Assessing the costs of risk management tools: A crop insurance scenario based on a stochastic partial equilibrium model approach

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Abstract

Following the move from a situation of stable, administratively determined prices and production linked subsidies to freely moving prices and decoupled subsidies, risk is of increasing concern within the EU agricultural sector. Also, significant increases in global market prices have further contributed to volatility. There are increasing interests in developing programmes aiming at providing assistance in risk management, which already exist in other countries such as the US on a large scale. The operation of these programmes is similar to insurance to some extent and therefore entails complex design issues. At the same time, these programmes generally involve policy support due to the presence of systematic risks within the sector. Thus, careful assessment is required. This paper examines a hypothetical scheme that provides protection against crop yield falls within the UK using the stochastic FAPRI-UK and EU-GOLD modelling system. The two key aspects investigated are the level of aggregation and the definition of reference. The choice of level of aggregation is closely related to the trade-offs between programme cost and its effectiveness in risk reduction. Furthermore, the definition of reference also has implications on programme costs and their variability.

Keywords stochastic modelling, risk management tool

JEL code Q1

1 Introduction

Risk is an inherent aspect of agricultural production systems. In the past, the Common Agricultural Policy (CAP) in the EU protected the agricultural sector from global markets through a variety of market management tools. In the past two decades, the CAP has changed significantly under successive reforms and at the same time world prices have increased substantially. As a result the EU agricultural sector has become more integrated with global markets, leading to increased exposure to volatile prices. Consequently, risk is of increasing interest to policy makers.

Given the changes in the global agricultural market, risk is an increasingly important issue in the policy agenda, not only in the EU but in other countries as well. In the US, the direct payment programme in which payments were made regardless of the production/market environments, has been replaced with payment programmes in which payments will be made only when certain adverse conditions occur (e.g. prices/ revenue fall below some predefined levels). This represents a shift in agricultural policy from price/income support to assistance in risk management.

The US has a long history of providing and subsidising agricultural insurance plans. The public subsidy is not uncommon in agricultural insurance and is justified on the basis that the agricultural system involves substantial systematic risks. Systematic risks contradict the insurability condition that risks need to be diversifiable. The US experience shows that despite the large menu of agricultural insurance plans there are substantial risks that cannot be covered, which have given rise to the latest revenue- payment programmes. These programmes resemble insurance to some extent, e.g. the definition of a triggering condition, payment made only when triggering conditions are satisfied, *etc*. In a hypothetical study by Coble *et al.* (2007), it is shown that this type of programme, if combined with crop insurance plans, is much more cost efficient in reducing farmers' risks than a combination of direct payment and counter-cyclical payment programmes. Although not as marked, some cost savings are estimated to be achieved in studies based on a proposed policy (Westhoff and Gerlt, 2013). However, the characteristics of the insurance-like programmes mean that they are more complex to design than the traditional farm programs in that they involve more parameters to be determined. Furthermore, given the need for public funding, careful ex-ante evaluation of these programmes is required.

Within the CAP in the EU, an income stabilisation tool has been added to Pillar II in the latest reform package, although the Single Farm Payment (SFP) still accounts for a large proportion of the budget under Pillar I. How long the current policy can be sustained is uncertain due to reasons such as WTO pressures. In the future, the SFP is likely to diminish and the role of income stabilisation tool may expand. In view of market and policy developments, the stochastic FAPRI-UK model has been developed to facility the investigation of risk within the EU agricultural sector. There are multiple methods to assess risk management tools; however, some of them, for example the use of historical data, are based on the existence of the tool in examination for multiple years (Goodwin and Mahul, 2004). Methods relying on historical data are not feasible within a large part of the EU, including the UK, given the very limited existence of the tools. Thus, the stochastic development of the model provides an important means to examine different risk management tools. It should be noted that the objective of the current paper is not to assess the specific programme set out in the latest CAP reform package but rather to examine the implications of different aspects of risk management tools. Specification of the hypothetical risk management tool draws on not only the specific CAP programme but also the experience of the US and the current model framework.

