Crop Protection Association

Plant Protection Products:

The value of their contribution to lowering UK household expenditure on food and drink

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I. Executive Summary

I.1. According to the United Nations a country's food security is defined as its population having, at all times, physical, social and economic access to sufficient, safe, nutritious food that meets their food preferences and dietary needs for an active healthy life. Economic access might more generally be described as affordability i.e., the level of food prices. In the UK it is indisputable that the prices, as well as the quality and variety, of food and drink is largely dependent on its agricultural industry's ability to grow sufficient quantities of crops at the quality and efficiency levels demanded. In part, the quantities of crops produced in the UK are related to its area of arable land but chiefly the volumes, quality and efficiency of what is produced are determined by the knowledge that is brought to bear i.e., the sophistication of the science applied, the farming techniques and farmer capabilities.

I.2. A testimony of the advanced level of knowledge in the UK agricultural industry is the levels and underlying growth of its crop yields. Agriculture's contribution to food security; indeed to living standards, is critically dependent on its attainment of high and consistent crop yields. These are the product of scientific research, the fruits of which are manifested in more resilient crops, the provision of nutrients via fertilizers and the improved efficacy of synthetic plant protection products. A wide range of academic studies confirm that were it not for the existence of crop protection products, not only would crop yields be significantly lower than their current levels but also the quality of what was produced would generally be lower.

I.3. Crops, particularly cereals, underpin the whole food system and basic economic principles dictate that in the absence of modern crop protection products food prices generally would be higher and the quality of much agricultural produce lower. This report attempts to quantify the value that products designed to protect crops from pests, disease and weeds make to the cost of food and thereby the living standards of UK households. It does this by first estimating the likely reduction in crop production. In the absence of plant protection products not only would crop yields be significantly lower than their current levels but also famers use of arable land would be less efficient, further reducing levels of crop production. Having estimated the decline in the production of crops it then calculates the likely impact on crop prices and thereby the knock-on effect for meat and dairy products and ultimately retail food and drink prices.

I.4. The latest official data shows that the average household currently spends £60.60 per week on food and non-alcoholic drinks consumed in the home.

This report estimates that, in the absence of plant protection products, this bill would rise by almost £11 a week – an increase of more than 17 per cent. Over the course of a year the cost to the average household of home consumed food and non-alcoholic drinks would increase by £562.

This compares to total weekly spending for an average household of £573 thus, the estimated increase of £11 per week implies that expenditure on food and non-alcoholic drinks consumed in the home would rise from its current 10.6 to 12.5 per cent of total expenditure. From another viewpoint, the UK's 27 million households would need to divert some £15bn from non-food expenditure to meet this higher cost.

I.5. Households also spend money on food eaten outside the home and the prices of these items would rise in the absence of plant protection products. According to the latest published data the average weekly spend by households on restaurants, take-aways and canteen meals was £30.80.
We estimate that this bill would rise by £1.20 or 4 per cent. Although the food content of these items of expenditure would rise in line with retail food prices, the overall percentage increase is lower than the increase for food and non-alcoholic drinks purchased for home consumption because the agricultural content accounts for a much smaller proportion of the final price once allowance is made for service costs, margins and VAT.

I.6. Another item of household expenditure that would rise in the absence of plant protection products is alcohol. Households spend money on these items to be consumed both within and outside the home. In the latest year for which data are available the average household spent £16.70 per week, or £868 per year, on alcoholic drinks. Cereals are critical inputs for beer and spirits which account for almost half of the weekly spend on alcohol and quality grapes also depend on plant protection products. However, after allowing for processing, marketing and retail mark-ups as well as excise taxes and VAT, the overall percentage increase for these items is estimated at 4 per cent. This results in an increase of £0.67 per week for the average household amounting to some £35 per year.

I.7. On the basis of the latest published data, the average household's total expenditure on food and drink, whether consumed within or outside the home, was £108.10 per week: equivalent to £5,621 per year. Following the withdrawal of plant protection products this expenditure would rise by some £13 per week or £658 per year: an increase of 12 per cent. Compared to median, weekly disposable earnings of £546 this implies that after allowing for income and council tax, a household half-way up the disposable earnings scale would need an additional 11 days of earnings to pay for the higher cost of food and drinks. Having allowed for the higher costs of alcohol and meals eaten outside the home, the total expenditure that the UK's 27 million households would collectively need to divert from discretionary items in order to meet the higher cost of food and drink rises to £18bn. This would inevitably have serious, adverse consequences for employment and income in the industries affected.

I.8. A focus on the average household underestimates the impact of higher food prices for many households; in particular households with children and pensioner households. Not surprisingly households with children spend a higher proportion of weekly expenditure on food. The latest data shows that households with two adults and two children spend £81.70 per week on food and non-alcoholic drinks for home consumption: equivalent to 10 per cent of their weekly expenditure.

Given the composition of expenditure within these two adult-two children households, the impact on their weekly outgoings in the absence of plant protection products, would amount to a rise of £15.10: an increase of 18.5 per cent. This means that over the course of a year expenditure on home consumed food and non-alcoholic drinks would rise by £786.50.

I.9. Poorer households with children spend a much higher proportion of their weekly expenditure on food. Households in the lowest quintile spend £63.70 per week on food and non-alcoholic drinks consumed in the home which amounts to 16.8 per cent of £379 total weekly expenditure. If food expenditure for households in this poorest group rose by 18.5 per cent, they would have to find another £11.70 per week and the share of expenditure devoted to food and non-alcoholic drinks for home consumption would rise to 19.8 per cent. Over the course of a year these poorer households would need to find an extra £612 – a severe challenge for already hard pressed households.

I.10. A similar picture emerges for pensioner households. On average, pensioner households with two adults spend £62.40 per week on food and non-alcoholic drinks consumed in the home: 13.6 per cent of their total weekly expenditure. Given the composition of food expenditure within these pensioner households the impact of the withdrawal of plant protection products would increase their weekly expenditure on these items by £11.65 a week or £606 per year: an increase of 18.7 per cent. Again, official data show that poorer pensioner households spend a much higher proportion of their weekly expenditure on food. Two adult pensioner households in the lowest quintile spend £58.30 per week on food and non-alcoholic drinks which amounts to 20.5 per cent of total weekly expenditure. For the poorest pensioner households an increase of almost 19 per cent in this weekly bill would be socially unacceptable.

I.11. The foregoing demonstrates that the higher food prices inherent in the absence of plant products would not only lower living standards but would also exacerbate income inequalities. This, however, is not the only adverse social impact. Higher food prices would present a serious challenge to healthy eating.

Some of the largest increases in prices, in the absence of plant protection products, would be for vegetables and fruit. We calculate that the retail level prices for these categories of food are likely to rise by at least 40 per cent.

Such an increase would seriously compromise the government's target for people to consume at least five portions of a variety of fruit and vegetables each day. Indeed, given that the cornerstone for improving the nation's health is access to a wide range of affordable foods, it would not be unreasonable to suggest that poorer health, particularly for vulnerable households, would be a consequence, posing a higher burden for the National Health Service and also negatively impacting on the country's economic performance.

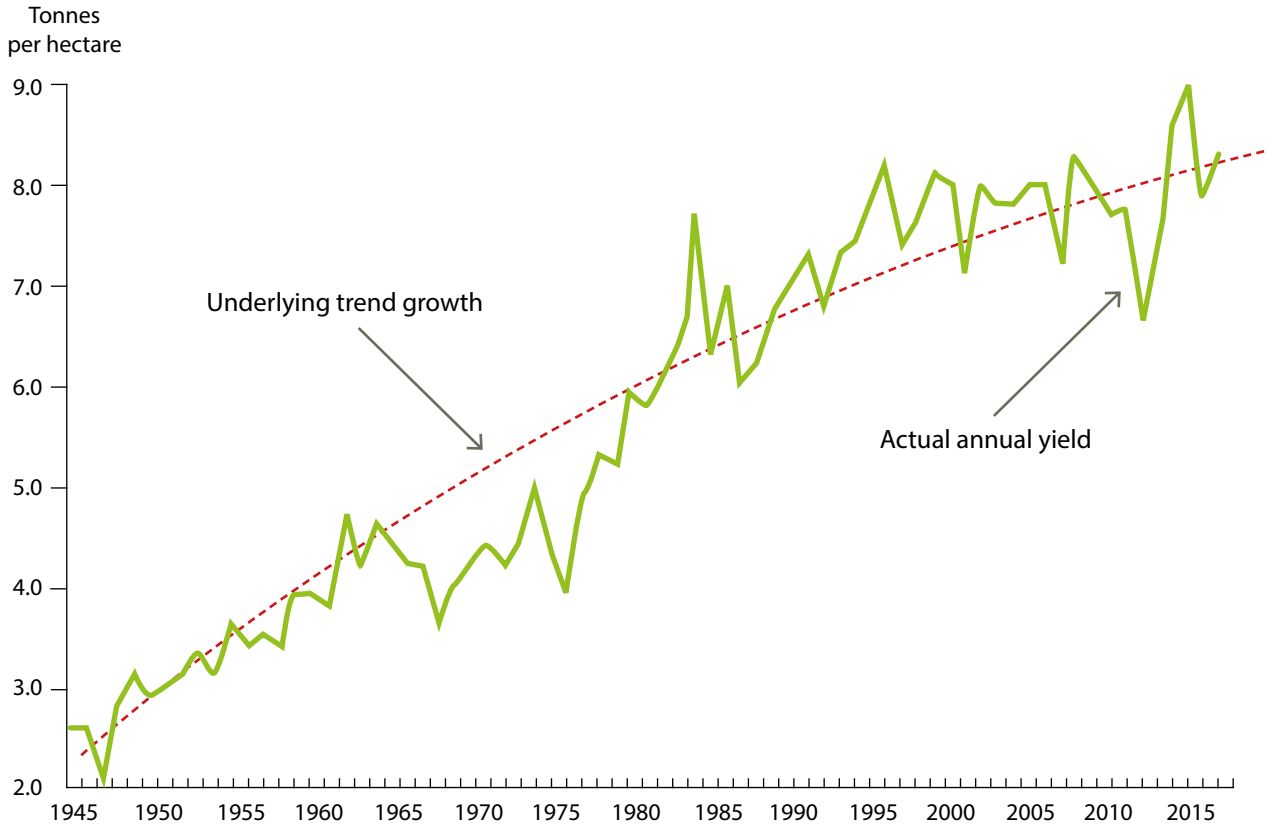
II. Introduction

II.1. A country's total production of agricultural products is the product of its area of farmed land and the amount produced per hectare. The fact that in most countries agricultural output has been increasing steadily over the past fifty years is due primarily to rising crop yields, particularly wheat. Wheat is the basic staple food of the major civilizations of Europe, West Asia and North Africa; indeed, it has been identified as fundamental to human civilisation[1] [superscripts refer to references in Appendix II]. Today, wheat accounts for a larger area of arable land than any other commercial crop. It provides the basis for bread, pasta and bakery products but also, as an animal feed, it is critical to the production of meat and dairy products and it is increasingly being used as a renewable, raw material for non-food products such as bio-plastics and biofuels.

