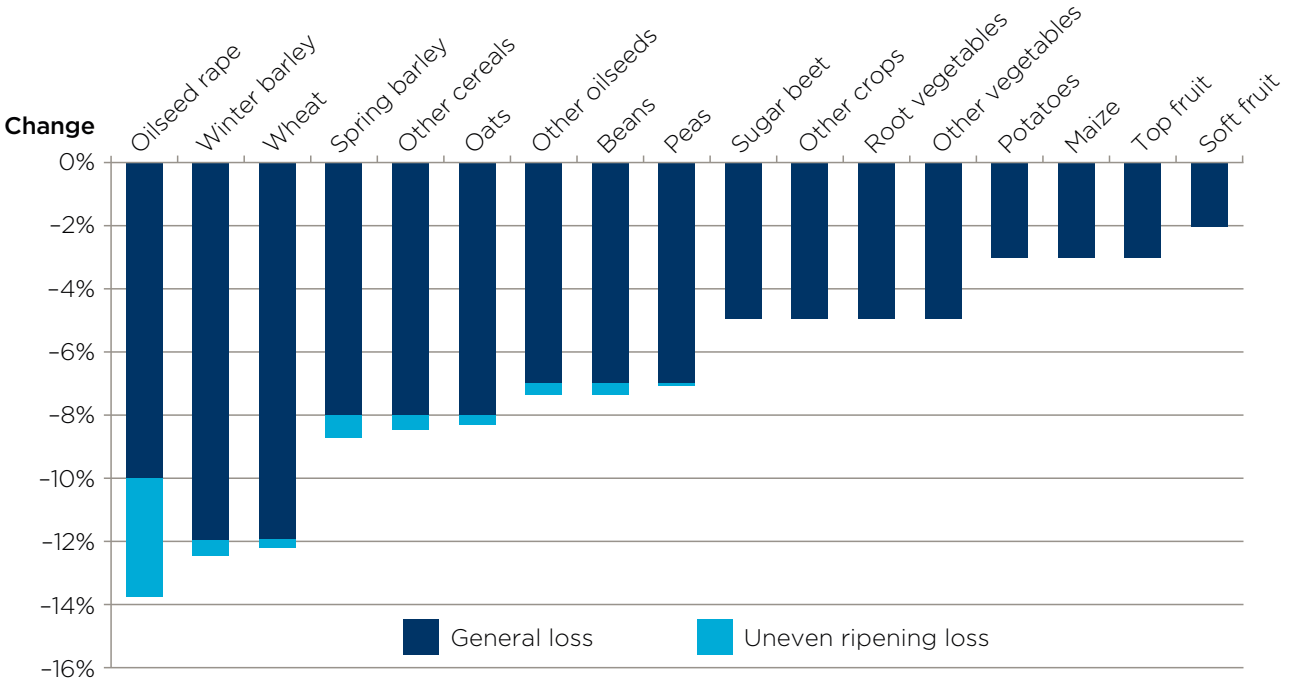
[21] Note that the product that would naturally be used is Reglone (diquat). This, itself, has potential issues around re-authorisation. For the purposes of this study, it assumed it will remain available. If it were to be lost, then, in oilseed rape, mechanically swathing the crop is likely to be required. This has a cost of over £40 per hectare, plus higher crop losses. Thus, the overall economic effect that this report estimates would be even greater.

3.4 LOSSES DESPITE CHANGING PRACTICES

Even with alternatives in place, the Andersons Centre analysis anticipates that the weed burden will increase because of a glyphosate ban. A combination of more mechanical means and alternative chemicals is unlikely to fully mitigate the effect on yields and quality from higher weed burdens.[22]

For example, one alternative proposed is pelargonic acid, applied to control for annual weeds. However, unlike glyphosate's broad spectrum control, no control of perennial weeds or large well established annuals would be achieved using pelargonic acid. Ultimately this will have an impact on crop outputs and crop prices that result.

Fig. 3: Predicted changes in yield, by cause and crop



Source: The Andersons Centre

[22] ADAS, "How valuable is glyphosate to UK agriculture and the environment?", *Outlooks on Pest Management*, December (2010): 280-4.

12 percent

Projected decline in wheat yields after a ban

3.4.1 Declining yields

The Andersons Model suggests that less effective weed management, following a ban on glyphosate, could result in reduced yields for some of the most important crops for UK farming. Yields may be hit in two important ways. The first is increased contamination through weeds: at present an application of glyphosate every other year, or one year in three, achieves a significant lowering of the overall weed burden that is not matched by alternatives, such as pelargonic acid. The second is a fall in the quality of crops due to uneven ripening at harvest time which reduces harvested volumes. At present, glyphosate is widely used for desiccation to avoid uneven ripening, and to allow harvesting at the optimum time to maintain quality and avoid mycotoxin contamination. In the absence of glyphosate as an option, the model assumes crop quality declines.

Taking account of all the changes in practices outlined, the analysis by the Andersons Centre suggests that the absence of glyphosate may, for example, lead to a decline in wheat yields of 12 percent. This is the result of a combination of factors: a three percent fall in yield for wheat treated with glyphosate pre-harvest due to uneven ripening,[23] and a more general yield loss across the entire crop due to cumulative build-up of grass and broadleaved weeds.[24]

Fig. 4: Post-ban price changes, by cause and crop

Crop	Uneven ripening					Weed grain effect	Cropping pattern impact	Overall price impact for whole crop
	Treated area (% of total) [1]	Premium (% mark-up) [2]	Base price (£) [3]	Premium (£) [4]=[2]*[3]	Overall impact of loss of premium (% of total price) [5]=([1]*[2]*[4])/[3]*-1	Drop in overall price (%) [6]	Drop in overall price (%) [7]	[5]+[6] or [7]
Combinable crops								
Wheat	4.47%	10.00%	150	15	-0.04%	-0.30%		**-0.34%**
Winter barley	15.44%	15.00%	137	21	-0.35%	-0.40%		**-0.75%**
Spring barley	14.73%	15.00%	137	21	-0.33%	-0.40%		**-0.73%**
Other cereals							-0.50%	**-0.50**
Fruit and vegetables								
Root vegetables							-3.00%	**-3.00%**
Other vegetables							-8.00%	**-8.00%**
Top fruit							-1.00%	**-1.00%**

Source: The Andersons Centre

[23] Around four percent of the total wheat crop.
[24] ADAS suggests a yield loss in both wheat and oilseed rape of 20%. The Andersons Centre believe that this may be rather high given the mitigation efforts and the rotational changes discussed elsewhere. A similar process has been undertaken for all the major crops grown in the UK, using the best available data and knowledge of industry experts.

