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CAP REFORM: HOW DECOUPLED ARE THE COMPENSATORY PAYMENTS?

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Abstract

In June 1992, the European Community's (EC's) Council of Ministers passed legislation that changes the way support is provided to EC cereals and oilseed producers. The legislation, called the 'CAP/Oilseeds Reform package' for brevity, reduces producer prices for all the major cereals and oilseed crops, but provides compensatory payments for each crop to offset these reductions. An important question regarding the compensatory payments is the extent to which they will offset the effects of the price cuts on production of each crop. Another way of putting this question is: how decoupled are the compensatory payments from the production of each crop?

To answer this question, it is first necessary to acknowledge that the compensatory payments, rather than being paid per tonne, are paid per hectare of area planted in each crop. Since in this way, the payments ought not to affect yield, they will not affect production in the same way as payments made per tonne of output, i.e., payments that are fully coupled to production. On the other hand, since they influence planting decisions, the payments are likely to have some effect on production (i.e. are probably not fully decoupled from production). A reasonable expectation, therefore, is that the compensatory payments package, as legislated, is only partially decoupled from production of each crop.

Consistent definitions of full decoupling, partial decoupling and full coupling are used to derive an 'index' which gives the 'rate of decoupling' for each crop. Data for use with this 'index' are derived using a simple model of EC crop production, which takes both the price reductions and compensatory payments into account, as well as the restrictions on planted area required by set-aside provisions in the legislation and the 'Blair House' (B-H) accord.

The results indicate that, with the set-aside and B-H area restrictions effective, the compensatory payments package is fully decoupled from production of wheat, rapeseed and soybeans. This result, while inconsistent with expectations of partial decoupling for all crops, is 'driven' by two factors. First, in relation to base period revenue from each crop (per hectare), the compensatory payments are far higher for oilseeds and coarse grains than for wheat. Second, imposition of the set-aside and B-H area restrictions on oilseeds, along with different ratios of payments to base revenues between oilseed crops, means that production with the set-aside and B-H restrictions in place is less than with the price cuts alone.

According to the estimates, the compensatory payments package is only partially decoupled from coarse grains and sunflower production, consistent with expectations. The rates of decoupling measured for these crops are 81% and 77% respectively.

The estimated decoupling rates are lower for all crops but wheat when the set-aside and B-H area restrictions are not imposed. Since these restrictions are not met by changes in financial incentives, and since they have a significant effect on rates of decoupling, it is important that they be effectively enforced. It is also clear from the analysis that alternative levels of compensatory payments across crops can achieve full decoupling for all crops. This could be done, for example, by setting the ratio of payments to base revenue for coarse grains and oilseed crops the same as that for wheat.

It should be noted that the analysis uses several simplifying assumptions, and so these results should be viewed as providing no more than one of a number of possible answers to this complex problem.
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1. Introduction

In June 1992, the EC Council of Ministers approved a package of agricultural policy reforms which are possibly the most significant development for European agriculture since the Common Agriculture Policy (CAP) was launched in 1962. Simply put, the reforms related to crop production involve significant producer price reductions for all crops, accompanied by compensatory payments (per hectare) paid to producers of each crop and a set-aside scheme for total arable land. An important question surrounding the effects of the reform package is the extent to which the compensatory payments will offset the effects of the price cuts on the production of each crop. Another way of putting this question is: how decoupled are the compensatory payments from the production of each crop?

A number of studies have looked at the effects of CAP Reform (and the oilseeds regime change legislated along with it), and most have acknowledged that the compensatory payments, as currently designed, are likely to have some effect on production. The focus of this work, however, has always been upon the overall effects of CAP/Oilseeds reform - the decoupling issue has only represented one aspect of each analysis. As a result, the approaches used to analyse the effects of CAP/Oilseeds reform either 'endogenise' the decoupling effect without actually providing an estimate of the rate of decoupling, use an explicit assumption about the extent to which the payments are decoupled, or merely emphasize that the payments are likely to be only partially decoupled. Information about the extent of decoupling is thus hard to come by, even though the decoupling issue has received considerable attention, and could be important in determining how the EC's compensatory payments will be treated under a Uruguay Round agreement.

The purpose of this paper is to come up with a clear answer to the question posed above. In particular, it is to provide estimates of the rate of decoupling for a number of arable crops in the EC to which the payments apply. In order to arrive at these estimates, it has been necessary to provide a definition of the rate of decoupling, and to construct a simple model of EC crop production which can differentiate between the effects of prices and compensatory payments/hectare on production. Unlike the models used in some of the studies cited above, however, the one used here is not complete enough to provide an assessment of the overall effect of CAP/Oilseeds reform - even for crops alone. This is due to the fact that many important 'pieces' are missing from the analytical framework used here, including demand-side effects, livestock/crop interactions, input markets and alternative uses of arable land. These omissions admittedly may introduce some error into the analysis, but the results generated are helpful in identifying how decoupled the compensatory payments package might be for each crop. The approach also offers a methodology which can be used to handle the issue of decoupling more

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1 Following a political decision to adopt a modified version of CAP/Oilseed Reform, originally proposed by EC Agriculture Commissioner Ray MacSharry in July, 1991, the Council passed a number of pieces of legislation (see EC (1992a, 1992b)), which converted CAP Reform into law.

2 While CAP Reform is primarily aimed at cereal and livestock markets in the EC, the general package includes changes to the EC oilseeds regime as well. The latter changes are primarily in response to a GATT panel ruling against the EC in December 1989, and its requirement that the EC remove crusher subsidies for the purchase of EC-produced oilseeds (GATT (1989)). On the other hand, reform of policies affecting cereals are apparently more in response to mounting budgetary costs of cereals surpluses (although it is an open question whether any reductions in EC expenditures on these crops will be achieved). The cereals reforms may also be viewed as the EC's response to pressures created during the GATT's Uruguay Round of negotiations.

rigorously, and provides a framework for further research into this issue.

To begin, a definition of the rate of decoupling is provided in Section 2. This establishes a basis for the model derived in Section 3. The numerical results are given in Section 4, along with an interpretation of these. A summary is provided in Section 5.

2. A Definition of the Rate of Decoupling

The surveyed literature suggests several definitions for decoupling; there is still considerable variation in the way that economists use this term (see Annex 4). With only one exception, however, the surveyed papers did not discuss partial decoupling in detail, since the central topic was usually full decoupling, and the design of alternative agricultural income support policies that could meet this objective. To arrive at a definition for partial decoupling, we can begin with one definition of full decoupling given in the literature:

"Policies which result in production .. levels which are the same as those which would occur in the absence of support are termed [fully] decoupled" (Roberts, Andrews and Hunter (1991, p. 204)),

and adapt it to suit the more general issue of partially decoupled policies. When applied to the specific issue of the EC's compensatory payments, this definition becomes:

**Definition 1. Full Decoupling**

If the provision of the EC's compensatory payments package results in production that is, for any crop, no greater than that which would occur without compensation, the package is fully decoupled from the production of that crop.

Josling and Mariani (1991, p. 10) and most other researchers have concluded that the compensatory payments provided under CAP/Oilseeds Reform are not fully decoupled from production. This is because the CAP/Oilseeds Reform legislation only allows payments for any crop once that crop is, or is about to be, planted. Since the payments in this way affect the area planting decision of producers, they are probably only partially decoupled from production. However, the legislation provides payments simultaneously for all crops (although not at the same compensation rate for all crops). It is necessary, therefore, to think of the compensation as a package, with cross-crop substitution based on relative rates of compensation. Under this generalised application of compensation, it is possible for production of some crops to be the same as, or less than that without compensation; this is particularly true if the compensation rate for any crop is less than that provided to alternative crops.

The compensatory payments package is not fully coupled to production either, since payments for any crop are not based on the level of production of that crop. The compensation rate per hectare

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4 The exception is Josling and Mariani (1991, pp. 8-10), who distinguish between policy design which would lead to full ("pure") decoupling, and design which would lead to only partial decoupling. However, this paper unfortunately does not provide a formal definition of the sort sought here, i.e., one which can encompass full decoupling, partial decoupling and full coupling of support to production.

5 Note that the phrase "without compensation" means the set of price cuts implied by CAP/Oilseeds Reform are not compensated at all; in other words, CAP/Oilseeds Reform only contains measures which will reduce producer prices.
for any crop is based instead on historic regional yields of the relevant aggregate of crops (cereals or oilseeds); fully coupled payments would be based on current (or projected) yields of the crop or crop aggregate.

With the difference between fully decoupled compensation and fully coupled compensation, and the complication of cross-crop substitution thus in mind, it is possible to define partial decoupling:

**Definition 2. Partial Decoupling**

If the provision of the EC's compensatory payments package results in production which is, for any crop, greater than that which would occur without compensation, but less than that which would occur if the package were fully coupled to production, the package is partially decoupled from production of that crop.

To complete the formalization of decoupling, a definition of full coupling (i.e., no decoupling) is provided:

**Definition 3. Full Coupling**

If the provision of the EC's compensatory payments package results in production that is, for any crop, the same as that which would occur if the compensation were provided like a deficiency payment (i.e., if payments for any crop area planted were based on production of the planted crop), the package is fully coupled to production.

These three definitions make it possible to formalise the meaning of the rate of decoupling. The rate of decoupling is designed in a way that encompasses full decoupling, partial decoupling and full coupling of policies to production. This flexibility is important, since due to differential rates of compensation across crops and cross-crop substitution possibilities, the measured rate of decoupling of the compensation is really an empirical question for each crop.

First, let's establish the notation. For crop i, denote production in the base as \( Q_i \).

Define \( Q_i^{PC} = Q_i + \Delta Q_i^{PC} \) as the new level of production of crop i due to the price cuts alone, where \( \Delta Q_i^{PC} \) represents the change in production due to the price cuts alone. Define \( Q_i^{PD} = Q_i + \Delta Q_i^{PD} \) as the new level of production due to the combination of compensation and price cuts as designed under the CAP/Oilseeds Reform legislation, where \( \Delta Q_i^{PD} \) is the change in production due to the combination of compensation and price cuts. Finally, define \( Q_i^{PE} = Q_i + \Delta Q_i^{PE} \) as the new level of production when the price cuts are accompanied by payments which are fully coupled to production (i.e. deficiency payments), where \( \Delta Q_i^{PE} \) is the change in production from the base (due to the combination of price cuts and fully coupled compensation package).

Given these preliminaries, the rate of decoupling is defined as follows:
Definition 4. The Rate of Decoupling

(i) If \( Q^{PC}_i \leq Q^{PD}_i \leq Q^{PE}_i \), \( DRate_i = \frac{(Q^{PD}_i - Q^{PE}_i)}{(Q^{PC}_i - Q^{PE}_i)} \);

(ii) If \( Q^{PD}_i < Q^{PC}_i \), \( DRate_i = 1 \).

Expression (i) allows the rate of decoupling \( DRate_i \) to take a value between 0 and 1, including 0 (which denotes full coupling) and 1 (which denotes full decoupling), i.e., \( 0 \leq DRate_i \leq 1 \). Partial decoupling is reflected when \( DRate_i \) is greater than 0 but less than 1 \( (0 < DRate_i < 1) \). Case (ii) allows for the possibility that production with the compensation package as designed under CAP/Oilseeds Reform will actually be less than production without compensation (a circumstance explained earlier as being possible where compensation is skewed across crops).

The rate of decoupling given in Definition 4 provides some rules to use when measuring the rate of decoupling of the compensation under CAP/Oilseeds Reform. A reasonable prior would be: \( 0 < DRate_i < 1 \) i.e., that the package is partially decoupled from production of all crops.

