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THE IMPACT ON YIELDS OF ARABLE CROPS OF MOVING FROM PRICE SUPPORT TO AREA PAYMENTS -- A STUDY OF THE CAP REFORM

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NOTE BY THE SECRETARIAT

This paper was written by Catherine Benjamin and Magalie Houée (INRA-Rennes, France) and addresses the impact on yields of moving from price support to area payments (taking as an example the 1992 CAP Reform). It is issued as an unclassified document under the responsibility of the authors.

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THE IMPACT ON YIELDS OF ARABLE CROPS OF MOVING FROM PRICE SUPPORT TO AREA PAYMENTS – A STUDY OF THE 1992 CAP REFORM

1. Introduction

The aim of the study is to measure the impact of the 1992 reform of the Common Agricultural Policy (CAP) on arable crop yields in the European Union (EU), and more specifically to quantify the impact that the introduction of compensatory area payments had on yields. The CAP reform in May 1992 consisted largely in reducing support prices and offsetting the ensuing loss of income with direct payments based on factors of production, *i.e.* acreage in the case of COP (cereal, oilseed and protein) crops.

In the literature on decoupling, the area payments introduced by the European Union in 1992 are usually defined as partially decoupled instruments (OECD, 2002). They affect the level of supply via land allocation mechanisms, in that they promote decisions to put land down to crops that ensure the highest area payments. In terms of their impact on yields, there are several hypotheses. One commonly accepted idea is that area payments adversely affect yield levels because, by offering an incentive to increase acreage, they reportedly push down the use of other factors of production, and hence yields. Another hypothesis holds that area payments do not affect yields as the amounts paid are not output-based. There is not any certainty that set-aside has an impact either, as some studies on American farming show (Epplin, 1997). It depends on the relative quality and quantity of the land that is set aside. If there is no obligation for set-aside land to be rotated, the least productive land is systematically left fallow and the average yield of cultivated land may rise. When comparing the effects on output levels of a reduction in price support and an increase in direct support, it is therefore crucial to see how yields evolve (i) following a reduction in support prices, (ii) following an increase in area payments and (iii) following set-aside (all three of which featured in the 1992 reform).

The earliest theoretical research on the implications for land allocation and the impact on yields of the new tools applying to arable crops in the 1992 reform of the CAP showed that the decrease in prices has an adverse impact on yields (due to lower input use) but that this may be cancelled out if the rate of compulsory set-aside is high (Guyomard and Mahé, 1995). While there is a consensus on the impact of price changes on yields, the impact of payments on yields is more ambiguous.

Econometric applications on the impact of the CAP regime on arable crops make it possible to measure the impact of individual instruments in the CAP (Oude and Lansink 1996; Guyomard *et al*, 1999) on output levels. Most empirical findings show that land-allocation elasticities with respect to compensatory payments are greater than output elasticities (Moro and Sckokai, 1999). This results implies that there is an increase in yields linked with compensatory payments. Another empirical study, however, which is based on individual data and introduces the impact of risk on farmers' behaviour, reaches the opposite conclusion (OECD, 2002). Consequently, much work remains to be done in the empirical field to shed light on and gain insight into the determinants of change in crop yields.

This paper is an attempt at an econometric estimate of the impact of CAP area payments on arable crop yields. Part 2 explains the choice of explanatory variables for yields. Part 3 goes on to describe the various specifications that were tested, while Part 4 sets out the estimates chosen, in the form of equations

and simulation charts. The paper ends with a summary and an interpretation of the findings, as well as suggested avenues for future work.

2. How can yields be modelised?

Traditional explanatory factors

Explaining arable crop yields is a classic problem when seeking the determinants behind a farmer's production decisions. The functional forms are usually very simple (linear relation). The traditional factors behind yield changes are weather conditions (rainfall, temperature), technological innovation (generally introduced as a linear trend with a positive effect), commodity price, variable factor prices and a variable measuring land quality (McDonald and Sumner, 2003). Of all these determinants, it is the climate change variables that usually have the greatest explanatory potential.

Choice of specifications differs with the country concerned

There are numerous econometric applications on the subject, but it is worth noting that specifications vary with the country concerned. Generally, the aims of an application will differ according to whether the empirical analysis is focusing on developing or developed countries. For developing countries, the main aim is to find the key factor that will increase yields and, more specifically, to measure the input of technological innovation. For studies on the developed world, and in particular the United States, the aim is to assess the role of government programmes (see next paragraph) and the impact of insurance cover. This is because farmers can take out insurance to cover risks stemming from yield variability owing to poor harvesting conditions.

Impact of government programmes and the role of set-aside

Many empirical applications on US farming have sought to measure the influence of government programmes on output, and in some cases the impact of set-aside on yields. This research often relates to individual farm data or annual data on individual American states. Generally speaking, much of the impact of government programmes relates to supply, essentially in terms of the acreage under crop (Choi, 1993). Economic variables (prices, policy variables) are retained in equations for cropping patterns, and yield equations are very straightforward, *i.e.* based on a simple trend (Chavas and Holt, 2001) or autoregressive (Duffy *et al.*, 1994).

The earliest applications sought to reveal "slippage", *i.e.* the increase in yields associated with government acreage control programmes. This stems partly from the withdrawal of less productive areas from cultivated farmland, which improves the average quality of land. Farmers can also achieve productivity gains on cultivated land by allocating more resources (family labour, better management) to a smaller area of land. In this case, the acreage under crop is introduced as an explanatory factor (Love and Foster, 1990; Epplin, 1997).

Finally, many applications seek to measure the acreage response to government programmes, particularly under risk. The studies address ways of reducing farm-income variability, which is due to some extent to the variability of yields. They look at the insurance policies offered to cover this variability. Research into yields looks at the distribution for this variable (Duffy *et al*., 1994; McDonald and Summer, 2003).

Modelling yields in partial equilibrium models

As for applications using aggregate data at the national level, there are the yield equations used in multi-market partial equilibrium models. When estimating yield equations, the model is based on a linear

trend. In the FAPRI model, cereal and oilseed yields are estimated as a function of a trend, an average commodity price lagged by five periods, the acreage given over to the commodity and the total acreage planted with cereals and oilseeds. CAP reform is not, *a priori,* taken into consideration in the yield estimate.

In the OECD AGLINK model, yields are estimated as a function of prices and a trend, and area payments have no direct impact. In the Policy Evaluation Model (PEM), yields respond implicitly to changes in input use in a production function with constant elasticity of substitution. As this is a comparative static model, trend is not taken into consideration and prices and area payments are the key determinants of yield.

3. Selecting the specifications for this study

The aim of the study is therefore to measure the impact of compensatory area payments and set-aside on arable crop yields in the leading European Union Member States. With the benefit of hindsight as to the initial CAP reform, *i.e.* observations gleaned over a sufficiently long period of time (1970-2000), it is possible to test whether there has been any structural change over the period studied. Various specifications have been tested for the yield equations. They are explained here and the results are set out in the Annex.

Choice of data: aggregate national data

The first issue concerns the choice of data. The earliest applications were based on annual data aggregated at the European level for the period 1970-2000, from the Eurostat New Cronos database. The data used are aggregated from national data, taking into account the entry of new Member States into the European Union since 1973. The base contains national observations on output and harvested acreage in the European Union. Yields are then calculated for each arable crop. For the estimated yields, a price has to be defined for each crop at the European level. It is assumed that there is a lead country market for each crop. This means that producer price changes in the other countries can be attributed to similar changes in the Member State deemed to be the lead country. The lead price is the price in the main country producing the crop, with the exception of soybean and sunflower for which only the Spanish price is available.

To summarise, the econometric estimates obtained on aggregate European data from all the yield equations tested are not of very good quality (see Annex, Part 1). With regard to the estimated coefficients in the specifications that were tested, there is great instability. These poor results can probably be put down to the fact that the aggregation masks contrasting changes in the Member States. The decision was therefore taken to work on national data, to give a better reflection of country-specific features.

The focus of the study is changes in yields and modelling of the 1992 reform in the leading EU producer countries, namely Germany, Spain, France, Italy and the United Kingdom. According to Table 1, these five countries account for an average of over 80% of total European output over the period 1990-2000 for each of the arable crops in the study. Different yield-equation specifications described in this paper were tested on data for these leading countries (specification tests, 1992 reform tests, projections).

Table 1. Share of EU output held by leading countries, average for 1990/2000

Average share (%)	Common wheat	Durum wheat	Barley	Maize	Rape-seed	Soybean	Sunflower
Germany	21	0.6	27	8	39	0.2	2
Spain	5	13	18	10	0.7	1	27
France	39	16	20	44	35	18	55
Italy	5	51	3	26	0.6	78	11
United Kingdom	18	0.07	15	0	18	0	0
Average for all five countries	88	81	83	88	93	97	97

Source: EUROSTAT

Basic specification: defining traditional determinants

The general specification of the yield equation is as follows:

$$rdt_{i,t}=rdt(p^*_{i,t},t,z_t) \quad (1)$$

where $rdt_{i,t}$ defines the yield of crop i in year t, $p^*_{i,t}$ the expected price in year t for crop i, t a linear trend and z_t a vector of variables representing the exogenous factors that may affect yields (*e.g.* support variable).

To estimate equation (1), disturbance is added to this specification. Yields are obtained as linear estimates in levels using the Ordinary Least Squares method (except in specific cases). It was verified that the basic hypotheses on the disturbance introduced into equation (1) were not rejected (no autocorrelation, stationary perturbations). The equations are estimated in levels, as this offers the advantage of ranking the effects of all the explanatory factors (technical change, policies).

Role of the trend

This analysis assumes that the trend coefficient measures the annual change in per hectare crop yield due to autonomous technical change. It is usually positive. Some studies (*e.g.* Supit, 1997 and Moss *et al*, 1993) use more refined (stochastic) forms to estimate the yield trend but do not include policy variables (those studies also use far longer observation periods, where the hypothesis of a persistent trend is less warranted).

Defining price expectations

When producers make these production decisions, they do not usually know the price of the commodity, except in the case of regulated markets, and must therefore rely on expected prices. Various expectation patterns were tested, based on prices lagged[1] by one, two or three periods (see Annex, Tables A8 and A15). Intervention prices were not used as indicators of expected prices because, as they follow a trend inversely related to that of payments, there would have been co-linearity.

1. Working on annual data, it is hard to test more refined patterns.

Introducing weather variables

Added to this basic specification are other variables such as dummy variables. Dummy variables[2] measure gain or loss of yield for a specific crop in specific years, owing in particular to exceptional weather conditions. They are used for years when there are peaks and troughs in yield indicating climate events (such as the drought in 1976). They are not necessarily the same for all of the commodities or countries under analysis. This is because the yield patterns for each crop in the same season are highly contrasted. Also, countries do not necessarily experience the same climate events at the same time. When several dummy variables had to be added to the specification, an attempt was made to group them into a single variable to gain degrees of freedom. This method did not enhance the quality of the estimate. Moreover, the assumption that the coefficients for different dummy variables are equal does not hold (Chow test). It was therefore deemed preferable to retain the specifications with different dummy variables.

Introducing input price

Variable input prices also determine input use and hence yield. Two tests were carried out to introduce input price into yield estimates: input price as a denominator of price and payment variables, and input price as an additional explanatory variable.

In the first case, the general price index deflator is replaced by input price in the basic specification. In the second, a new explanatory variable, the input price in t-1, is added to the basic specification.

Supplementary tests

Introducing cross-price effects

In the specifications below, there is deemed to be no substitution relation between crops, in other words the yield equations have been treated separately. The assumption is that there may be substitution or complementary relations between crops. To rule out any *a priori* assumptions on the substitution or complementary relations between crops, all of the cross-price effects are introduced into the yield equations. In other words, prices of the other crops are added to each yield equation, and symmetry constraints are imposed on cross prices. In addition, a system of yield equations is defined and estimated using the iterative Zellner method (SURE). Any insignificant cross-price effects are removed from the equations (see Annex, Tables A7 and A14).

Measuring the impact of the 1992 CAP reform

The second category of tests, on farm policy, provides various ways of accounting for the CAP reform. The reform can be taken into consideration by introducing a support variable, but it can also generate structural change in yield development or in farmer response to prices (introduction of a dummy variable over the period of the reform).

Various tests are conducted on the inclusion of the 1992 CAP reform. In the chosen specifications, the basic area payment rate for cereals (or oilseeds) is introduced, calculated for each country as indicated below. The estimates for the European Union, given in the Annex, use the level of payment per tonne. It matters little which specification is used since, as indicated below, reference yields for each commodity and country remain unchanged over the period.

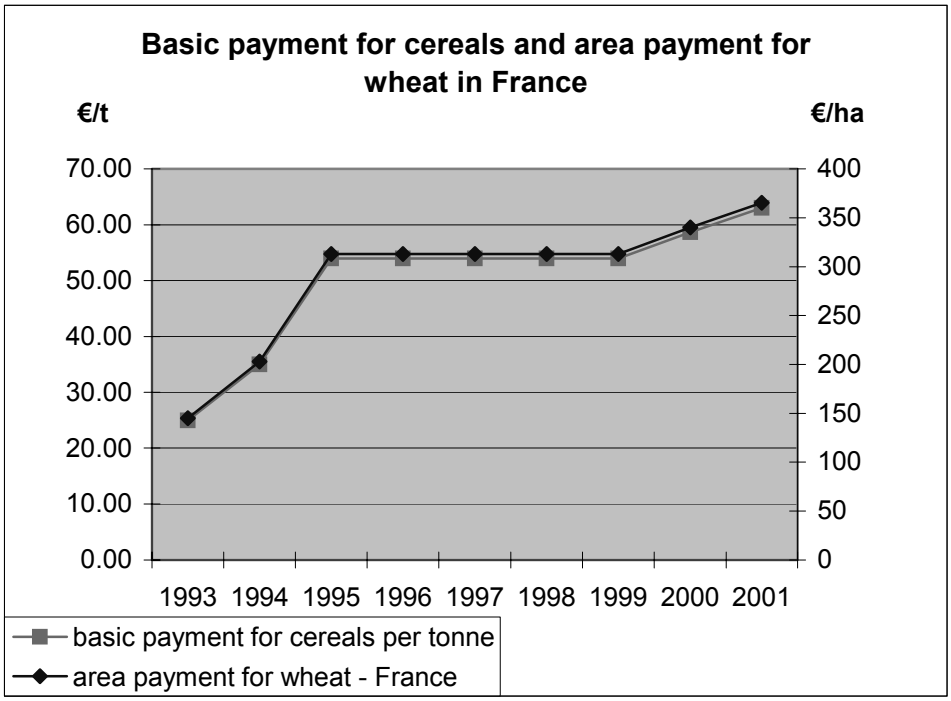
2. A dummy variable attributes a value of 1 to a specific year or period, otherwise a value of 0.