Different glyphosate usage rates mean the impact on yields revealed by the model, varies by crop. For example, for oilseed rape the expected yield loss is almost 14 percent, with almost four percent of this predicted to be due to uneven ripening.

Importantly, without glyphosate, over time, a build-up of (especially perennial) weeds will affect all land within the arable rotation. Consequently, losses can be expected to apply across the entire crop area, not just the portion receiving a glyphosate application in any one year.

3.4.2 Lower prices

Any fall in the quality of a crop will also result in a change in the price that farmers receive for it. Different quality levels of the same crop attract different prices according to their possible usage. For example, on average, farmers received £127 per tonne of malting barley in 2015, while lower quality feed barley cost £107 per tonne.[25] While no change in price is anticipated for some crops following a glyphosate ban, for others the effect is notable.

Uneven ripening of the barley crop might, for example, lead to a downgrading from malting specification (which commands a premium) to basic feed barley. A similar downgrading might be anticipated across all combinable crops. Additionally, the Andersons Centre analysis suggests that a 'weed grain effect' (lower yields and quality due to the presence of more weeds) can be expected to reduce prices for the whole crop. In the modelling, these effects are reflected by an overall 0.8 percent and 0.3 percent drop in barley and wheat prices, respectively. Moreover, a likely shift in cropping patterns (discussed in the next section) will result in price changes for fruit and vegetables, as spring crops typically command higher prices.

[25] Department for Environment, Food and Rural Affairs, *Agriculture in the United Kingdom 2015* (London: Department for Environment, Food and Rural Affairs, 2016).

3.5 SHIFT IN CROPPING PATTERNS

The Andersons Centre model also explores how a ban on glyphosate can be expected to have an impact on cropping patterns in UK farming, as the usability of land is affected by weeds. Glyphosate has facilitated the shift to a predominantly autumn-based planting schedule in the combinable crops sector—being mainly winter wheat and winter oilseed rape. With autumn cropping, the window between harvesting the previous crop and planting the next one is short. Glyphosate has allowed weed (particularly black-grass) control to take place within this window. Without it, given the greater time needed for mechanical cultivation for weed control, a shift to more spring cropping is likely.[26]

As cropping patterns change, the use of variable inputs such as seeds, fertilisers and pesticides will alter. This too is explored in the model. In addition, production systems are expected to change– for example, different cultivation systems are implemented. These effects have been built into the Andersons Centre's model and alter the costs experienced by farmers across several categories, including machinery costs, fuel, labour, and so on. The major cost changes included in the model are as follows:

- Seed costs drop in proportion to smaller cropped areas.
- Fertiliser costs also drop for a similar reason. Any land used for spring crops only is assumed to need a quarter less fertiliser than winter combinable crops; the same is true for temporary grass land. No fertiliser is applied to fallow land.
- Similarly, pesticide costs will also change. Notwithstanding the specific additional costs outlined above, it is assumed that the cost of pesticides on spring cropping land is a quarter less than those of winter combinable crops. Any additional land in fallow or temporary grass achieves a 100 percent saving on pesticides cost (aside from the specific herbicides outlined in the previous section).
- In terms of operational costs, some savings are likely in spring cropping compared to autumn cropping. For example, lower yields can make harvesting quicker and there are fewer applications of fertiliser and sprays. However, these savings are likely to be relatively small. Therefore, it is assumed that the cost of operations on spring cropping land is 10 percent less than those of winter combinable crops. Any additional land in fallow or temporary grass achieves a 100 percent saving.

There are other cost changes that could be made, for example lower crop storage costs due to lower output. Furthermore, although the grass area has risen in the model, no additional livestock output has been included. It is assumed that grazing livestock would become more extensive.

These are the main cost changes captured in the Andersons Centre's model. With knowledge of the likely implications that a glyphosate ban will have on farm operations, as modelled, a picture of post-ban UK agriculture can be developed. This is the subject of the chapter four.

[26] ADAS, "How valuable is glyphosate to UK agriculture and the environment?", *Outlooks on Pest Management*, December (2010): 280-4.

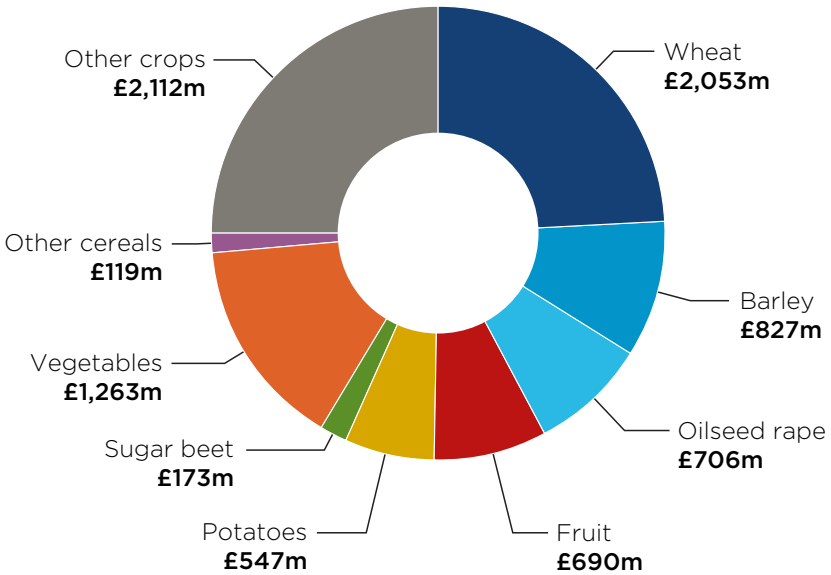
4. UK FARMING AFTER A BAN

15 percent

Projected fall in UK cereal production after a ban

The results of the Andersons Centre model suggest that the impact of a glyphosate ban on yields, price, and land use patterns will, in turn, produce a marked shift in cropping in the UK agricultural sector. The profitability of crops partly determined by how easily they can be grown on the land, and so it can be expected that, over time, the area in use for some crops will decline, with other crops taking up the space to compensate. These different crops will, in turn, have different revenue and cost patterns to the current situation, with a knock-on impact on the profitability and competitiveness of UK farming.