The rate of decoupling for each crop can be estimated by separating the effects of the price cuts from those due to the compensatory payments package. This involves computation of three solutions for each crop:

S1) Production effects of price cuts alone (payments for all crops zero or fully decoupled);

S2) Production effects of CAP/Oilseeds Reform (price cuts with compensatory payments per hectare for crops; and

S3) Production effects of price cuts with fully coupled compensatory payments for all crops (i.e. payments treated as being equivalent to deficiency payments).

These solutions can then be used with Definition 4 to give measured rates of decoupling for each crop. In order to obtain solutions to S1, S2 and S3 it has been necessary to build a simple model of EC crop production, which is outlined below.

3. The Model

The main premise behind the model developed in this section is that, because the compensatory payments in the CAP Reform package are not the same for all cereal and oilseed crops, and, because payments for any crop are contingent on that crop being planted, they will affect the acreage allocation decision of the producer. However, because the payment levels are based on historic, regional yields, (and unpredictable political influences), they ought not to affect any one producer's yield decision (nor
affect aggregate yield)\(^6\) \(\) Prices, and price changes, on the other hand, ought to affect both the yield and acreage allocation decisions, since producer revenue from the market depends not only what crop is planted, but how much is produced per hectare. This difference in interpretation of the effects of the two policy instruments is crucial, and ensures a priori that the impacts of changes in each instrument on production will be different, even when the two are financially equivalent.

The approach also employs an important assumption which is related to the point made above - that area and yield decisions are separable. In other words, it assumed that the choice of which crop to plant (i or j) is separate from the decision about how many resources to devote to the crop planted\(^7\). One typical justification for this assumption is that different information is used in each decision - farmers must decide whether or not to plant a crop based on price, compensatory payment and yield expectations before the crop is planted in any given year. Yield, on the other hand, can be affected during the growing season by decisions made about how much additional investment to make in the planted crop (cultivation, irrigation, etc), depending on weather and new and possibly changing expectations about crop and input prices\(^8\).

A final, simplifying, assumption is that uses of land other than for the crops studied can be ignored. These alternative uses include production of crops other than those studied, livestock production, and non-agricultural enterprises (e.g. for recreation). The advantage in doing this is that the complications of adding these markets to the model are avoided. A disadvantage is that the policy changes analysed may, in some cases, make these alternative uses look quite attractive. The potential drawbacks of this assumption are are discussed in more detail later.

In order to incorporate these opening assumptions in a more rigorous specification, let production of crop i be represented by:

\[(1) \quad Q_i = A_i \cdot Y_i ; \quad i = 1,...,n\]

where: \(Q_i\) is output of crop i ('000 tonne)
\(A_i\) is area planted in crop i ('000 hectares),
\(Y_i\) is average yield for crop i (tonnes/ha), and
\(n\) is the number of crops being considered.

\(^6\) It is possible that cereals and oilseed producers might, in any region, 'band together' to ensure that - even after CAP Reform is implemented - yields remain high in that region, thereby ensuring themselves equal or even higher payments in the future (in spite of lower price incentives to produce). Adjustments of the analysis for this type of effect is not made, nor is any account taken of the possibility that yields for the land left in production will increase due to rotational set-aside (greater fertility due to more frequent use of fallow/cover crop) or set-aside of land with the lowest base yield.

\(^7\) This assumption has been used on numerous occasions and is reflected in specifications used by Westhoff et al (1991), and Josling and Mariani (1991) in analyses of CAP Reform. In a paper devoted to the issue of separability of yield and area response, Gemmill (1978) concludes that this type of specification should, "as a rule-of-thumb ... be used in all circumstances" (p.190).

\(^8\) Under the CAP Reform legislation, the use of intervention and threshold price to support internal market prices for cereals will continue. As in the old CAP system, these mechanisms provide, at best, bounds on the internal market price, which will continue to vary during any crop year, depending on internal market conditions. For oilseeds, the previous system of crusher subsidies (which could be changed to stabilise producer prices) will be removed, leaving producers of oilseeds facing the world price (at the EC border) for their crops. As a result, all crop producers will face market price uncertainty under CAP/oilseeds reform, and have to form expectations about these prices when making decisions.
The total differential of (1) is:

\begin{equation}
(2a) \quad dQ_i = dA_i * Y_i + dY_i * A_i \quad ; \quad i = 1,...,n.
\end{equation}

With the use of (1), (2a) can be re-expressed as:

\begin{equation}
(2b) \quad \frac{dQ_i}{Q_i} = \frac{dA_i}{A_i} + \frac{dY_i}{Y_i} \quad ; \quad i = 1,...,n.
\end{equation}

A revenue function is used to represent area planted in each crop. This gives the maximum revenue that a given input endowment can achieve (Chambers (1986, p. 262)). In this multicrop setting, any given input bundle can provide a large variety of crop mixes, so that to maximise revenue, the producer must choose the best combination of crops to plant. This allocation 'problem', in which planted area is treated as the 'output', and can be represented as:

\begin{equation}
(3) \quad H(\vec{P},X) = \max_{A} \left\{ \sum_{i=1}^{n} \vec{P}_i A_i : X; A,X \in T^A \right\},
\end{equation}

where: \( \vec{P} \) is a 1xn vector comprised of elements \( \vec{P}_i = \text{gross revenue/ha} = P_i Y_i + D_i \);

\( P_i \) is the farm-level market price (ECU/tonne) for crop \( i \);

\( D_i \) is the compensatory payment (in ECU/hectare) for crop \( i \) (fixed, irrespective of yield) - also referred to as the compensatory payment for crop \( i \);

\( X \) is an input aggregate (\( X = m(\vec{X}) \), where \( \vec{X} \) is a 1xk vector of planted area inputs \( X_r \)

(e.g. arable land, labour, machinery) and \( m \) is an aggregator function;

\( A \) is a 1xn vector comprised of elements \( A_i = \text{area (ha)} \) planted in crop \( i \); and

\( T^A \) is the technology set, i.e. the set of combinations of aggregate input and planted area which are feasible.

The revenue function \( H \) is assumed to fulfill the usual regularity conditions required for duality (i.e. homogeneous of degree 1 in prices, convex in \( X \), twice-continuously differentiable, etc.).

Note that (3) embodies two important assumptions: input separability and joint production technology. Input separability allows us to represent revenue maximisation in terms of a single-input, multiple output technology (Chambers (1986, p. 285)). This also implies that inputs are not allocated to specific crops, but rather to the whole multicrop 'enterprise' (i.e. the technology is 'joint'). While it is true that certain types of inputs are crop-specific in reality (e.g. seed, planting equipment etc.), this simplification allows us to focus on the policy reform, which is not directed at input markets or

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9 A revenue function is chosen instead of a profit function to represent area planted for two reasons. First, it allows us to concentrate on output markets, holding input decisions fixed. Since the reforms are meant to control crop output and area planted (not inputs), this is reasonable. Second, providing it fulfills certain 'regularity' conditions, the revenue function is able to represent all relevant properties of the production technology (Dixit and Norman (1980, p. 31)).
decisions. It thus allows us to hold inputs fixed at unobserved base levels - without explicitly adjusting the levels - as area planted to each crop changes (see Dixit and Norman (1980, p.31)); due to the jointness assumption, this simplification should have no impact on relative areas planted in each crop.

Given the regularity properties of \( H \), it is possible to differentiate (3) to obtain the optimal levels to plant in each crop, i.e.:

\[
A_i(\bar{P},X) = \frac{\partial H(\bar{P},X)}{\partial \bar{P}_i} \quad ; \quad i = 1,...,n.
\]

Total differentiation of (4), following (2a) gives:

\[
dA_i(\bar{P},X) = \sum_{j=1}^{n} \frac{\partial A_i(\bar{P},X)}{\partial \bar{P}_j} \cdot d\bar{P}_j + \frac{\partial A_i(\bar{P},X)}{\partial X} \cdot dX \quad ; \quad i = 1,...,n.
\]

Since we are holding \( X \) fixed at the base level, the second term in (5) is set to zero.

Profitability of each crop, once it is planted is assumed to be maximised in the form:

\[
\Pi_i(P_i,w,t) = \max_{G_i} \left\{ P_i \cdot Y_i(G_i(P,w),U(t)) - w \cdot G_i(P,w) : A_i \right\} \quad G_i,Y_i \in T_i^Y(t)
\]

where: \( w \) is the price for the input aggregate \( G_i \);

\( G_i \) is an an aggregate of inputs used to control yield = \( f(z_i) \), where \( z_i \) is a 1xq vector of input quantities \( z_i \) and \( g_i \) is an aggregator function;

\( U(t) \) is a variable representing year to year variations in yield not controllable by the producer (e.g. due to weather); and

\( T_i^Y(t) \) is the set of combinations of \( G_i \) and \( Y_i \) possible with the technology used at time \( t \).

Notice that separate yield technologies are assumed for each crop, and that decisions about yield-related inputs for crop \( i \) are not related to those pertaining to crop \( j \) (i.e the yield technology is non-joint). This profit function, which is dual to the yield possibilities set \( T_i^Y(t) \), if once-differentiable with respect to prices \( P_i \) and \( w \), provides profit-maximising yield for crop \( i \) through partial differentiation with respect to prices \( P_i \) (Diewert(1982,p. 581):

\[
Y_i(P_i,w,t) = \frac{\partial \Pi_i(P_i,w,t)}{\partial P_i}
\]

Total differentiation of (7) - providing (6) is twice continuously differentiable gives:

\[
dY_i(P_i,w,t) = \frac{\partial Y_i(P_i,w,t)}{\partial P_i} \cdot dP_i + \frac{\partial Y_i(P_i,w,t)}{\partial w} \cdot dw + \frac{\partial Y_i(P_i,w,t)}{\partial t} \cdot dt.
\]

For purposes of this analysis, input prices are assumed to remain fixed at base period levels, so that as with the area allocation problem, input issues can be excluded. This means that the second term in (8) is set to zero and excluded from the policy analysis. It should also be noted that any increase in yield due to improved land quality (e.g. due to set-aside of the most marginal land or improvements in
With the additional structure provided by total differentials (5) and (8), it is possible to define the terms \( dA_i \) and \( dY_i \) in (2a) and (2b) with more precision. The effects of CAP/Oilseeds reform on production can be modelled first by expansion of (5) and (8) through substitution and use of the chain rule giving:

\[
\frac{dA_i}{A_i} = \sum_{j=1}^{n} \varepsilon_{ij} \cdot \left(1 + \varepsilon_{ij} \frac{P_j}{P_i} \right) \cdot \frac{dP_j}{P_j} + \sum_{j=1}^{n} \varepsilon_{ij} \cdot \frac{dD_j}{P_j} + \sum_{j=1}^{n} \varepsilon_{ij} \cdot \varepsilon_{yt} \cdot \frac{dt}{t} ; \quad \text{and}
\]

\[
\frac{dY_i}{Y_i} = \varepsilon_{i} \frac{dP_i}{P_i} + \varepsilon_{iy} \cdot \frac{dt}{t} , \quad i = 1, \ldots, n .
\]

where: \( \varepsilon_{ij} = \frac{\partial A_i}{\partial P_j} \cdot \frac{P_j}{A_i} \) is the elasticity of area planted in crop \( i \) from a change in revenue from crop \( j \),

\( \varepsilon_{ip} = \frac{\partial Y_i}{\partial P_i} \cdot \frac{P_i}{Y_i} \) is the elasticity of yield of crop \( i \) due to change in the price of crop \( i \); and

\( \varepsilon_{yt} = \frac{\partial Y_i}{\partial t} \cdot \frac{t}{Y_i} \) is average annual 'autonomous' yield growth (i.e. after increases in yield due to output and input price effects are removed from the total yield growth rate and year to year variations due to uncertainties averaged out. This captures annual shifts in yield caused by changes in the yield possibilities set \( Y_i(t) \)).