II.2. Demand for agricultural products is largely driven by population and economic growth i.e., rising affluence. By 2050, global demand for food is projected to be almost 50 per cent higher than it is today[2] in response to the world's population increasing at a little less than one per cent per year[3] and a doubling in the size of the global economy.[4] These projections imply an additional 500,000 tonnes of cereals will need to be produced annually by 2050 and the United Nations Food and Agriculture Organisation (FAO) estimates that ninety per cent of this growth would be as a result of higher yields and increased cropping intensity.[5] In part this reflects the steady encroachment of urbanisation on arable land in many parts of the world but also it is now widely accepted that increasing the agricultural land area is unacceptable as it would involve biodiversity loss and an increase in greenhouse gas emissions. It follows that there is no other option than to increase yield efficiency and in this respect plant protection products (PPPs) have a critically important role. By protecting cereals, and crops in general, against diseases, pests and weeds, PPPs help ensure that the world's demand for an affordable, wide choice of high-quality food products can be met. Moreover, as the natural resources available to agriculture, including water and arable land, become increasingly scarce and climate change threatens to disrupt agricultural production, the role of crop protection has been elevated to help counter the challenge of food security – or more correctly food insecurity – facing populations.

II.3. A basic irreducible essential for wellbeing is food security which has been defined as being met when 'all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life'.[6] Economic access might more commonly be described as affordability or more precisely affordable food prices. Agriculture's contribution to affordable food prices is critically dependent on its attainment of high and rising yields for all crops, but particularly cereals. The level and growth of crop yields is the product of scientific research involving not only crop breeding but also advances in the composition of the inputs and the practices that are applied to growing crops. The fruits of this research are manifested in higher yielding, more resilient crops as well as the greater efficacy of nutrients e.g., fertilizers and synthetic PPPs. Since synthetic PPPs were developed in the 1940s there have been major increases in agricultural productivity, both in quantity and quality. This productivity growth has produced a threefold increase in the yields of the world's main grains (wheat, barley, maize, rice and oats) since 1950.[7] The growth of wheat yields in the UK is set out in Figure 1.

Figure1: The Growth of Wheat Yields in the UK



Source: Defra

II.4. The purpose of this report is to quantify the contribution that PPPs (hereafter unless otherwise stated PPPs are implicitly synthetic) make to the affordability of food and hence, to the living standards of UK households. Our approach is to attempt to estimate how much higher the average household's expenditure on food would be in the absence of PPPs; in essence, this involves calculating how much higher food prices would be. A wide range of academic studies confirm that the withdrawal of crop protection products would result in a sustained and widespread reduction in crop yields.[8] As there is very limited scope for increasing the area of the world's arable land, without the support of PPPs the world's total production of arable crops would be significantly lower than it currently is, let alone meeting the world's increasing demand for food. We know from basic economic principles that when the gap between demand and supply widens the result is higher prices. The idea that the UK's population could avoid higher food costs by resorting to imports is infeasible. It would be both illogical and hypocritical in the extreme to deny UK farmers the benefits of PPPs while importing food produced using such techniques. Rather, in what follows, the assumption underpinning the calculations is that farm industries across the world would not have access to PPPs. In this situation the world would produce less food and trade in food products would shrink. That said, as a rich country, the UK would be in a stronger position to import agricultural produce than many, albeit at higher prices but at considerable cost to poorer countries and the UK's balance of payments.

II.5. This report is based on a three-stage methodology and consequently what follows is divided into three sections. The first section estimates the impact on production of crops, and in particular cereals, in the UK following the withdrawal of PPPs. Based on reputable, independent studies, it demonstrates that the withdrawal would result in a significant fall in production of the crops for which the food chain has its highest demand. The second section calculates the impact on farm-gate prices of the removal of PPPs. It includes not only the likely rises in the prices for a range of crops but also the implications of higher feed costs for the prices of meat and livestock products. The third section translates the changes in farm-gate prices into increases in retail food and drink prices. Armed with this information it goes on to calculate the additional expenditure which would be necessary for households seeking to maintain current levels of food consumption.

III. Assessing the Loss of Yields

III.1 In this section we estimate the impact of the withdrawal of PPPs on the production of arable crops in the UK and in particular the production of wheat. Based on reputable, independent studies, we demonstrate that the withdrawal would result in a significant fall in production of the crops for which the food chain has its highest demand. As noted in the introduction, production of any crop is the product of the average yield and the total area grown. As observed in the introduction, it is beyond dispute that crop yields would be significantly lower in the absence of PPPs. It is also the case that the total area devoted to the crops for which there is high demand would shrink as farm practices and systems adjust to the new situation. In this section we will first explain why in the absence of PPPs crop yields would be significantly lower before going on to consider the impact on crop areas and production.

III.2 Pre-harvest crop yields are vulnerable to an over or under supply of abiotic factors such as water, temperature, irradiation and nutrients. They are also vulnerable to biotic factors; namely, weeds, pathogens and insects. PPPs have been developed for the prevention and control of crop losses due to biotic factors, both pre-harvest and during storage (post-harvest losses). Below we focus primarily on pre-harvest losses. The vast majority of crops in existence have been bred for conventional agriculture i.e., they have been produced to make effective use of inorganic fertilizers and PPPs. Studies show that contemporary varieties lack important traits that makes them more vulnerable to the removal of PPPs.[8] Erich-Christian Oerke and his colleagues at the University of Bonn have, over the past thirty years, conducted extensive research into crop losses due to the incidence of weeds, pathogens and insects, such that they are considered the primary reference in this field. Their work has shown that overall crop yields would be significantly lower than their current levels without the use of PPPs.[9]

III.3 Dr. Oerke defines two 'loss rates:' the potential loss; and the actual loss. The potential loss is defined as the reduction from theoretically attainable yields that would arise in the absence of any physical, biological or chemical crop protection. In practice, actual yields fall short of their potential – the so called 'yield gap' – hence, the actual loss is defined as the reduction in recorded average yields in the absence of the application of any contemporary crop protection practices. Although Dr. Oerke's work confirms the effectiveness of PPPs we cannot directly apply his results to the UK. In part, because his results are presented as worldwide, or regional, averages – e.g., for wheat he shows actual losses ranging from 14 to 40 per cent – and generally losses tend to be greater the higher recorded yields. But also, because he measures the efficacy of PPPs by calculating, in isolation, the percentage of potential losses prevented by modern crop protection practices. In fact, the impact on crop yields of removing PPPs can only properly be assessed by adopting a dynamic approach; namely, after allowing for the changes to farming systems, and the build-up of pests, that would be provoked by the abandonment of PPPs. In the absence of PPPs there would be changes to cropping practices – the introduction of alternative varieties of crops, the modification of crop rotations and reduced fertilisation – all of which are generally associated not only with reduced yields but also with reductions in the areas growing higher yielding crops.

III.4 The foregoing implies that using the ratio of organic to conventional crop yields as a guide to the impact of farming without PPPs is not sufficient. It does however serve as a first step in the calculation. Although studies show that cereal yields depend to a significant extent on access to inorganic fertilizers,[10] organic farmers generally have plentiful supplies of both animal and green manures for fertilizers. This reflects the fact that currently organic farming might accurately be described as a niche sector – it is practised on less than 7 per cent of the EU's farmed land and more to the point, organic cereals production accounts for less than 3 per cent of the total area.[11] An analysis of published studies, comparing organic and conventional crop yields, showed that in Northern Europe, organic yields of individual crops are on average 70 per cent of conventional yields i.e., 30 per cent lower.[12] But this does not capture the longer term resistance effects which experts argue would increase the yield losses – in the case of wheat by a further 5 per cent or more.[13] Moreover, as climate change gathers momentum, diseases and insects may spread more widely, reaching damaging population densities e.g., aphids are expected to be particularly responsive to climate change.[14] Average reductions in crop yields of 30-35 per cent in the absence of PPPs is very much in accord with a study focused on England and Wales which acknowledged a wide consensus that organic production results in cereal yields around 35 per cent lower than are achieved, on average, under conventional agriculture.[15] However, a major problem with all such comparisons is the small scale of organic production.

Crop types and patterns vary with locality, climate and farmer capabilities. If farmers in areas less suited to organic production were forced to adopt organic methods the yield gap would be wider and yields would be further lowered by the loss of the 'halo effect;' namely, organic farmers currently benefit from the control of pests on neighbouring farms using conventional methods.