Fig. 5: Sources of farms' crop income, 2015



Source: Defra (2016)

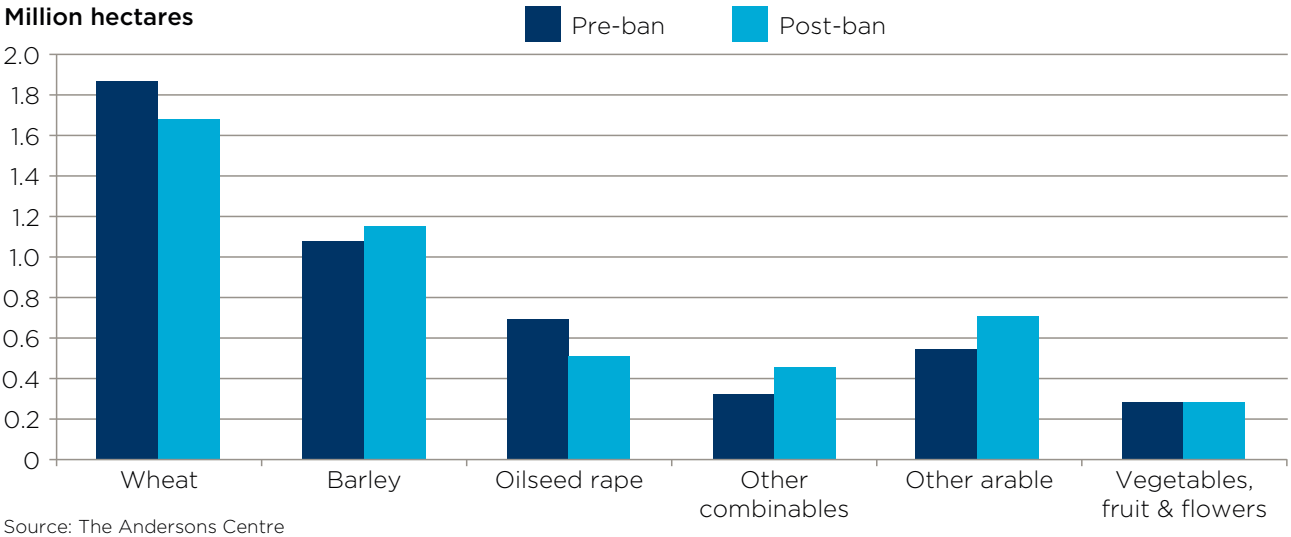
4.1 CHANGES IN PRODUCTION

Most notably in the Andersons Centre model, the absence of glyphosate is forecast to lead to a sharp decline in production of two of farming's biggest earners—wheat and oilseed rape. Data from Defra indicate that wheat and oilseed rape are the most and third-most important crops, respectively, in terms of the value of output generated for farmers.[27]

However, following a ban and subsequent decline in competitiveness of UK crops, the land area devoted to these two crops is expected to drop by ten percent for wheat and 27 percent for oilseed rape—mainly due to a reduction in autumn planting. Overall the modelling shows that the total land area planted with combinable crops is projected to fall by four percent following a glyphosate ban.[28] The model assumes that other crops will be planted on this land, with farmers favouring the next most productive and profitable alternative.

[27] The second most valuable in output terms is barley. (Department for Environment, Food and Rural Affairs, *Agriculture in the United Kingdom 2015* (London: Department for Environment, Food and Rural Affairs, 2016).)
[28] All non-crop farm activities, such as rearing livestock, are assumed to be unchanged following a ban, as is the total area farmed.

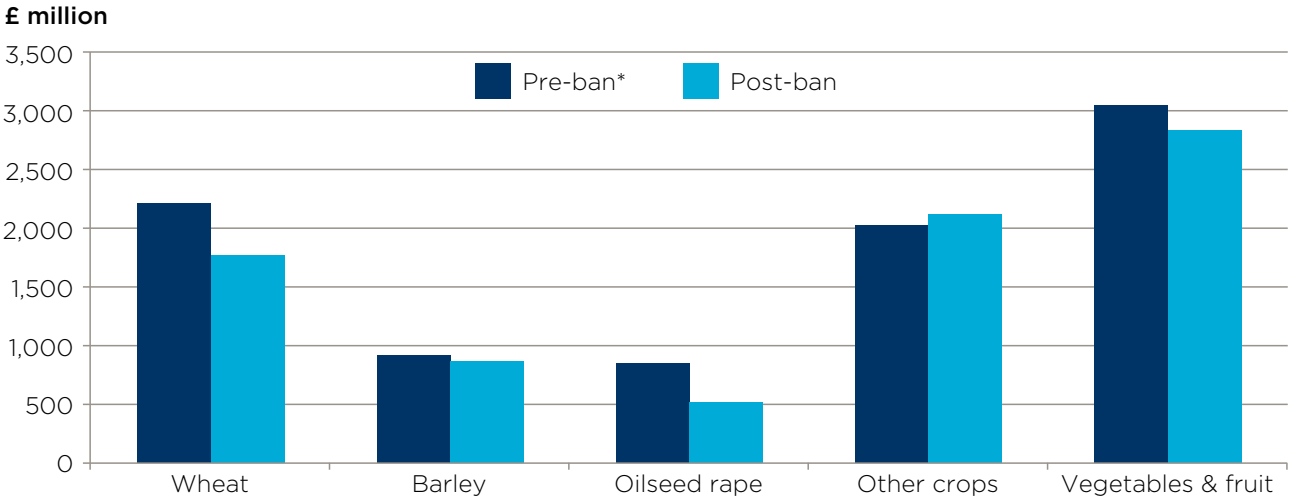
Fig. 6: Change in UK cropping hectares following a glyphosate ban