Introducing area payments

The area payment for each commodity is defined by the basic payment expressed in €/t, as set at EU level, and the regionalised reference yield. Each Member State defines a reference yield based on historical output levels over the period 1986-1990 (an average excluding minimum and maximum values over the period). There are reference yields for small grains (wheat and barley), maize and oilseeds in each country. Regionalisation plans are drawn up by dividing the country into smaller or larger territorial units. For France, the unit is the *département*, but the departmental reference yields are weighted with the national average yield. German yields are based on the *Länder*, whereas the geographical units used for Italy are extremely small. Furthermore, the reference yield is set for the entire period (1992 onwards for oilseeds and 1993 onwards for cereals).

Reference yields differ across commodities and countries, but remain the same over the entire period. They are given in the Annex. Consequently, trends in the various payments for a particular group (cereals or oilseed), expressed in €/ha, are identical. The basic payment for cereals and area payments for wheat or maize display virtually the same trends (see Figure 1).

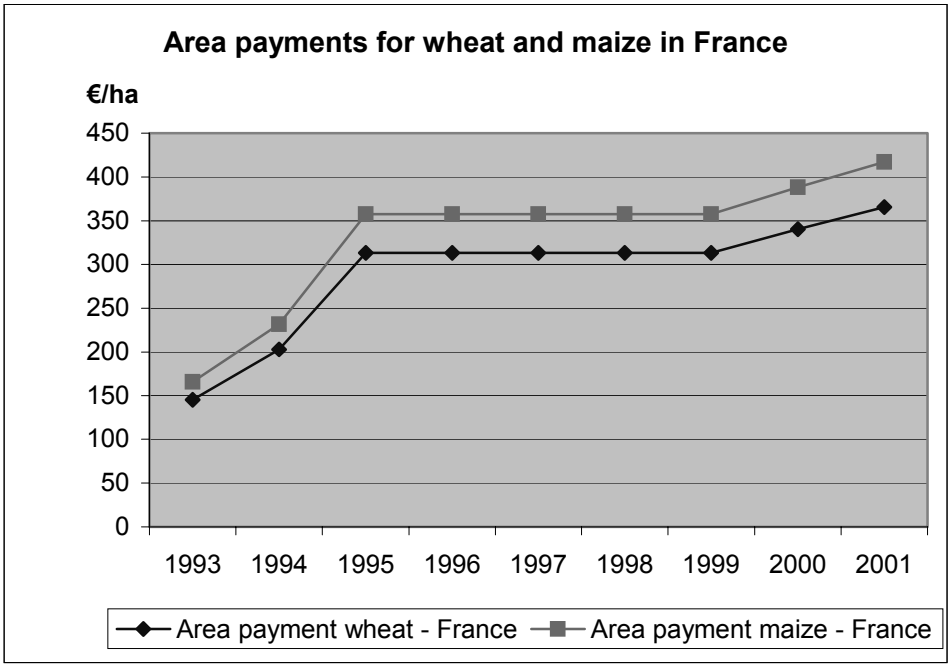
Figure 1. Trends in basic payment for cereals and area payment for common wheat in France



The basic payment for cereals in €/t displays exactly the same trend as the area payment for common wheat in France. The same applies to the other commodities and in the other countries, since the basic payment is simply multiplied by a scalar.

Figure 2 compares area payments for various commodities in the country concerned. The area payments calculated with the same basic payment, like the payments for wheat and maize, will necessarily display the same trend but at a different level. In economic terms, the trends in area payments for each crop are therefore co-linear, and it is impossible to introduce cross-payments within cereals or within oilseeds.

Figure 2. Trends in area payments for common wheat and maize in France



Representing quantitative constraints

Wit regard to the management of compensatory payments at the national level, there are two types of constraint, namely the reference area as determined by the regionalisation plan and the maximum guaranteed area (MGA) for each crop. Reference areas are defined for all crops giving entitlement to compensatory payments (cereals, oilseeds, protein crops and set-aside). There are cases of MGA overshoots, which lead to proportional cuts in compensatory payments. The level of payment is also subject to compliance with an MGA requirement for some crops, namely durum wheat, rice, irrigated soybean, and oilseeds.

Separate information is available on MGA overshoots for cereals and oilseeds. To include penalties in the definition of the area payment variable, the same overshoot series is used for all cereals. Again, trends in payments across the different commodities will remain the same. Consequently, the inclusion of penalties will not provide any insight for the study on the impact of CAP reform.

Introducing set-aside

To measure the impact of set-aside on trends in yields, set-aside acreage was added to the basic specification, which comprises a constant, the crop price in t-1 (deflated by input price), a trend, the area payment in t (deflated by input price) and dummy variables. The results are given in the Annex (Tables A9 and A16).

Testing structural change in the trend and/or the constant in 1992

A dummy variable is introduced, covering the period 1992-2000. The aim is to test whether the reform has an impact on average yield alone. The results for France and Italy are given in the Annex (Tables A10 and A11 for France, and Tables A17 and A18 for Italy).

Yields projected for the period 1970-1992 and comparison with observed yields

The aim is to see how yields would have changed if there had been no reform in 1992. Yields are accordingly estimated over the period 1970-1992, then projected over the period 1993-2000. For the projections, the specification chosen for the yield equations includes the following explanatory variables: a constant, the crop price in t-1, a trend and country-specific dummy variables. The projections obtained from these estimates are then compared with observed yields. The estimation results for 1970-1992 are given in the Annex, and charts comparing the projected yields prior to reform, the estimated yields and the observed yields are given in Part 4 below.

4. Results

The various specifications described in Part 2 were tested for the various European Union Member States. Details of all the results are included in the Annex. This part contains the specifications chosen because they fit well, and because they give stable and economically consistent results. Yields are estimated in levels, depending on the basic specification, as a linear function of the expected crop price, the area payment (in t), and a trend. The method used is Ordinary Least Squares. The tests also reveal some stability in the results; regardless of the specification, the impact of prices or payments on yields is the same.

France

Estimation results

In the case of France, yields of common wheat, durum wheat, barley, maize and rapeseed are estimated as a function of the crop price in t-1 deflated by input price, a trend, the area payment rate in t deflated by input price and dummy variables representing climate events. Depending on the crop, there are three types of payment: one for small grains, one for maize and one for oilseeds. The results are set out in Table 2.

As the R^2 shows, the fit is good but the number of dummy variables is high. Unsurprisingly, the trend has a significantly positive effect in all the yield equations. As expected, crop price has a significantly positive effect on yields of common wheat and barley. For the other crops, price does not have a significant impact on yield in the equations in Table 2. The area payment rate has a negative impact on yield in all the yield equations, but only for durum wheat is the estimated coefficient significantly different from zero.

Projections

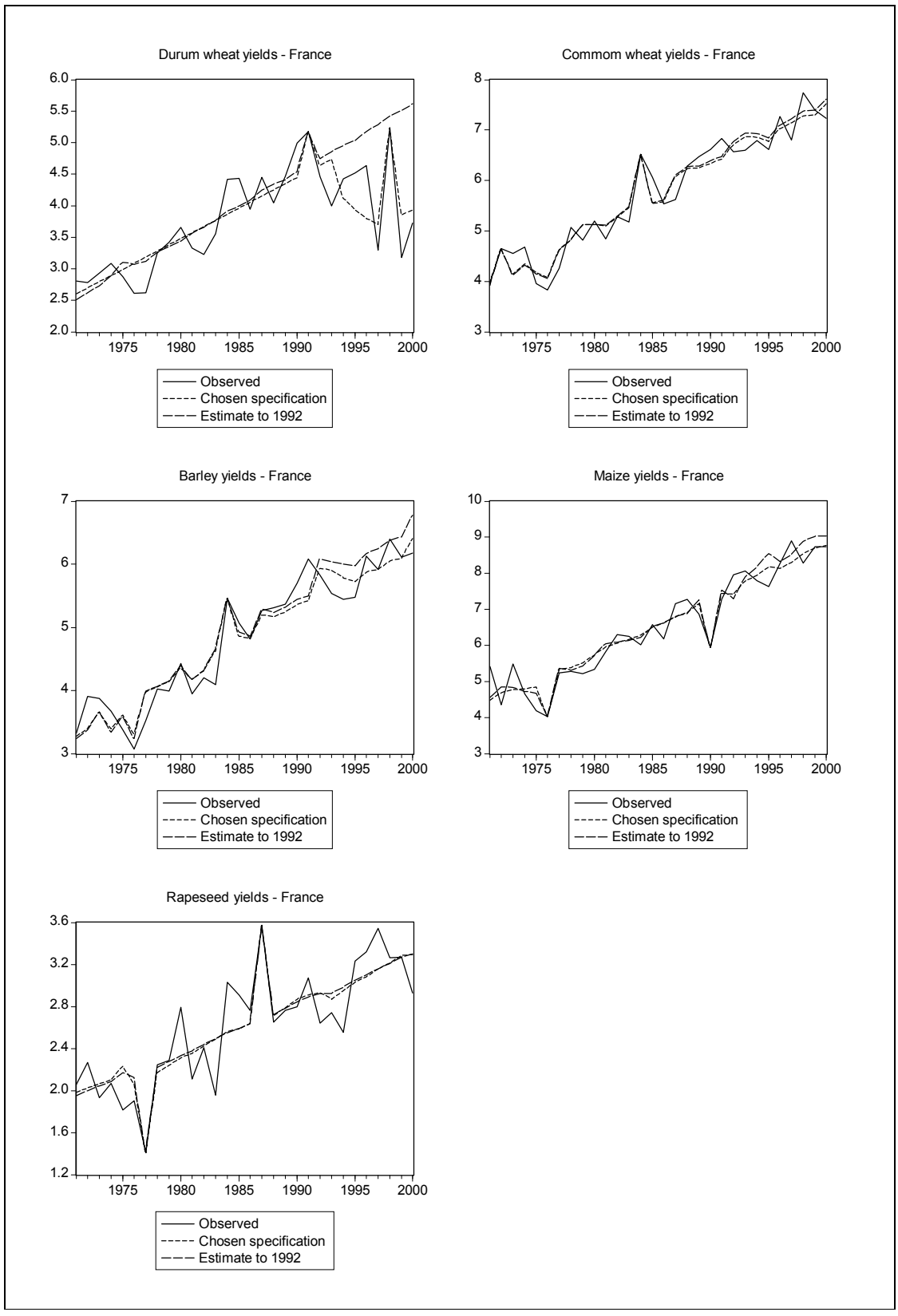
The estimation results for the main arable crop yields in France prior to reform are set out in the Annex. Figure 3 compares the projections based on this equation with observed yields and yields estimated with the equation in Table 2.

Table 2. France - estimated yields (1970-2000)

	Common wheat	Durum wheat	Barley	Maize	Rapeseed
Constant	-1.08	2.37	-3.12	5.98	1.21
	(-0.53)	(1.84)	(-1.37)	(2.52)	(2.07)
Own price in t-1	2.07	-0.005	2.78	-0.93	0.19
	(2.26)	(-0.01)	(2.63)	(-0.78)	(0.98)
Trend	0.23	0.10	0.24	0.12	0.067
	(5.58)	(2.85)	(5.30)	(2.83)	(4.01)
Area payment in t	-0.013	-0.43	-0.09	-0.012	-0.019
	(-0.16)	(-3.77)	(-1.25)	(-0.10)	(-0.54)
Dummy in 72	0.62				
	(1.87)				
Dummy in 76				-1.32	
				(-2.61)	
Dummy in 77					-0.69
					(-2.34)
Dummy in 84	0.89		0.63		
	(2.85)		(2.05)		
Dummy in 87					0.81
					(2.79)
Dummy in 90				-1.44	
				(-2.86)	
Dummy in 91		0.56			
		(1.18)			
Dummy in 98		1.24			
		(2.52)			
R^2	0.94	0.75	0.92	0.92	0.81
Adjusted R^2	0.93	0.70	0.91	0.91	0.77

Figures in brackets are t-statistics

Figure 3. France – yields estimated with the chosen specification, yields simulated without payments or set-aside (estimate for 1970-1992), and observed yields



For cereals, the yields simulated without payments or set-aside (estimated up to 1992 and subsequently projected) are higher than observed yields and yields estimated for 1970-2000 with the chosen specification. The difference is fairly substantial for durum wheat and barley, but very slight for common wheat and maize. Conversely, there is no marked difference between projected and observed yields of rapeseed. It would therefore seem, from these estimates, that the introduction of area payments and set-aside had a negative impact on the yields of leading cereals, but not rapeseed.

To conclude, while the introduction of payments and set-aside appears to have had a negative impact on cereal yields in France, only in the case of durum wheat can this be put down partly to area payments since, for the other cereals and for rapeseed, the estimated equations did not reveal that payments had had a negative impact on yields significantly different from zero.