The development of the stochastic FAPRI-UK model is based on its deterministic counterpart. The stochastic model incorporates key uncertainty sources of the sector: crop yield, demand, macro economic conditions, world prices and exchange rates and provides bands of projections of key variables in the sector, which in turn reflect the potential impact of uncertainties on the agricultural sector. In this paper, we use the FAPRI-UK stochastic partial equilibrium modelling system to assess a risk management tool in the crop sector within the UK. The hypothetical tool is based on short falls in crop yields. In the future, the analysis will be extended to other sectors and also revenue and income issues where possible.

2 Literature review

A large number of studies are based in the US, wherein there is a large suite of risk management tools including insurance plans and price-/revenue-based programmes. Table 1 shows the layers of the programmes and insurance plans in the previous and the latest farm bills in the US. Most of these layers have both an upper and a lower bound, which together define the part of risk they cover. The layers on the top of the table cover shallow loss while the bottom layers cover deeper loss. Take the third column as an example. Under the

Agricultural Risk coverage component payments are made once crop revenue falls below 86% of the reference and payment is capped at 10%, which means any loss below 76% of the reference will not be covered. Crop insurance plans underneath generally cover loss between 50% and 85%, depending on the choices of the farmers. Together, this means that for the occurrence of a large loss, the farmer can choose to 1) cover different parts of the loss using different programmes with no overlapping; 2) cover different parts of the loss using different programmes with some of them double covered (as represented by the grey area in Table 1); and 3) cover different parts of the loss using different programmes with some of them not covered at all. These programmes and their combinations present a complex decision problem to the farmers but the complexity is no less for the programme designers.

Table 1 Overview of US Commodity Programmes and Crop Insurance Programmes (Grey areas show potential overlapping of the payments; modified based on Lubben et al. 2013)

2008 Farm Bill Option 1	2008 Farm Bill Option 2	2014 Farm Bill Option1	2014 Farm Bill Option 2	2014 Farm Bill Option 3
Direct payment, Counter-cyclical payment	Discounted direct payment, Average Crop Revenue Election (double triggered at farm and state level)	Agricultural Risk Coverage: county level, crop base, capped coverage	Agricultural Risk Coverage: farm level, whole farm base, capped coverage	Price Loss Coverage with Supplemental Coverage Option
Farm level revenue insurance plans *or* County level revenue insurance plans	Farm level revenue insurance plans *or* County level revenue insurance plans	Farm level revenue insurance plans *or* County level revenue insurance plans	Farm level revenue insurance plans *or* County level revenue insurance plans	Farm level revenue insurance plans *or* County level revenue insurance plans
Farm level yield insurance plans *or* County level yield insurance plans	Farm level yield insurance plans *or* County level yield insurance plans	Farm level yield insurance plans *or* County level yield insurance plans	Farm level yield insurance plans *or* County level yield insurance plans	Farm level yield insurance plans *or* County level yield insurance plans
Market loan rates	Market loan rates (Discounted)	Market loan rates	Market loan rates	Market loan rates

This paper focuses on two key aspects of the insurance-like programme design: aggregation level and the definition of reference.

It is apparent from Table 1 that the aggregation level of the programmes varies. County level outcomes are used as much as farm level but more aggregate level outcomes have also been used. There seems to be no clear answer as to whether the programme should be based at the farm level, county level, or above. Programmes based on individual farms are more prone to asymmetric information problems (both adverse selection and moral hazard), which are noted in the literature (Coble and Miller 2006; Goodwin and Mahul 2004; Zulauf et al. 2013). Analogous to private insurance schemes, dealing with asymmetric information problems concerns the viability of the programme if farmers are asked to bear or to a lesser extent share the programme costs. Another challenge of designing a programme based on farm level outcomes concerns the derivation of an appropriate baseline for future periods. This is particularly difficult when the historical data period is short or the basis of the data keeps changing. Coble and Miller (2006) notes that the constant evolvements of individual farms in terms of size have resulted in extensive adjustment procedures for farm insurance policies based on individual farms.