Source: The Andersons Centre

As a result of changes to the cropped areas and reduced yields for some crops, overall production of UK crops falls in the model following a glyphosate ban. The Andersons Centre predicts that total cereal production will shrink by 15 percent. Wheat production will fall by over 20 percent, and barley production by five percent. The decline in wheat production is expected to directly cut the value of UK crop output by five percent. However, the most notable fall is projected for oilseed rape, which sees a 37 percent fall in production due to the combination of a 27 percent decline in its anticipated cropped area and a fall in yield of nearly 14 percent. This fall is projected to lead to a decline of more than three percent in income from crops.

Fig. 7: Changes in value of UK crop production following a glyphosate ban



Source: The Andersons Centre. Note: *Pre-ban figure are five year average for 2011–2015

£940m

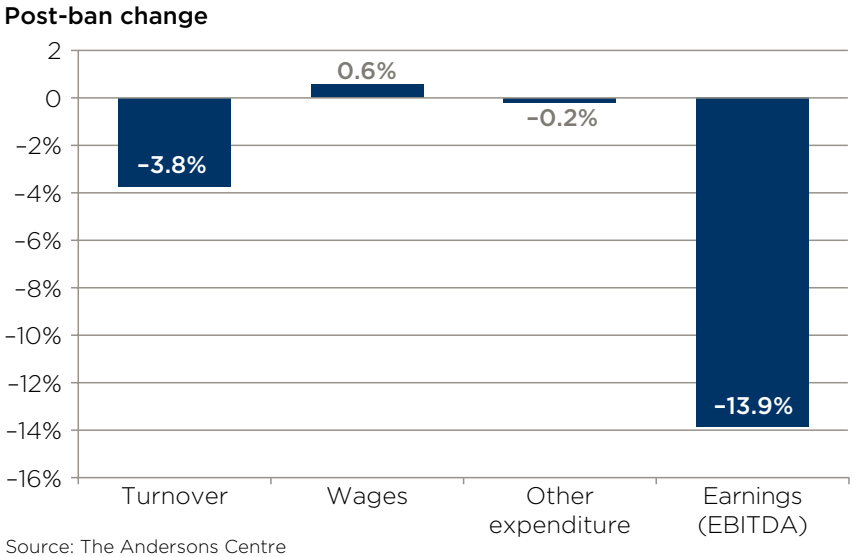
Projected reduction in UK farms' output after a ban

4.2 CHANGES IN FARM TURNOVER AND PROFITABILITY

The model also explores how downward shifts in production and reduced prices for certain crops can be expected to affect the collective turnover of the UK's farms. The latest data published by Defra indicate that over the five years to 2015, the UK's farms achieved an average output of £24.7 billion per year.[29] Modelling by the Andersons Centre estimates that a glyphosate ban would reduce this output by some £940 million, or 3.8 percent. To place this into context, UK farmers received some £2.8 billion in total each year from the EU through the Common Agricultural Policy.

Productivity in the sector is also expected to fall as more labour-intensive operations are needed in the absence of glyphosate. Modelling based on industry standard processes and costs suggests that the mix of crops and techniques that would result from the ban would be more labour intensive that at present.[30] This would lead to some 1,000 more people being employed in farming after a glyphosate ban (bringing total farm employment to around 478,000). But as output is expected to fall, the productivity of these and all other jobs in agriculture is forecast to decline following a ban.

Fig. 8: The impact of a glyphosate ban on farm turnover, costs and earnings



Source: The Andersons Centre

Increased employment means an increase in wage costs and an accompanying decline in farm profits. It is estimated that the increased employment above will be accompanied by a £13 million increase in wage payments (assuming wage rates remain the same after a ban), to over £2.4 billion. Spending on other inputs is expected to drop slightly (by £31 million) to just over £15.6 billion. In the five years to 2015, annual farm profits averaged over £6.6 billion; under a ban this is predicted to fall to £5.7 billion.[31]

[29] Department for Environment, Food and Rural Affairs, *Agriculture in the United Kingdom 2015* (London: Department for Environment, Food and Rural Affairs, 2016).
[30] As set out in the Farm Management Handbook (John Nix, *Farm Management Handbook 2017* (Melton Mowbray: The Pocketbook, 2017).)
[31] Measured before interest, taxation, depreciation and amortisation (EBITDA).

4.3 CHANGES IN GDP AND PRODUCTIVITY

The Andersons Centre model demonstrates that a glyphosate ban would reduce the direct contribution of the agriculture sector to UK GDP by more than £900 million annually. Farms directly contribute to the UK economy through the gross value added (GVA) they create.[32] Agriculture's GVA averaged £9.0 billion over the five years to 2015. The decline in earnings for farmers that would follow a glyphosate ban can be expected to cut the sector's GVA contribution to GDP by more than £900 million, to £8.1 billion.

Several metrics can be used to measure the efficiency of UK farms and each tells the same story of the negative impact on UK farming of a ban on glyphosate. On the simple measure of farm efficiency as the ratio of output to costs, the ban results in a four percent decline in efficiency to 1.20 reflecting the decline in output from £24.7 billion to £23.8 billion.[33] The preferred measure of efficiency used by economists is labour productivity where the gross value added generated by each worker is calculated.

This measure shows the impact of the removal of glyphosate from farms' input: here the aforementioned decline in GVA forecast by the Andersons Centre coupled with the expected increase in employment after a ban means a ten percent decline in productivity.