Italy

Estimation results

In the case of Italy, yields of common wheat, durum wheat, barley and maize are estimated as a function of the crop price in t-1 deflated by the general price index, a trend, the area payment rate in t deflated by the general price index and dummy variables representing climate events. Depending on the crop, there are two types of payment: one for small grains and one for maize. The results are given in Table 3.

Table 3. Italy - estimated yields (1970-2000)

	Common wheat	Durum wheat	Barley	Maize
Constant	2.76 (3.06)	1.05 (1.08)	-0.25 (-0.37)	0.61 (0.65)
Own price in t-1	-0.40 (-1.70)	-0.03 (-0.15)	0.16 (0.87)	0.67 (2.18)
Trend	0.05 (3.08)	0.04 (2.04)	0.09 (8.01)	0.16 (10.44)
Area payment in t	-0.006 (-0.07)	-0.08 (-0.56)	-0.47 (-5.30)	0.21 (3.19)
Dummy in 77	-0.31 (-1.55)	-0.43 (-1.49)	-0.37 (-1.97)	
Dummy in 88	-0.34 (-1.81)			
Dummy in 89		-0.76 (-2.59)		
R^2	0.94	0.65	0.92	0.96
Adjusted R^2	0.92	0.58	0.91	0.95

Figures in brackets are t-statistics.

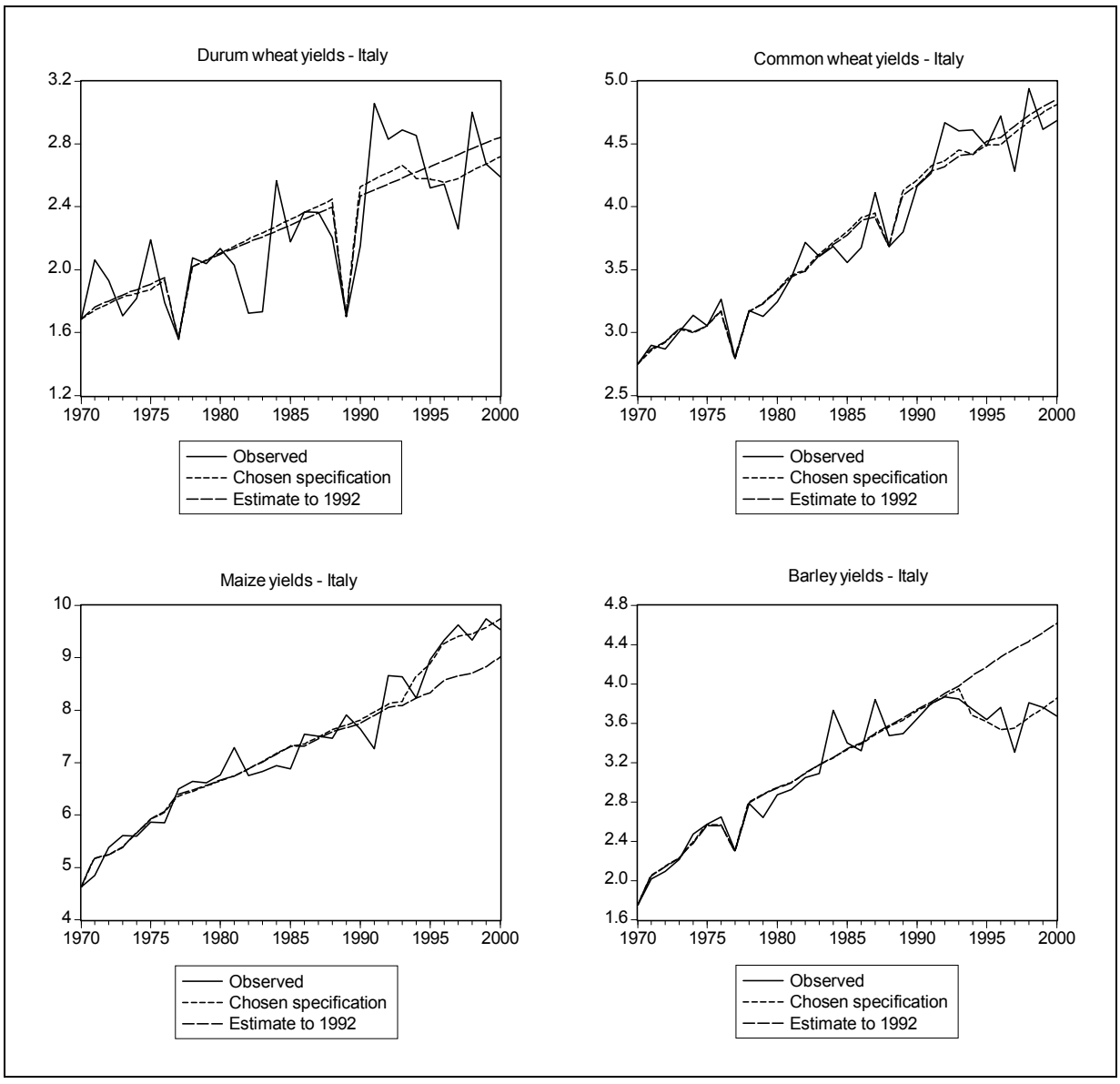
The fit is good for common wheat, barley and maize. Unsurprisingly, the trend has a significantly positive effect in all the yield equations. While crop price, as expected, has a significantly positive effect for maize, the impact is significantly negative for common wheat, and not significantly different from zero for durum wheat and barley. The area payment variable has a negative impact in the yield equations for common wheat, durum wheat and barley, but only the estimated coefficient for barley is significantly different from zero. The area payment variable has a significantly positive effect in the yield equation for maize. While the equation estimating the yield fits the trend, the equation does not reproduce annual yield

changes well (see Figure 4). One reason why the trend predominates in the estimate could be the sharp rise in maize yields over the period, as it more than doubled.

Projections

The estimation results for the main arable crops in Italy prior to the reform are given in the Annex. In Figure 4, the projections based on this equation are compared with observed yields and yields estimated with the equation in Table 3.

Figure 4. Italy: yields estimated with the basic specification, yields simulated without payments or set-aside (estimate for 1970-1992), and observed yields



In the case of Italy, the durum wheat and common wheat yields simulated without payments or set-aside (estimated up to 1992, then projected) are higher than observed yields and yields estimated with the basic specification. For both crops, 1998 was an exceptional year when observed yields were higher than yields simulated without the reform and estimated yields. For barley, there is a very substantial difference

between yields simulated without the reform and observed yields, the maximum being 1.05 t/ha. The introduction of area payments and set-aside in 1992 caused a slight fall in the yields of durum wheat and common wheat, and a more marked fall in barley yields. The introduction of area payments and set-aside did not have the same impact on maize: the yields simulated without payments or set-aside (estimated until 1992, then projected) are lower than observed yields and yields estimated with the basic specification. The introduction of area payments and set-aside intensified maize yields in Italy.

In the case of Italy, the introduction of area payments and set-aside therefore appears to have had a negative impact on trends in the main arable yields, with the exception of maize. Only in the case of barley, however, can the decline in yield be partly attributed to the introduction of payments because, in the case of common and durum wheat, the payment coefficient is negative but not significantly different from zero.

Spain

Estimation results

In the case of Spain, the yields of common wheat, durum wheat, barley, maize and sunflower are estimated as a function of crop price in t-1 deflated by the general price index, a trend, the area payment rate in t deflated by the general price index, and dummy variables representing climate events. Depending on the crop, there are two types of payment: one for small grains and one for maize. The results are given in Table 4.

Table 4. Spain - Estimated yields (1970-2000)

	Common wheat	Durum wheat	Barley	Maize	Sunflower
Constant	-4.16 (-1.18)	-6.96 (-1.16)	-1.40 (-0.62)	-5.32 (-1.52)	-0.70 (-1.04)
Own price in t-1	0.95 (1.21)	1.32 (1.08)	0.75 (1.36)	0.59 (0.84)	0.17 (1.51)
Trend	0.13 (2.08)	0.19 (1.79)	0.062 (1.51)	0.29 (3.98)	0.032 (2.61)
Area payment in t	-0.17 (-0.67)	-1.47 (-4.12)	0.26 (1.00)	-0.13 (-0.57)	0.039 (0.30)
Dummy in 84	0.63 (1.69)	1.32 (2.38)	0.70 (1.70)		0.27 (1.57)
Dummy in 88		0.64 (1.14)	0.81 (1.93)		0.38 (2.04)
R^2	0.69	0.59	0.42	0.95	0.49
Adjusted R^2	0.64	0.50	0.30	0.94	0.37

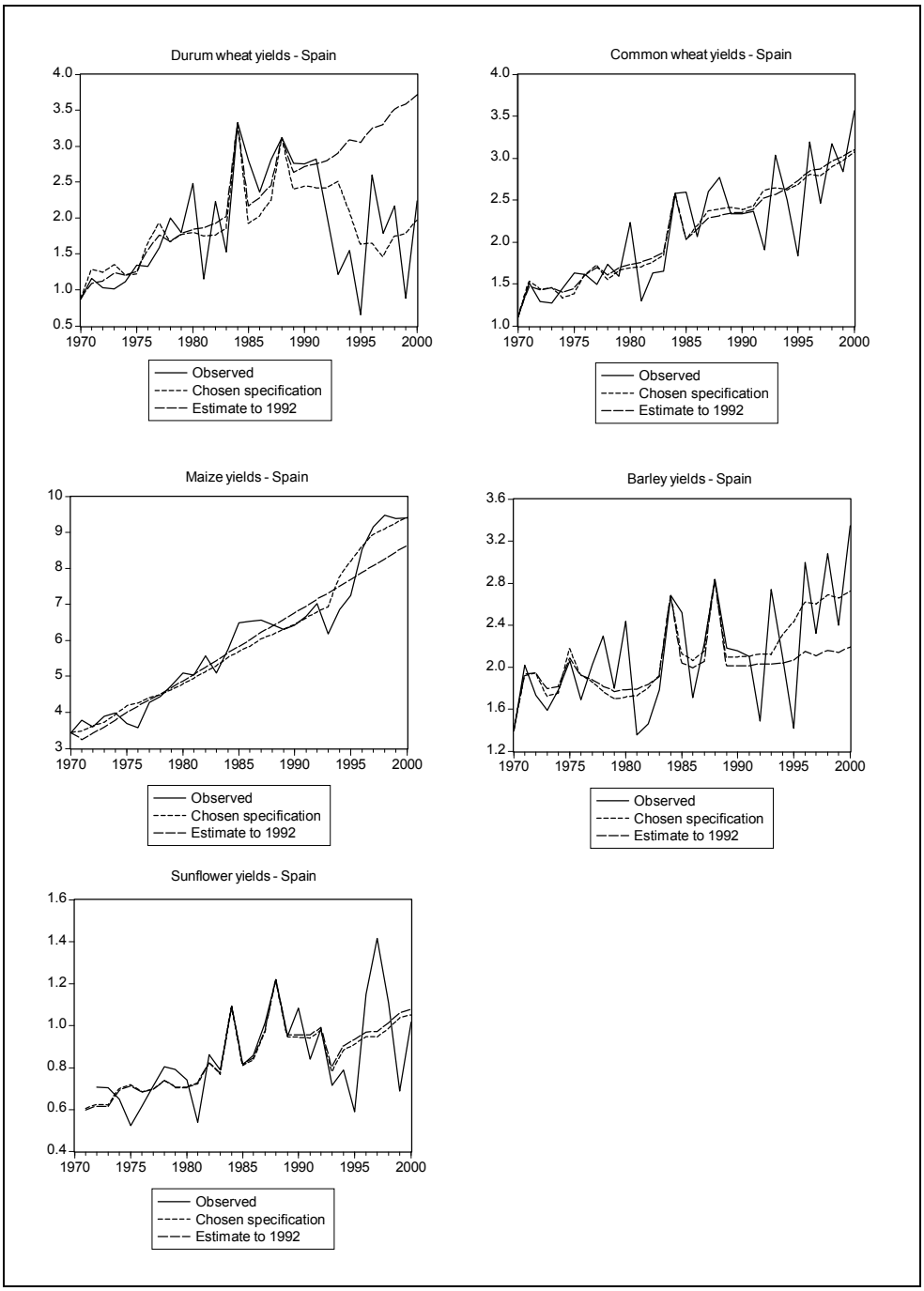
Figures in brackets are t-statistics

The yield fit is good, except for barley and sunflower where it is poor. Unsurprisingly, the trend has a significantly positive effect in all the yield equations. Crop price, as expected, has a positive effect in all the yield equations but the effect is only significant for barley and sunflower. The area payment variable has a negative impact in the yield equations for common wheat, durum wheat and maize, but only the estimated coefficient for durum wheat is significantly different from zero. However, the area payment variable has a slight effect that is significantly positive in the yield equations for barley and virtually none in that of sunflower.

Projections

The estimation results for the main crops in Spain prior to reform are set out in the Annex. In Figure 5, the projections based on this equation are compared with the observed yield and the yield estimated using the equation in Table 4.

Figure 5. Spain - yields estimated with the basic specification, yields simulated without payments or set-aside (estimate for 1970-1992), and observed yields



In the case of Spain, the durum wheat yields simulated without payments or set-aside (estimated up to 1992, then projected) are markedly higher than observed yields and yields estimated with the basic specification (maximum difference 2.7 t/ha). For common wheat, the yields simulated without payments or set-aside are slightly higher than those estimated with the basic specification, while observed yields fluctuate between these two estimates. The same effects are observed for sunflower yield, as the yields simulated without payments or set-aside are on average higher over the period 1993-2000 than the observed yields. The introduction of payments and set-aside in 1992 therefore appears to have led to a decline in yields of durum wheat, common wheat and sunflower in the case of Spain. According to the estimates, the introduction of payments contributed to this decline only in the case of durum wheat, as the coefficients associated with them are not significantly different from zero in the yield equations for durum wheat and barley.