III.5 To be clear, we are not assuming that the loss of PPPs would mean a wholesale switch to organic farming – farms would still have access to inorganic fertilizers – but the foregoing makes clear crops would be grown under 'semi-organic' conditions and consequently there would be a significant reduction in crop yields. The more so as the studies referred to point to a wider gap between the yields achieved by organic farms and conventional farms in high yielding areas of Europe e.g., the UK – particularly in the case of wheat. But, a focus on yield losses is not sufficient. What really matters for the supply and therefore the prices of agricultural products is the level of production and, as observed above, this depends not only on the level of yields but also on the likely consequences for land use in the absence of PPPs. Crop production technology and especially crop protection methods are changing continuously. For example, in the UK, changing techniques such as precision farming have reduced the volume of PPPs used on farms by around 50 per cent since 1990 reflecting the fact that most, if not all, UK arable farms apply a diverse range of crop protection methods, not just PPPs; a practice known as integrated pest management (IPM). The reduction in the use of PPPs to more efficient levels suggests the scope for offsetting the loss of PPPs with alternative crop protection methods is limited and therefore, in the absence of PPPs, farm practices would be forced to change in an effort to mitigate the impact on yields of the loss of protective products.

III.6 The high yields achieved by modern agricultural systems are the result of crops being grown in monocultures supported by high rates of fertiliser usage, but this renders them more susceptible to a wide range of insect pests and diseases while weed control remains a major problem in cereal crops. Again, a reasonable guide to the likely changes in farming practices in the absence of PPPs is provided by organic farming which prohibits the use of synthetic crop protection practices. Organic farming systems show that in the absence of PPPs arable farms would be forced to adopt less productive crop rotations. Rotating crops is the traditional agronomic approach to controlling nutrients, weeds, pests and disease infestations. While it is assumed that farms would still have access to the nutrients provided by inorganic fertilizers they would be forced to adjust their rotations in an effort to mitigate the threat from weeds, pests and disease.

III.7 Over the past sixty years as conventional farming practices have advanced, crop rotations have been dramatically simplified involving a reduction in the number of crop species. This decrease in the number of crop species in arable rotations and simplified land-use patterns greatly increases the difficulties of reverting to old, more varied crop rotations. Rotations seek to protect against weeds, pests and disease by interrupting the life-cycles of these harmful organisms but this involves avoiding using the same land to grow the same crop in a following year and/or switching to lower yielding spring sown crops. Thus, by reverting to such rotations the total area of high yielding wheat would be reduced in favour of an increase in lower yielding minor cereal crops and to 'clean the ground' the area of prime arable land sown to grass/clover would rise and more land might be devoted to crops such as maize for anaerobic digestion plants. The only way to avoid the loss of cereals production inherent in a wholesale switch to less productive rotations would be a significant increase in the total arable area. While the Government could, theoretically, adopt policies to encourage an increase in the area under cultivation this would be prohibitively difficult. There would be widespread societal resistance to converting non-productive land e.g., parklands, woodlands, to arable production let alone running counter to multiple environmental protection policy objectives.

III.8 The reversion to less productive rotations could result in an increase in the production of some minor crops; that is, crops for which there is only a limited demand e.g., beans, oats, but the crop for which the food industry has the greatest demand; namely, wheat would suffer a significant fall in production. Moreover, as rotations are not as effective as PPPs in dealing effectively with weeds, pests and disease, resistance effects would build-up and the incidence of crop failures would increase, amounting, in effect, to larger declines in the average level of production. Once changes in the availability of land are allowed for the declines in production become much greater than implied by focusing on yields alone.[16] This is demonstrated by a study that attempted to estimate how much food could be produced in England and Wales under organic agriculture. It estimated that for wheat the proportional loss of production would be about double the proportional reduction in yields i.e., 66 per cent.[15]

III.9 Given that farming practices are influenced by locality, climate and farmer capabilities it is important, when attempting to estimate the loss of production, to rely on studies that directly relate to the UK. Two recent studies that provide an authoritative guide to the impact on crop production following the withdrawal of PPPs are those published by ADAS[17] and Andersons.[18] The ADAS study was carried out in response to EU proposals to restrict agriculture's access to a range of PPPs. One of the scenarios analysed, based on an assessment by the Pesticides Safety Directorate[19] came close to the complete absence of PPPs – it assumed cuts in the availability of active substances ranging from 72 per cent for fungicides to 100 per cent for insecticides. Similarly, the Andersons study included a scenario bordering on the complete removal of PPPs. These scenarios have guided our assessment of the likely reduction in the production of arable crops.

III.10 The ADAS study focussed on three crop systems: wheat, potatoes and vegetable brassicas. The study's rationale for selecting wheat reflected not only the overwhelming dominance of cereals production – 67 per cent in 2018[20] – but also its relevance to all groups of PPPs. Potatoes were included because they are a staple food and susceptible to blight while brassicas represent a significant area of horticultural crops, – 27,308ha in 2017[21] – and year-round production. Production losses were estimated over a period of three to five years in order to allow for the build-up of resistance effects. The study concluded that even though some PPPs would still be available to farmers, the production of wheat, potatoes and brassicas would fall by 62, 53 and 77 per cent respectively. Based on the ADAS study and the other studies reported above we set out in Table 1 our estimates for the reduction in the production of key arable crops. In the case of cereals, the fall in production is the product of both lower yields and reduced productive areas. For higher value crops e.g., potatoes and horticultural crops the fall in production largely reflects the loss of yields as it is assumed the areas devoted to these crops would be maintained, perhaps even increased, but only at the expenses of large falls in the cereals area.

Table 1: Current Crop Yields and Estimated Losses in the Absence of PPPs

Crop	Current1 Yield (tonnes/hec)	Per cent Reduction[2] (%)	Unprotected yield (tonnes/hec)	Fall in production[2] (%)
Wheat	8.2	35	5.3	50
Barley	6.1	30	4.2	35
Oilseed rape	3.6	45	2.0	70
Potatoes	46.2	60	18.5	40
Roots & onions	48.3	60	19.3	50
Brassicas	16.3	65	5.7	65
Legumes	4.5	45	2.5	45
Desert apples	29.2	40	17.5	40
Soft fruit	15.6	45	8.6	40

[1]Defra statistics average for 2015-2018 years. [2]Estimates based on items 9, 12, 13, 14, 15, 17 and 18 in references

III.11 The Andersons' study attempts to estimate the impact, inter alia, of the removal of most – but not all – PPPs on the cropping patterns and financial viability of a model farm. Its results suggest reversion to plough-based cultivation techniques rather than minor no-till – which includes cost implications – and to mitigate the damage from pests and disease there would be a shift to crops with stronger resistance traits but at the cost of lower yields. For combinable crops weeds become a major problem for crop yields. The inability to 'clean-up' fields before planting, and take out patches of persistent weeds – along with not being able to desiccate crops pre-harvest – would force large scale shifts to spring crops – spring wheat yields are typically 30 per cent lower than for winter sown varieties – and significant areas would put down to fallow or grass leys. Where there is the opportunity, some land currently under combinable cropping might be rented out for potato, sugar beet and vegetables on short-term contracts and as noted above more land is likely to be devoted to growing maize for anaerobic digestion.

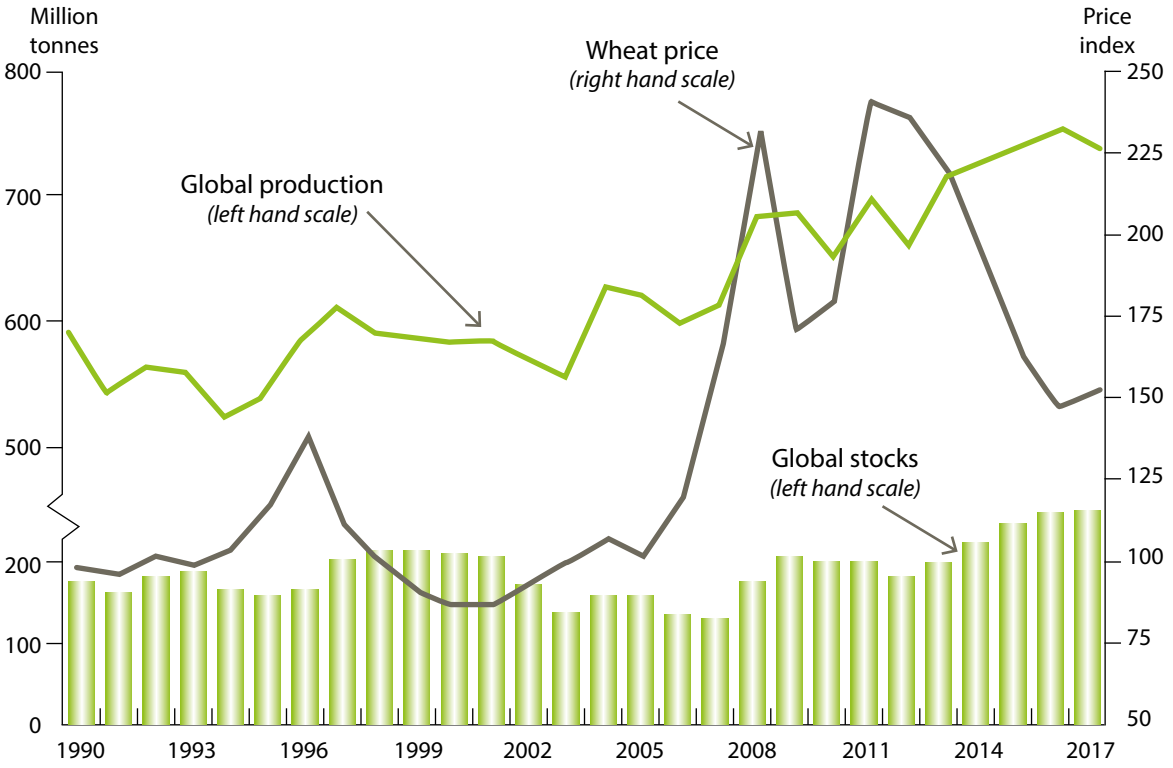
III.12 Not explicitly taken into account in the data set out in Table 1 are the effects of post-harvest crop losses. Both quantitative and qualitative food losses occur at all stages in the post-harvest system. All harvested crops are vulnerable and can become infected after harvest by diseases widespread in the air and/or pest infestations in storage facilities. The grain industry is committed to maintaining a 'zero tolerance' policy for live insects and other biological contamination but the policy is in part dependent on PPPs, as well as facilities that circulate and cool the air around stored crops. There appear to be no quantitative estimates of the contribution PPPs make to limiting post-harvest losses but it is safe to say that in their absence – as indicated by the experience of developing countries – the potential additional loss of output could be significant.