These challenges imply that policies based on more aggregate levels could be much more cost effective. Outcomes of more aggregate levels are generally recorded for longer periods and they are also much less manipulatable. Moreover, delineation of the units themselves changes much slower than individual farms. The process of aggregation also contributes to savings in cost as it smoothes out idiosyncratic risks, i.e. risks specific to individual farms or small regions, leading to less variable aggregate outcomes (be it crop yields, revenue or income). However, the programmes based on more aggregate outcomes may be less effective in terms of risk reduction, as rather than disappearing, the idiosyncratic risks are left to the farmers. The magnitudes of the idiosyncratic risks differ substantially across different farms. For farms located within or close to the main production region, their individual crop yields are closely correlated with the aggregate counterpart due to similarity in weather and subsequently their shortfall in yields are more likely to be compensated by high prices, which occur when aggregate crop yields are low. On the contrary, farms that are located far from the main production region and experience more distinct weather conditions are exposed to greater idiosyncratic risks. Their individual crop yields are only weakly correlated with the aggregate ones. Subsequently, they are more likely to be exposed to the miss-match situation in which low yield and low price happen at the same time (or vice versa). The same rule applies for comparisons between small regions and more aggregate ones. Dismukes *et al.* (2011) examines the Average Crop Revenue Election (ACRE) programme with alternative aggregate trigger levels (farm, county and crop district levels) as opposed to the State level. Although variabilities (in terms of both yield and revenue) at the farm level are unsurprisingly the greatest, the extent to which these are larger than the county level (i.e. the next most disaggregated level) varies widely across crops. This implies that there is no clear answer as to whether the benefits of using more disaggregate outcomes outweigh the costs, which depends on the particular risk profiles of the units under investigation.

Another key aspect is the way in which the reference is defined. Reference is an inherent component in insurance-like programmes as it defines the "normal" condition and subsequently the adverse conditions. In the case of crops, typically a reference yield and a reference price are needed, which determine the normal production quantity and value respectively. Reference yield is often defined using an Olympic average of historic observations in the preceding years. This is common in the US policies and also used in the newly introduced income stabilisation tool in CAP. However, the use of the Olympic average smoothes out inter year variability, but not entirely. This is noted in Bielza Diaz-Caneja *et al.* (2008), which analyses several hypothetical insurance schemes in the EU based on regional indicators including crop yields and a weather index. However, the impacts of using the Olympic average are not fully explored in their paper. Furthermore, average historic prices between 2002 and 2006 are used in the estimation of loss. Agricultural prices have increased significantly since 2007 and thus the estimated programme costs are likely to be lower than would be the case in more recent years.

Other papers that assess insurance type tools within the EU include Mary *et al.* (2013). Based on a representative farm in France, Mary *et al.* (2013) uses a stochastic dynamic farm model to investigate the impact of another risk management tool, an income stablisation tool, on farm income. The income stablisation tool investigated is similar to the one incorporated within the CAP post-2013 reform. The study provides valuable insights into the costs associated with this scheme at the farm level. However, given the heterogeneity across farms both within a country and across Europe, it is not possible to obtain a general cost estimation for the sector as a whole.

Within this study, the recently developed stochastic FAPRI-UK model is used to assess the introduction of a crop insurance scheme in the UK. The scheme insures against shortfalls in crop yields. Future analysis will examine other risk management tools, such as revenue and income schemes as noted earlier. For crop producers, shortfalls in yield represent the major source of production risk; however, they are also exposed to price risk from both the output and input side. This entails three broad types of insurance: yield, revenue and income insurance. Among the three, income insurance covers the most risk sources and is therefore the most relevant in terms of stabilising farmers' income. However, every time a new risk source is added the pricing of the insurance becomes more complicated as not only the distribution of the risk, but also its joint distributions with other risk sources, need to be taken into account appropriately. Investigation of the crop insurance scheme is warranted in its own right given the common application of this scheme elsewhere and the need for public funding to cover systematic risk. In addition, the analysis sheds light on the design of the income stabilisation tool proposed under the CAP post-2013 reforms.

We investigate a scheme based on a UK average versus an alternative scheme based on the four individual countries. In reality, the level of disaggregation could be greater. Here we use the FAPRI-UK partial equilibrium modelling framework to shed light on the question of how the choice of the level of aggregation interacts with the programme cost and variability of cost. Furthermore, the results of near term and mid-term projections are compared to demonstrate potential uncertainties of the programme itself introduced by the choice of reference definition.

3 Methodology

3.1 The stochastic FAPRI-UK modelling system

The stochastic FAPRI-UK modeling system has developed based on its deterministic counterpart. The deterministic FAPRI-UK model is a partial equilibrium model of the agricultural sector (including the crop, livestock, dairy and biofuel sectors) of the UK. It is run in conjunction with the EU-GOLD model developed and maintained by FAPRI, University of Missouri so that results represent market equilibrium of the whole EU. The deterministic model generates single point estimates for prices, livestock numbers *etc.* based on normal weather conditions, specific macro-economic and other exogenous assumptions.