These more precise expressions (9) and (10), when substituted into expression (2b), make the change in output now a function of acreage and yield elasticities and the price/compensatory payment changes, or:

\[
\frac{dQ_i}{Q_i} = \sum_{j=1}^{n} \varepsilon_{ij} \cdot \left(1 + \varepsilon_{ij} \frac{P_j}{P_i} \right) \cdot \frac{dP_j}{P_j} + \sum_{j=1}^{n} \varepsilon_{ij} \cdot \frac{dD_j}{P_j} + \sum_{j=1}^{n} \varepsilon_{ij} \cdot \varepsilon_{yt} \cdot \frac{dt}{t} + \varepsilon_{iy} \cdot \frac{dP_i}{P_i} + \varepsilon_{iy} \cdot \frac{dt}{t} , \quad i = 1, \ldots, n .
\]

Note that (11) fits a style of analysis - termed 'equilibrium displacement modelling' - which is currently a popular means of looking at the effects of policy and other market shocks on agricultural supply and demand (see, for example Guyomard and Mahé (1993), Piggott(1992), Hertel (1989)).
As explained in Section 2, in order to measure the degree of decoupling of the compensatory payment package, three solutions to (11) are computed for each crop:

(S1) full decoupling: \( \frac{dP_i}{P_i} = \Delta P_i < 0 \forall i, \frac{dD_i}{P_i} = 0 \forall i \);

(S2) CAP/Oilseed Reform: \( \frac{dD_i}{P_i} = \Delta D_i > 0 \forall i, \frac{dP_i}{P_i} = \Delta P_i < 0 \forall i \); and

(S3) full coupling: \( \frac{(dD_i(Y_i)^{-1})}{P_i} = \frac{\Delta P_i^c}{P_i} > 0 \forall i, \frac{dP_i}{P_i} = \Delta P_i < 0 \forall i \).

where: \( \Delta P_i \) are the price cuts (in percent) due to CAP/oilseed reform;
\( \Delta D_i \) are the revenue effects (in percent) of the (partially decoupled) compensatory payments; and
\( \Delta P_i^c \) are the equivalent price effects (in percent) of the compensatory payments (if fully coupled).

All changes in policy are relative to the base period (1991/92) and after CAP/Oilseeds reform has been fully implemented (in 1998/1999, 7 years from a base crop year of 1991/92).

For solution (S1), the CAP/oilseed reform package is limited to the set of price cuts alone (i.e. no compensatory payments for any crop, or payments full decoupled for all crops), and (11) is restricted to:

\[
(12) \quad \frac{\Delta Q_i^{PC}}{Q_i} = \frac{dQ_i}{Q_i} \left| \frac{dP_i}{P_i} = \Delta P_i < 0 \forall i; \frac{dD_i}{P_i} = 0 \forall i \right. = \sum_{j=1}^{n} \xi_{ij} A \cdot \left(1 + \xi_{ij} Y_P\right) \cdot \frac{P_j}{P_i} + \sum_{j=1}^{n} \xi_{ij} \cdot \xi_{ij} Y_T \cdot \frac{dt}{t} + \xi_{ij} Y_P \cdot \frac{\Delta P_i}{P_i}.
\]

For solution (S2), the full CAP/oilseed reform package is implemented, and (11) is respecified as:

\[
(13) \quad \frac{\Delta Q_i^{PD}}{Q_i} = \frac{dQ_i}{Q_i} \left| \frac{dP_i}{P_i} = \Delta P_i < 0 \forall i; \frac{dD_i}{P_i} = \Delta D_i > 0 \forall i \right. = \sum_{j=1}^{n} \xi_{ij} A \cdot \left(1 + \xi_{ij} Y_P\right) \cdot \frac{\Delta P_j}{P_j} + \sum_{j=1}^{n} \xi_{ij} \cdot \xi_{ij} Y_T \cdot \frac{dt}{t} + \xi_{ij} Y_P \cdot \frac{\Delta P_i}{P_i}.
\]
And, for solution (S3), (11) becomes:

\[
\frac{\Delta Q_{pi}^{PE}}{Q_i} = \frac{dP_i}{P_i} = \frac{\Delta P_i}{P_i} < 0 \forall i ;
\]

\[
\frac{(dD_i(Y_{j}^{-1}))}{P_i} = \frac{\Delta P_i}{P_i} > 0 \forall i
\]

\[
= \sum_{j=1}^{n} \xi_{ij} \cdot \left(1+\xi_{ij}^{YP}\right) \cdot \left(\frac{\Delta P_j}{P_j} + \frac{\Delta P_{ei}}{P_{ei}}\right) + \sum_{j=1}^{n} \xi_{ij} \cdot \xi_{ij}^{YT} \cdot \frac{dt}{t} ; \quad i=1,...,n.
\]

Expressions (12), (13) and (14) look only at the effects of changes in financial incentives due to CAP/Oilseeds reform. The CAP/Oilseeds reform package also requires 'large' farmers to remove some of their land from cereals/oilseed production if they wish to receive the compensatory payments. For the EC as a whole, this leads to an aggregate rate of set-aside which is less than the rate required for large farmers, but greater than zero. Thus, if the reduction in total area planted in the n crops - due to the financial policy changes - is less than the aggregate rate required, producers must idle some of their land. The reduction scheme assumed in this analysis is that producers first decide what crop mix they would plant under the new prices, with or without compensation. Given these levels, area planted in each crop is reduced by the same proportion for all crops until the set-aside requirement is met. This allows the model to meet the aggregate set-aside rate required, without changing the crop mix chosen with the financial policy changes alone. This method allows the restricted crop mix to reflect the changes due to new returns across crops, while ensuring that the set-aside requirement is met.\textsuperscript{10}

A second restriction on area planted relates to oilseeds only. In November, 1992, the EC and the United States reached an agreement on agricultural subsidies which limits area planted in oilseeds to 5.128 m. ha, less 10%. This so-called 'Blair House' (B-H) accord would thus limit oilseeds area to 4.615 m. ha. (AgraEurope(1992, p. E/1). This restriction is imposed on the planted area solution in a similar way to the set-aside provision, (although the details about how this will be achieved are omitted). If the area planted in oilseed crops is still greater than 4.615 m. ha, after aggregate set-aside rate has been met for all arable land, a further reduction is made to oilseed area, proportionate to area planted in each crop with set-aside imposed.

The two planted area restrictions complicate the analysis considerably, and the options for solution comparisons (for purposes of calculating decoupling rates) expand. To keep the analysis manageable, two sets of solutions are computed. First, the model is set up to compute S1-S3 without the set-aside provision or B-H area restriction imposed. Since it is unclear how effective the set-aside provisions, and the restrictions required by the B-H accord will be, this set of solutions allows us to estimate the decoupling rate for each crop under the assumption that both area restrictions are completely ineffective.

\textsuperscript{10} Compensatory payments are made on set-aside area as well. These payments are not incorporated into the model, since set-aside returns are viewed as being infra-marginal (representing only 9% of returns to total crop land, on average). In May 1993, the EC Council agreed to an increase in payments to set-aside area, relative to the level set in the July '92 legislation - see EC(1993b, p. 42). If the payments are indeed inframarginal, then such changes, even if significant, should not affect area allocation decisions.
The second set of solutions are based on the assumption that both the CAP/Oilseeds Reform aggregate set-aside rates and the 10% B-H area reduction are completely effective. These, along with the three solutions mentioned above give a total of six numerical outcomes (for each crop):

(S1U) Change in production of crop i due to price cuts alone (full decoupling), no set-aside, no B-H accord imposed (solution to (12) without CAP/Oilseed Reform set-aside or B-H restrictions on area planted);

(S1R) Change in production crop i due to price cuts alone (full decoupling), with set-aside, B-H accord imposed (solution to (12) with CAP/Oilseed Reform set-aside and B-H restrictions on area planted);

(S2U) Change in production of crop i due to CAP/Oilseed Reform - price cuts with compensatory payment package as designed - no set-aside, no B-H accord imposed (solution to (13) without CAP/Oilseed Reform set-aside or B-H restrictions on area planted);

(S2R) Change in production of each crop i due to CAP/Oilseed Reform - price cuts with compensatory payment package as designed - with set-aside, B-H accord imposed (solution to (13) with CAP/Oilseed Reform set-aside and B-H restrictions on area planted);

(S3U) Change in production of crop i due to price cuts with fully coupled compensatory payment package - no set-aside, no B-H accord imposed (solution to (14) without CAP/Oilseed Reform set-aside or B-H restrictions on area planted);

(S3R) Change in production of each crop i due to - price cuts with fully coupled compensatory payment package - set-aside, B-H accord imposed (solution to (14) with CAP/Oilseed Reform set-aside and B-H restrictions on area planted).

We can thus, for each crop i, generate two DRate estimates for each crop, using two sets of solutions:

(CU) use solutions S1U, S2U and S3U to determine the rate of decoupling (DRate) of the CAP/Oilseed Reform compensatory payments package for each crop, no CAP/Oilseed Reform set-aside or B-H restriction on area planted imposed; and

(CR) use solutions S1R, S2R and S3R to determine the rate of decoupling (DRate) of the CAP/Oilseed Reform compensatory payment package for each crop, with CAP/Oilseed Reform set-aside and B-H restriction on area planted imposed.

Solution set CU allows us to estimate the decoupling rate of the compensatory payments package by looking only at the financial aspects of CAP/Oilseeds Reform. Decoupling rates estimated using the set of solutions CR are more realistic, since these are constrained by the set-aside and B-H planted area provisions. A comparison of DRate estimates generated with solution sets CU and CR gives us useful information regarding the importance of the set-aside and B-H planted area restrictions, both in terms of the DRate estimates themselves, and in relation to the constraints on production achieved by having these two controls in place.
4. Quantitative Results and Discussion

Base period and policy data

The model developed in Section 3 can now be applied to some base period data, elasticity values and price/compensatory payment policy information. Five major EC crops - wheat, coarse grains, rapeseed, soybeans and sunflower - are included in the analysis (i.e., n = 5). Base period data on area planted, yield, production, revenue and prices by crop provide the necessary market information, while price change, compensatory payments, aggregate effective set-aside rate, and B-H restriction on planted oilseed area data provide the policy information; both sets of information are relatively easy to collect. Elasticity information regarding area and yield response for these crops is harder to come by. For this analysis, acreage elasticities are computed for the base period (1991/92 crop year) using a CDE revenue function (Surry (1993), Hertel et al (1990), Hanoch (1975)). Details regarding the methodology and data used to derive the elasticities are given in Annex 2. For the yield elasticities $\xi_{YP}$, a level of 0.25 for all crops is assumed. These assumed yield elasticities are also used to compute yield growth rates $\xi_{YT}$ (see Annex 3).

The base period and CAP Reform market and policy data are presented in Table 1. Note that there is more certainty regarding the producer price in 1998/99 for wheat and coarse grains than for rapeseed, soybeans and sunflower, since oilseed prices will be at 'world' levels and cereals prices will be supported at the target price of 110 ECU/tonne. An effective set-aside rate of 9% (relative to the 1989-1991 base specified in the legislation) is assumed for total crop area planted in the five crops studied. 12

11 Note that, because the CAP Reform legislation leaves some aspects of the future application of the policy open-ended, there is also some uncertainty about the levels that compensatory direct payment will be set at in the future. The data in Table 1 may therefore not accurately represent the policy setting in 1998. However, without further information, a more accurate representation of the policy setting under CAP Reform is not possible. In addition to this general uncertainty about how the compensation policy will change, predicting payments for oilseeds is made more difficult because these will be adjusted if the year-year change in 'world' prices for these crops is > +/- 8%. Moreover, to the extent that prices for cereals are not supported at the target price level, results for both sets of crops may change.