III.13 As we will discuss in the next section the falls in production shown in the right-hand column of Table 1 will lead to higher farm-gate prices – at least for the crops for which the food chain has a high demand e.g., wheat. The influence of much higher prices will, to a limited extent, mitigate some of the large changes in the areas sown e.g., where possible areas of grassland may be switched to growing arable crops as farmers struggle to maintain viable businesses. However, for the reasons explained, the extent of any switching i.e., ploughing grassland to grow cereals, would be limited by agronomic considerations. More to the point, the switching would be driven by the increases in crop prices. That is, the greater the switching the higher the increase in crop prices which implies that the price increases shown in Table 1 should properly be viewed as minimum increases. Moreover, the loss of PPPs would mean that some locations would no longer be suitable for arable production. The evidence suggests that despite large price increases, the reversion to less productive arable rotations is likely to be accompanied by large scale structural change involving the loss of arable farm businesses.

IV. Estimating the Impact on Farm-gate Prices

IV.1 In this section we attempt to provide an estimate of the impact on farm-gate prices of the removal of PPPs. Calculating the price response to lower levels of crop production is complicated by a number of factors – see Appendix I for a more detailed explanation. The prices of agricultural products that are traded on international markets are dominated by prices on world markets. That said, as observed above, in the absence of PPPs the availability of imports would be severely limited, if non-existent, and certainly the price would be very high. We do know that on global markets stock-to-use ratios – essentially the effect of imbalances in demand and supply – are a major influence on prices as well as rises in energy prices, exchange rate movements and speculation.[22] It follows that in the absence of PPPs, the world's supply of crops would fall relative to demand resulting in much higher prices. Indeed, research suggests that a simple model of global, annual supply and demand that incorporates changes in stock levels storage can largely explain the volatility of crop prices including the price spikes in 2007/2008 and 2010/2011.[23] As indicated in Figure 2 relatively small declines in production – given rising demand – result in significant falls in stock levels and substantial increases in price. Between 1997 and 2007 global production hardly increased while consumption increased by 7 per cent. The result was a 38 per cent fall in stocks from a peak in 1999 and a 117 per cent rise in prices between 2004 and 2008.

Figure 2: Global Wheat Production, Stocks and Prices



Source: Kanas State University and FAO

IV.2 As previously observed, production is the product of yields and area. Between 1997 and 2007 the world's area of cereal crops declined fractionally – by less than half a percent[24] – which suggests that a lack of yield growth was largely responsible for the increase in wheat prices over that period. The foregoing demonstrates the existence of a significant price response when the production of crops fails to keep pace with demand. The foregoing is indicative; it is clear that the combination of a fall in the production of an agricultural product and the absence of substitutes will result in a more than proportional increase in the product's price.

IV.3 Another approach to assessing the price impact is to compare the comparative yields and farm-gate prices for key agricultural products when produced by conventional and organic systems. We noted above that in the absence of PPPs the overwhelming bulk of crops would be grown under 'semi-organic' conditions. The data set out in Table 2 suggests that for a 40-50 per cent reduction in crop yields a 100 per cent increase in farm-gate prices is not an unreasonable starting point. In fact, the data set out in Table 2 is likely to underestimate the rise in farm-gate prices.

In part because, as explained in the previous section, the fall in production for some key crops e.g., wheat is likely to be greater than implied by the reduction in yields. Thus, the approach set out in Table 2 is promising but it probably underestimates the price response at the farm level and it tells us nothing about the impact of lower crop production on the prices of meat and livestock products.

Table 2: Comparative Conventional and Organic Yields and Prices

	Conventional	Organic	Percentage difference
Milling winter wheat			
Yield *(tonnes per hec)*	8.5	4.6	-45.7
Price *(£ per tonne)*	137.5	272.5	98.2
Ware potatoes			
Yield *(tonnes per hec)*	45.0	25.0	-44.4
Price *(£ per tonne)*	134.0	387.5	189.2
Winter beans			
Yield *(tonnes per hec)*	4.1	3.05	-25.6
Price *(£ per tonne)*	145	337.5	132.7

Source: ABC (see reference 25) averages for three years 2016-2018.

IV.4 Yet another approach is to estimate the likely minimum increase in farm gate prices necessary to maintain farm incomes faced with lower crop production. That is, by how much would farm gate prices need to rise in order to offset the adverse effects of new rotations and lower production on gross margins? The results of this exercise are set out in Table 3. Using respected, published estimates of the revenue – yield multiplied by price – and variable costs, it is possible to calculate by how much a fall in a crop's yield and area reduces a farm's gross margin and by how much the price would need to rise in order to maintain the starting gross margin after adjusting direct production costs for the new rotations and the removal of PPPs. Table 3 shows the indicative price increases obtained by such an exercise for the broad categories of crops using data averaged over three years. Wheat and barley are identified separately given the major contribution of these crops across a wide range of food and drink products.

Table 3: Farm-gate Price Response Necessary to Protect Arable Margins

Crop	Current yield	Yield reduction	Production change	Current price (£)[1]	New Price (£)	Percentage price rise
Milling wheat	8.7	35%	-50%	145.0	253.0	80%
Feed wheat	9.1	35%	-48%	135.0	237.6	80%
Malting barley	6.5	45%	-33%	140.0	226.8	60%
Feed barley	7.4	45%	-6%	127.0	207.0	50%
Oilseed rape	3.8	45%	-80%	320.0	492.8	100%
Ware potatoes	45.0	60%	-36%	140.0	378.0	150%
Sugar beet	76.0	50%	-48%	27.0	52.9	95%
Carrots	65.0	60%	-40%	170.0	430.1	120%
Winter cabbage	45.0	60%	-48%	225.0	573.8	120%
Vining peas	4.5	40%	-30%	275.0	445.5	70%
Desert apples	35.0	50%	-50%	675.0	1,431.0	110%
Strawberries	20.0	60%	-40%	2,650.0	5,750.5	110%

[1]*Price per tonne. Author's calculations based on ABC reference 25.*

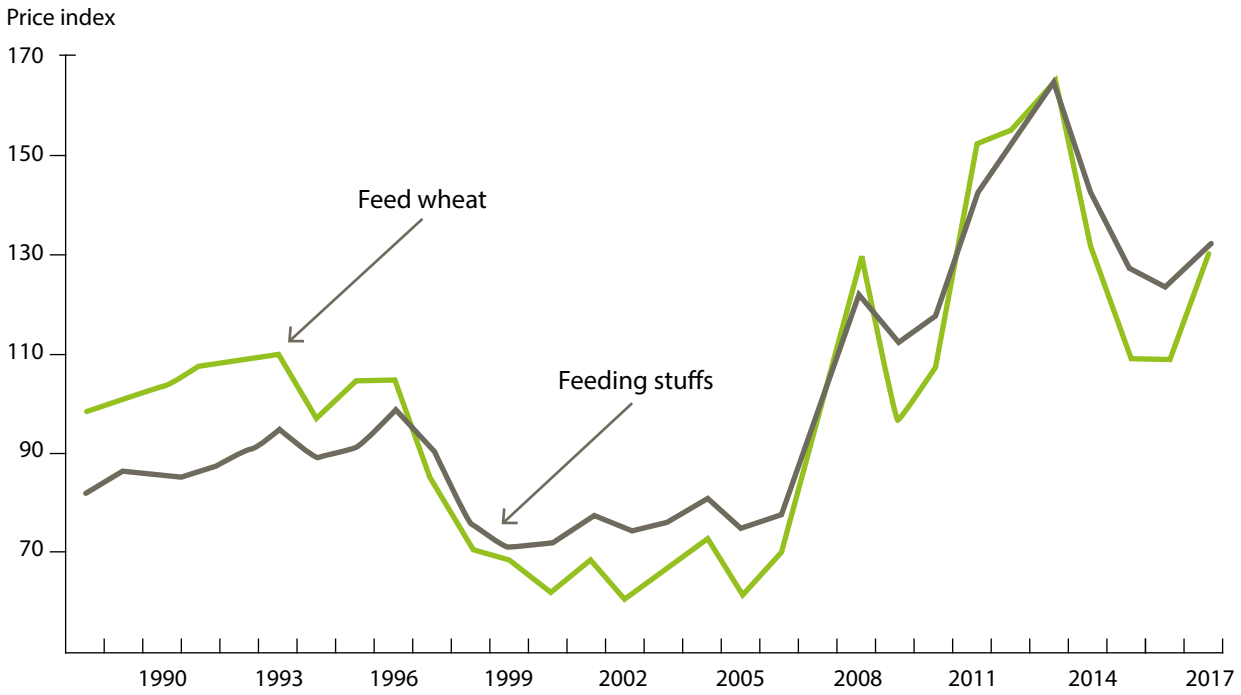
IV.5 Taken together the alternative methods of attempting to calculate the rise in farm-gate prices for crops suggest increases in the order of 100 per cent. It might fairly be observed that the scale of the fall in production shown for various crops in Table 3 would involve ether a large increase in imports of such agricultural products and/or a dramatic change in diets. As a rich country the UK would be in a position to purchase from world markets despite higher prices but, as noted in the previous section, the higher crop prices would provide an incentive to plough-up grassland; hence, in reality the fall in production would not be as large as that shown in Table 3. But to facilitate this mitigation, arable prices must remain sufficiently high to make the conversion of less productive grassland attractive.