Within the stochastic FAPRI-UK modelling system, the following sources of uncertainty are incorporated:

i. crop yields;

ii. meat (beef, lamb, pigmeat and poultry) demand; and

iii. macro-economic conditions (oil prices, GDP and exchange rates) and world agricultural commodity prices.

It is not feasible to sample all the possible sources of uncertainty. Rather the approach used involves focusing on the key elements that impact both supply and demand side uncertainty so that the resulting price and quantity distributions are acceptably consistent with historical observations (Meyer et al., 2010). This approach diminishes the potential of generating distributions that might result in implausible outcomes that would inevitably become buried under a mountain of data and allows the isolation of the impact of particular sources of uncertainty.

The first and second sources (crop yields and meat demand) are based on the deviate terms within the relevant equations. The deviates represent variations that are not accounted for by the explanatory variables within the equation. The deviates therefore capture the stochastic component of crop yields and meat demand. Within the crop yield equations the deviates primarily reflect variation in weather conditions, while those within the demand equations reflect various factors including food scares due to disease outbreaks or the consumption impact of health fads. Uncertainty due to macro-economic conditions is based on variation of the exogenous variables (i.e. oil prices, GDP and exchange rates).

Stochastic modelling involves a number of steps. The first step is to estimate the distributions of the deviates or exogenous variables based on historical data. The objective is to obtain plausible distributions, which reflect the observed variability of specific variables. The next step involves estimating the correlations of the exogenous variables or deviates. This ensures that the stochastic projections maintain the observed historic relationships among variables. Next, based on the estimated distributions, 500 correlated random draws are made of the selected variables. Finally, the partial equilibrium modelling system is solved for each of the 500 sets of exogenous variables/deviates and generates the values of the endogenous variables. The models are simulated using Excel, with stochastic draws generated using Simitar (Richardson et al., 2000). Full details of the stochastic modelling system are provided in Feng *et al.* (2013)[a,b].

In terms of crop yield deviates, basic statistics of the crop yield deviates in the UK are presented in Table 2[1]. For all four countries, wheat has a higher standard deviation than

[1] Both wheat and barley are incorporated in the stochastic modelling. However, for brevity the discussion of the crop insurance payment within this paper focuses on wheat.

barley. This is associated with the fact that there is greater switching between spring and winter variety for barley than for wheat. The switch between varieties already incorporates variations in weather conditions to some extent and thus the impact on aggregate yield is smaller for barley. Most of the crop yield deviates are negatively skewed, corresponding to findings in the literature. Thus, following suggestions in the literature the beta distribution is assumed. The advantage of using the beta distribution is that it allows negative skewness. The estimated parameter values for the beta distributions are also presented in Table 2. These estimations are supported by the hypothesis tests. Moreover, correlations between crop yield deviates in the UK are presented in Table 3.

Table 2 Basic Statistics of UK Crop Yield Deviate Data and Estimated Parameter Values for the Beta Distribution

	Basic Statistics					Estimated Parameters for Beta Distribution	
	Min	Median	Max	St Dev	Skewness	alfa	beta
Wheat_England	-1.47	0.03	0.84	0.51	-0.99	1.36	1.41
Barley_England	-0.65	0.10	0.66	0.30	-0.13	1.74	1.71
Wheat_Wales	-1.09	0.11	1.01	0.55	-0.20	1.29	1.41
Barley_Wales	-0.44	-0.04	0.72	0.30	0.46	1.11	1.65
Wheat_Scotland	-1.92	-0.10	0.92	0.59	-1.29	1.02	1.32
Barley_Scotland	-1.14	0.04	0.63	0.42	-1.01	1.62	1.25
Wheat_Northern Ireland	-1.60	0.12	0.87	0.65	-1.00	1.59	0.96
Barley_Northern Ireland	-1.21	0.04	0.66	0.46	-0.88	1.34	0.96

Table 3 Correlations of Crop Yield Deviates in the UK
Note: 1) WH and BA stand for wheat and barley respectively