4.4 CHANGES IN THE STRUCTURE OF UK FARMING

A ban on glyphosate may also play a role in accelerating a restructuring of the farming sector. The analysis presented above describes a snapshot of the impact a glyphosate ban would have on the economic footprint of agriculture in the UK. However, the impact of a ban may be even more keenly felt over the longer term. Lower output, and reduced profitability and efficiency over a prolonged period risks weakening farms financially, potentially causing some to cease production. Consequently, the ban could accelerate the trend towards consolidation of smaller farms to exploit economies of scale. Such a change would have social implications too, such as a reduction in traditional family farms in some areas.

[32] Analogous to the sum of EBITDA and compensation of employees.

[33] A simple measure describes how effectively farms can turn £1 of expenditure into output, and the larger the ratio the greater the efficiency (or profits). A ratio of less than one would indicate that farms are extremely inefficient and lose money for every £1 spent. Over the five years from 2010 to 2015, UK farms recorded an average annual output of £24.7 billion, and spent £19.7 billion on intermediate inputs, labour, depreciation, rent and interest. This gives an output to cost ratio of 1.25. After a ban, output is expected to fall to £23.8 billion, while costs are forecast to remain unchanged.

5. THE EFFECT OF A BAN ON UK JOBS AND GDP

The economic impact of the ban will be felt beyond agriculture. By changing the contribution the sector makes to the UK economy, knock-on effects will have implications for GDP, employment and tax revenues across the country. Overall, the modelling suggests that the economic footprint of farming in the UK will shrink following a ban. This chapter sets out how this impact can be expected to ripple through the rest of the economy.

5.1 INTRODUCTION TO ECONOMIC IMPACT ANALYSIS

The total contribution of the agricultural sector to the UK economy can be thought of as the sum of its impacts through three channels (Fig. 9). These are the:

- Direct impact, which is the activity taking place on UK farms, as reflected in the wages and employment of farm workers and the profits of the business owners;
- Indirect impact, or supply chain impact, that occurs because farmers buy inputs of goods and services from other UK businesses, which in turn buy supplies from further UK-based firms; and,
- Induced impact, or wage-expenditure impact, which is the economic activity stimulated in UK consumer-facing industries as farm workers, and employees in the farms' UK-based supply chains, spend their wages.

We analyse these channels of impact using three core metrics:

- Employment, measured on a headcount basis so that it is possible to make comparisons to national statistics;
- Gross value added contribution to the UK economy; and,
- Tax receipts generated by the UK activity supported through the three channels.

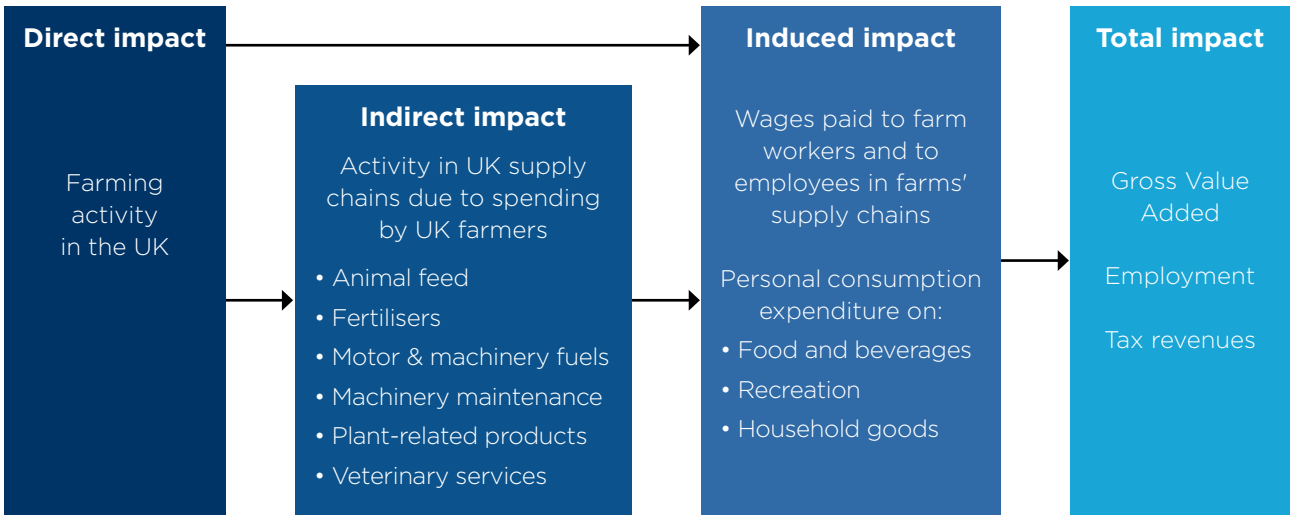
Gross value added (GVA) is a similar concept to the more familiar gross domestic product (GDP), in that it is a measure of the value of goods and services produced across a sector or supply chain. The only difference is that GVA is measured at the 'basic price' received by the producers, i.e. net of sales such as VAT and gross of subsidies, whereas GDP is measured the 'market price' paid by the purchasers, i.e. including sales taxes and excluding subsidies.

The indirect and induced GVA impacts are worked out by taking the pattern of the farming sector's procurement as a starting point, and applying ratios found in the UK National Accounts 'input-output table' – a table showing transactions between different sectors of the UK economy, the split in each industry's GVA between employment costs and profits, and the pattern of household expenditure. Jobs and taxes are worked out from there using further ratios found in official datasets.

For this study the direct, indirect and induced contributions of the agricultural sector were modelled twice, once to measure the average annual contribution of the industry to the UK economy between 2011 and 2015 (the 'baseline'), and once to estimate what the contribution would have been in a hypothetical situation where a ban in glyphosate had been in place. The latter took into account data supplied by the Andersons Centre concerning how the pattern of farmers' income and spending would be affected by such a ban. The economic impact of the ban is taken to be the difference between the total contribution made with and without the ban in place.

This study assesses the net impact of a glyphosate ban on arable farming in the UK, and the subsequent change in agriculture's relationship with the rest of the UK economy. However, it is not a full net analysis of a glyphosate ban, as the potential alternative uses of the resources used by agriculture (and its supply chain) are not accounted for. This is standard in economic impact studies due to the difficulty of estimating second-best uses for economic resources.