IV.6 The higher prices set out in Table 3 take no account of demand influences. For crops where substitutes are limited e.g., milling wheat, the price increases might be much larger – see Appendix I for a more formal explanation of demand effects. Some idea of the demand impact is provided by comparing the position of milling wheat in Tables 2 and 3. As noted above, the prices of organically produced cereals are currently constrained by the need to compete with conventionally grown crops. Moreover, in the absence of PPPs, the threat of shortages would see food processors and livestock farmers aggressively seeking to secure sufficient supplies to meet households' demand for food. Thus, the price rises set out in Table 3 should be viewed as being biased towards the low end of the likely increases that would pertain in the absence of PPPs if households sought to maintain existing diets.

IV.7 For most of the UK's population, their diets include meat, meat products, eggs, milk and dairy products. Meat and livestock products account for more than half of the value of UK agriculture's output and approximately one third of the average household's expenditure on food. Livestock farms depend heavily on arable farms. Several crops and/or their by-products are key inputs for meat and dairy production systems – mainly as feeds but also as bedding. Practically all grazing livestock systems depend to some degree on cereal based feeds though the dependency varies according to a farm's access to pasture and grass for silage. In contrast pig and poultry units are completely dependent on cereal based feeds. If the prices of crops used for animal feed rise, then so will the prices of the products that depend on these crops as inputs. The growth of modern, productive farming techniques has not only reduced the dependence of arable farms on manure fertilizers, thereby allowing the specialisation of meat and livestock production, but also they have facilitated higher stocking rates on grasslands. In the absence of PPPs – which are also used on grasses – stocking rates are likely to decline at a time when there would be pressure to increase the country's arable area. In the absence of PPPs, the higher prices for meat and meat products that households would suffer as a result of increased feed costs are likely to be exacerbated by the loss of some of the price benefits arising from specialisation.

IV.8 Cereals and their by-products undergo processing as they are converted into animal feeds. Not surprisingly there is a very high correlation between the prices of cereals and cereal based animal feeds. Figure 3 confirms the relationship and it can be quantified by using statistical regression techniques. That is, estimating by how much the average prices of animal feeds rise following an increase in cereal prices.

Figure 3: Price Series for Animal Feeds and Feed Wheat



IV.9 Armed with such estimates and using published data on livestock gross margins it is possible to calculate the impact of higher cereal and other arable crop prices on livestock production costs. For the results set out in Table 4 the increase in the prices of feeds – compounds and straight grains – have been raised 65 per cent based on the application of regression techniques to the increases set out in Table 3. Furnished with these higher feed costs, the rises in the farm-gate prices for milk, meat and eggs shown in Table 4 are those necessary to maintain the gross margin for such products, again averaged over the three years 2015-2018. Although the increase in crop-based feed costs – mainly cereals and oilseeds – is similar for all the products shown, the implications for farm-gate prices vary according to the share of costs accounted for by feeds. As can be seen the impact is much greater for pigs and poultry than for silage beef and spring lamb where grass rather than purchased grains dominates feed costs. Once again, it is important to remind that these supply side generated price increases are likely to be increased by market forces as demand for these meats and products will exceed supply– see Appendix I for a fuller explanation.

Table 4: Farm-gate Price Response Necessary to Protect Livestock Margins

Product	Gross Margin[1] £	Feed Costs[1] £	Overall percentage rise in feed costs[2]	Percentage rise in product price to restore GM
Milk	1,023.0	668.9	54%	20%
Cereals beef	264.0	417.0	60%	32%
Silage beef	442.0	229.0	60%	17%
Spring lambs	50.3	13.8	60%	10%
Pork	2.3	36.1	60%	56%
Bacon	5.3	44.9	60%	55%
Poultry broilers	0.25	1.2	60%	54%
Poultry eggs[3]	2.9	12.6	60%	52%

[1]£'s per animal, Author's calculations based on ABC (reference 15). [2]Concentrates and bulk feed [3]Per hen, free range

V. Calculating the Consequence for Household Food Expenditure

V.1 In this section we attempt to translate the farm-gate prices estimated in the previous section for crop and livestock products that would pertain in the absence of PPPs into increases in retail food and drink prices. An approach that has been used in the past is to estimate the theoretical relationship between a rise in the price of an agricultural product and the retail price of a food product has been to calculate the so-called 'farmer's share.' This compares the retail price of say a kilo of carrots to the price the grower receives for a kilo of carrots. These shares for a selection of food products are set out in Table 5.

Table 5: Percentage Farm-gate Shares 2017

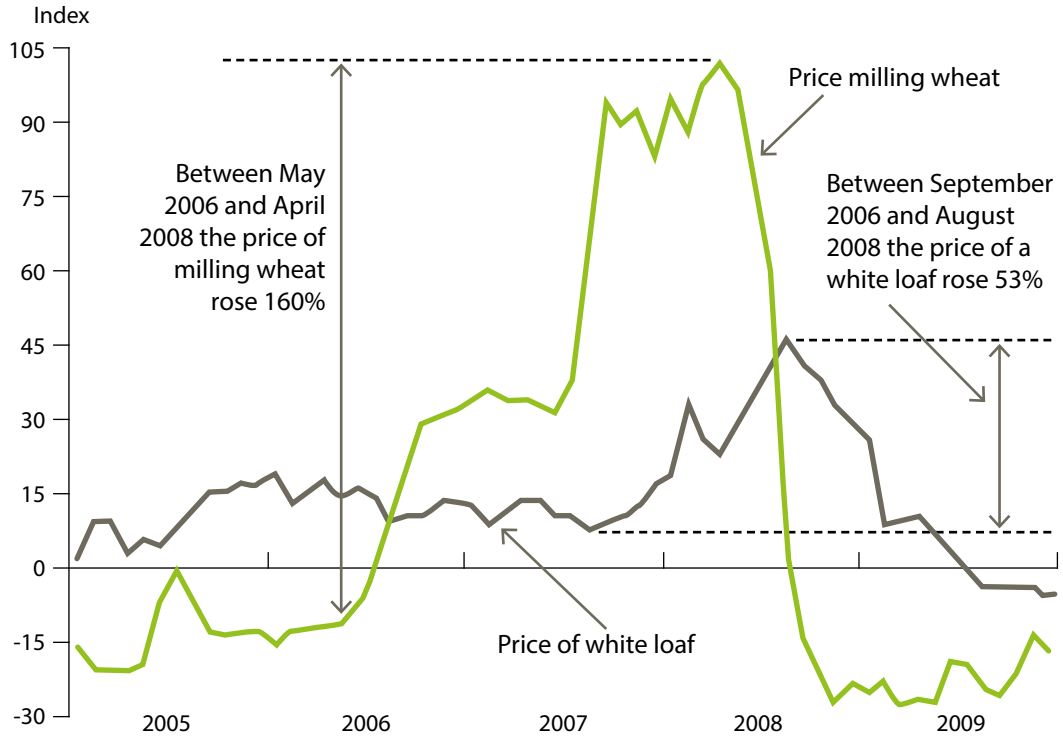
Product[1]	Bread	Milk[2]	Poultry	Pork	Beef	Lamb	Eggs[3]	Potatoes	Apples
Farmers' share	8%	38%	47%	42%	51%	51%	38%	25%	42%

Source: Defra. [1]per kilo, [2]per lit, [3]per dozen

V.2 The data set out in Table 5 is however, not sufficient to calculate the impact on retail prices of a rise in the farm-gate prices of arable or livestock products. This is because the estimated shares must be augmented by making allowance for the margins earned by other sellers in the food chain. For example, if the farm-gate price for say wheat, rises as a result of a reduction in yield, the price of a loaf of bread, for which milling wheat is the key raw material input, will rise by a greater absolute amount than implied by the cash equivalent of the eight per cent weighting in Table 5. Having left the farm, as it travels down the supply chain, wheat will be subject to a number of processing, distribution and retail costs. The normal practice is for each stage e.g., milling or baking, as part of its value adding activities to add a margin to cover overheads, capital costs and profits. Thus, at each stage of the chain, the higher cost of wheat is augmented by the protection of margins – see Appendix I for a more detailed explanation. For example, between 2006 and 2008 the price of milling wheat rose by 160 per cent suggesting – on the basis of Table 5 – an increase in the price of a loaf of bread of almost 13 per cent. In the event, the average price of a white loaf of bread increased by more than 50 per cent though other factors such as general inflation will have contributed to the increase in the price of bread – see Figure 4.

V.3 Again, statistical regression techniques provide a practical method for isolating the relationship between the percentage increases in say wheat and the retail price of bread as other supply chain costs are rising e.g., fuel and wages. We have used this technique to obtain relationships for all the broad categories of foods and the results are set out in column 3 of Table 6. However, we cannot merely raise expenditure on the food categories by calculated percentage increases. To do so would be to risk overestimating the overall rise in expenditure as no allowance would have been made for the effects of demand. Raising the price of food amounts to a reduction in the purchasing power of consumers' income and all other factors remaining unchanged – in particular the prices of non-food items and disposable incomes – this necessarily results in consumers reducing the volumes of food and non-food purchased as the price of food rises.

Figure 4: Movement of wheat and bread prices



V.4 A number of statistical studies have been carried out in the UK to estimate the effects of changes in the retail prices of food and drink on purchasing behaviour.[26, 27, 28] These studies are consistent in showing that if the price of food and drink products increase consumers generally, out of a mixture of necessity and habit, do not radically alter their purchasing behaviour. This follows because food is the most basic of all necessities and consequently higher food prices are generally accompanied by a less than proportionate fall in the volumes purchased. The corollary is that expenditure on food items rises – see Appendix I for a fuller explanation – though if the higher prices persist then in the long run they look for cheaper alternatives.[27] The response of consumption to a rise in a food product's price is measured by the price elasticity of demand. Formally, it measures the percentage change in consumption for a product given a percentage change in its price.