12 Note that while participants in the 'general' compensation scheme must set-aside 15% of their land (EC 1992b, p16), there are a number of reasons the average area of crop land set-aside in the EC will be different from this level:

(i) the 'simplified' scheme open to small producers does not require set-aside. In some regions, 'small producers' - those who produce < 92 tonnes of cereals per holding (ibid., p. 12) can represent over 50% of total producers in some member-states (Mariani and Josling (1991),Table 1, Table B.2);

(ii) incentives to cheat in reporting total and set-aside acreage will create 'slippage' in the area of land claimed to be set-aside. 'Large' producers may also break up their holdings to claim the 'small' holding exemption;

(iii) producers may 'opt out' of rotation schemes if they set-aside more than 15% of their land (EC(1992b, p. 16)); and

(iv) producers may 'opt out' of the compensation plan altogether because they do not lodge an application for the compensatory payment or because it is more profitable to keep all of their land in production (i.e. the compensation is not attractive enough for them to set-aside part of their land - for example, see Barnes et al (1993)).

An effective set-aside rate of 9% for total crop land is therefore assumed, based on a survey of various studies and these considerations.
<table>
<thead>
<tr>
<th>Crop</th>
<th>Production (Qi) '000 tonne</th>
<th>Area (Ai) '000 ha</th>
<th>Yield (Yi) tonne/ha</th>
<th>Farm price (Pi) ECU/tonne</th>
<th>Compensatory payment (Di) ECU/ha</th>
<th>Gross revenue (P-i) ECU/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat*</td>
<td>85528</td>
<td>15933</td>
<td>5.4</td>
<td>184</td>
<td>0</td>
<td>968</td>
</tr>
<tr>
<td>Coarse grains*</td>
<td>80982</td>
<td>17397</td>
<td>4.7</td>
<td>169</td>
<td>0</td>
<td>787</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>7367</td>
<td>2453</td>
<td>3.0</td>
<td>344</td>
<td>0</td>
<td>1033</td>
</tr>
<tr>
<td>Soybeans</td>
<td>1547</td>
<td>481</td>
<td>3.2</td>
<td>384</td>
<td>0</td>
<td>1235</td>
</tr>
<tr>
<td>Sunflower</td>
<td>4063</td>
<td>2423</td>
<td>1.7</td>
<td>497</td>
<td>0</td>
<td>833</td>
</tr>
<tr>
<td><strong>Crop totals:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereals</td>
<td>166510</td>
<td>33330</td>
<td>-</td>
<td>-</td>
<td></td>
<td>4615</td>
</tr>
<tr>
<td>Oilseeds</td>
<td>12977</td>
<td>5357</td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td><strong>All five crops</strong></td>
<td>179487</td>
<td>36687</td>
<td>-</td>
<td>-</td>
<td></td>
<td>35283</td>
</tr>
</tbody>
</table>

**NOTES:**

* Wheat is an aggregate of common and durum wheat. Coarse grains is an aggregate comprised of rye and meslin, barley, oats/mixed cereals and maize.

**SOURCES:**


Base period price data for all crops from most recently available OECD PSE tables. These are converted into crop year from calendar year data using a simple average for cereals and a weighted average of the form 3/12*(1991 price) + 9/12*(1992 price) for oilseeds. These adjustments reflect the July/June crop year for cereals and the October/September crop year for oilseeds. These are effective prices, in that they include direct payments and levies, if any are applied, as well as the average EC-wide effects of 'green rates'.

CAP Reform prices for wheat and coarse grains, assumed to be supported at the target level, are from EC (1992a, p. 23).

CAP Reform price for soybeans from FAPRI baseline forecast (CARD(1993)). Rapeseed price and sunflower price also from same forecast - see Annex 1 for details.

CAP Reform compensatory direct payments for wheat and coarse grains derived - see Annex 1.

CAP Reform compensatory direct payments for rapeseed, soybeans and sunflower obtained from EC(1992b, p. 15).

CAP Reform set-aside maximum total area derived - see Annex 1.

A comparison of price changes across crops shows that these vary considerably, from -66% for sunflower (the largest price cut) to -35% for coarse grains (the smallest price cut). Compensation levels, although the same across cereals and across oilseed crops, differ between crops within and across these two groups in terms of their impact on base period revenue. These differences are quite extreme, with the compensatory payment to sunflower (the crop with the highest effect on revenue) representing 43% of base revenue, and the compensatory payment for wheat (with the smallest effect) representing only 21% of base revenue. This unequal impact of the compensatory payments on base revenue, accompanied by a skewed set of price cuts across crops is an important feature of CAP/Oilseeds Reform, and leads to significant differences in measured rates of decoupling across crops.

Results for price cuts alone (no compensatory payments, or payments fully decoupled)

Results from the model for solutions S1U and S1R are given in Tables 2a-2d. Table 2a contains the policy and other data used to provide the model - in this case, captured by equation (12) - with rates of change in the explanatory variables.

Table 2b gives the planted area changes caused by the price cuts alone, with and without the set-aside and B-H provisions. As the first column of numbers indicate, without accounting for yield trend effects (which in turn affect the planted area decision), set-aside, or B-H, area planted in wheat and all three oilseed crops decreases, while area planted to coarse grains increases. This makes sense, since coarse grains has the lowest price reduction of all crops (at -35%), it becomes more attractive than the other crops. Even with opportunities for substitution between crops limited, it is still preferable to plant coarse grains than wheat or oilseeds where possible. Area effects of yield trends - the second column of numbers - are positive for all crop areas planted except coarse grains (which has the lowest rate of yield trend (see Annex 3)). When combined (third column), the price and trend effects mean that without the set-aside or the B-H area restrictions, crop area is significantly reduced only for sunflower, with area planted in soybeans increasing by the greatest amount (+7%), relative to 1991.

The planted area responses due to the price cuts alone contribute to a 'lower bound' estimate of the production effects of the reforms, since we would expect production (and area planted) to be lowest under this policy setting. It is possible that under a reform of this nature (no compensation or compensation fully decoupled), alternative uses of land may be more attractive than crop production. To the extent that under this type of policy reform, land would be removed from crop production altogether (and, for example used for livestock production or non-agricultural purposes), the area responses to the price cuts alone may be underestimated, since the model excludes alternative land uses. Such potential 'bias' in the price cut results could lead to an overestimate of the rate of decoupling for all crops.

Since the total unrestricted area in crops is greater than the maximum area allowed under the CAP/Oilseed Reform set-aside provision, area in each crop is reduced by the same proportion (8.6%), this being the amount needed to reduce total area to the maximum allowable (see column d' of Table 2b). In addition, if the planted area in oilseed crops is higher than the maximum allowed under the B-H accord even with set-aside imposed, a further reduction in oilseed area is needed (see column e). Together, these restrictions - when applied to the unrestricted planted area - give the restricted planted area (column f). With these adjustments, the reduction in planted area is greatest for sunflower (-25%) and smallest for soybeans (-3%).
Solutions S1U and S1R: Calculation of CAP/Oilseeds Reform price effects (compensatory payments fully decoupled)

### Table 2a. Policy Changes, CAP/Oilseeds Reform with Price Changes Alone

| Crop      | Price cuts: dPi/Pi | Compensatory payments: * | Area set-aside required for oilseeds under B-H*** | New restricted area planted, crop i (1000 ha) | New unrestricted area planted, crop i (1000 ha) | Area reduction required for oilseeds (set-aside)**: | New change in area planted, crop i | Change in yield of crop i due to trend: EYT i dt/t | Total change in yield of crop i m+h+k | New gross revenue (P-i): ECU/ha | Change in revenue from trend: EYTi dt/t |
|-----------|---------------------|--------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|---------------------------------|-----------------------------------|----------------------------------|-----------------------------------|----------------------------------|
| Wheat     | -0.40               | 0                        | 0.00                                          | 16151                                          | -0.086                                        | 14751                           | -7%                               |                                  |                                   |                                   |
| Coarse grains | -0.35             | 0                        | -0.00                                         | 17381                                          | -0.086                                        | 15522                           | -9%                               |                                  |                                   |                                   |
| Rapeseed  | -0.39               | 0                        | 0.04                                          | 2582                                           | -0.086                                        | 2331                            | -5%                               |                                  |                                   |                                   |
| Soybeans  | -0.49               | 0                        | 0.07                                          | 513                                            | -0.086                                        | 467                             | -3%                               |                                  |                                   |                                   |
| Sunflower | -0.66               | 0                        | -0.18                                         | 1997                                           | -0.086                                        | 1817                            | -25%                              |                                  |                                   |                                   |
| Cereals   | -                   | -                        | 0.01                                          | 33532                                          | -0.086                                        | 30647                           | -8%                               |                                  |                                   |                                   |
| Oilseeds  | -                   | -                        | -0.05                                         | 5072                                           | -0.086                                        | 4615                            | -14%                              |                                  |                                   |                                   |
| All five crops | -               | -                        | -0.00                                         | 38804                                          | -0.086                                        | 35262                           | -9%                               |                                  |                                   |                                   |

* This is the variable dDi/Pi. As expression (12) indicates, this is set to zero for all i crops for the fully decoupled solutions.
** Assume base year '91/92 t = 1. Since CAP Reform is assumed to be fully implemented by the '98/99 crop year, dt/t = 7 for all i

### Table 2b. Area Response to Price Changes Alone

| Crop      | Price effect**: a | Trend effect**: b | dAVAi: | New unrestricted area planted, crop i (1000 ha) | Area reduction required for oilseeds (set-aside)**: d | Area set-aside required for oilseeds under B-H*** e | New restricted area planted, crop i (1000 ha) | New change in area planted, crop i | Change in yield of crop i due to price cuts: EYPi*(dPi/Pi) | Total change in yield of crop i due to trend: EYT i dt/t | New gross revenue (P-i): ECU/ha | Change in revenue from trend: EYTi dt/t |
|-----------|-------------------|-------------------|--------|-----------------------------------------------|-----------------------------------------------|---------------------------------|-----------------------------------|-----------------------------------|----------------------------------|-----------------------------------|----------------------------------|
| Wheat     | -0.02             | 0.03              | 0.01   | 16151                                          | -0.086                                        | 14751                           | -7%                               |                                  |                                   |                                   |                                   |
| Coarse grains | 0.06              | -0.06             | -0.00  | 17381                                          | -0.086                                        | 15522                           | -9%                               |                                  |                                   |                                   |                                   |
| Rapeseed  | -0.00             | 0.05              | 0.04   | 2582                                           | -0.086                                        | 2331                            | -5%                               |                                  |                                   |                                   |                                   |
| Soybeans  | -0.09             | 0.15              | 0.07   | 513                                            | -0.086                                        | 467                             | -3%                               |                                  |                                   |                                   |                                   |
| Sunflower | -0.24             | 0.07              | -0.18  | 1997                                           | -0.086                                        | 1817                            | -25%                              |                                  |                                   |                                   |                                   |
| Cereals   | -                  | -                  | 0.01   | 33532                                          | -0.086                                        | 30647                           | -8%                               |                                  |                                   |                                   |                                   |
| Oilseeds  | -                  | -                  | -0.05  | 5072                                           | -0.086                                        | 4615                            | -14%                              |                                  |                                   |                                   |                                   |
| All five crops | -               | -                  | -0.00  | 38804                                          | -0.086                                        | 35262                           | -9%                               |                                  |                                   |                                   |                                   |

* Price effect is SUMj [EAij]*[dPj/Pj], where EAij are the area elasticities EAij, 'weighted' by (1 + EYPj) for each j.
Trend effect is SUMj [EAij]* [EYT i]*[dt/t]. These components are equivalent to terms in expression (12) dealing with area allocation effects.
** d' = (max-d(all))/d(all), where max is the maximum total area in arable crops (see Table 1), and d(all) is the unrestricted area in all five crops.
Thus, area in each crop is reduced by the % difference between the maximum area and unrestricted area planted in all crops, and d' indicates the % reduction from unrestricted area required for each crop to meet the aggregate set-aside restriction.
*** e = (4615-(1 + d'(oil))*(d(oil)))/(1 + d'(oil))*d(oil), where d'(oil) and d(oil) are the unrestricted area in oilseeds and the area reduction required for oilseeds.
This implements the so-called Blair-House (B-H) agreement: total oilseeds plantings are limited to 5.128 m. ha less 10%, or 4.615 m. ha.