For maize and barley, the yields simulated without payments or set-aside (estimated up to 1992, then projected) are lower than observed yields and yields estimated with the basic specification. According to the estimates, the introduction of area payments and set-aside would appear to have intensified maize and barley yields in Spain. However, these results should be regarded with precaution as the barley yield equation is of poor quality and, as for Italy, the equation chosen does not properly represent annual variations in maize output, which more than tripled over the period.

United Kingdom

Estimation results

In the case of the United Kingdom, common wheat and barley yields are estimated as a function of the crop price in t-1 deflated by the general price index, a trend, the area payment rate in t deflated by the general price index, and dummy variables representing climate events. The area payment variable is identical for common wheat and barley. The results are given in Table 5.

The yield fit is good. Unsurprisingly, the trend has a significantly positive effect in the yield equations for common wheat and barley. The impact of crop price is not significantly different from zero in either of the equations. The area payment variable has a negative effect on yields in both equations, but here too the estimated coefficients are not significant.

Table 5. United Kingdom – Estimated yields (1970-2000)

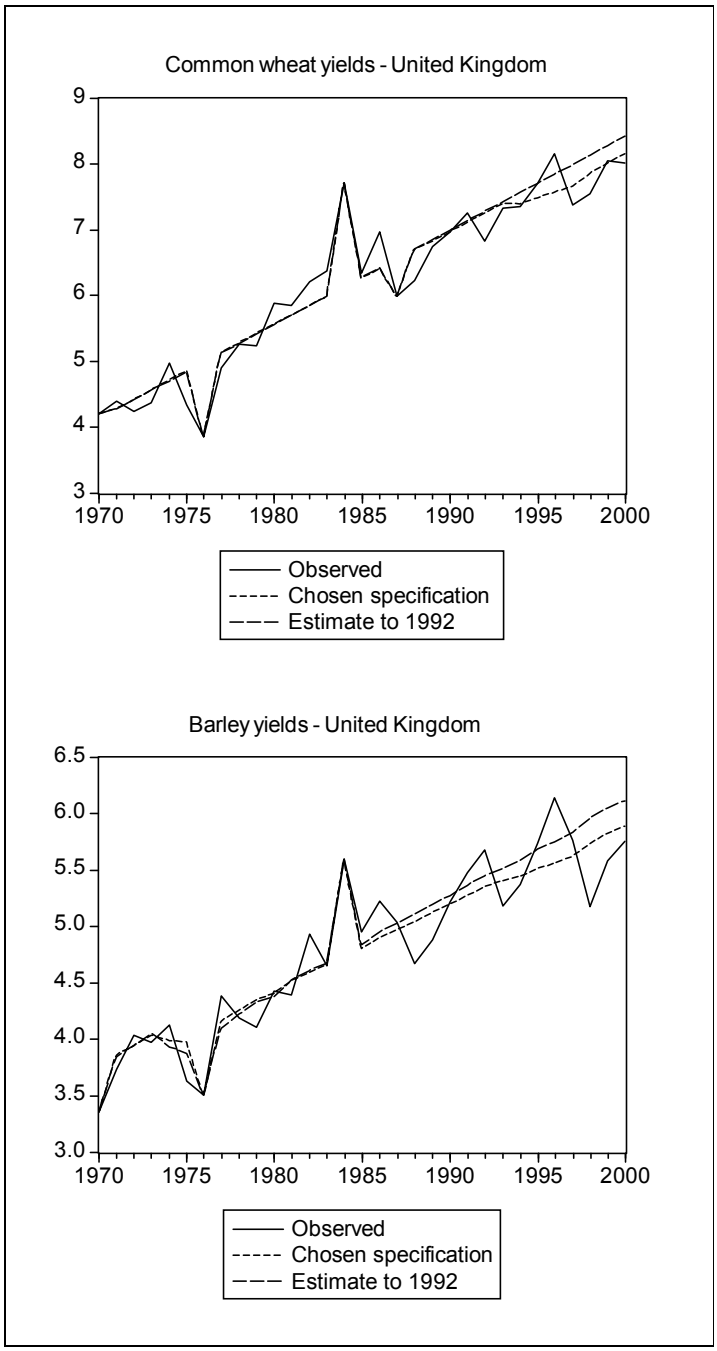
	Common wheat	Barley
Constant	1.34	2.87
	(1.17)	(3.38)
Own price in t-1	0.013	-0.17
	(0.05)	(-0.79)
Trend	0.14	0.064
	(6.65)	(4.12)
Area payment in t	-0.048	-0.017
	(-0.55)	(-0.24)
Dummy in 76	-1.15	-0.64
	(-3.39)	(-2.24)
Dummy in 84	1.59	0.88
	(4.68)	(3.10)
Dummy in 87	-0.54	
	(-1.59)	
R^2	0.95	0.88
Adjusted R^2	0.94	0.85

Figures in brackets are t-statistics.

Projections

The estimation results for the main crop yields in the United Kingdom prior to reform are set out in the Annex. In Figure 6, the projections based on this equation are compared with observed yields and yields estimated using the equation in Table 5.

Figure 6. United Kingdom - yields estimated with the basic specification, yields simulated without payments or set-aside (estimated for 1970-1992), and observed yields



In the case of the United Kingdom, the common wheat and barley yields simulated without payments or set-aside (estimated up to 1992, then projected) are higher than observed yields and yields estimated with the basic specification. For both crops, 1996 was an exceptional year when observed yields were higher than yields simulated without the reform and estimated yields. The introduction of area payments and set-aside therefore appears to have caused a decline in common wheat and barley yields in the United Kingdom.

Germany

Estimation results

In the case of Germany, yields of common wheat, barley, maize and rapeseed are estimated as a function of the crop price in t-1 deflated by the general price index, a trend, the area payment rate in t deflated by the general price index, and dummy variables reflecting climate events. Depending on the crop, there are three types of payment: one for small grains, one for maize and one for oilseeds. The results are set out in Table 6.

Table 6. Germany - Estimated yields (1970-2000)

	Common wheat	Barley	Maize	Rapeseed
Constant	1.23 (0.54)	2.13 (1.15)	2.43 (0.57)	1.04 (1.07)
Own price in t-1	0.10 (0.28)	-0.012 (-0.04)	0.10 (0.13)	0.011 (0.07)
Trend	0.12 (3.04)	0.079 (2.43)	0.11 (1.43)	0.053 (3.52)
Area payment in t	0.04 (0.58)	-0.057 (-0.94)	0.15 (1.25)	-0.19 (-1.99)
Dummy in 76	-0.65 (-2.23)	-0.41 (-1.68)	-0.86 (-1.57)	
Dummy in 81				-0.38 (-1.45)
Dummy in 87		-0.40 (1.65)		
Dummy in 88	0.74 (2.49)		0.95 (1.93)	
R^2	0.94	0.90	0.85	0.63
Adjusted R^2	0.93	0.88	0.81	0.57

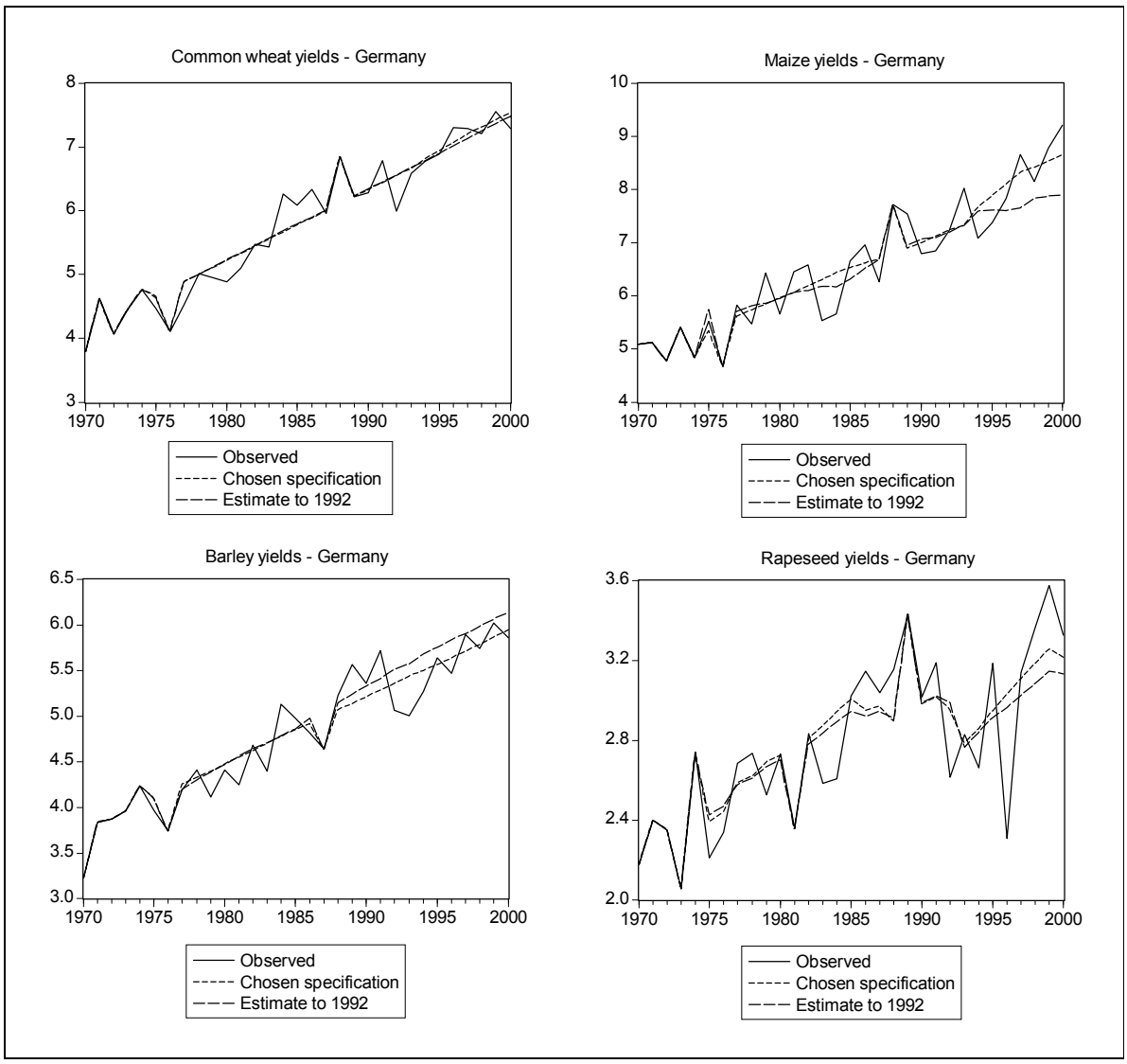
Figures in brackets are t-statistics.

The yield fit is generally good. Unsurprisingly, the trend has a significantly positive effect. While crop price has a positive effect in all the yield equations except for barley, in all cases the estimated coefficients are not significantly different from zero. The impact of payments on yield is only significantly negative for rapeseed.

Projections

The estimation results for the main arable crops in Germany prior to reform are given in the Annex. In Figure 7, the projections based on this equation are compared with observed yields and yields estimated with the equation in Table 6.

Figure 7. Germany - yields estimated with the basic specification, yields simulated without payments or set-aside (estimate for 1970-1992), and observed yields



In the case of Germany, the yields simulated without area payments or set-aside (estimated up to 1992, then projected) for common wheat, maize and rapeseed are lower than observed yields and yields estimated with the basic specification. Differences between the yields simulated without payments or set-aside and the observed yields are relatively low for common wheat (maximum 0.28 t/ha). For maize yields, the greatest difference is 1.32 t/ha. Yields in Germany rose after 1992 for common wheat, maize and rapeseed. For barley, the converse is true. The barley yields simulated without payments or set-aside (estimated up to 1992, then projected) are higher than observed yields and yields estimated with the basic specification (maximum difference 0.57 t/ha). However, it is difficult to attribute these changes solely to the introduction of payments and set-aside, owing to the reunification of Germany in 1991.

5. Interpretation and summary of results

Stable results for France

Before comparing the impacts of area payments and set-aside in EU Member States, we have summarised the results of the tests conducted for France and given in Part 2 of the Annex. Table 7 summarises the effects and significances of the main yield equation variables, namely price, area payments and the set-aside variable. The specifications tested always include the explanatory variables from the basic specification, together with others such as the price of the other commodities or support for other crops.

Table 7. France - Effects and significances of price, area payment and set-aside variables in the yield equations

	Basic specification	Introduction of cross – prices	Cross prices and support	Price in t-1, t-2 and t-3	Introduction of set-aside
Common wheat					
Price	>0*	>0*	>0*	>0	>0*
Area payment	<0	<0	>0	<0	>0
Set-aside					<0
Durum wheat					
Price	<0	>0	>0	>0	>0
Area payment	<0*	<0*	<0*	<0*	<0*
Set-aside					>0*
Barley					
Price	>0*	>0*	>0*	>0*	>0*
Area payment	<0	<0*	>0	<0*	>0
Set-aside					<0*
Maize					
Price	<0	>0	<0	<0	<0
Area payment	<0	>0	<0	<0	>0
Set-aside					<0
Rapeseed					
Price	>0	>0	>0	>0	>0
Area payment	<0	<0	<0*	<0	<0
Set-aside					<0

* Estimated coefficient significant at 10%

The effects and significances remain the same, regardless of the test. For instance, the common wheat price is significantly positive for all the specifications tested and the area payment for this commodity is never significant. This demonstrates the stability of the results and hence the reliability of the impacts of introducing area payments and set-aside.