V.5 The difficulty here is that the price elasticity of demand is not sufficient. This is because when the prices of all food products are rising the scope to switch to a cheaper substitute is severely limited. In this situation it is necessary to measure how much consumption of a particular product will switch when the price of a substitute product is also rising. Formally, the technique employed to measure this is the cross-price elasticity of demand – see Appendix I for more details – and the end result is that the fall in overall consumption of food products is much smaller than suggested by individual price elasticities of demand. Faced with a general increase in the price of food products households will necessarily switch expenditure from discretionary non-food items in an attempt to maintain the levels of food consumption they consider appropriate, if not vital. The results of these calculations for food and non-alcoholic drinks consumed by the average household, are set out in Table 6 based on official estimates of household food expenditure[29].

Table 6: Impact on Weekly and Annual Household Food expenditure

	Current expenditure				Rise in expenditure	
	Pounds per week	Pounds per year	Per cent increase	Overall elasticity	Pounds Per week	Pounds per year
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Bread	3.8	197.6	18%	-0.019	0.67	34.89
Cakes & pastries	2.0	104.0	12%	-0.024	0.23	12.18
Biscuits	2.3	119.6	12%	-0.037	0.27	13.82
Cereal products	4.6	239.2	18%	-0.037	0.80	41.46
Milk & dairy products	4.6	239.2	7%	-0.036	0.31	16.41
Cheeses	2.0	104.0	7%	-0.012	0.14	7.19
Beef & veal	2.0	104.0	11%	-0.016	0.22	11.26
Mutton & lamb	0.6	31.2	4%	-0.023	0.02	1.22
Pork	0.6	31.2	23%	-0.024	0.13	7.00
Poultry	2.3	119.6	24%	-0.021	0.54	28.10
Bacon & ham	0.9	46.8	18%	-0.025	0.16	8.21
Sausages	0.9	46.8	16%	-0.051	0.14	7.11
Other meat products	5.5	286.0	16%	-0.021	0.86	44.80
Eggs	0.7	36.4	24%	-0.004	0.17	8.70
Fats	1.2	62.4	15%	-0.017	0.18	9.20
Sugar & preserves	0.5	26.0	5%	-0.016	0.02	1.28
Fresh potatoes	0.8	41.6	85%	-0.007	0.68	35.11
Processed potatoes	1.6	83.2	23%	-0.026	0.36	18.64
Green vegetables	1.4	72.2	57%	-0.015	0.79	40.87
Other vegetables	2.9	150.8	52%	-0.006	1.50	77.95
Processed vegetables	1.8	93.6	23%	-0.026	0.40	20.97
Fresh fruit	4.5	234.0	32%	-0.027	1.40	72.86
Processed fruit	0.9	46.8	16%	-0.032	0.14	7.25
Confectionery	3.6	187.2	5%	-0.016	0.18	9.21
Soft drinks/juices	4.9	254.8	5%	-0.012	0.24	12.59
Other foods3	5.5	286.0	5%	-0.012	0.27	14.13
Total	**60.6**	**3,151.2**	**17.3%1**	**-0.352**	**10.81**	**562.14**

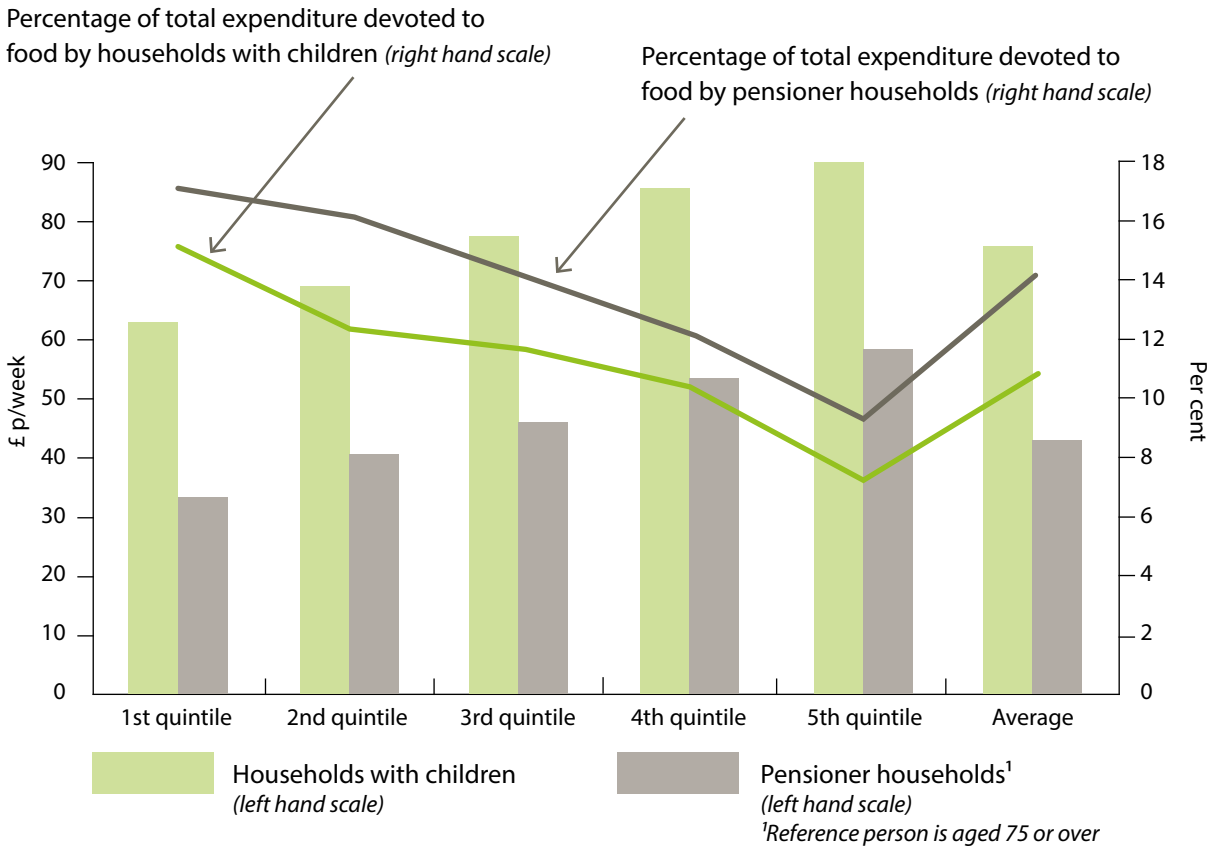
[1]Weighted over percentage increase in food prices, [2]Weighted implied overall elasticity for food, [3]Includes items whose price will be directly impacted e.g., baby food, soups, sauces, as well as items indirectly impacted e.g., fish.

Source: Office for National Statistics, UK financial year 2018

V.6 As can be seen from Table 6, in the absence of PPPs the average household's expenditure of £60.60 per week on food and non-alcoholic drinks consumed in the home would be almost £11 a week higher. This amounts to an increase of 17.3 per cent and over the course of a year households would need to spend an additional £562 on these items. Average household weekly spending for the financial year ending 2018 was £572.6[29] implying that expenditure on food and non-alcoholic drinks consumed in the home would rise from its current 10.6 to 12.5 per cent of total expenditure. Another way of viewing this estimated increase in spending is that the UK's 27 million households would collectively need to divert some £15bn from non-food discretionary expenditure in order to meet the higher cost of food and non-alcoholic drinks consumed in the home.

V.7 Focusing on the position of the 'average' household underestimates the impact of higher food prices for many households; pensioner households and households with children typically devote a larger share of weekly expenditure to food and non-alcoholic drinks. Figure 5 shows the situation for households with children and pensioner households according to disposable quintile groups.

Figure 5: Food and Non-alcoholic Drinks Expenditure according to Disposable



V.8 Not surprisingly households with children spend a higher proportion of weekly expenditure on food. On average, in the financial year ending in 2018, such households with two adults and two children spent £81.7 per week on food and non-alcoholic drinks for home consumption: equivalent to 10 per cent of their weekly expenditure. Given the composition of expenditure within these two adult-two children households, the impact of no PPPs on their outgoings would amount to a rise of £15.10 per week; an increase of 18.5 per cent. This means that over the course of a year expenditure on home consumed food and non-alcoholic drinks would rise by £786.50. The data set out in Figure 5 relates to all households with children. What it shows is that poorer households spend a much higher proportion of their weekly expenditure on food. Households in the lowest quintile spent £63.70 per week on food and non-alcoholic drinks consumed in the home in the financial year 2018, which amounts to 16.8 per cent of £379.6 total weekly expenditure. If food expenditure for households in this poorest group rose by 18.5 per cent, they would have to find another £11.8 per week and the share of expenditure devoted to food and non-alcoholic drinks for home consumption would rise to 19.9 per cent. Over the course of a year these poorer households would need to find an extra £612 – a severe challenge for already hard pressed households.

V.9 A similar picture emerges for pensioner households. Expenditure on food and non-alcoholic drinks consumed in the home is, as would be expected, lower than for households with children. On average, pensioner households with two adults spent £62.40 per week on these items in the financial year ending 2018. This amounts to 13.6 per cent of total weekly expenditure. Given the composition of food expenditure within these pensioner households the impact of the withdrawal of PPPs would increase their weekly expenditure on food by £11.65; an increase of 18.7 per cent. This means that over the course of a year expenditure on food and non-alcoholic drinks consumed in the home would rise by £605.80. Again, Figure 5 reveals that poorer pensioner households spend a much higher proportion of their weekly expenditure on food. Two adult pensioner households in the lowest quintile spend £58.30 per week on food and non-alcoholic drinks which amounts to 20.5 per cent of total weekly expenditure. For the poorest pensioner households an increase of almost 19 per cent in this weekly bill would be socially unacceptable.