### Table 2c. Yield and Revenue Changes due to Price Cuts Alone

<table>
<thead>
<tr>
<th>Crop</th>
<th>Change in yield of crop i, due to price cuts: EYPi*(dPi/Pi)</th>
<th>Total change in yield of crop i m+h+k</th>
<th>New yield (Vi) tonne/ha</th>
<th>New gross revenue (P-i) ECU/ha</th>
<th>Change in revenue from trend: EYTi dt/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>-0.10</td>
<td>0.15</td>
<td>6.2</td>
<td>679</td>
<td>-31%</td>
</tr>
<tr>
<td>Coarse grains</td>
<td>-0.09</td>
<td>0.09</td>
<td>5.1</td>
<td>556</td>
<td>-29%</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>-0.10</td>
<td>0.18</td>
<td>3.5</td>
<td>744</td>
<td>-28%</td>
</tr>
<tr>
<td>Soybeans</td>
<td>-0.12</td>
<td>0.33</td>
<td>4.3</td>
<td>841</td>
<td>-32%</td>
</tr>
<tr>
<td>Sunflower</td>
<td>-0.16</td>
<td>0.15</td>
<td>1.9</td>
<td>330</td>
<td>-60%</td>
</tr>
</tbody>
</table>

NOTE: EYPi and EYT i are the yield elasticities (price and trend respectively). Components h and k estimated in this Table represent the terms in expression (12) which deal with yield change.

### Table 2d. Changes in Crop Production due to Price Cuts Alone

<table>
<thead>
<tr>
<th>Crop</th>
<th>Solution S1U*: c+m</th>
<th>Solution S1R**: g+m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>16%</td>
<td>6%</td>
</tr>
<tr>
<td>Coarse grains</td>
<td>8%</td>
<td>-0%</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>22%</td>
<td>13%</td>
</tr>
<tr>
<td>Soybeans</td>
<td>39%</td>
<td>30%</td>
</tr>
<tr>
<td>Sunflower</td>
<td>-3%</td>
<td>-10%</td>
</tr>
</tbody>
</table>

* Unrestricted change in Qi (CAP price changes + trend, without area restrictions).
** Restricted change in Qi (CAP price changes + trend, with area restrictions).
Table 2c gives the yield effects of the price cuts alone. At a yield price elasticity of 0.25 for all crops, yield decreases by between 9% and 16% (first column of numbers) relative to the base period, depending on the crop. Yield trend effects offset the price cuts, however - in fact, positive trend effects more than completely offset the effects of the price cuts, leading to yields for all crops which are between 9% and 33% higher than in the base period, when both effects are combined (third column of data). Changes in revenues are also estimated by comparing the product of new price and new yield with base period revenue for each crop. At the new (higher) yield levels, the price cuts reduce revenue/ha significantly: from between -28% for rapeseed to -60% for sunflower, if compensation is not provided.

Table 2d puts acreage and yield effects together to determine the production effects of the price cuts alone (with and without area restrictions). Here we see that, without the set-aside or B-H restrictions imposed, production of all crops but sunflower increases relative to the base period, with cereals production increasing between 8% and 16% relative to the base period, and rapeseed and soybean production increasing by 22% and 39% respectively. With set-aside and B-H imposed (solution S1R), production still increases for three out of five crops, but these changes are much more moderate than without set-aside. Thus, the set-aside and B-H restrictions clearly play an important role in 'disciplining' production of all crops, even when a very significant price-reduction package is imposed.

Results for CAP/Oilseeds Reform (price cuts with compensatory payments paid per hectare)

Solutions S2U and S2R are presented in Tables 3a-3d. The policy and other data used in the model - equation (13) in this case - are given in Table 3a. With the exception of the compensatory payments, these are the same as for solutions S1U and S2R. The direct payments, in proportion to base revenue, are lowest for cereals (21% for wheat and 26% for coarse grains), and are highest for oilseed crops, especially rapeseed (35%) and sunflower (43%).

Planted area results for these solutions - without set-aside imposed - are comprised of three components (Table 3b, first three columns of numbers), with the price and trend effects the same as those discussed above for the price cuts alone. With the new component - the change in area planted due to the compensatory payments package (second column of data), it can be seen that the cross-crop compensation differences (i.e. higher rates of compensation for oilseeds) have the effect of reducing area planted in wheat (by 5%) and increasing the area planted in the oilseed crops (by between 3 and 14%). Coarse grains area also increases (by 2%), mostly because the relatively lower compensation rate for wheat makes this crop more attractive than wheat.

The compensatory payment package thus has a negative effect on area planted in wheat and, more logically, a positive effect in area planted in coarse grains and oilseeds, relative to the base period. The counterintuitive result for wheat is 'driven' by differing rates of compensation, and the ability to, on average, substitute one crop for another. Since, relative to base revenue, wheat has the lowest rate of compensation, land is attracted out of wheat production for planting other crops when compensation is provided.

The total unrestricted area planted in crops - see column e of Table 3b - is again greater than the maximum area allowed under the CAP/Oilseed Reform set-aside provision. As before, area in each crop is reduced by the same proportion (8.8%), this being the amount needed to reduce total area to the maximum allowable (see column e' of Table 3b)). The B-H restriction must also be imposed, since even with the assumed set-aside rate, land planted in oilseeds must be reduced by a further 10%. These
Solution S2U and S2R: Calculation of CAP/Oilseed Reform effects (price cuts with compensatory payments as in Legislation)

Table 3a. Policy Changes, CAP/Oilseeds Reform with Compensatory Payments as designed in the Legislation

<table>
<thead>
<tr>
<th>Crop</th>
<th>Price cuts: dPi/Pi</th>
<th>Compensatory Implementation payments: dOi/P-i dtlk •</th>
<th>period: dtlk *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>-0.40</td>
<td>0.21</td>
<td>7</td>
</tr>
<tr>
<td>Coarse grains</td>
<td>-0.35</td>
<td>0.28</td>
<td>7</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>-0.39</td>
<td>0.35</td>
<td>7</td>
</tr>
<tr>
<td>Soybeans</td>
<td>-0.49</td>
<td>0.29</td>
<td>7</td>
</tr>
<tr>
<td>Sunflower</td>
<td>-0.66</td>
<td>0.43</td>
<td>7</td>
</tr>
</tbody>
</table>

* Assume base year '91/92 t = 1. Since CAP Reform is assumed to be fully implemented by the '98/99 crop year, dt/t = 7 for all i.

Table 3b. Area Response to Price Changes with Compensatory Payments as in CAP/Oilseed Reform Legislation

<table>
<thead>
<tr>
<th>Crop</th>
<th>Price effect*: a</th>
<th>Compensation effect*: b</th>
<th>Trend effect**: c</th>
<th>dAi/Al: Unrestricted area planted, crop i (’000 ha)</th>
<th>New restricted area planted, crop i (’000 ha)</th>
<th>Area set-aside required for oilseeds under B-H***: e’</th>
<th>Area reduction required for oilseeds: e”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>-0.02</td>
<td>-0.05</td>
<td>0.03</td>
<td>-0.04</td>
<td>15339</td>
<td>-0.089</td>
<td>-12%</td>
</tr>
<tr>
<td>Coarse grains</td>
<td>0.06</td>
<td>0.02</td>
<td>-0.06</td>
<td>0.02</td>
<td>17383</td>
<td>-0.089</td>
<td>-7%</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>-0.00</td>
<td>0.09</td>
<td>0.05</td>
<td>0.14</td>
<td>2785</td>
<td>-0.089</td>
<td>-7%</td>
</tr>
<tr>
<td>Soybeans</td>
<td>-0.09</td>
<td>0.03</td>
<td>0.15</td>
<td>0.10</td>
<td>530</td>
<td>-0.089</td>
<td>-10%</td>
</tr>
<tr>
<td>Sunflower</td>
<td>-0.24</td>
<td>0.14</td>
<td>0.07</td>
<td>-0.04</td>
<td>2326</td>
<td>-0.089</td>
<td>-21%</td>
</tr>
<tr>
<td>Cereals</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.01</td>
<td>33073</td>
<td>-0.089</td>
<td>-10%</td>
</tr>
<tr>
<td>Oilseeds</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.05</td>
<td>5640</td>
<td>-0.089</td>
<td>-10%</td>
</tr>
<tr>
<td>All five crops</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.00</td>
<td>38713</td>
<td>-0.089</td>
<td>-10%</td>
</tr>
</tbody>
</table>

* Price effect is SUMj [EAlj]"[dPi/Pi] where EAlj are the area elasticities EAij, 'weighted' by (1+EYPj) for each j. Compensation effect is SUMj [EAlj]"[dDj/P-j]. Trend effect is SUMj [EAlj]"[ETYj]*[dt/t]. These components are equivalent to the terms in expression (13) dealing with area allocation effects.

** c = (max - c(a11))/e(a11), where max is the maximum total area in arable crops (see Table 1), and e(all) is the unrestricted area in all five crops.

*** c”=(4615-(1+e(oil))’e(oil))/(1+e(oil))’e(oil), where e’(oil) and e(oil) are the unrestricted area in oilseeds and the area reduction required for oilseeds. This implements the so-called Blair-House agreement: total oilseeds plantings are limited to 5.128 m. ha less 10%, or 4.615 m. ha.

Table 3c. Yield and Revenue Changes: Price Cuts with Compensatory Payments as Designed in the Legislation

<table>
<thead>
<tr>
<th>Crop</th>
<th>Change in yield, due to price cuts: EYPi(dPi/Pi)</th>
<th>Change in yield, of crop i due to trend: EYTi*dtt</th>
<th>Total change in yield of crop i</th>
<th>New yield revenue (P-i)</th>
<th>New gross revenue from change in revenue from</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>-0.10</td>
<td>0.26</td>
<td>0.15</td>
<td>6.2</td>
<td>885</td>
</tr>
<tr>
<td>Coarse grains</td>
<td>-0.09</td>
<td>0.17</td>
<td>0.09</td>
<td>5.1</td>
<td>762</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>-0.10</td>
<td>0.28</td>
<td>0.18</td>
<td>3.5</td>
<td>1103</td>
</tr>
<tr>
<td>Soybeans</td>
<td>-0.12</td>
<td>0.45</td>
<td>0.33</td>
<td>4.3</td>
<td>1200</td>
</tr>
<tr>
<td>Sunflower</td>
<td>-0.16</td>
<td>0.31</td>
<td>0.15</td>
<td>1.9</td>
<td>689</td>
</tr>
</tbody>
</table>

NOTE: EYPi and EYTi are the yield elasticities (price and trend respectively). Components k and m estimated in this Table represent the terms in expression (13) which deal with yield change.

Table 3d. Changes in Crop Production due to CAP Reform: Price Cuts with Compensatory Payments as Designed in the Legislation

<table>
<thead>
<tr>
<th>Crop</th>
<th>Solution S2U*: k+d+n</th>
<th>solution S2R**: h+n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>11%</td>
<td>3%</td>
</tr>
<tr>
<td>Coarse grains</td>
<td>10%</td>
<td>1%</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>31%</td>
<td>11%</td>
</tr>
<tr>
<td>Soybeans</td>
<td>43%</td>
<td>23%</td>
</tr>
<tr>
<td>Sunflower</td>
<td>11%</td>
<td>-7%</td>
</tr>
</tbody>
</table>

* Unrestricted change in Qi (CAP price changes + compensatory payments + trend, without area restrictions).

** Restricted change in Qi (CAP price changes + compensatory payments + trend, with area restrictions).
combined restrictions, when added to the unrestricted change in planted area, give restricted planted area (column f). The reduction in planted area, after these restrictions, is greatest for sunflower (-21%) and smallest for soybeans (-7%) and coarse grains (-7%).