	WH_EN	BA_EN	WH_WA	BA_WA	WH_SC	BA_SC	WH_NI	BA_NI
WH_EN	1.00							
BA_EN	0.72	1.00						
WH_WA	0.56	0.47	1.00					
BA_WA	0.28	0.36	0.49	1.00				
WH_SC	0.58	0.39	0.51	0.22	1.00			
BA_SC	0.43	0.38	0.43	0.41	0.85	1.00		
WH_NI	0.44	0.42	0.61	0.39	0.68	0.65	1.00	
BA_NI	0.04	0.17	0.38	0.29	0.29	0.43	0.58	1.00

3.2 The crop insurance scheme

With the simulated stochastic baseline, model outputs are used to assess the introduction of a crop insurance scheme for the UK for wheat. Firstly, within the analysis outlined in this paper it is assumed that there is no production impact of the payment scheme.

The crop insurance scheme provides a payment when crop yields of a specific year fall below a certain percentage of the Olympic average of the preceding five years (within the following text, this is referred to as "trigger yield"). The Olympic average is calculated based on observations excluding the highest and the lowest. The Olympic average is used in some of the proposed US programmes and is also in line with WTO rules on stabilisation tools for farm income (Bielza Diaz-Caneja *et al.* 2008; Paulson, 2013). The payment is calculated as follows:

$$Total\ Payment_n = \max(The\ Trigger\ Yield - Actual\ Yield, 0) * Reference\ Price * Area \quad [1]$$

Two scenarios are investigated. In the first scenario, the trigger yield is based on UK national yields in preceding years and is applied to all four countries (i.e. England, Wales, Scotland and Northern Ireland). Two different percentages are used. That is, the trigger yield is defined as 90% and 85% of the Olympic average of the national wheat yields in the preceding five years[2,3]. In the second scenario, the trigger yield is based on the individual country yields and

[2] Bielza Diaz-Caneja *et al.* 2008 shows that based on the FADN data 15% yield reduction at NUTS-2 level (more precisely, the FADN region level, which is rarely more disaggregated than the NUTS-2) has very similar impacts as 30% yield reduction at farm level.

[3] A third percentage 80% is also examined. However, the likelihood of triggering payment is below 1% and therefore these results are not presented here.

each country has their own trigger yield. Again, the two percentages 90% and 85% are used. With regards to reference price, both the Olympic average of prices in the preceding five years and the projected year prices in which the policy is triggered of the year are used. The value of the production loss may be best evaluated using the price at harvest time; however, this will be known only after the uncertainty has disappeared. Two sets of prices are used for comparison purposes. Premium per hectare is then calculated assuming loss ratio equal to 1 as in Equation 2, i.e. premium just covers the expected payment. Or, in other words, the amount to be paid ensures the programme statistically balances. Within the insurance literature, this is called “actuarially fair premium”; but actual premium in insurance plans will be higher as there are various loadings (for risk reserve, administration costs *etc*.) to be added on top of the actuarially fair premium.

$$Premium\ per\ Hectare = \frac{E(Total\ Payment)}{Production\ Area} \quad [2]$$

While the modeling system accounts for uncertainty in yields for the main crops within the EU, the following analysis focuses on wheat. The results for specific crops vary based on different distributions of the crop yields and the correlation among them but the general conclusions concerning level of aggregation and reference yield/price definition still hold.

4. Results

Results are presented for both the end of projection period and the near terms.

4.1 End of projection period

Triggering frequencies, expected payment and per hectare premium of the scheme are presented in Table 4. Expected payments and per hectare premium are evaluated using the Olympic average of historic prices in the preceding 5 years. A comparison between using historic and projected prices is presented in Table 5 and is discussed in the following paragraph. Triggering frequencies and per hectare premium are the lowest when a UK national trigger yield scheme is used in both the 10% and the 15% trigger scenarios. The national results are largely driven by the results for England as this region contributes over 90% of total UK wheat production. However, it should be noted that despite accounting for such a high proportion of wheat, England still faces some country specific risk as indicated by its larger triggering frequency and per hectare payment when compared to the national ones. This highlights the smoothing out effect of aggregation. Total expected payment using the national trigger yield case is lower than the country specific scheme by about 20% under the 10% trigger scenario and by more than 50% under the 15% trigger. The higher payments under the country specific trigger are contributed by the three smaller but more variable regions. For Wales, Scotland and Northern Ireland, moving from a national trigger yield scheme to a country specific trigger yield scheme leads to nearly double triggering frequencies. Among these countries, the increases in per hectare premium are the largest for Northern Ireland: 160% under the 10% trigger scenario and 400% in the 15% scenario.