V.10 The foregoing demonstrates that the higher food prices inherent in the withdrawal of PPPs would not only lower living standards but also exacerbate income inequalities. This, however, is not the only adverse social impact. The absence of PPPs would present a serious challenge to healthy eating and thereby the population's health in general. Some of the largest increases in prices set out in Table 6 are for vegetables and fruit. The average household devotes almost a quarter of its total food expenditure to purchasing vegetables and fruit, including processed products. We calculate that retail prices for these categories of food are likely to rise by at least 40 per cent in the absence of PPPs. This would seriously compromise the government's target for people to consume at least five portions of a variety of fruit and vegetables each day. Indeed, given that the cornerstone for improving the nation's health is access to a wide range of affordable foods, it would not be unreasonable to suggest that poorer health, particularly for vulnerable households, would be a consequence of the absence of PPPs. High prices would result in attempts to switch to cheaper, possibly less nutritious foods posing a higher burden for the National Health Service and also the country's economic performance. When nutritional needs are not met, people become prone to illness, perform worse at school, and have lower productivity. Medical evidence suggests that inadequate nutrition in young children has adverse long-term consequences due to its largely irreversible effects on an individual's physical and mental development.[30]

V.11 So far our focus has been on food and non-alcoholic drinks that are consumed in the home. But households also spend money on alcohol, some of which is consumed in the home and some is consumed outside the home. Expenditure on alcohol would also be impacted by the absence of PPPs though the overall effect would be lower because the agricultural content accounts for a much smaller share of the final price for these products. Cereals are a key input for beer and spirits but the existence of excise taxes, that can range from 30 per cent for beer to more than 60 per cent on spirits, as well as the costs of service in pubs and restaurants means that even a 60 per cent increase in the price of malting barley would add only a small percentage to the price of beer and spirits.[31] The growing of high quality grapes also depends on PPPs so in their absence the prices of wine would also be higher, but for reasons already given the percentage increase would be small. It is beyond the scope of this report to attempt to apply the same degree of analysis to estimating the impact of the absence of PPPs on alcoholic drinks consumed both inside and outside the home. However, based on the grain and grape content of alcohol we estimate that the overall impact would be an average increase of 5 per cent for alcoholic drinks – see Table 7.

Table 7: Weekly and Annual Expenditure on Alcohol and Eating Out.

	Expenditure				Increased Spending	
	Pounds per week	Pounds per year	Per cent increase	Overall elasticity	Pounds Per week	Pounds per year
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
At home:						
Beer, larger, cider	2.2	114.4	3%	-0.39	0.05.	2.44
Wines & champagne	4.5	234.0	5%	-0.07	0.21	10.88
Sprits	2.0	104.0	4%	-0.15	0.07	3.58
Away from home:						
Alcohol	8.0	416.0	5%	-0.15	0.34	17.78
Restaurants meals	18.6	967.2	5%	-0.35	0.60	31.43
Take away & snacks	10.2	530.4	7%	-0.35	0.46	24.13
Canteens & schools	2.0	104.0	5%	-0.35	0.10	5.15
Total	**47.5**	**2,470.0**			**1.83**	**95.39**

Source: HMRC estimates for alcoholic drinks elasticities in reference 22

V.12 Very similar considerations apply to food consumed outside the home. The food content of the price paid will necessarily be smaller where it includes the restaurant or pub's overheads and service costs as well as 20 per cent VAT. We might reasonably expect the service element to be a smaller proportion for takeaways and the application of VAT depends to a large degree on whether the food is sold hot or cold. Similarly most catering is subject to VAT but certain premises e.g., schools and hospitals are exempt. These factors make it very impractical to attempt to apply the same degree of analysis to estimating the impact of the absence of PPPs on food consumed outside the home as we have done for food eaten in the home. Overall the impact would be significantly smaller than the calculated increase of 17.3 per cent for food and non-alcoholic drinks consumed at home. After allowing for the protection of margins in restaurants and pubs we assume that the overall increase in prices will average around 5 per cent in restaurants and a little higher – 7 per cent – for takeaways to reflect the fact that service is a smaller proportion of the final price and VAT does not apply on all purchases. We believe that these increases continue to err on the side of caution. The levels of expenditure on alcoholic drinks and food eaten outside the home are set out in Table 7 alongside the impact of our assumed price increases.

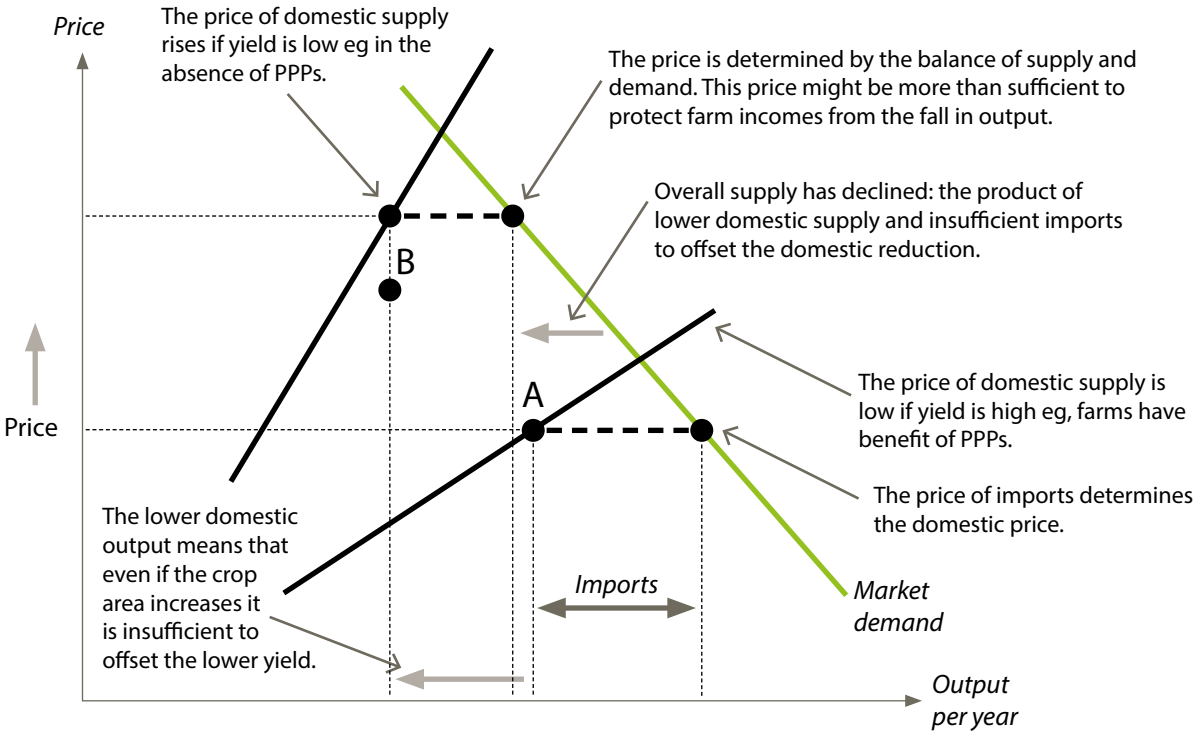
V.13 As is the case for food consumed in the home, the effect of a general increase in prices for alcohol and food eaten outside the home the final effect for expenditure will be subject to price and cross price elasticities of demand. Again, if prices generally rise the scope for substitution i.e., switching to cheaper alternatives is severely limited. That said, arguably consumption of these products is more discretionary than is the case for food consumed in the home. Following across the board rises in prices, as indicated by the calculated overall price elasticities, consumption for these products – particularly for beer and meals out – will decline but overall expenditure will rise. The results set out in Table 7 suggests an increase in expenditure on alcohol and food eaten outside the home of £1.80 per week amounting to an additional annual cost of £95.4.

V.14 On the basis of the latest data for the financial year ending in 2018, the average household's total expenditure on food and drink, whether consumed within or outside the home, was £108.10 per week: equivalent to £5,621 per year. We estimate that following the withdrawal of PPPs this expenditure would rise by some £13 per week or £658 per year: an increase of 12 per cent. According to official data, median, weekly disposable earnings for the financial year 2018 were £546.32 Although median earnings represents the mid-point, rather than the average, on the earnings scale it implies that after allowing for income and council tax, a household half way up the disposable earnings scale would need an additional 11 days of earnings to pay for the higher cost of food and drinks. Having allowed for the higher costs of alcohol and meals eaten outside the home, the total expenditure that the UK's 27 million households would collectively need to divert from discretionary items in order to meet the higher cost of food and drink some rises to £18bn. This would inevitably have serious, adverse consequences for employment and income in the industries affected.

Appendix I: The Economics of Price Rises

AI.1 The farm-gate price of a crop is strongly influenced by its yield (i.e., output per unit of land). Many factors in addition to yield influence the final price in particular, the total supplied i.e., area grown multiplied by average yield, the level of demand which will be influenced by the quality of the crop. Domestic supply is frequently augmented by imports and generally if these are unrestricted, given the level of demand it will be the price of imports that fixes the domestic market price. Demand is determined by consumers' disposable incomes and preferences as well as the prices of not only substitute crops but all other goods and services on offer. Importantly, if the availability of imports is restricted and all other influences remain unchanged e.g., no change in the level of domestic demand, at the end of the growing season the price of the crop will vary inversely with its yield. In a particular year stochastic events such as adverse weather or disease, will influence the yield but over a period of time improvements in crop breeding, farm techniques and PPPs have caused yields to grow and hence the price to decline. The effect of these developments i.e., technological advance, on the domestic supply curve in an individual year, is shown in Figure AI.1; namely, technological advances tends to lower it position and its slope. The yield curve is upward sloping reflecting the fact that the higher the price expected by farmers at the start of the season the greater the effort applied e.g., more fertilizers and expenditure on PPPs. In the absence of PPPs the supply curve shifts upwards reflecting the reduction in yield and it becomes much steeper indicating the greater difficulty of increasing yields in the absence of PPPs e.g., resort to hand weeding as well as higher production costs if more land is brought into production.