With the compensatory payments package as designed under CAP/Oilseeds Reform, the payments are assumed by construction not to have an effect on yield, so the yield effects given in Table 3c are the same as for solutions S1U and S1R. The revenue effects of the combined changes (last two columns of Table 3b) are different from those under the price cuts, however, since compensation is added in. Revenue changes are now much smaller for all crops, with moderate decreases in revenue for wheat, coarse grains and soybeans, and a moderate increase in revenue for rapeseed. The reduction in sunflower revenue is still quite large (at -17%).

The combined effects of CAP/Oilseeds Reform on area and yield are given in terms of the production responses given in Table 3d. For wheat, the compensation package without set-aside induces a smaller increases in production than the price cuts alone (+11% vs. +16%). This result is attributable to the area responses described above. For coarse grains and all three oilseed crops, the production increase with the compensatory payments package as designed (no set-aside or B-H) are larger than the production effects of price cuts alone - ranging between +10 and +43% instead of between -3% and +39%.

When the set-aside and B-H restrictions are imposed, the production changes due to CAP/Oilseeds Reform are reduced considerably, with wheat and coarse grains production increasing by only 3% and 1% respectively (relative to the base period). Production of rapeseed increases by 11% and production of soybeans by 23%. Sunflower production actually decreases, relative to the base period. In relation to the restricted production changes due to the price cuts alone, only production of coarse grains and sunflower are higher than the compensatory payments. For wheat, the reasons are the same as discussed above, but the effect for rapeseed and soybeans can be explained by the B-H restrictions on area. The B-H area restriction on oilseeds is almost met by CAP/Oilseeds Reform set-aside when price cuts alone are applied, whereas with compensation, an large additional decrease in area planted in all oilseed crops is needed. Moreover, the distribution of area planted across oilseeds crops differs from that with price cuts alone, since sunflower area increases more than the other two oilseed crops with compensation. As a result, when the B-H restriction is imposed, production of rapeseed and soybeans actually decreases relative to the level with restricted price cuts.

Results for price cuts with fully coupled compensatory payments

Tables 4a-4d present the last set of solutions - price cuts with compensatory payments treated as price-equivalents (Solutions S3U and S3R to equation (14)). Table 4a gives the policy and other data entered into the model - here the price cuts are offset directly (but not totally) for each crop, since the compensatory payments are converted into price equivalents (at base yields).

Without set-aside or B-H restrictions, area allocation effects with this policy treatment are similar to those for CAP/Oilseeds Reform (as designed in the legislation), except that the compensation effects are somewhat greater - see second column of numbers in Table 4b and compare with second column of Table 3b. The changes are larger (more negative for wheat, more positive for coarse grains and oilseeds crops) than when the payments are made per hectare because the fully coupled payments package also affects yield, an influence which is built back into the area allocation.
Table 4a. Policy Changes, CAP/Oilseeds Reform with Compensatory Payments Fully Coupled

<table>
<thead>
<tr>
<th>Crop</th>
<th>Price cuts: dPi/Pi</th>
<th>Compensatory payments: (D/YPi)/Pi</th>
<th>Implementation period: dt/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>-0.40</td>
<td>0.21</td>
<td>7</td>
</tr>
<tr>
<td>Coarse grains</td>
<td>-0.35</td>
<td>0.26</td>
<td>7</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>-0.39</td>
<td>0.35</td>
<td>7</td>
</tr>
<tr>
<td>Soybeans</td>
<td>-0.49</td>
<td>0.29</td>
<td>7</td>
</tr>
<tr>
<td>Sunflower</td>
<td>-0.66</td>
<td>0.43</td>
<td>7</td>
</tr>
</tbody>
</table>

* Yi is the base yield.
** Assume base year '91/92 t = 1. Since CAP Reform is assumed to be fully implemented by the '98/99 crop year, dt/t = 7 for all i.

Table 4b. Area Response to Price Changes and Fully Coupled Compensatory Payments

<table>
<thead>
<tr>
<th>Crop</th>
<th>Price Compensation Effect: a</th>
<th>Trend Compensation Effect: b</th>
<th>New Unrestricted Area Planting d</th>
<th>New Unrestricted Area Planting e</th>
<th>Area Set-Aside Required for Oilseeds f</th>
<th>New Restricted Area Planting g</th>
<th>Restricted Change in Area Planting h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>-0.021</td>
<td>0.06</td>
<td>-0.05</td>
<td>15136</td>
<td>-0.089</td>
<td>-</td>
<td>13785</td>
</tr>
<tr>
<td>Coarse grains</td>
<td>0.064</td>
<td>-0.03</td>
<td>0.02</td>
<td>17821</td>
<td>-0.089</td>
<td>-</td>
<td>16231</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>-0.044</td>
<td>0.11</td>
<td>0.16</td>
<td>27040</td>
<td>-0.089</td>
<td>-0.124</td>
<td>2267</td>
</tr>
<tr>
<td>Soybeans</td>
<td>-0.087</td>
<td>0.04</td>
<td>0.15</td>
<td>532</td>
<td>-0.089</td>
<td>-0.124</td>
<td>426</td>
</tr>
<tr>
<td>Sunflower</td>
<td>-0.242</td>
<td>0.17</td>
<td>0.07</td>
<td>2408</td>
<td>-0.089</td>
<td>-0.124</td>
<td>1922</td>
</tr>
</tbody>
</table>

* Price effect is SUMj [EAij]*[dPj/Pj] where EAij are the area elasticities EAij, 'weighted' by (1 + EYPD) for each j. Compensation effect is SUMj [EAij]*[(D/YPj)/Pj]. Trend effect is SUMj [EAij]*[ETYij]/dt. These components are equivalent to the terms in expression (14) dealing with area allocation effects.
** e' = (max - c(a))/e(a), where max is the maximum total area in arable crops (see Table 1), and c(a) is the unrestricted area in all five crops.
*** e'' = 4615/(1 + e(oil))*e(oil))/(1 + e(oil))*e(oil), where e(oil) and e(oil) are the unrestricted area in oilseeds and the area reduction required for oilseeds. This implements the so-called Blair-House agreement: total oilseeds plantings are limited to 5.128 m. ha less 10%, or 4.615 m. ha.

Table 4c. Yield and Revenue Changes: Price Cuts with Fully Coupled Compensatory Payments

<table>
<thead>
<tr>
<th>Crop</th>
<th>Change in Yield, due to Price Cuts:</th>
<th>Change in Yield, due to Compensatory Payments:</th>
<th>Total Change in Yield of Crop i:</th>
<th>New Gross Revenue: P(h)</th>
<th>Change in Revenue from Revenue: ECU/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>-0.10</td>
<td>0.05</td>
<td>0.25</td>
<td>6.4</td>
<td>916</td>
</tr>
<tr>
<td>Coarse grains</td>
<td>-0.09</td>
<td>0.07</td>
<td>0.17</td>
<td>5.4</td>
<td>796</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>-0.10</td>
<td>0.09</td>
<td>0.28</td>
<td>3.8</td>
<td>1158</td>
</tr>
<tr>
<td>Soybeans</td>
<td>-0.12</td>
<td>0.07</td>
<td>0.45</td>
<td>4.5</td>
<td>1248</td>
</tr>
<tr>
<td>Sunflower</td>
<td>-0.18</td>
<td>0.11</td>
<td>0.31</td>
<td>2.1</td>
<td>719</td>
</tr>
</tbody>
</table>

NOTE: EYPi and ETYi are the yield elasticities (price and trend respectively). Components k and m and n estimated in this Table represent the terms in expression (14) which deal with yield change.

Table 4d. Changes in Crop Production due to CAP Reform: Price Cuts and Fully Coupled Compensatory Payments

<table>
<thead>
<tr>
<th>Crop</th>
<th>Solution S3U: a*d+p</th>
<th>Solution S3R: a*h+p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>15%</td>
<td>7%</td>
</tr>
<tr>
<td>Coarse grains</td>
<td>18%</td>
<td>8%</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>42%</td>
<td>19%</td>
</tr>
<tr>
<td>Soybeans</td>
<td>51%</td>
<td>29%</td>
</tr>
<tr>
<td>Sunflower</td>
<td>25%</td>
<td>5%</td>
</tr>
</tbody>
</table>

* Unrestricted change in Qi (CAP price changes + compensatory payments in price equivalents + trend, without area restrictions).
** Restricted change in Qi (CAP price changes + compensatory payments in price equivalents + trend, with area restrictions).
decision (compare equations (13) and (14)). The unrestricted area planted with fully coupled payments is thus higher for each crop except wheat - see column e in Table 4b and compare with column e in Table 2b.

As before, the total unrestricted area planted in crops - see column e of Table 4b - is greater than the maximum area allowed under the CAP/Oilseed Reform set-aside provision. Again, area planted in each crop is reduced by the same proportion (8.9%), this being the amount needed to reduce total area to the maximum allowable (see column e' of Table 4b). The B-H restriction must also be applied, since area planted in oilseeds must be reduced by a further 12% (see column e") to reach 4.615 m. ha. With these restrictions in place, area planted in all crops is reduced by between 7% (coarse grains) and 21% (sunflower).

When treated as fully coupled payments (i.e. equivalent to price incentives), compensation has a significantly positive effect on yield growth: While the price and trend effects are the same as in previous cases, the yield effects of fully coupled compensation (Table 4c, second column of numbers) result in an increase in yield between +5% for wheat and coarse grains to +11% for sunflower. This additional yield effect, when added to the trend and price cut effects, means that yields increase by between 15% for coarse grains and 40% for soybeans, relative to the base period.

The revenue effects of fully coupled payments are positive for coarse grains (+1%), rapeseed (+12%) and soybeans (+1%). Revenue declines for wheat (-7%) and sunflower (-14%). Of the three scenarios, then, this one has the least negative effect on total crop producer revenue.

The combined effects of area and yield (Table 4d) are, for the unrestricted case, larger than either the price cuts alone or the partially decoupled payments package for all crops but wheat. For the four crops (coarse grains, rapeseed, soybeans and sunflower), this result fits our intuition - fully coupled payments ought to result in the largest increases in production. For wheat, the production change with full coupled payments is actually less than with the price cuts alone; this is the same counterintuitive result discussed before. The provision of compensation actually reduces area planted in wheat (relative to levels with the price cuts alone), although yield effects of fully coupled support mean that the production change is greater than when the payments are made on a per hectare basis.

The restricted production effects (second column of data in Table 4d), are much smaller than the unrestricted effects for all crops, with increases in production ranging between +5% for sunflower to +29% for soybeans.

Summary of results and decoupling estimates

The production effects of the six policy variants (solutions S1U/S1R, S2U/S2R and S3U/S3R) are summarised in Table 5, along with a decoupling estimate (DRate) for each crop with and without set-aside. DRate is calculated for each crop using Definition 4 (presented in Section 2).

Since the production effects for each solution have already been discussed, further explanation of these results is not needed. However, to illustrate how the production effects of the three 'classes' of policy change are related, the data are graphed in Figures 1 and 2.