Fig. 9: Core economic impact channels



10 percent

Projected decline in agriculture's contribution to GDP

5.2 THE WIDER ECONOMIC IMPACT OF POST-BAN AGRICULTURAL PRACTICES

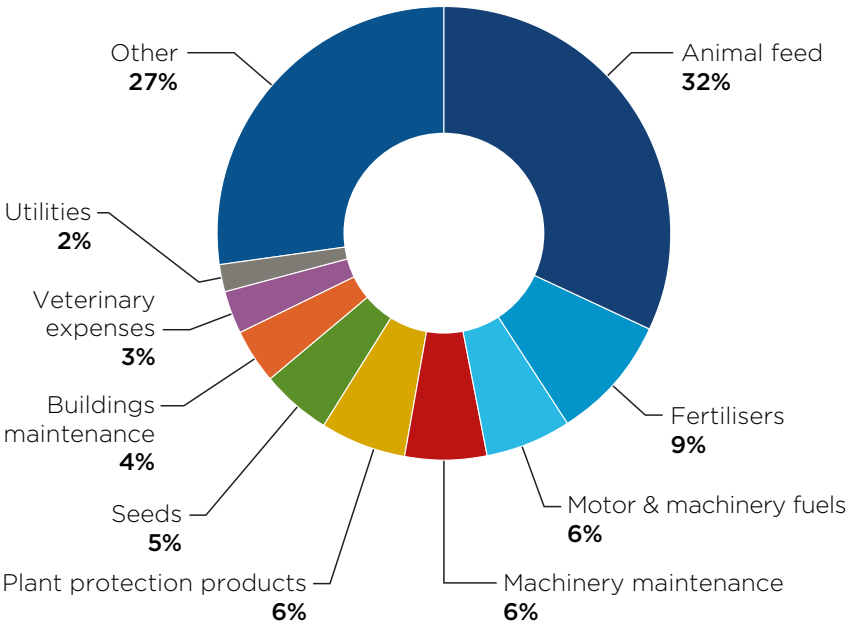
As reported in the previous chapter, in direct terms a ban would result in a reduction in GDP and an increase in employment in the agricultural sector. We have highlighted how a ban will reduce the contribution agriculture directly makes to UK GDP by £900 million, to £8.1 billion. But while the value contributed by farms declines, the change in operations necessitated by a glyphosate ban can be expected to result in a further 1,000 people being employed in the UK's agriculture sector.

5.2.1 Impact on supply chains

Beyond the overall changes to GDP and jobs, the ban can also be expected to have a knock-on effect in agriculture's supply chains. To deliver its produce agriculture relies on broad and diverse supply chains that span the country. UK businesses provide crucial inputs to farming, ranging from seeds and fertilisers, to utilities and maintenance. In the five years to 2015, UK farms collectively spent nearly £15.7 billion on inputs of goods and services annually. Around one-third of this was accounted for by animal feed, with a further tenth spent on fertilisers. Plant protection products, including glyphosate, represented six percent of the sector's spending on goods and services.

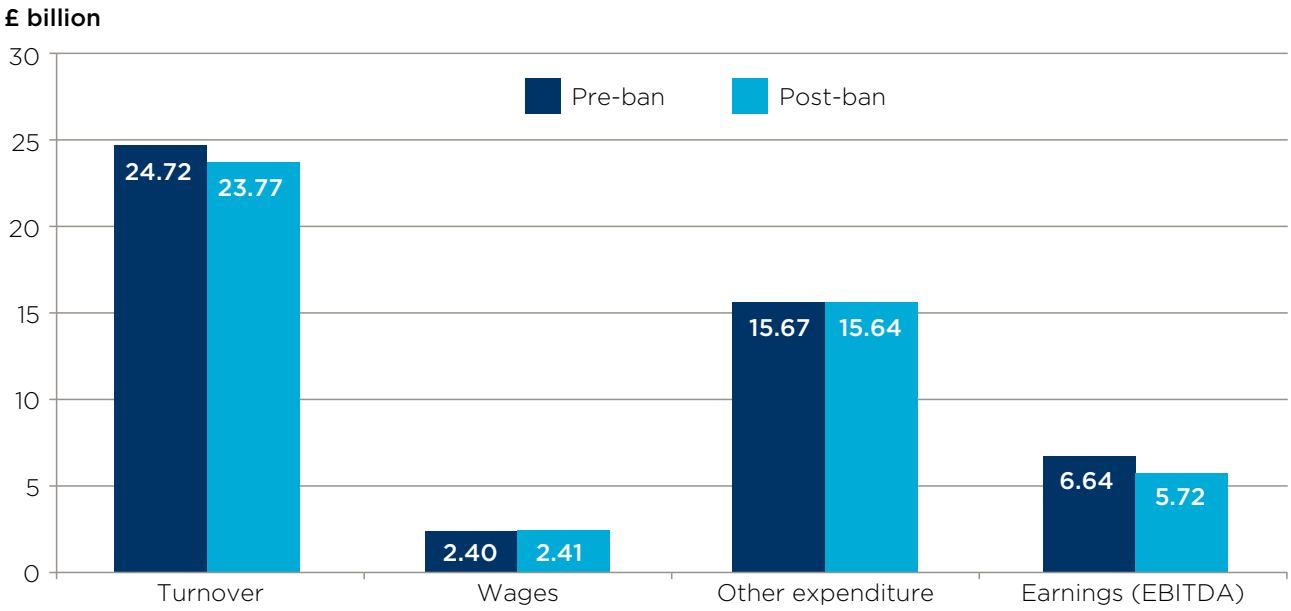
Our impact modelling shows that a ban would curb farms' aggregate spending on inputs only slightly, as reductions in spend on glyphosate are countered by an increased spend in other areas. The main impact of the ban would be on farmers' profits and, therefore, the sector's direct contribution to GVA. Wages, which are also part of direct GVA, are virtually unaffected, while the impact on other spending—which results in the indirect impact—is modest.