Table 7 also contains information on the impact of set-aside on yields. Only in the case of barley does the introduction of set-aside and the relevant payments appear to have a significantly negative impact on yield.. The effect of these two variables is negative but not significantly so in the case of wheat, maize and rapeseed. Conversely, the durum wheat yield appears to have been positively affected by the introduction

of set-aside and the relevant payments, which would appear to indicate that a sufficient acreage of less productive land was set aside to push up average yields.

Summary of results by country

Table 8 recapitulates the effects of the area payment variable for each country in the chosen equations, as described in Part 4.

Table 8: Impact of the area payment variable in cereal yield equations for the leading EU Member States

	Common wheat	Durum wheat	Barley	Maize	Rapeseed/ sunflower
France	-	-*	-	-	-
Germany	+	n.s.	-	+	-
Spain	-	-*	+	-	+
Italy	-	-	-*	+*	n.s.
United Kingdom	-	n.s.	-	n.s.	n.s.

n.s.: not studied.

* Estimated coefficient significant at 10%.

The « + » sign indicates that the area payment variable has a positive effect on yields, in other words the introduction of area payments can be said to have led to an increase in yields. A « – » sign indicates that the payment variable led to a decline in the relevant crop yield. The area payment variable has a negative impact on yields in France and the United Kingdom but is significantly different from zero only for durum wheat in France. For Spain and Italy, the payment variable has a negative impact on three commodities, and in the case of maize in Italy the impact is significantly positive. For Germany, the payment variable has a positive effect for common wheat and maize yields and a negative effect for barley yields, but neither were very significant and the impact of reunification might be distorting the results. To summarise, the negative impact of payments on yields is significantly different from zero only for durum wheat in France and Spain, and for barley and maize in Italy.

Projected yields for the main arable crops in the leading EU Member States make it possible to compare yields without the introduction of payments and set aside prior to 1992 with observed yields and yields estimated over the entire period. This comparison, summarised in Table 9, shows more clearly that the introduction of area payments and set-aside had a negative impact on yields, without this being specifically attributable to the introduction of area payments, set-aside or any other factor occurring in the early 1990s.

Table 9. Impact of introducing area payments and set-aside on cereal yields in the leading EU Member States (comparison of projected and observed yields)

	Common wheat	Durum wheat	Barley	Maize	Rapeseed/ sunflower
France	-	-	-	-	0
Germany	+	n.s.	-	+	+
Spain	-	-	+	+	-
Italy	-	-	-	+	n.s.
United Kingdom	-	n.s.	-	n.s.	n.s.

n.s.: not studied.

The « + » sign indicates that the impact of the area payments and set-aside was positive, in other words yields increased. The sign « – » indicates that the introduction of payments and set-aside led to a decline in the relevant yield.

The introduction of payments and set-aside had a negative impact on cereal yields in France. For common wheat and barley, it generated a decline in yields in four of the five countries studied. For maize, the effect of these changes on yields is fairly positive, one explanation being the poor specification of the equations for Italy and Spain, in that the strong upward trend predominates in the estimates which do not reproduce annual yield changes. In fact, maize yields more than doubled in Italy and more than tripled in Spain over the period, possibly due to increased use of irrigation.

Considering yield changes in the broader European context, Table 10 shows average cereal output over the period 1990-2000 in the EU producer countries studied and recalls the impact of area payments and set-aside on yields.

Table 10. Cereal output in the various EU producer countries as an average over the period 1990-2000 (thousand tonnes)

Thousand tonnes	Common wheat	Durum wheat	Barley	Maize
France	32583	1394	9481	14053
	-	-	-	-
Germany	17908	n.s.	12534	2599
	+		-	+
Spain	3959	1108	8689	3261
	-	-	+	+
Italy	3790	4306	1472	8384
	-	-	-	+
United Kingdom	14642	n.s.	6994	n.s.
	-		-	

n.s.: not studied.

The sign beneath the tonnage figure shows the impact of payments and set-aside on yields.

According to the projections, the introduction of area payments and set-aside has a negative impact on common wheat and maize yields in France, the main EU producer of those two commodities. It has a negative impact on barley yields in Germany and France, the two leading barley producers in the EU. It also has a negative impact on durum wheat yields in Italy, the leading EU producer of that commodity. Consequently, introducing area payments and set-aside has a negative impact on yields in the leading country producing each crop. In France and the United Kingdom, the introduction of payments and set-aside has a negative impact on yields of the cereal with the highest output in those countries (common wheat). In Germany, Spain and Italy, the introduction of area payments and set-aside has a positive effect on yields of the cereals with the highest output in those countries, *i.e.* common wheat, barley and maize, respectively.

For cereals, Table 11 shows the magnitude of the estimated impact of introducing area payments and set-aside, *i.e.* the average percentage change in yields between the results obtained with the basic specification and those projected without payments or set-aside.

Table 11. Average percentage changes in cereal yields compared with the results obtained with the basic specification for the leading producer countries

Average over 1993-2000	Common wheat	Durum wheat	Barley	Maize
France	-1	-27	-5	-3
Germany	+0.6	n.s.	-3	+5
Spain	-1	-83	+16	+6
Italy	-0.6	-3	-16	+6
United Kingdom	-3	n.s.	-3	n.s.

n.s.: not studied.

In the five leading producer countries, the effects of area payments and set-aside on common wheat yields are relatively low: average changes are around 1% (in absolute terms) in all of the countries except for the United Kingdom, where the average is 3%. The effects of area payments and set-aside on yields are lowest for common wheat, compared with other cereals. Furthermore, the effects on yields of introducing area payments and set-aside are greatest for the cereals with the lowest output, namely durum wheat in France, maize in Germany and barley in Italy.

Conclusions

While the introduction of area payments and set-aside in 1992 appears to have had negative effects on the leading crop yields in the main EU countries, it is difficult, on the basis of this study, to attribute this to the introduction of area payments in most cases. This is because many of the price and payment coefficients are low and not very significant (*i.e.* the probability of them being different from zero is very low).

For all of the countries and crops in the study, the trend is clearly upward and the dummy variables for climate events are also significant. The effect of crop price on yield is significantly positive in only three cases, whereas the impact of area payments on yield is significantly negative in only two cases and significantly positive in one case. The percentage differences between the yield projected without area payments or set-aside and the observed or simulated yield over the whole period, as indicated in Table 11, are very low in most of the cases and hard to explain in others.

As this study does not allow any definite conclusions, it would be advisable to continue the research. It would, for instance, be interesting to work at a more disaggregated level, namely at the regional level, on long time series to give a more uniform picture of the regions. There is also scope to try using the regional yield variability on shorter series covering the implementation of the reform. In terms of explanatory variables, further work could be conducted on the impact of set-aside on yields. Another avenue would be to study the development of yields and their determinants in other countries that have introduced area payments.

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Annex

ALTERNATIVE SPECIFICATIONS

This Annex contains the estimation results of the tests carried out on the European Union (EU) and the individual countries in the study but not selected for inclusion in the main paper. Unless stated otherwise, they were obtained with the Ordinary Least Squares method.

1. Estimation results for the European Union

Yields were first estimated for the EU as a whole, over the period 1970-2000. The data were aggregated from national data and take into account the entry of new EU Member States since 1973, as indicated in Table A1. The yields for each commodity are based on harvested output and the combined acreage of all the countries concerned.

Table A1. Definition of the European Union

Member States in 1973	France FRG (Germany as from 1991) Italy Belgium Luxembourg Netherlands United Kingdom Ireland Denmark
Joined in 1981	Greece
Joined in 1986	Portugal Spain
Joined in 1995	Austria Finland Sweden

In the estimates, one national market is considered to be the European leader for each crop (Table A2). This assumption means that producer-price changes in the other countries are attributable to producer-price changes in the lead country. The lead price is the price in the main country producing the relevant crop, with the exception of soyabean and sunflower where only the Spanish price is available.

Table A2. Definition of lead markets in terms of prices

Crop	Lead market
Common wheat	France
Durum wheat	Italy
Barley	France
Maize	France
Rapeseed	France
Soyabean	Spain
Sunflower	Spain

1.1. Introducing basic payments

In the basic specification, yield equations are estimated as a linear function of the expected crop price, a trend, the basic payment variable (€/t) in t and dummy variables. The results are given in Table A3.

Table A3. Estimation results for EU cereal yields (1970-2000)

	Common wheat	Durum wheat	Maize	Barley
Constant	2.44	-0.31	0.74	1.39
	(1.73)	(-0.36)	(0.45)	(0.89)
Own price in t-1	-0.08	0.26	0.40	0.60
	(-0.24)	(1.70)	(0.96)	(1.50)
Trend	0.08	0.06	0.15	0.04
	(3.82)	(3.97)	(5.50)	(1.81)
Cereal payment in t	0.39	-0.26	1.36	0.75
	(0.98)	(-0.68)	(2.44)	(1.72)
Dummy[3] in 1976	-0.55		-0.69	-0.64
	(-2.29)		(-1.94)	(-2.36)
Dummy in 1984	1.13			1.01
	(4.58)			(3.68)
Dummy in 1991		0.80		
		(3.17)		
R^2	0.94	0.68	0.94	0.62
Adjusted R^2	0.93	0.63	0.93	0.53

Figures in brackets are t-statistics.

The yield equation fit is good. Crop price has a significantly positive effect for durum wheat and barley. The payment variable has a significantly positive effect for maize and barley. According to this equation, the introduction of area payments and set-aside appears to have intensified maize and barley yields. For common wheat, higher yields are also noticeable. Only durum wheat yields appear to have declined with the introduction of area payments and set-aside.

1.2. Estimating yields prior to reform

The aim of this estimate is to see how yields would have changed if area payments and set-aside had not been introduced in 1992. Yields are accordingly estimated over the period 1970-1992 (Table A4), then projected over the period 1993-2000. To obtain projections, the specification chosen for the yield equations comprises the following explanatory variables: a constant, the crop price in t-1, a trend and dummy variables.

3. A dummy in 1976 equals 1 in 1976 and 0 the other years.

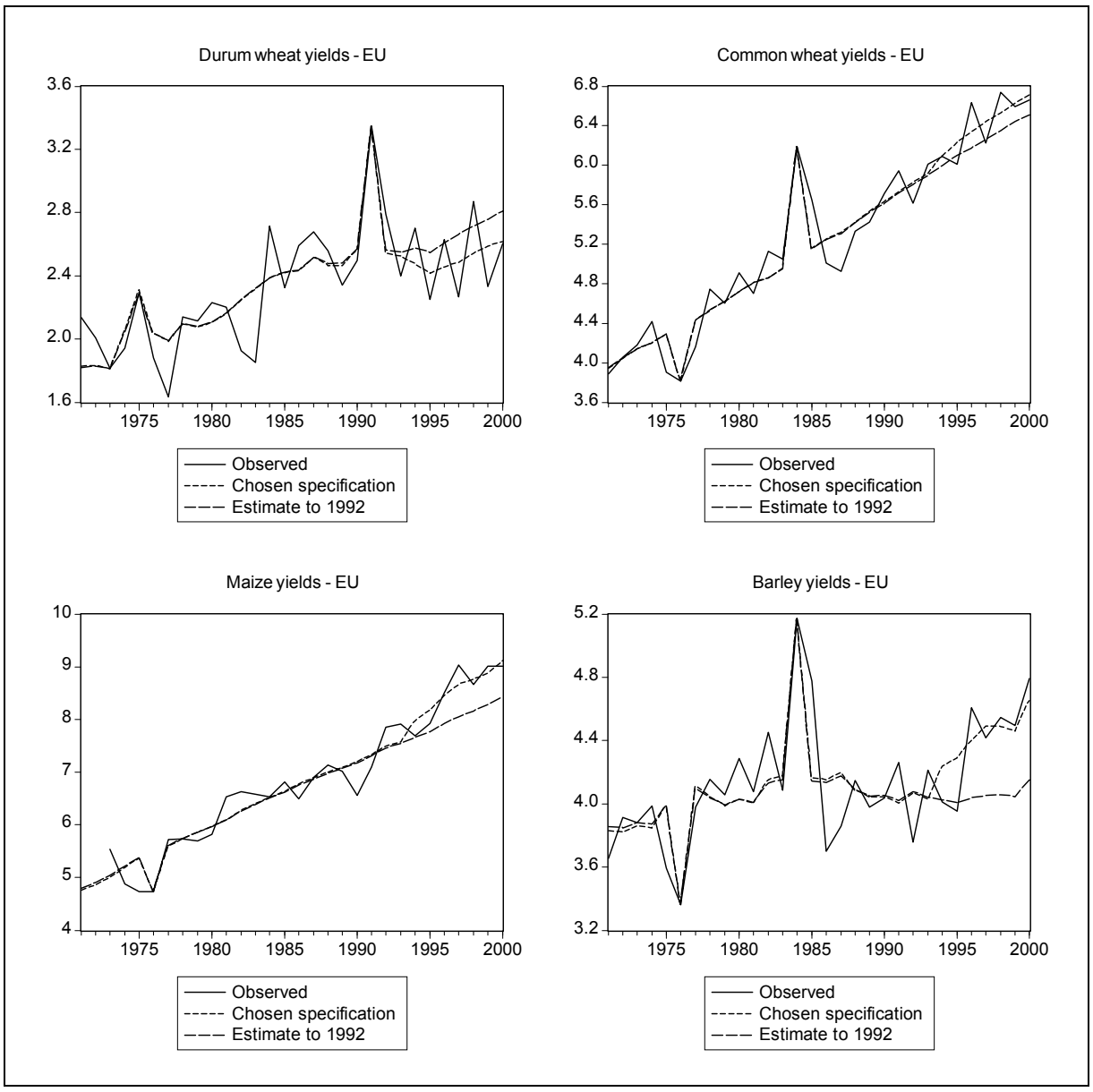
Table A4. Estimation results of cereal yields over the period 1970-1992

	Common wheat	Durum wheat	Maize	Barley
Constant	2.69	-0.30	1.63	1.81
	(1.78)	(-0.36)	(0.90)	(1.07)
Own price in t-1	-0.15	0.26	0.16	0.49
	(-0.40)	(1.72)	(0.35)	(1.14)
Trend	0.08	0.06	0.13	0.04
	(3.43)	(4.07)	(4.63)	(1.47)
Dummy in 1976	-0.55		-0.72	-0.63
	(-2.18)		(-1.94)	(-2.20)
Dummy in 1984	1.14			1.03
	(4.39)			(3.51)
Dummy in 1991		0.80		
		(3.32)		
R^2	0.90	0.73	0.86	0.60
Adjusted R^2	0.88	0.69	0.84	0.51

Figures in brackets are t-statistics.