As can be seen from Figure 1, the production effects - without set-aside or B-H imposed - follow the expected pattern for coarse grains and oilseeds: the production increase is lowest for the fully
Table 5. Summary of Solutions and Decoupling Rate Estimates: CAP/Oilseeds Reform

<table>
<thead>
<tr>
<th>Crop</th>
<th>Solutions 1*</th>
<th>Solutions 2*</th>
<th>Solutions 3*</th>
<th>Decoupling Rate: DRate**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crop production effects: price cuts alone (or compensatory payments fully decoupled)</td>
<td>Crop production effects: price cuts w. compensatory payments as designed under CAP/Oilseeds Reform</td>
<td>Crop production effects: price cuts with fully coupled compensatory payments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Production (000 tonne)</td>
<td>Change in production</td>
<td>Production (000 tonne)</td>
<td>Change in production</td>
</tr>
<tr>
<td></td>
<td>S1U</td>
<td>S1R</td>
<td>S2U</td>
<td>S2R</td>
</tr>
<tr>
<td>Wheat</td>
<td>74945</td>
<td>91991</td>
<td>95093</td>
<td>87797</td>
</tr>
<tr>
<td>Coarse grains</td>
<td>5748</td>
<td>8324</td>
<td>5687</td>
<td>8176</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>6157</td>
<td>91991</td>
<td>95093</td>
<td>87797</td>
</tr>
<tr>
<td>Soybeans</td>
<td>2157</td>
<td>91991</td>
<td>95093</td>
<td>87797</td>
</tr>
<tr>
<td>Sunflower</td>
<td>3956</td>
<td>91991</td>
<td>95093</td>
<td>87797</td>
</tr>
</tbody>
</table>

*S1U, S2U and S3U are Solutions 1, 2, and 3 respectively, without area (set-aside, B-H) restrictions imposed. S1R, S2R and S3R are Solutions 1, 2, and 3 respectively, without area (set-aside, B-H) restrictions imposed.

** The unrestricted DRate estimates (CU) are computed using S1U, S2U and S3U (i.e., without set-aside or B-H area restrictions imposed). The restricted DRate estimates (CR) are computed using S1R, S2R and S3R (i.e., with set-aside and B-H area restrictions imposed). Note that if c is < a or d < b, DRate = 1. This corresponds with Definition 4(n).

Figure 1. Production Change: CAP Reform vs. 1991
3 scenarios, no set-aside, B-H

Figure 2. Production Change: CAP Reform vs 1991
3 scenarios w. set-aside, B-H
decoupled payments and highest for the fully coupled payments, with the production effects of CAP/Oilseeds Reform in between. For wheat, however, this is not the case - production effects of the payments as designed in the CAP/Oilseeds Reform legislation are smaller than those induced with the price cuts alone. This is because, as discussed above, the provision of compensatory payments package actually reduces area planted in wheat, since the compensatory payments, being relatively larger for coarse grains and oilseeds, attract land out of wheat production and into these crops.

When set-aside and B-H is imposed (Figure 2), the production effects illustrated in Figure 1 are mirrored for wheat and coarse grains, but at lower levels of change; there with a slight decrease in coarse grains production when compensation is fully decoupled from production. For oilseeds, however, the patterns of production change are altered when the area restrictions are imposed. Area is reduced equally across oilseed crops from the unrestricted levels, first at the rate required to meet the set-aside restriction for total arable land, and then by any additional amount needed to meet the maximum oilseed area set in the B-H accord. Because the CAP/Oilseed Reform compensatory payments package attracts area into sunflower (relative to planted oilseed areas with the price cuts alone), when the set-aside and B-H restrictions are imposed, production is actually lower for rapeseed and soybeans than with the price cuts alone.

The production effects illustrated by Figures 1 and 2 are captured in the decoupling estimates given in the last two columns of Table 5. Here, we see that, both with and without set-aside, the estimated decoupling rate for wheat is 1 (i.e. the compensatory payments package is fully decoupled from the production of this crop). This is consistent with part (ii) of Definition 4 given in Section 2, and while a surprising result, is easily explained by the substitution effects created when compensation is applied (see discussion in Section 3 above).

Without area restrictions, measured rates of decoupling for coarse grains and oilseed crops are between 0 and 1, i.e., the compensatory payments package is only partially decoupled from production of these crops. The decoupling rates, from least to most decoupled, are: 51% (sunflower); 55% (rapeseed), 70% (soybeans) and 78% (coarse grains). These results, unlike that for wheat, fit the prior suggested in Section 2, i.e., that the measured DRate will be greater than 0 and less than 1 for all crops.

When the area restrictions are applied (set-aside for all crops, and B-H planting limit for oilseeds), the decoupling rate for coarse grain and oilseed crops change considerable. Now, the compensatory payments package is fully decoupled from production of rapeseed and soybeans (along with wheat), while the decoupling rates for the remaining two crops increase: DR for coarse grains rises to 81% and that for sunflower increases to 77%. These decoupling rate estimates are more appropriate for evaluation of the compensatory payments package than the estimates with no area restrictions, since they take into account the effects of set-aside and B-H planted area controls. However, a comparison of the two sets of results show the importance of both area restrictions - they clearly raise the decoupling rates for all crops but wheat, and lead to significantly different conclusions about decoupling for rapeseed and soybeans.

These results lead to an interesting question: would it be possible, given the asymmetric price cuts chosen by the EC, to design a compensation package which is fundamentally the same as that outlined in the CAP/Oilseeds Reform legislation, but which is fully decoupled from production? In one sense, the compensation package, as designed, almost meets one objective of decoupling - providing support which is not commodity-specific. But this attempt falls short of the objective because compensation is set at the same level within crop groups (cereals and oilseeds) rather than for all crops. And, as Table
3a indicates, the ratio of the compensatory payments per hectare differ considerably across crops within the two groups, even when the levels are the same for all crops within the group. This ratio for wheat is only 21%, while for sunflower it is 43%. This lack of balance in the ratio of compensatory payments to base period revenues across crops assures, a priori, that the production effects of the package will differ across crops (i.e. that rates of decoupling will not be the same for all crops).

An alternative configuration of the policy which would achieve full decoupling would be to set the ratio of compensation to base revenue at the same level for all crops. Then, because relative rates of compensation would be the same for all crops, no further change in production would take place once new levels were chosen in response to the price cuts. More technically, homogeneity of degree zero in the supply functions of all crops means that compensation at the same ratio will not change the distribution of production, once it has adjusted to the price cuts. In this case, the compensatory payments package will be fully decoupled from production of all crops, even without the set-aside and B-H restrictions on planted area.

This alternative approach to compensation implies differing levels of compensatory payments for each crop. For example, the ratio of compensatory payment to base revenue is lowest for wheat (at 21%). If this rate were applied to all crops, the compensatory payments would be set as follows (with change from CAP/Oilseed Reform levels in parentheses):

- Wheat: 207 ECU/ha (0%)
- Coarse Grains: 164 ECU/ha (-20%)
- Rapeseed: 216 ECU/ha (-40%)
- Soybeans: 258 ECU/ha (-28%)
- Sunflower: 174 ECU/ha (-51%).

The largest reduction in payments would have to be made for sunflower, and the smallest for coarse grains, given the same payment for wheat as provided by the legislation. Of course, any ratio of compensation to base revenue could be chosen (e.g. 30% or 40%), and the outcome would be the same if this ratio were applied to all crops: the payments package would be fully decoupled from production.

While the analysis is less concerned with forecasting production under CAP/Oilseeds Reform than with relative policy effects, the production responses estimated for the actual Reforms (i.e. solutions S2U and S2R) indicate that production of all crops would increase substantially without the set-aside and B-H area provisions. The production changes estimated are very dependent on the yield trend estimates, but even so, a comparison of the results for CAP/Oilseed Reform in Figures 1 and 2 shows that set-aside (and the B-H accord) represents an important constraint on the production of each crop, resulting in an actual decrease in production of sunflower (1998 vs. 1991). Even with these planted area constraints, the increase in soybeans and rapeseed production is still substantial, at 23% and 11% respectively. An additional implication is that, because the financial impacts of the reforms are insufficient in themselves to achieve a significant reduction in area planted in cereals and oilseeds, the incentives for producers of all crops to 'cheat' on the set-aside and B-H provisions will be very high. Without changes in the financial incentives, effective enforcement of the set-aside provisions will thus be essential, if the reforms are to control cereals and oilseeds production growth.
Discussion

The decoupling estimates described above - particularly for wheat - may be dismissed by some as unrealistic. In fact, it would be fairly easy to find fault with the analysis presented here, and in anticipation of this reaction, and to put these results in context, some caveats must be issued.

First, the model used is a simple, partial equilibrium framework, and does not take account of a number of influences on crop production. One important feature missing is alternative uses of crop land (e.g., livestock production, recreation). This is a potential source of error, particularly for the production change estimates under the price cuts alone, to the extent that other uses attract land out of crops, reducing area planted in each crop when compensation is not provided. If this 'missing' effect is substantial, the decoupling estimates provided here are too high (i.e. the payment package appears to be more decoupled from production than it actually is).

Second, it has been necessary to make assumptions, both about changes in prices for crops due to CAP Reform, and the levels of compensatory payments in the final year of implementation. It is possible, for example, that compensation in the future may be lower (e.g. due to budgetary pressures) or higher (e.g. due to political pressures), and prices/set-aside rates may be higher or lower than those levels used here. Moreover, the base period data used, although carefully checked a number of times, may change as statistics are revised. To the extent that any of these data change, so will the decoupling estimates for each crop.

Third, no adjustment was made to the estimated yield trend effects. It is possible that the 'autonomous' yield growth experienced in the past may not carry on into the future, i.e. that yields have 'peaked' 13. More importantly, lower producer returns under each of the three policy settings may slow autonomous yield growth at differential rates, with lowest growth under the price cuts, and highest growth with fully coupled payments. To the extent that yield would be affected in this way, different decoupling rate estimates would be obtained.

Finally, because the approach uses comparative statics (over a seven year period), 'dynamic' elements are not incorporated. If paths of adjustment to the policy changes are significantly different from the linear ones assumed here, the decoupling estimates may be in error.

While these caveats 'weaken' the results somewhat, there are a number of fairly 'robust' points which can be drawn from the analysis:

i) Critics of CAP/Oilseeds Reform who have assumed that the compensatory payments package is fully coupled to production ought to re-evaluate their positions. The results indicate that the payment package is fully decoupled from production of three out of five crops, and partially decoupled (between 77 and 81%) for two crops when the set-aside and B-H area restrictions are imposed. The pivotal role that cross-crop substitution, 'unbalanced' policy effects and the set-aside, B-H area restrictions play in yielding this outcome should not be ignored;

13 As a way of testing whether lower 'autonomous' yield growth affects decoupling rates, the model was run using one alternative set of yield trend elasticities, based on a more recent period (1986-1991), reflecting lower yield growth rates for all crops. While this alternative set of calculations led to lower production levels under all three policy scenarios, the decoupling rates estimated for each crop, both with and without set-aside, were almost identical to the estimates given in Table 5. For this reason, and because yield trend is assumed to be the same for all three policy settings, the possible influence of lower yield trends on the results are probably quite small.
ii) The methodology used here provides insights which are 'hidden' by supply functions which combine yield and trend effects. In order to assess the effects of the policy reforms properly, it seems to be essential to separate area and yield decisions, and to test/measure assumptions about the extent to which the payments influence each. Given this 'foundation', the approach suggested here seems to offer a number of opportunities for further research into the decoupling issue; and

iii) The financial impact of CAP/Oilseeds Reform is not sufficient to remove enough land from production to meet the maximum planted area allowable under an assumed average set-aside rate of 9%. Moreover, the B-H restriction on oilseeds area is not met, even when set-aside is imposed. This means that there will be an incentive for producers to 'cheat' on the set-aside provisions, and so enforcement of the provisions will be essential to prevent substantial increases in crop production by 1998. How enforcement will be carried out, especially for the B-H restrictions, is an open question which the European Commission will have to grapple with.

4. Conclusion

Beginning with a formal definition of three forms of decoupling, an 'index' which can measure the rate of decoupling of the EC's compensatory payments package was derived. A prior expectation that the payments would be partially decoupled from production was also suggested as a reasonable hypothesis to test. Using a simple model of EC crop production and information regarding CAP/Oilseeds Reform policy changes, it was possible to measure production change for three policy scenarios: payments fully decoupled from production, payments provided as designed in the CAP/Oilseeds Reform legislation, and payments fully coupled to production. These results were then used, along with the definitions developed, to measure the rate of decoupling of the compensatory payments package from production of five major crops in the EC (wheat, coarse grains, rapeseed, soybeans and sunflower).