Table 5 compares the expected total payment of programmes using different reference prices under the 10% trigger scenario. For England, if projected harvest prices are used, programme payments are consistently higher by more than 10%. However, the differences are less marked in the other three countries. This indicates that there is more likely to be a positive EU price response following a yield reduction in England compare to elsewhere. In other words, the "natural hedge" mechanism is the strongest in England. This is driven by two factors: 1) England is a much bigger wheat producer and thus more influential in the price determination process; and 2) wheat yield in England is more correlated with the other larger producers (France and Germany) within the EU.

As England is such a large producer within the UK, the protection it receives from a programme based on a national trigger yield is only slightly less than a country specific programme. However, this does not hold for the other three countries. Table 6 shows that in Wales, Scotland and Northern Ireland the number of simulations in which a payment would be triggered under a national scheme is 30% compared to a country specific scheme when their yields fall below 90% of their country Olympic average of yields. The proportion falls to below 20% under the 15% trigger. This reflects the greater level of idiosyncratic risks felt within these countries. Under the 15% trigger scenario, differences in per hectare premium between the case of national triggering yield and the country specific triggering yield are more marked for all countries. However, the values need to be treated with care as the analysis is based on 500 total simulations and the small triggering frequencies means that the actual number of triggering is very small.

Table 4: Key Results of the Crop Insurance Scheme

	10% trigger				15% trigger			
	2021		2019-2021 Average		2021		2019-2021 Average	
	National Scheme	Country Specific Scheme	National Scheme	Country Specific Scheme	National Scheme	Country Specific Scheme	National Scheme	Country Specific Scheme
Wheat								
Frequencies of Trigger								
EN	0.058	0.066	0.055	0.063	0.014	0.014	0.011	0.012
WA	0.058	0.096	0.055	0.090	0.014	0.022	0.011	0.017
SC	0.058	0.102	0.055	0.099	0.014	0.030	0.011	0.029
NI	0.058	0.114	0.055	0.123	0.014	0.038	0.011	0.053
Expected Payment (thousands)	4483	5235	4052	4727	552	845	332	569
EN		4611		4055		700		440
WA		91		66		12		7
SC		481		536		120		107
NI		53		70		13		15
Per Hectare Premium								
EN	2.34	2.58	2.10	2.32	0.29	0.39	0.17	0.25
WA	2.34	3.73	2.10	3.05	0.29	0.48	0.17	0.28
SC	2.34	5.04	2.10	5.18	0.29	1.26	0.17	1.12
NI	2.34	6.12	2.10	7.43	0.29	1.51	0.17	1.73

Table 5 Expected Payments based on 10% Trigger: Comparison between Olympic Average of Historic Prices and Projected Prices

	2021			Average of 2019-2021		
	OA of historic price	Projected price	Percentage Differences	OA of historic price	Projected price	Percentage Differences
EN	4611	5164	1.12	4183	4630	1.11
WA	91	97	1.07	75	79	1.05
SC	481	529	1.10	496	535	1.08
NI	53	56	1.07	65	68	1.04

Table 6 Comparison of Triggering Incidences: National Scheme versus Country Specific Scheme (2021)

	10% Trigger				15% Trigger			
	Number of Trigger			Percentage of Overlapping Trigger w.r.t. Coutry Specific Trigger	Number of Trigger			Percentage of Overlapping Trigger w.r.t. Coutry Specific Trigger
	National Scheme	Country Specific Scheme	Overlapping Triggers		National Scheme	Country Specific Scheme	Overlapping Triggers	
EN	29	33	28	85%	7	7	7	100%
WA	29	48	14	29%	7	11	2	18%
SC	29	51	15	29%	7	15	2	13%
NI	29	57	16	28%	7	19	2	11%