Figure AI.1 Yields, PPPs and Farm-gate Prices

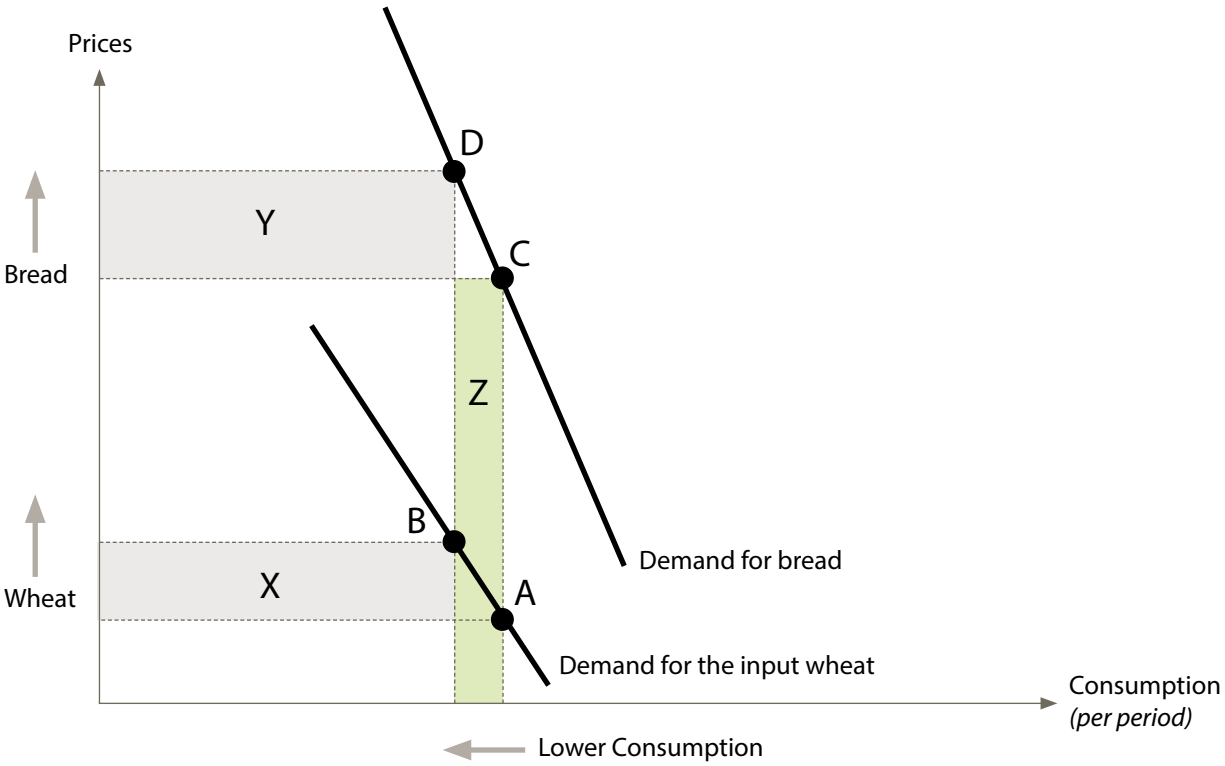


AI.2 Figure AI.1 also makes clear the dominance of demand in determining the price. When the domestic price was represented by point A it generated a level of income for producers. In the event of lower yields, all other influences remaining constant, the price will rise and importantly in the case of agricultural products, the percentage rise in price in these circumstances will be greater than the percentage fall in output – see the discussion of elasticities below for an explanation. It follows that farm incomes would actually rise if overall supply declined. Point B in Figure AI.1, captures this nuance; suggesting that although a price increase to this level would be sufficient to protect farm incomes it is demand rather than supply conditions that will dominate.

AI.3 In order to estimate the impact of yield induced higher crop prices on the prices paid by consumers for final food products we need to be cognisant of the fact that only a proportion of the retail price is accounted for by the agricultural content. Retail food prices have to cover not only the price of the agricultural product, but also the additional costs incurred in the supply chain which include haulage, processing, and retailing as well as the profit margin at each stage in the supply chain. Figure AI.2 summaries the situation. If the farm-gate price for say wheat, rises from A to B as a result of a reduction in yield, the price of say bread, for which wheat is the raw material input, will rise from C to D. This increase in the price of bread reflects the higher price of wheat but as noted above, it will also be influenced by the margins processors and retailers charge. Thus, the absolute rise in the price of a loaf of bread i.e., the cash increase, is likely to be greater than the cash increase in the wheat used in the loaf. This is shown by the shaded area Y – the absolute increase going to the retailer/ processor – which is larger than the cash increase in the wheat used in the production of the loaf of bread – shaded area X. The relationship between changes in the prices of agricultural products and the prices of final food products can be estimated using statistical regression techniques - in essence, the technique uses historical time series data to identify how say, the price of a loaf of bread is likely to alter following a change in the price of wheat. It should be noted that as the cash increase in the price of a final food product e.g., a loaf of bread, is added to many other costs in addition to wheat e.g., logistics, milling, baking etc, the percentage increase in the price of the final food product is much smaller than the percentage increase in the price of the agricultural input e.g., wheat.

AI.4 The extent to which processors and retailers can maintain their margins will be influenced by demand. Higher prices will cause consumers to purchase lower volumes but food is a necessity and, at least for basic food products, consumers are more likely to switch expenditure from discretionary consumption to support the purchase of food. In this situation the fall in food consumption is likely to be small. The magnitude of any reduction in the consumption of a particular food product following a rise in its price is measured by a concept known as 'its own price elasticity of demand.' This is defined as a measure of the percentage fall in consumption for a given percentage increase in the real price of an individual food product, i.e., after allowing for inflation driven changes in prices generally and holding all other influences constant e.g., real incomes, preferences and the prices of other food products. We are by definition working with real prices as we are implicitly holding all other prices and consumers' incomes constant. For food products the elasticity coefficient generally lies between 0 and -1. This reflects the fact noted above that for a given percentage increase in the price of a food product e.g., 5 per cent, the fall in the volume consumed will be small and certainly less than 5 per cent. An elasticity coefficient between 0 and -1 also means that despite lower consumption, expenditure on the food product will rise. For example. if the price of a food product rises by 5 per cent and consumption falls by one per cent – this is a price elasticity of -0.2 – expenditure will rise by approximately 4 per cent. Figure AI.2 attempts to illustrate this outcome i.e., the additional expenditure represented by the area Y is greater than the savings from consuming a lower volume, the shaded area Z.

Figure AI.2: The Impact of a Rise in the Price of Wheat



AI.5 Unfortunately we cannot simply use estimates of own price elasticities for our calculation here. This is because all other influences are not being held unchanged. As explained, in the absences of PPPs the prices of all food and drinks products would rise. The effect of this is to reduce the scope for consumers to switch consumption from a product whose price has risen to one whose price has not. This substitution effect is captured by the concept of 'cross-price elasticity of demand.' This measure the change in consumption of a substitute product say, margarine if the price of butter rises while the price of margarine remains unchanged. If sales of margarine rise 3 per cent following a 5 per cent increase in the price of butter this implies a cross price elasticity coefficient of 0.6. Thus, to estimate the impact of no PPPs on consumption patterns and total food expenditure we apply the effects of both the own and cross price elasticities of demand to the higher food prices. As the scope for switching to cheaper alternatives is severely curtailed if food prices in general increase, consumers' have little choice but to switch expenditure from non-food, discretionary products to food.

AI.6 In Table AI.1 the first column shows the own price elasticities for various food groups and the second column the proportion of total expenditure on food consumed in the home that is devoted to each group according to official surveys.[29] Column three shows the implied price elasticity for each group when allowance is made for each groups' own and cross price elasticities. Column four shows what this adjusted elasticity implies for the increase in expenditure on food in the individual groups if food prices generally rise by 10 per cent. Overall expenditure on food increases by 9.75 per cent following a 10 per cent, across the board rise in food prices, reflecting the fact that following a general increase in the price of food, households are likely to reduce expenditure on non-food items in order to maintain consumption.

Table AI.1: Elasticities for Food Products Excluding Fish

Food item	Own Price Elasticity[1]	Weighting in total Food Expenditure[2]	Adjusted Price Elasticity[3]	Increase in expenditure if 10% rise in all food price
	(1)	*(2)*	*(3)*	*(4)*
Bread	-0.40	5.3%	-0.019	9.81%
Cakes & pasties	-0.56	3.5%	-0.024	9.76%
Biscuits & cereal products	-0.50	11.1%	-0.037	9.63%
Liquid milk & products	-0.34	8.5%	-0.036	9.64%
Cheese	-0.36	3.9%	-0.012	9.88%
Beef & veal	-0.45	3.9%	-0.016	9.77%
Mutton & lamb	-1.29	1.0%	-0.023	9.77%
Pork	-0.82	1.2%	-0.024	9.76%
Poultry	-0.52	4.0%	-0.021	9.79%
Bacon & ham	-0.78	3.6%	-0.025	9.75%
Cooked poultry	-0.77	1.2%	-0.051	9.49%
Other meat products	-0.26	14.0%	-0.012	9.79%
E.g.gs	-0.28	1.4%	-0.004	9.96%
Fats	-0.75	2.2%	-0.017	9.83%
Sugars & preserves	-0.79	0.9%	-0.016	9.84%
Fresh potatoes	-0.12	1.6%	-0.007	9.93%
Processed potatoes	-0.6	4.3%	-0.026	9.74%
Fresh green vegetables	-0.66	2.3%	-0.015	9.85%
Other fresh vegetables	-0.33	10.1%	-0.006	9.94%
Processed vegetables	-0.60	3.9%	-0.026	9.74%
Fresh fruit	-0.29	8.6%	-0.027	9.73%
Processed fruit	-0.81	3.6%	-0.032	9.68%
Overall price elasticity			**-0.3534**	**9.75%**

Sources: [1]V. Lechene for own price and cross price elasticities, see references, 26; [2]Family Food Expenditure 2016/17, Defra, London; [3]Author's calculations, [4]Weighted average

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