Fig. 10: Inputs in UK farming



Source: The Andersons Centre

Fig. 11: The impact of a glyphosate ban on farmers' income and outlays



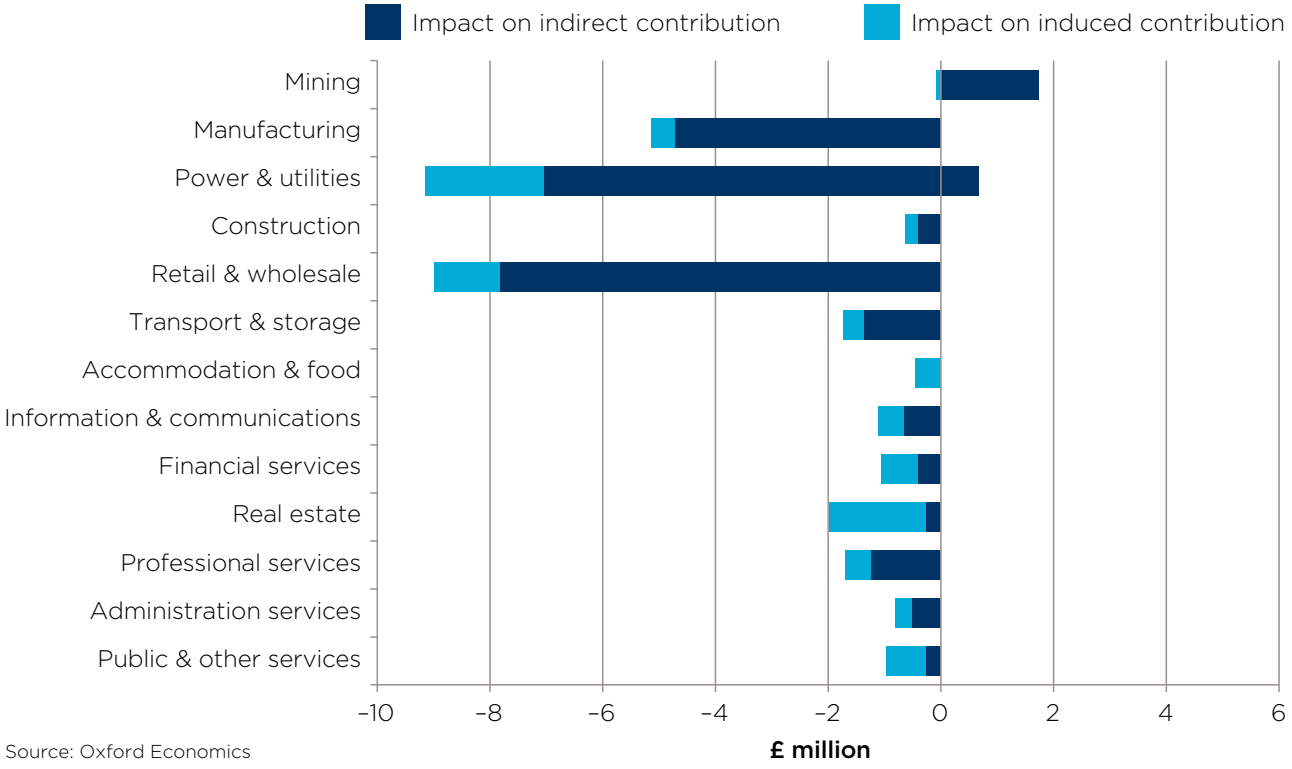
Source: The Andersons Centre

Significantly however, the impact on spending as a result of the ban will not be uniform across all spending categories. The overall composition of farming's inputs can be expected to change as operations adjust to the post-ban environment. This means that while some costs will increase—for example, spending on fuel will increase due to increased spray passes—savings will also take place—for example, spring cropping incurs lower fuel costs than autumn cropping. Analysis by the Andersons Centre shows that once all costs are offset, spending on seeds and fertilisers can be expected to fall by 1.3 percent and 4.1 percent respectively. At the same time, the increased need for other forms of weed control, and an increase in the number of spray passes, is estimated to result in increased spending on plant protection, motor fuels and vehicle maintenance, with these costs up by 2.2 percent, 1.2 percent and 1.0 percent respectively.

Agriculture's purchases of goods and services from UK businesses stimulate economic activity throughout the rest of the economy. The bespoke model we have constructed for this study enables us to map the transactions between industrial sectors and quantify agriculture's supply chain impact in the UK. Furthermore, it enables us to quantify how this impact will change once a ban on glyphosate comes into operation.

The model suggests that the impact of the ban would be to reduce the indirect contribution of agriculture to the UK economy by £12 million, with an associated loss of 250 jobs. This would also result in a £3 million reduction in tax revenues. Because of changes in the pattern of farmers' spending, the impact is unequal across the economy, with most the impact borne by the wholesale and retail, and manufacturing sectors. Most other sectors see a small drop in GVA and jobs, although mining and power benefit a little.

Fig. 12: Indirect and induced GVA impacts by sector



Source: Oxford Economics

5.2.2 Induced impact in the wider consumer economy

The impact of the glyphosate ban would also ripple beyond agriculture's supply chain into the wider consumer economy. The wage-financed spending of people working within agriculture, or in its supply chain, forms the final channel of the sector's economic footprint in the UK. This reflects the economic contribution that arises when employees in the sector and within its supply chain make purchases at retail and leisure outlets throughout the UK.

The analysis shows that, in total, a ban would reduce agriculture's induced GVA contribution by £7 million, with an associated jobs loss of around 100. Tax revenues are also expected to be £1 million lower than they would otherwise be. The induced impact is relatively minor as the spending power of farm workers in aggregate is little changed, so that only the net reduction in the spending power of workers in the supply chain has any effect here. The induced impact is spread fairly evenly across the economy, in contrast to the indirect impact which is focused on particular sectors.

Taking the indirect and induced impacts together, the £19 million GVA loss and 350 jobs impact is not negligible, but is modest compared with the direct impact affecting the agricultural sector itself.

5.2.3 Total impact of a glyphosate ban on the UK economy

By taking account of these supply chain and consumer spending effects on top of the direct effects in agriculture, we can fully quantify the potential economic impact of the changes to UK agriculture that would accompany a glyphosate ban.