The cereal yield fit is good. The results are the same as those obtained with the basic specification for 1970-2000. Figure A1 gives the yields estimated with the basic specification for 1970-2000, the yields estimated for 1970-1992 and projected for 1993-2000, and the cereal yields observed in the EU.

Figure A1. Cereal yields estimated with the basic specification, projected yields (estimate for 1970-1992) and observed yields



For common wheat, barley and maize, the yields observed following the 1992 reform are higher than the yields projected without area payments or set-aside. Only the observed durum wheat yield is lower than the projection. According to these results, introducing area payments and set-aside appears to have intensified cereal yields, with the exception of durum wheat.

Table A5 gives the estimated oilseed yields for 1970-1992 and projections for 1993-2000. The oilseed yield fit is good for rapeseed and soybean, and poor for sunflower. Figure A2 compares the changes in yields projected without payments or set-aside with the changes in payments observed and estimated over the whole period for oilseeds.

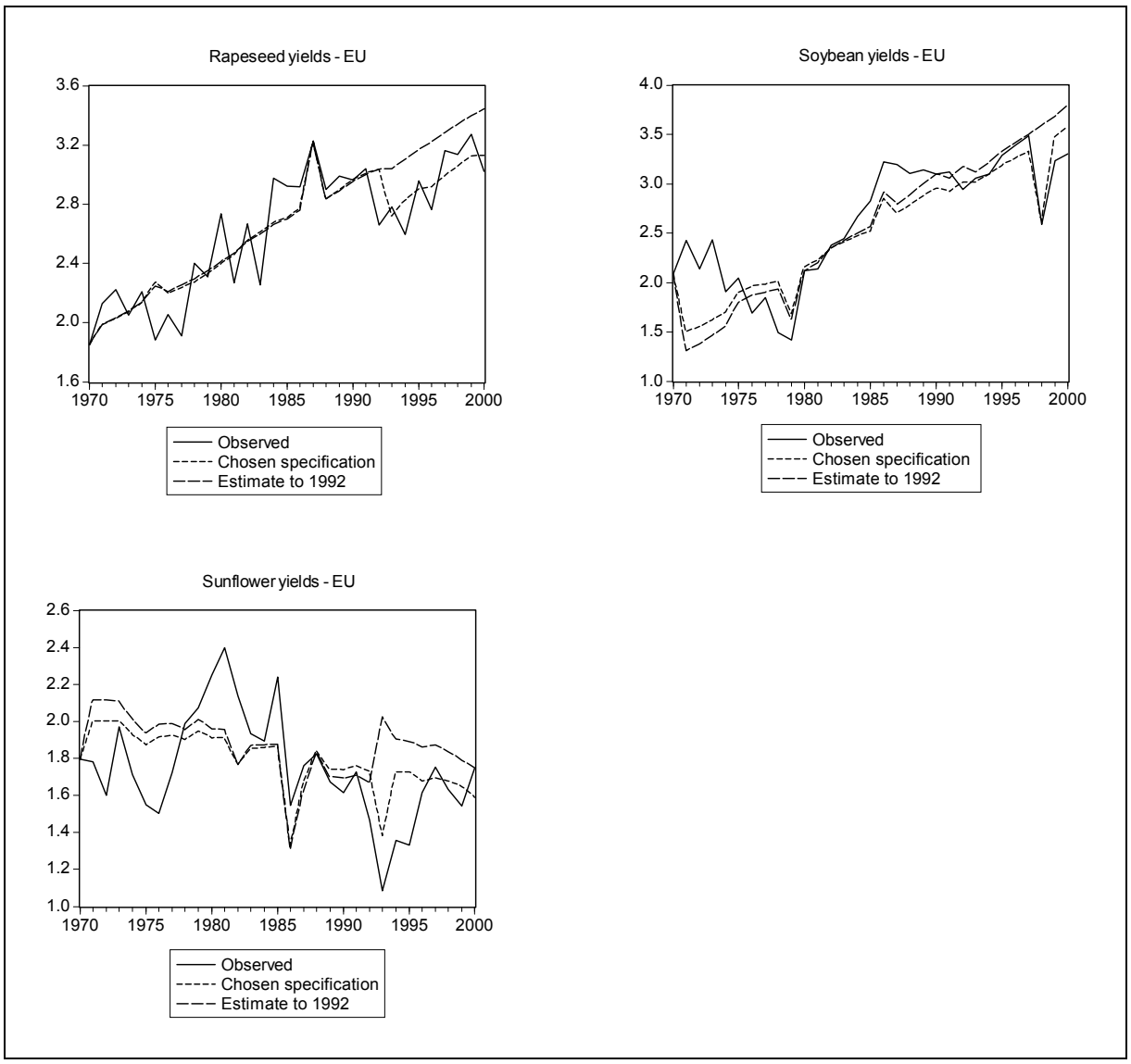
Table A5. Estimation results for oilseed yields over the period 1970-1992

	Rapeseed	Soyabean	Sunflower
Constant	0.55	-1.06	3.34
	(0.64)	(-0.88)	(2.48)
Own price in t-1	0.07	0.12	-0.20
	(0.44)	(0.85)	(-1.66)
Trend	0.06	0.09	-0.03
	(3.67)	(3.27)	(-0.80)
Dummy in 79		-0.38	
		(-1.89)	
Dummy in 86		0.27	-0.51
		(1.36)	(-3.02)
Dummy in 87	0.41		
	(1.65)		
R^2	0.74	0.88	0.55
Adjusted R^2	0.70	0.84	0.44

Figures in brackets are t-statistics.

For oilseeds, the yields observed after the 1992 reform are lower than the yields projected without area payments or set-aside and those estimated with the basic specification for 1970-2000. Although the sunflower yield fit is poor, the yields projected without area payments or set-aside are higher than the observed yields. According to these estimates, introducing area payments and set-aside appears to have caused a decline in oilseed yields in the European Union.

Figure A2. Oilseed yields estimated with the basic specification (1970-2000), yields projected for 1993-2000 (without payments or set-aside) and observed yields



To refine these results, estimates were produced for the leading arable-crop producing countries in the EU. The tests that were not selected are set out in this annex, whereas the chosen specifications and comparative charts appear in the main paper.

2. Tests on France

2.1. Introducing area payments

Each yield equation is estimated as a linear function of the expected crop price, a trend and the area payment for cereals (oilseeds). The area payment is defined using the basic payment and the regionalised reference yield. For France, there are reference yields for small grains, maize, sunflower, soyabean and rapeseed. This gives five area payment variables, given in Table A6.

Table A6. Definition of area payments – France
(Unit: €/ha)

	Small grains	Maize	Rapeseed	Soyabean	Sunflower
1992			501.67	699.17	494.17
1993	145	165.50	469.25	653.99	462.24
1994	203	231.70	469.25	653.99	462.24
1995	261	297.90	568.04	791.67	559.55
1996	315.17	359.73	568.04	791.67	559.55
1997	315.17	359.73	568.04	791.67	559.55
1998	315.17	359.73	568.04	791.67	559.55
1999	315.17	359.73	568.04	791.67	559.55
2000	340.28	388.39	492.07	685.80	484.72
2001	365.40	417.06	435.67	607.18	429.15
2002	365.40	417.06	379.26	528.58	373.59

Source : CAP Monitor (Agra Europe).

The equations corresponding to this specification are given in Table 2 of the main paper. Crop price has a positive effect for common wheat, barley and rapeseed. In the yield equations for durum wheat and maize, own price is negative but not significant. The payment variable has a negative effect in all the yield equations but is only significant for durum wheat.

2.2. Introducing cross-price effects

In each yield equation, all the price effects of the other crops are introduced, with no *a priori* assumption regarding substitution/complementarity relations between crops. Symmetry constraints are imposed and the estimating method used is the iterative Zellner method (SURE). The following explanatory variables were selected: a constant, crop price in t-1 (deflated by the input price), price of the other crops in t-1 (deflated by input price), a trend, an area payments variable in t (deflated by input price) and dummy variables. No account is taken of substitution/complementarity relations if they are not significant at the 20% threshold. The results are given in Table A7.

Table A7. Estimation results for yields in France with cross-price effects and area payments in t (1970-2000)

	Common wheat	Durum wheat	Barley	Maize	Rapeseed
Constant	-2.24	2.24	-4.78	5.19	-0.70
	(-1.13)	(1.69)	(-3.06)	(2.66)	(-0.70)
Price in t-1					
Common wheat	1.57				
	(2.56)				
Durum wheat		0.42			
		(1.08)			
Barley	0.73	0.22	2.00		
	(1.68)	(1.55)	(4.06)		
Maize		-0.84		0.18	
		(-1.93)		(0.16)	
Rapeseed	0.27		0.36	0.34	0.14
	(1.65)		(2.60)	(1.34)	(0.83)
Trend	0.25	0.12	0.28	0.11	0.10
	(6.23)	(3.80)	(8.76)	(3.23)	(4.49)
Area payment in t	-0.056	-0.56	-0.15	0.10	-0.006
	(-0.94)	(-5.51)	(-3.37)	(0.95)	(-0.24)
Dummy in 76				-1.02	
				(-2.19)	
Dummy in 77					-0.66
					(-3.25)
Dummy in 84	0.59		0.28		
	(2.30)		(1.62)		
Dummy in 87					0.80
					(3.98)
Dummy in 90				-1.23	
				(-3.03)	
Dummy in 98		0.88			
		(2.19)			
R^2	0.94	0.73	0.94	0.93	0.80
Adjusted R^2	0.92	0.66	0.92	0.91	0.71

Figures in brackets are t-statistics.

The results reveal substitution/complementarity relations between crops. The complementarity relations (significant at the 20% threshold) are as follows: common wheat and barley, common wheat and rapeseed, durum wheat and barley, barley and rapeseed, maize and rapeseed. There is a substitution relation between durum wheat and maize. The results for the payment variable remain the same; only the estimated coefficient for the payment in the barley yield equation becomes significantly different from zero, compared with the results obtained without cross-price effects (cf. Table 2). The fit is not as good for common wheat, durum wheat and rapeseed (R^2 and adjusted R^2 are lower than those in Table 2).

2.3. Introducing prices in t-1, t-2 and t-3

In each yield equation, crop price is introduced in t-1, t-2 and t-3. The other explanatory variables are as follows: a constant, the area payment for the crop in t, a trend and dummy variables. Prices and payments are deflated by the input price. The results are given in Table A8.

Table A8. Estimation results of yields in France with crop price introduced in t-1, t-2 and t-3 (1970-2000)

	Common wheat	Durum wheat	Barley	Maize	Rapeseed
Constant	-3.19	4.21	-4.30	10.48	1.94
	(-0.88)	(1.97)	(-1.12)	(2.48)	(2.84)
Price in t-1	1.58	0.33	2.26	-1.27	0.26
	(1.41)	(0.66)	(2.15)	(-0.88)	(1.26)
Price in t-2	1.45	-0.79	0.93	-0.67	0.31
	(1.33)	(-1.59)	(0.92)	(-0.72)	(1.43)
Price in t-3	-0.05	-0.20	0.03	-1.33	-0.65
	(-0.05)	(-0.42)	(0.03)	(-1.37)	(-3.29)
Trend	0.27	0.07	0.27	0.05	0.05
	(3.83)	(1.19)	(3.64)	(0.72)	(2.91)
Area payment in t	-0.007	-0.48	-0.14	-0.14	-0.023
	(-0.08)	(-4.21)	(-1.83)	(-1.17)	(-0.66)
Dummy in 76				-1.05	
				(-1.88)	
Dummy in 84	0.88		0.65		
	(2.76)		(2.15)		
Dummy in 87					0.83
					(3.13)
Dummy in 90				-1.54	
				(-3.41)	
Dummy in 98		1.20			
		(2.43)			
R^2	0.94	0.76	0.93	0.95	0.85
Adjusted R^2	0.92	0.68	0.91	0.93	0.81

Figures in brackets are t-statistics.

The estimated coefficients for price in t-1 and area payments are the same as those estimated in the equations without the various lags (Table 2). The signs and significances are the same, except for barley, where the payment becomes significant. The estimated coefficient for crop price in t-2 is significantly different from zero for common wheat, durum wheat and rapeseed, but does not have the same effect on the yields of these three commodities. This is because the price in t-2 has a positive effect in the yield equation for common wheat and rapeseed, and a negative effect in the yield equation for durum wheat. The crop price in t-3 is significant for maize and rapeseed, and in both cases the impact is negative. The fit is better for maize and rapeseed, and less good for common wheat and durum wheat, than the fit in Table 2.

2.4. Introducing set-aside

To measure the impact of set-aside on yields, the set-aside acreage (in t) is added to the explanatory variables in the basic specification, *i.e.* a constant, crop price in t-1 (deflated by the input price), a trend, the area payment in t (deflated by the input price) and dummy variables. The estimation results are given in Table A9.