4.2 Reference Yield – Comparison between near term and end of projection period

The above analysis demonstrates that the level of aggregation plays a key role in determining programme cost and effectiveness. This section explores the implications of variable reference yields. Table 7 presents the total expected payments and triggering frequencies for both the near term (2015) and end of projection period (2021)[4]. Under both the 10% and the 15% trigger yield scenarios, expected payments in England and Scotland (particularly England) are much higher at the end of the projection period. This is because the Olympic average reference yields for England and Scotland in 2015 are relatively low. The Olympic averages are calculated based on the period 2010-2014, of which four fifths are actual data. There are multiple poor harvests in this period that lead to the low reference yield in 2015. With a low reference yield, a larger reduction is needed to trigger an insurance

[4] Payments are calculated based on the Olympic average of historic prices, but conclusions remain the same using the projected price.

payment (lowering the trigger frequency) and the payments based on shortfalls are smaller than they would have been if the harvests had been normal during the reference period (smaller payment resulted). For example in England, the triggering frequency in 2015 is only one quarter of that in 2021 and the expected payment in 2015 is less than a tenth of that in 2021. This highlights that the choice of reference can itself introduce variability. Even though the Olympic average system removes the most extreme observations, the reference yield is still affected by abnormal yields for prolonged period. The variability of reference yield could lead to substantial variations in the triggering probability and payment costs of the insurance-like payment scheme.

Table 7 Comparisons between Near Term and End of Projection Period Triggering Frequencies and Expected Total Payments

	10% trigger						**15% trigger**					
	2015		2021		2019-2021 Average		2015		2021		2019-2021 Average	
	National Scheme	Country Specific Scheme	National Scheme	Country Specific Scheme	National Scheme	Country Specific Scheme	National Scheme	Country Specific Scheme	National Scheme	Country Specific Scheme	National Scheme	Country Specific Scheme
Wheat												
Expected Payment (thousands)	294	689	4483	5235	4052	4727	0	40	552	845	332	569
EN		315		4611		4055		0		700		440
WA		93		91		66		6		12		7
SC		235		481		536		27		120		107
NI		47		53		70		7		13		15
Frequencies of Trigger												
EN	0.014	0.016	0.058	0.066	0.055	0.063	0.000	0.000	0.014	0.014	0.011	0.012
WA	0.014	0.112	0.058	0.096	0.055	0.090	0.000	0.018	0.014	0.022	0.011	0.017
SC	0.014	0.062	0.058	0.102	0.055	0.099	0.000	0.012	0.014	0.030	0.011	0.029
NI	0.014	0.100	0.058	0.114	0.055	0.123	0.000	0.032	0.014	0.038	0.011	0.053

5. Conclusion and Discussion

In this paper, a hypothetical crop insurance scheme within the UK is examined using the recently developed stochastic FAPRI-UK partial equilibrium modeling system. The objective is to explore some of the key issues in designing risk management tools. The stochastic FAPRI-UK modeling system incorporates crop yield and meat demand uncertainties within the EU, and uncertainties in macroeconomic conditions as well as world agricultural commodity prices. The hypothetical crop insurance scheme examined in this paper makes a payment when a shortfall in crop yield reaches a certain percentage (10% and 15%). Future analysis will be extended to other sectors and revenue/income schemes where possible.

The analysis demonstrates that a risk management tool based at a high level of aggregation generates cost savings, but that this is achieved by weakening the effectiveness of the tool in terms of reducing risk. The weakening in effectiveness does not happen evenly to individual regions. If the insurance-like programme is subsidised, these features will be translated into public spending. Within the UK, the weakening in yield risk reduction for wheat is much greater for Wales, Scotland and Northern Ireland than for England. Furthermore, given the size of the wheat sector and the correlations with other large producers in the EU, the “natural hedge” is strongest in England. Or, in other words, yield shortfalls in England are more likely to be compensated by higher prices. This leads to higher programme costs when it is evaluated using projected harvest prices compared to that using historic prices. However, payment for yield reduction (and therefore programme cost) in England may potentially be discounted if projected prices are used for evaluation as producers already receive some compensation from higher prices. For the other three small wheat producing countries, their yields and prices are only weakly correlated. A revenue programme may not entail lower cost. This implies that there is greater need for investing a revenue based programme for England than the other countries. Furthermore, programme cost and its variability are shown to be dependent on the reference definition, the Olympic average of yields in this paper.

The design of risk management tools is more complex compared traditional direct payment programmes as it involves more parameters to be determined. A well designed risk management tool requires the right determination of all the key parameters.

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