In total, we estimate that a ban will reduce the contribution of agriculture to UK GDP by £930 million. This is equivalent to nearly a fifth of the Cambridge economy, or a tenth of Liverpool's economy. While the majority of lost GDP occurs within agriculture itself, there are knock-on effects in the wider economy. Indeed, although we estimate some 1,000 additional jobs will be supported in agriculture to implement the new practices, an estimated 350 fewer jobs will be supported in the rest of the economy.

Moreover, a glyphosate ban will have significant repercussions for government revenue. We estimate that a ban will lead to a reduction in the tax revenues generated by agriculture and its supply chain of some £193 million, equivalent to £3 for every UK resident, and sufficient to fund the annual salaries of over 7,000 nurses.

£930m

Estimated reduction in agriculture's economic footprint in the UK

5.3 POTENTIAL LONG-TERM ECONOMIC IMPLICATIONS OF A GLYPHOSATE BAN

The fall in UK farmers' competitiveness also risks worsening the trade balance in agricultural goods—particularly crops. If glyphosate were not approved for use in the UK (or EU) after 2017 but remained available in the rest of the world, this would place domestic production at a considerable disadvantage. The implication is that other regions would be able to produce food at a lower cost and could be expected to gain market share at the expense of the UK. At the time of writing, with the UK's post-Brexit trade arrangements unclear, but a hard Brexit seemingly likely, any impact on trade flows may be magnified.

The production impact of an EU-wide ban on glyphosate might also affect global prices, and therefore food prices, for consumers in the UK and elsewhere. Agricultural products are commodities and are traded on world markets. Therefore, it is fair to assume that sufficient volumes are available in the EU or worldwide to replace reduced domestic supplies, with little impact on food prices. Indeed, food prices are only partly linked to the cost of the raw material going into food production—prices also reflect processing and distribution costs, and retailers' margins. Within only one country, the UK say, a ban on glyphosate would not be expected to affect food prices.

However, the non-approval of glyphosate is likely to occur at a pan-European level and therefore the rest of the Single Market would be grappling with a sharp fall in output in the same way as the UK. In some commodities, the EU comprises a large portion of global output—for example the EU accounts for around 20 percent of world wheat production. Therefore, the effect of falls in EU production could be significant enough to raise the global price.

A glyphosate ban may, therefore, precipitate a shift in the UK's food trading position. Our initial modelling assumed that the demand for crops is unchanged and satisfied by global markets when UK production is reduced. In other words, businesses in the UK that are reliant on crops—breakfast cereal manufacturers for example—continue to operate, but now draw on imported rather than domestically produced crops. Consequently, the UK will either import more, export less or a combination of both, following a ban. For example, the UK imported some 1.7 million tonnes of wheat in 2015, and exported 2.0 million tonnes.[34] Modelling by the Andersons Centre indicates that after a ban domestic wheat production could fall by nearly 3.1 million tonnes. Therefore, a possible outcome to make up this shortfall would be for exports of wheat to stop, and imports to increase by two-thirds to 2.8 million tonnes. In this scenario, earnings from wheat exports would disappear, while the UK's import bill would increase.

Over the long term the ban may also lead to substantial changes in the UK's food processing industry. While it is reasonable to assume that imports will make up shortfalls in the short term, the story may be very different in the longer-term as a reliance on imported crops persists. Consequently, costly importing practices may influence future investment decisions, encouraging firms to relocate processing plants to where crops are produced rather than continuing to import crops. The extent and timing of this impact is unknowable, as firms review investments at different rates and will prioritise proximity to inputs and proximity to customers differently. But, with more than 100,000 jobs in the UK's bakery and grain mill processing sectors, the long-term implications could be potentially sizeable.[35]

[34] Department for Environment, Food and Rural Affairs, *Agriculture in the United Kingdom 2015* (London: Department for Environment, Food and Rural Affairs, 2016).

[35] The most recent data from the ONS *Annual Business Survey* reports 97,000 people worked in the manufacture of bakery and farinaceous products sector in 2015. Employment data in 2015 is supressed for the manufacture of grain mill products, starches and starch products sector for confidentially reasons, however in 2014 some 10,000 people were employed in the sector.

6. CONCLUSION

The EU is currently debating whether to renew the license for the use of glyphosate-based herbicides. Its decision, due before the end of 2017, could have far reaching implications for the UK's agricultural sector.

Widespread use of the herbicide in agriculture makes UK farmers vulnerable to a ban. Glyphosate has become a key input for the UK's farmers—who treated nearly a third of arable land with the herbicide in 2014—providing a cheap and effective tool for tackling weeds. Use of glyphosate has facilitated faster preparation of land prior to planting, increased the number of crop rotations possible, and engendered higher yields than other weed management options. Consequently, a failure to renew glyphosate's license can be expected to have a significant negative impact on UK farmers.

A ban on glyphosate use is projected to lead to falling yields and production within the UK's agricultural sector. Indeed, analysis conducted by the Andersons Centre indicates a ban could reduce the value of farm output by £940 million. While the available alternatives to glyphosate will require more workers, these will be low productivity jobs. Moreover, such a challenging business environment will potentially presage a restructuring of UK agriculture, with smaller farms absorbed into larger commercial operations to make lower profitability levels more bearable.

But the impact of a ban is not just limited to agriculture. The changes in farming practices that result from a ban can be projected to reduce agriculture's contribution to GDP by some £930 million, as the sector's demand for inputs from British suppliers alters. And falling profits in agriculture and its supply chain are projected to cause tax revenues to fall by £193 million—equivalent to the salaries of more than 7,000 nurses.

The long-term implications of a ban could be greater still. Falling domestic production will see an increasing reliance on imports, which will weigh on future investment decisions in the UK's food processing industry.

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June 2017

The results presented here are based on modelling and information provided by third parties, including the Andersons Centre, upon which Oxford Economics has relied in producing its report and forecasts in good faith. Any subsequent revision or update of those data will affect the assessments and projections shown.

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