Table A9. Estimation results for yields in France with set-aside acreage (1970-2000)

	Common wheat	Durum wheat	Barley	Maize	Rapeseed
Constant	-1.37	2.24	-3.87	6.30	1.22
	(-0.67)	(1.79)	(-1.79)	(2.53)	(1.97)
Price in t-1	2.20	0.05	3.12	-1.11	0.19
	(2.39)	(0.11)	(3.12)	(-0.88)	(0.91)
Trend	0.23	0.10	0.26	0.11	0.06
	(5.71)	(2.97)	(5.94)	(2.62)	(3.84)
Area payment for crop in t	0.09	-0.68	0.09	0.04	-0.017
	(0.75)	(-3.54)	(0.81)	(0.26)	(-0.34)
Set-aside acreage	-0.0002	0.00047	-0.0004	-0.00015	-5 10-6
	(-1.11)	(1.57)	(-2.08)	(-0.54)	(-0.03)
Dummy in 72	0.61				
	(1.86)				
Dummy in 76				-1.36	
				(-2.62)	
Dummy in 77					-0.70
					(-2.28)
Dummy in 84	0.87		0.60		
	(2.81)		(2.08)		
Dummy in 87					0.81
					(2.73)
Dummy in 90				-1.48	
				(-2.87)	
Dummy in 91		0.59			
		(1.28)			
Dummy in 98		1.61			
		(3.03)			
R^2	0.94	0.78	0.94	0.92	0.81
Adjusted R^2	0.93	0.72	0.92	0.91	0.75

Figures in brackets are t-statistics.

For common wheat, maize and rapeseed, the set-aside acreage does not have a significant effect. For durum wheat, the set-aside acreage has a significantly positive effect. For barley, the set-aside acreage has a significantly negative effect. However, these effects are extremely slight. The results on the effect of area

payments are not as good as those in Table 2 of the main paper, and in the end this specification was not selected.

2.5. Test for structural change in the trend

The equation in Table A10 tests for structural change in the trend from 1992 onwards. In the chosen specification, the explanatory variables are as follows: a constant, crop price in t-1, a trend (with a multiplicative dummy from 1992 onwards), the area payment and dummy variables.

The multiplicative dummy for the trend is not significant for common wheat, durum wheat or rapeseed. For these commodities, there can be said to be no change in the impact of the trend on yields. For barley and maize, the multiplicative dummy for the trend is significant, but the effect varies across crops. From 1992 onwards, the effect of the trend on barley yields is less strong. For maize, the trend has a stronger impact on yields after the reform. The results concerning the effects of payments remain the same, and the estimated coefficients for the payments are not significant except in the case of durum wheat.

Table 1. Table A10. Estimation results of yields in France with structural change in the trend (1970-2000)

	Common wheat	Durum wheat	Barley	Maize	Rapeseed
Constant	-1.66	2.10	-5.28	6.87	1.24
	(-0.79)	(1.60)	(-2.09)	(2.88)	(2.08)
Own price in t-1	2.31	0.06	3.75	-1.34	0.18
	(2.48)	(0.14)	(3.23)	(-1.12)	(0.94)
Trend	0.24	0.12	0.29	0.09	0.065
	(5.69)	(3.25)	(5.57)	(2.18)	(3.82)
Trend multiplied by a dummy for 1992-2000	-0.016	-0.016	-0.025	0.028	0.025
	(-1.15)	(-0.81)	(-1.73)	(1.51)	(0.46)
Area payment for crop in t	0.11	-0.35	0.11	-0.22	-0.14
	(0.84)	(-1.84)	(0.82)	(-1.24)	(-0.53)
Dummy in 72	0.64				
	(1.93)				
Dummy in 76				-1.42	
				(-2.86)	
Dummy in 77					-0.70
					(-2.31)
Dummy in 84	0.85		0.54		
	(2.72)		(1.81)		
Dummy in 87					0.81
					(2.77)
Dummy in 90				-1.38	
				(-2.82)	
Dummy in 98		1.21			
		(2.40)			
R^2	0.94	0.74	0.93	0.93	0.81
Adjusted R^2	0.93	0.69	0.92	0.91	0.76

Figures in brackets are t-statistics.

2.6. Test for structural change in the trend and constant

The equation in Table A11 is used to test for structural change in the trend from 1992 and the constant. In the chosen specification, the explanatory variables are as follows: a constant, a dummy variable after the reform (equal to 1 as from 1992), the crop price in t-1, a trend (with a multiplicative dummy from 1992 onwards), the area payment and dummy variables.

Table A11. Estimation results for yields in France with structural change in the trend and constant (1970-2000)

	Common wheat	Durum wheat	Barley	Maize	Rapeseed
Constant	-1.88	1.57	-5.51	7.01	1.67
	(-0.89)	(1.46)	(-2.189)	(2.87)	(2.69)
Dummy for 1992-2000	-1.91	9.95	-2.27	-1.52	-3.31
	(-0.88)	(3.55)	(-1.12)	(-0.50)	(-1.75)
Own price in t-1	2.42	0.23	3.85	-1.41	0.104
	(2.55)	(0.62)	(3.33)	(-1.15)	(0.20)
Trend	0.24	0.13	0.29	0.09	0.054
	(5.72)	(4.45)	(5.67)	(2.06)	(3.08)
Trend multiplied by a dummy for 1992-2000	0.07	-0.46	0.077	0.09	0.031
	(0.71)	(-3.64)	(1.83)	(0.71)	(0.59)
Area payment for crop in t	-0.04	-0.42	-0.067	-0.34	0.44
	(-0.18)	(-1.57)	(-0.32)	(-1.15)	(1.05)
Dummy in 72	0.62				
	(1.88)				
Dummy in 76				-1.44	
				(-2.84)	
Dummy in 77					-0.78
					(-2.66)
Dummy in 84	0.84		0.54		
	(2.69)		(1.80)		
Dummy in 87					0.84
					(2.99)
Dummy in 90				-1.39	
				(-2.79)	
Dummy in 98		1.73			
		(3.97)			
R^2	0.95	0.84	0.94	0.93	0.83
Adjusted R^2	0.93	0.79	0.92	0.91	0.78

Figures in brackets are t-statistics.

Introducing a dummy variable additively changes the results. The multiplicative dummy for the trend is not significant for any crop except durum wheat. For that commodity, the effect of the trend on yields becomes negative following the reform. Introducing the dummy additively for the period 1992-2000 reveals any change in the constant following the reform. This dummy variable is only significant for durum wheat and rapeseed. The constant in the durum wheat equation is much higher after the reform, *i.e.* from 1992 onwards, with a value of over 10. For rapeseed, the constant becomes negative following the reform. The results for the effects of payments remain the same, and the estimated coefficients for payments are not significant except in the case of durum wheat.

2.7. Projections

The estimation results obtained over the period 1970-1992 are given in Table A12, while changes in projected and observed yields are given in Figure 3 of the main paper.

Table A12. Estimation results for yields in France over the period 1970-1992

	Common wheat	Durum wheat	Barley	Maize	Rapeseed
Constant	-1.43	1.77	-3.81	8.37	1.60
	(-0.65)	(1.80)	(-1.56)	(3.07)	(2.39)
Own price in t-1	2.23	0.19	3.09	-2.14	0.08
	(2.24)	(0.57)	(2.74)	(-1.56)	(0.36)
Trend	0.23	0.12	0.25	0.08	0.05
	(5.30)	(4.36)	(5.24)	(1.67)	(2.89)
Dummy in 72	0.61				
	(1.82)				
Dummy in 76				-1.57	
				(-2.96)	
Dummy in 77					-0.76
					(-2.47)
Dummy in 84	0.87		0.60		
	(2.74)		(1.90)		
Dummy in 87					0.88
					(3.00)
Dummy in 90				-1.65	
				(-3.14)	
Dummy in 91		0.52			
		(1.47)			
R^2	0.92	0.85	0.90	0.87	0.76
Adjusted R^2	0.90	0.83	0.89	0.84	0.71

Figures in brackets are t-statistics.

The estimation results for yields in France over the period 1970-1992 are good. The same results are found: the estimated coefficients for own prices of common wheat and maize are positive and significantly different from zero.

3. Tests on Italy

3.1. Introducing area payments

Each yield equation is estimated as a linear function of the expected crop price, a trend, and the area payment for cereals (oilseeds). The area payment is defined using the basic payment and the regionalised reference yield. For Italy, there are reference yields for small grains, maize, oilseeds and rice. This gives four area payment variables, which are shown in Table A13.

Table A13. Definition of area payments for Italy
(Unit: €/ha)

	Small grains	Maize	Oilseeds	Rice
1992			258.33	
1993	77.50	187.50	241.64	
1994	108.50	262.50	241.64	
1995	139.50	337.50	292.51	
1996	168.45	407.55	292.51	
1997	168.45	407.55	292.51	104.76
1998	168.45	407.55	292.51	203.70
1999	168.45	407.55	292.51	308.46
2000	168.45	407.55	292.51	308.46
2001	181.88	440.02	253.39	308.46
2002	195.30	472.5	224.35	308.46

Source : CAP Monitor (Agra Europe).

The price and payment variables are deflated by the general consumer price index. The commodities are chosen according to their importance and data availability. In the case of Italy, for instance, the crops under consideration are common wheat, durum wheat, barley and maize. The estimation results are given in Table 3 of the main paper.

The yield fit is generally good. The area payment effect is significant for barley and maize but the effects are contrasted, *i.e.* negative in the barley yield equation and positive in the maize equation. For common wheat and durum wheat, the payment variable is negative but not significant.

3.2. Introducing cross-price effects

In each yield equation, all the price effects of the other crops are introduced, without any *a priori* assumptions as to substitution/complementarity relations between crops. Symmetry constraints are imposed and the Zellner (SURE) method of estimation is used. The explanatory variables selected are as follows: a constant, the crop price in t-1 (deflated by the general consumer price index), the price of the other crops in t-1 (deflated by the general consumer price index), a trend, an area payment variable in t (deflated by the general consumer price index) and dummy variables. No account is taken of substitution/complementarity relations that are not significant at the 20% threshold. The results are given in Table A14.

Table A14. Estimation results for yields in Italy with cross-prices and area payments in t (1970-2000)

	Common wheat	Durum wheat	Barley	Maize
Constant	2.38	1.57	0.21	0.89
	(3.13)	(1.90)	(0.29)	(0.93)
Price in t-1				
Common wheat	0.04			
	(0.16)			
Durum wheat		0.09		
		(0.53)		
Barley	-0.35		-0.20	
	(-1.90)		(-0.75)	
Maize		-0.41	0.75	0.35
		(-2.23)	(2.48)	(0.84)
Trend	0.05	0.03	0.08	0.15
	(4.13)	(2.17)	(6.12)	(8.90)
Area payment in t	-0.004	-0.16	-0.33	0.18
	(-0.05)	(-1.25)	(-3.38)	(2.90)
Dummy in 77	-0.33		-0.45	
	(-1.92)		(-2.61)	
Dummy in 88	-0.24			
	(-1.79)			
Dummy in 89		-0.68		
		(-2.95)		
R^2	0.94	0.67	0.93	0.96
Adjusted R^2	0.92	0.60	0.91	0.95

Figures in brackets are t-statistics.

The results show that there are substitution/complementarity relations between the various crops. The substitution relations (significant at the 20% threshold) are as follows: common wheat and barley, and durum wheat and maize. There is complementarity between barley and maize. The results for the payment variable remain the same, with the exception of the estimated coefficient for the payment in the yield equation for durum wheat which becomes significantly different from zero (for a threshold just above 20%), compared with the results obtained without the cross-price effects (Table 3). The fits are similar.

3.3. Introducing prices in t-1, t-2 and t-3

Various lags in the price effects are introduced. In each yield equation, crop price is introduced in t-1, t-2 and t-3. The other explanatory variables are as follows: a constant, the area payment for the crop in t, a trend and dummy variables. Prices and payments are deflated by the general consumer price index. The results are given in Table A15.

Table A15. Estimation results for yields in Italy with crop price introduced in t-1, t-2 and t-3 (1970-2000)

	Common wheat	Durum wheat	Barley	Maize
Constant	3.21	0.97	0.36	1.12
	(3.01)	(0.52)	(0.33)	0.85
Price in t-1	0.38	0.16	0.16	-0.10
	(0.87)	(0.63)	(0.52)	(-0.15)
Price in t-2	-1.01	0.10	-0.31	0.95
	(-2.26)	(0.36)	(-0.83)	(1.22)
Price in t-3	0.14	-0.38	0.18	-0.26
	(0.39)	(-1.06)	(0.51)	(-0.46)
Trend	0.04	0.05	0.08	0.15
	(2.18)	(1.41)	(4.34)	(6.71)
Area payment in t	-0.013	-0.24	-0.43	0.23
	(-0.13)	(-1.45)	(-3.87)	(3.16)
Dummy in 77	-0.64	0.10	-0.48	
	(-2.73)	(0.20)	(-1.79)	
Dummy in 88	-0.28			
	(-1.50)			
Dummy in 89		-0.77		
		(-2.62)		
R^2	0.94	0.71	0.90	0.95
Adjusted R^2	0.92	0.60	0.87	0.94

Figures in brackets are t-statistics.

The estimated coefficients for price in t-1 are not significant for any of the crops. The estimated coefficient for crop price in t-2 is significant only for common wheat (negative effect). The price variable lagged 3 periods is never significant. The results for area payments are the same as those in Table 3 of the main paper, with the exception of durum wheat where the estimated coefficient for the area payment variable becomes significant. The fit is less good for maize and barley, but better for durum wheat (no difference for common wheat).

3.4. Introducing set-aside

To measure the impact of set-aside on yields, the set-aside acreage in t is added to the selected explanatory variables, i.e. a constant, the crop price in t-1 (deflated by the general consumer price index), a trend, the area payment in t (deflated by the general consumer price index) and dummy variables. The results obtained with the set-aside acreage are given in Table A16.

Table A16. Estimation results for yields in Italy with set-aside acreage (1970-2000)

	Common wheat	Durum wheat	Barley	Maize
Constant	2.66	0.87	-0.43	0.70
	(3.04)	(0.92)	(-0.66)	(0.75)
Price in t-1	-0.36	0.01	0.21	0.63
	(-1.61)	(0.07)	(1.22)	(2.04)
Trend	0.05	0.04	0.09	0.16
	(3.27)	(2.21)	(8.66)	(10.36)
Area payment for crop in t	-0.13	-0.26	-0.62	0.26
	(-1.12)	(-1.40)	(-5.23)	(3.09)
Set-aside acreage	0.0006	0.0009	0.0008	-0.0006
	(1.63)	(1.49)	(2.00)	(-0.95)
Dummy in 77	-0.31	-0.42	-0.37	
	(-1.64)	(-1.51)	(-2.12)	
Dummy in 88	-0.33			
	(-1.80)			
Dummy in 89		-0.74		
		(-2.57)		
R^2	0.94	0.68	0.94	0.96
Adjusted R^2	0.93	0.60	0.92	0.95

Figures in brackets are t-statistics.

The effect of the set-aside acreage on yields is slightly positive but significant for common wheat, durum wheat and barley. For the first two cereals the significance of the area payment is better than in the equation in Table 3. For maize, however, the area payment still has a significantly positive effect but the effect of the set-aside acreage is not significant. For symmetry with the basic equations for the other countries, these equations are not included in the main paper.

3.5. Test for structural change in the trend

The equation in Table A17 is used to test for structural change in the trend from 1992 onwards. In the chosen specification, the explanatory variables are as follows: a constant, the crop price in t-1, a trend (with a multiplicative dummy from 1992 onwards) and dummy variables.

Table A17. Estimation results for yields in Italy with structural change in the trend (1970-2000)

	Common wheat	Durum wheat	Barley	Maize
Constant	2.48 (3.15)	0.97 (1.05)	-0.27 (-0.39)	0.44 (0.50)
Own price in t-1	-0.27 (-1.31)	0.03 (0.16)	0.17 (0.90)	0.80 (2.73)
Trend	0.05 (3.59)	0.035 (1.97)	0.09 (7.85)	0.15 (11.86)
Trend multiplied by dummy for 1992-2000	0.01 (2.93)	0.011 (1.81)	0.001 (0.30)	0.014 (2.10)
Area payment for crop in t	-0.30 (-2.33)	-0.38 (-1.76)	-0.50 (-3.43)	0.07 (0.71)
Dummy in 77	-0.35 (-2.00)	-0.45 (-1.57)	-0.37 (-1. 49)	
Dummy in 88	-0.26 (-1.57)			
Dummy in 89		-0.67 (-2.33)		
R^2	0.95	0.70	0.92	0.96
Adjusted R^2	0.94	0.61	0.91	0.96

Figures in brackets are t-statistics.

For all the commodities excluding barley, there is a change in the trend from 1992 onwards. The coefficient estimated for the trend is higher from 1992 onwards for all of the commodities. The results for price effects remain the same (compared with the results in Table 3). The results for the payment variable differ from the previous ones. The area payment becomes significant for all of the commodities except rapeseed; the payment has a negative impact on yields.

3.6. Test for structural change in the trend and constant

The equation in Table A18 is used to test for structural change in the trend from 1992 onwards. In the chosen specification, the explanatory variables are as follows: a constant, a dummy variable introduced additively over the period 1992-2000, the crop price in t-1, a trend (with a multiplicative dummy as from 1992) and dummy variables.

Table A18. Estimation results for yields in Italy with a structural change in the trend and constant (1970-2000)

	Common wheat	Durum wheat	Barley	Maize
Constant	2.47	0.93	-0.33	0.41
	(3.14)	(0.97)	(-0.49)	(0.48)
Dummy for 1992-2000	1.76	0.81	3.17	-4.18
	(1.01)	(0.27)	(1.63)	(-1.38)
Own price in t-1	-0.27	0.03	0.17	0.83
	(-1.32)	(0.19)	(0.97)	(2.87)
Trend	0.05	0.035	0.09	0.15
	(3.63)	(1.95)	(8.23)	(11.03)
Trend multiplied by dummy for 1992-2000	-0.03	-0.007	-0.007	0.11
	(-0.74)	(-0.11)	(-1.60)	(2.17)
Area payment for crop in t	-0.14	-0.31	-0.23	-0.08
	(-0.73)	(-0.91)	(-1.05)	(-0.58)
Dummy in 77	-0.34	-0.43	-0.36	
	(-1.98)	(-1.53)	(-1. 98)	
Dummy in 88	-0.26			
	(-1.59)			
Dummy in 89		-0.67		
		(-2.28)		
R^2	0.96	0.70	0.93	0.96
Adjusted R^2	0.94	0.60	0.91	0.96

Figures in brackets are t-statistics.

Introducing a dummy variable over the period 1992-2000 leads to changes in the results. This dummy variable is significant for barley and maize but the constant is not significant for either crop. The multiplicative dummy for the trend is significant for barley and maize. The trend has a weaker impact on barley yields after the reform and a stronger impact on maize yields. The payment variable is not significant for any crop.

3.7. Projections

To obtain the projections, the specification chosen for the yield equations comprises the following explanatory variables: a constant, the crop price in t-1, a trend and dummy variables. The yield equations are estimated over the period 1970-1992. The projections for 1993-2000 are compared with observed yields. The estimation results obtained for 1970-1992 are given in Table A19, while charts showing the development of projected and observed yields are included and discussed in the main paper (Figure 4).

Table A19. Estimation results for yields in Italy over the period 1970-1992

	Common wheat	Durum wheat	Barley	Maize
Constant	2.72	0.99	-0.39	0.69
	(3.35)	(1.00)	(-0.60)	(0.70)
Own price in t-1	-0.38	-0.002	0.19	0.64
	(-1.81)	(-0.01)	(1.13)	(1.98)
Trend	0.05	0.04	0.10	0.16
	(3.46)	(1.98)	(8.64)	(9.96)
Dummy in 77	-0.31	-0.43	-0.37	
	(-1.75)	(-1.48)	(-2.10)	
Dummy in 88	-0.33			
	(-1.97)			
Dummy in 89		-0.73		
		(-2.46)		
R^2	0.92	0.55	0.93	0.90
Adjusted R^2	0.90	0.46	0.92	0.89

Figures in brackets are t-statistics.

4. Spain

4.1. Introducing area payments

Each yield equation is estimated as a linear function of the expected crop price, a trend, and the area payment for cereals (oilseeds). The area payment is defined using the basic payment and the regionalised reference yield. For Spain, there are reference yields for small grains and maize. The two area payment variables are defined in Table A20.

Table A20. Definition of area payments for Spain
(Unit: €/ha)

	Small grains	Maize
1992		
1993	57	154.25
1994	79.8	215.95
1995	102.6	277.65
1996	123.89	335.28
1997	123.89	361.99
1998	123.89	361.99
1999	123.89	361.99
2000	133.76	361.99
2001	143.64	388.71
2002	143.64	388.71

Source : CAP Monitor (Agra Europe)

The price and payment variables are deflated by the general consumer price index. The estimation results for the basic specification are given in Table 4 of the main paper.

The yield fit is good, except for barley and sunflower where it is poor. Crop price has a positive effect in all of the yield equations but the effect is only significant for barley and sunflower. The area payment variable has a negative effect in the yield equations for common wheat, durum wheat and maize, but only the estimated coefficient for durum wheat is significantly different from zero. The area payment variable has a positive effect in the yield equations for barley and sunflower. The trend has a significantly positive impact in all of the yield equations.

4.2. Projections

To obtain the projections, the chosen specification for the yield equations comprises the following explanatory variables: a constant, the crop price in t-1, a trend and dummy variables. The yield equations are estimated for 1970-1992 and given in Table A21.

Table A21. Estimation results for yields in Spain over the period 1970-1992

	Common wheat	Durum wheat	Barley	Maize	Sunflower
Constant	-3.25	-4.82	-0.56	-1.17	-0.62
	(-1.04)	(-0.96)	(-0.29)	(-0.50)	(-1.23)
Own price in t-1	0.76	0.84	0.56	0.11	0.14
	(1.09)	(0.81)	(1.19)	(0.21)	(1.66)
Trend	0.12	0.16	0.05	0.19	0.03
	(2.05)	(1.73)	(1.35)	(4.51)	(3.73)
Dummy in 84	0.63	1.23	0.72	0.45	0.26
	(1.93)	(2.95)	(2.10)	(2.22)	(2.77)
Dummy in 88		0.58	0.84		0.35
		(2.38)	(2.40)		(3.49)
R^2	0.65	0.77	0.44	0.94	0.79
Adjusted R^2	0.60	0.72	0.31	0.93	0.74

Figures in brackets are t-statistics.

Figure 5 in the main paper gives observed yields, yields estimated for 1970-2000 with the basic specification, and projected yields without the introduction of area payments or set-aside (*i.e.* estimated for 1970-92 then projected for 1993-2000).

5. United Kingdom

5.1. Introducing area payments

Each yield equation is estimated as a linear function of the expected crop price, a trend, and the area payment for cereals (oilseeds). The area payment is defined using the basic payment and the regionalised reference yield. For the United Kingdom, there is a reference yield for cereals only. The level of the area payment variable is given in Table A22.

Table A22. Definition of area payments for the United Kingdom (Unit:€/ha)

	Small grains
1992	
1993	148.25
1994	207.55
1995	266.85
1996	322.24
1997	322.24
1998	322.24
1999	322.24
2000	347.91
2001	373.59
2002	373.59

Source : CAP Monitor (Agra Europe)

The price and payment variables are deflated by the general consumer price index. The estimation results for the basic specification are given in Table 5 of the main paper. The yield fits are good. Crop price has a positive effect in the yield equation for common wheat and negative in the barley yield equation, but in both cases the estimated coefficients are significantly different from zero. The area payment variable has a negative effect in all the yield equations, but the estimated coefficients are not significant.

5.2. Projections

To obtain the projections, the chosen specification for the yield equations has the following explanatory variables: a constant, the crop price in t-1, a trend and dummy variables. The yield equations are estimated for 1970-1992 and given in Table A23.

Table A23. Estimation results for yields in the United Kingdom over the period 1970-1992

	Common wheat	Barley
Constant	1.31	3.07
	(1.14)	(4.46)
Own price in t-1	-0.01	-0.27
	(-0.04)	(-1.57)
Trend	0.14	0.06
	(6.79)	(5.12)
Dummy in 76	-1.13	-0.61
	(-3.37)	(-2.65)
Dummy in 84	-1.58	0.88
	(-4.68)	(3.82)
Dummy in 87	-0.57	
	(-1.69)	
R^2	0.94	0.90
Adjusted R^2	0.92	0.88

Figures in brackets are t-statistics.

Figure 6 in the main paper gives observed yields, yields estimated for 1970-2000 with the basic specification, and projected yields without the introduction of area payments or set-aside (*i.e.* estimated for 1970-92 then projected for 1993-2000).

6. Germany

6.1. Introducing area payments

Each yield equation is estimated as a linear function of the expected crop price, a trend, and the area payment for cereals (oilseeds). The area payment is defined using the basic payment and the regionalised reference yield. For Germany, there are reference yields for small grains and maize, and the two area payment variables are given in Table A24.

Table A24. Definition of area payments for Germany
(Unit:€/ha)

	Small grains	Maize
1992		
1993	138.50	154.25
1994	193.90	215.95
1995	249.30	277.65
1996	301.04	335.28
1997	301.04	335.28
1998	301.04	335.28
1999	301.04	335.28
2000	325.03	361.99
2001	349.02	388.71
2002	349.02	388.71

Source : CAP Monitor (Agra Europe)

The price and payment variables are deflated by the general consumer price index. The estimation results for the basic specification are given in Table 6 of the main paper. The yield fits are good. Crop price has a positive effect in all the yield equations except barley, but in every case the estimated coefficients are not significantly different from zero. The area payment variable has a positive but not significant effect for common wheat and maize. The impact of the payment is negative for barley and rapeseed. The trend has a significantly positive impact in both yield equations.

6.2. Projections

To obtain the projections, the specification chosen for the yield equations comprises the following explanatory variables: a constant, the crop price in t-1, a trend and dummy variables. The yield equations are estimated for 1970-1992 and given in Table A25. Figure 7 in the main paper compares projected yields without area payments or set-aside, simulated yields and observed yields.

Table A25. Estimation results for Germany over the period 1970-1992

	Common wheat	Barley	Maize	Rapeseed
Constant	1.40	2.91	7.36	0.23
	(0.51)	(1.52)	(1.58)	(0.22)
Own price in t-1	0.07	-0.15	-0.81	0.20
	(0.16)	(-0.47)	(-0.93)	(1.21)
Trend	0.12	0.07	0.02	0.05
	(2.48)	(1.99)	(0.28)	(3.44)
Dummy in 76	-0.66	-0.41	-1.11	
	(-1.97)	(-1.72)	(-2.08)	
Dummy in 81				-0.38
				(-1.68)
Dummy in 87		-0.43		
		(-1.79)		
Dummy in 88	0.72		0.98	
	(2.16)		(2.07)	
Dummy in 89				0.53
				(2.19)
R^2	0.89	0.87	0.77	0.70
Adjusted R^2	0.86	0.84	0.70	0.63

Figures in brackets are t-statistics.