The rates of decoupling were first measured without taking set-aside and 'Blair House' (B-H) restrictions on planted area into account. Decoupling rates for four out of five crops were between zero and one (i.e. the compensatory payments package is only partially decoupled from production of these crops). These results fit the prior expectation, and give decoupling rates of (from least to most decoupled): 51% for sunflower; 55% for rapeseed; 70% for soybeans; and 78% for coarse grains. The estimated decoupling rate for wheat is 1, i.e. the compensation package is fully decoupled from wheat production. This latter result, although somewhat surprising and inconsistent with prior expectations, is caused by cross-crop substitution; relatively higher compensatory payments for other crops (in relation to base period revenue) mean that, when compensation is provided, some land is drawn out of wheat production and planted in other crops.

The counterintuitive result for wheat is compounded when the set-aside and B-H area restrictions are imposed. Since the changes in financial incentives is insufficient to draw enough land out of production to meet either area restriction, planted area is reduced from the solution levels to meet

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14 As acknowledged in footnote 11, payments are made to set-aside area, and, at the rate set in the legislation (same as payment for planted area), this represents between 23% and 52% of revenue from planted area for solutions under CAP/Oilseeds Reform (S2U and S2R). To the extent that these payments are an incentive for producers to be honest about the actual area and quality of land that they set-aside, the enforcement problems are mitigated. But payments cannot ensure that the set-aside rules are being respected without enforcement and monitoring, since even at these generous levels of payments for set-aside land, the revenue from having a crop in the ground is far higher.
these constraints. In the process, the decoupling rates change, and the compensatory payments package becomes fully decoupled, not only from wheat production, but also from the production of rapeseed and soybeans. The decoupling rates for the other two crops also increase (to 81% for coarse grains and 77% for sunflower).

It is not yet clear whether the set-aside and B-H area restrictions will be as effective as assumed in the analysis. The combination of price reductions and compensatory payments does not in itself draw enough land out of production to meet the two area constraints. This suggests that there will be a considerable financial incentive for farmers, when submitting their set-aside plans, to inflate the area taken out of production. As a result, strict enforcement of the set-aside provisions will be necessary to reduce planted area and keep crop production under some control. Moreover, since for four out of five crops, the measured rate of decoupling depends upon the effectiveness of these provisions, conclusions about the 'decoupledness' of the compensatory payments package from production of these crops hinges on the success of the two area restrictions.

In either case, the analysis opens a number of avenues for further thinking about CAP/Oilseed Reform. For example, it is possible to design a compensatory payments package which is fully decoupled from production of all crops. This can be done by setting the payments so that the ratio of the payment to base revenue is the same for all crop. This would entail different levels of compensatory payments for each crop, and likely a significant reduction in payments to oilseeds crops (to make these more in line with payments to cereals crops).

The methodology itself also provides a useful framework with which to analyse the reforms, and can be used to test a multitude of policy variants. While the approach does have a number of limitations which may reduce the accuracy of results obtained with it, further research could determine which of these limitations are 'important' and which are not.

Finally, the results indicate that the payments are far more decoupled from production than many observers and critics of CAP/Oilseed Reform have thought. While subject to a number of caveats, the estimates of decoupling obtained here suggest that concerns about the compensatory payments - that they will significantly distort production and trade - ought to be re-evaluated. If the set-aside and B-H restrictions are indeed effective, there may not be as strong a need to make the compensatory payments package subject to GATT internal support disciplines, although it is clear that the payments would still have a positive impact on coarse grains and sunflower production. One way in which the EC could ensure that competitors for world grain and oilseed markets are not injured by the payments is to redesign the compensation package so that it has a more balanced effect on crop revenues, as suggested in the example above.


CARD (1993), "Baseline Forecast from FAPRI model", photocopied set of tables, Centre for Agricultural and Rural Development, Iowa State University, February.


Hertel, T.W., E.B. Peterson, P.V. Preckel et al (1990), "Notes on the Constant Difference Elasticity (CDE) Functional Form and its Implementation in Applied General Equilibrium Models", Staff Paper 90-10, Department of Agricultural Economics, Purdue University, June.


Sarris, A.H. (1992), "Implications of EC Economic Integration for Agriculture, Agricultural Trade and Trade Policy", paper prepared for the 31st European Seminar of the European Association of Agricultural Economists, Frankfurt am Main, December.


ANNEXES

1. Calculation of Direct Compensatory Payments/Hectare for Cereals

The CAP Reform legislation regarding the compensatory direct payments to cereals producers (EC(1992b)), while designed to make payments per hectare, actually only provides the compensation rate in ECU per tonne (in 1998, this will be 45 ECU/tonne (ibid., p. 15)). This is due to the fact that, in order to make the payments, the Commission first requires information from each Member State regarding historic regional yields for cereals; to compensate producers in any region, the Commission will then use these historic yield data to calculate the compensation rate/hectare, i.e.:

\[
D_i^r = 45 \cdot Y_{rc}^r ; i \in C ; r = 1 \ldots R
\]

where: 
- \(D_i^r\) is the compensatory direct payment (per hectare) to producers of cereal crop \(i\) in region \(r\),
- \(Y_{rc}^r\) is the average cereals yield in region \(r\),
- \(C\) is the set of cereal crops eligible for compensation (see EC (1992b, p. 19), and
- \(R\) is the total number of production regions included in the regionalisation plans submitted to the Commission by member states.

At time of writing, regional yield data had not yet been published in the Official Journal publications available to the author, and so, while ideally an EC-wide average yield could be computed with regional data to arrive at an average EC-wide compensation rate, an alternative approach must be taken to obtain an estimate of the yield. Specifically, EC-wide average yield for cereals crops are obtained the crop years 1986/87 to 1990/91. An average of these yields is then calculated, excluding the highest and lowest yield. It should be noted: (a) that the compensation rate of 45 ECU/tonne in the CAP legislation may not be the one applied in 1998; and (b) that historic yield data for a more recent period (e.g. 1989-1994) may be used to compensate producers in 1998. Political decisions may also play a role in determining the levels of compensation.

Data for yields of wheat and coarse grains crops, and the EC-wide compensation rate for cereals are provided in Table A1.1. The direct compensatory payment for cereals computed with these data is 207 ECU/hectare.

\[\text{1 The legislation also allows Member States to set up plans for all producers in the Member State (i.e. compensation rates would depend on historic yields for each producer). The transactions cost of such a scheme is so high that we would expect this to be unfeasible, at least in the foreseeable future.}\]
Table A1.1 Estimation of average EC Compensatory Direct Payments: Cereals, 1998/99

<table>
<thead>
<tr>
<th>Crop</th>
<th>1986/87</th>
<th>1987/88</th>
<th>1988/89</th>
<th>1989/90</th>
<th>1990/91</th>
<th>Area ('000 ha)</th>
<th>Production ('000 tonne)</th>
<th>Yield (tonne/ha)</th>
<th>Average yield with min/max removed</th>
<th>Estimated average compensatory direct payment/ hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common wheat</td>
<td>12924</td>
<td>13005</td>
<td>12811</td>
<td>13422</td>
<td>12792</td>
<td>12924</td>
<td>64900</td>
<td>5.02</td>
<td>4.93</td>
<td>5.34</td>
</tr>
<tr>
<td>Durum wheat</td>
<td>2783</td>
<td>2855</td>
<td>2720</td>
<td>2824</td>
<td>2956</td>
<td>2783</td>
<td>7238</td>
<td>2.60</td>
<td>2.64</td>
<td>2.45</td>
</tr>
<tr>
<td>Wheat</td>
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<td>15860</td>
<td>15531</td>
<td>16246</td>
<td>15748</td>
<td>15707</td>
<td>72138</td>
<td>4.59</td>
<td>4.51</td>
<td>4.83</td>
</tr>
<tr>
<td>Rye and meslin</td>
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<td>1050</td>
<td>954</td>
<td>951</td>
<td>945</td>
<td>1023</td>
<td>3060</td>
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<td>2.89</td>
<td>3.00</td>
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<tr>
<td>Barley</td>
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<td>12345</td>
<td>12219</td>
<td>11764</td>
<td>11353</td>
<td>12648</td>
<td>46839</td>
<td>3.70</td>
<td>3.86</td>
<td>4.15</td>
</tr>
<tr>
<td>Oats/mixed cereals</td>
<td>2007</td>
<td>1855</td>
<td>1835</td>
<td>1783</td>
<td>1500</td>
<td>2007</td>
<td>6009</td>
<td>2.59</td>
<td>3.07</td>
<td>3.17</td>
</tr>
<tr>
<td>Maize</td>
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<td>3778</td>
<td>4038</td>
<td>3970</td>
<td>3497</td>
<td>3934</td>
<td>25400</td>
<td>6.46</td>
<td>6.84</td>
<td>6.98</td>
</tr>
<tr>
<td>Coarse grains</td>
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<td>18928</td>
<td>19046</td>
<td>18468</td>
<td>17295</td>
<td>19612</td>
<td>81308</td>
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<tr>
<td>Cereals</td>
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<td>34714</td>
<td>33043</td>
<td>35319</td>
<td>153446</td>
<td>4.34</td>
<td>4.41</td>
<td>4.70</td>
</tr>
</tbody>
</table>


Note: Yield data are computed with the area and production data. These conform, for the disaggregated crops, with data given in the source publications; only exception is oats and mixed cereals for 1986, where the yields given in EC(1989, p. T168) appear to be incorrect.
2. Estimation of Market Prices for Oilseed Crops under CAP/Oilseed Reform

Although the CAP/oilseeds reform legislation provides a target price of 110 ECU/tonne for cereals for the 1995/96 marketing year onwards, and this can be assumed to represent the market price in the last year of implementation (1998), there is no similar guide for prices of oilseed crops (rapeseed, soybeans and sunflower), since these prices are to be set at 'world' market price levels. As a result, it is necessary to obtain forecast 'world' market price data for these commodities, valued in ECU at an EC port, in order to provide the model with price changes for the oilseed crops.

CARD(1993) provides a forecast (for 1998) of the price of soybeans at the EC border (CIF Rotterdam), and it was possible to obtain similarly defined data for rapeseed and sunflower, although these are not reported in the CARD (1993) tables\(^2\). For 1998, then, the prices forecasted by the FAPRI model and used in this analysis to represent market prices to producers for oilseed crops are:

- rapeseed: 210 ECU/tonne
- soybeans: 197 ECU/tonne, and
- sunflower: 171 ECU/tonne.

3. Estimation of Maximum EC Crop Area under Set-Aside Planted Area Restrictions

The CAP/Oilseed Reform Legislation requires that area reduction plans be submitted in order for large producers to receive compensatory payments. These plans establish the "average number of hectares ... down to arable crops ... during 1989, 1990 and 1991" (EC(1992b, p. 13, Article 2, para 2)). Then this planted area must be reduced by 15%.

To take account of the fact that the analysis 'lumps' small and large producers together, an average set-aside rate of 9% has already been arrived at (see fn. 12, main text). It is also necessary to arrive at a similar aggregate level for the area down to arable crops in 1989, 1990 and 1991. This is done by collecting data for area planted to all cereals and oilseed crops in those years and computing a three year average (see Table A1.2), which for the arable crops considered in this analysis, was 38.772 million hectares. This area is then reduced by the assumed 9% average set-aside rate to arrive at a maximum planted area with set-aside of 35.283 million hectares.

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\(^2\) Obtained through personal communication with Mike Helmar, CARD, June 1, 1993.
Table A1.2 Calculation of EC 'base area' for set-aside

<table>
<thead>
<tr>
<th>Area ('000 ha)</th>
<th>1989/90</th>
<th>1990/91</th>
<th>1991/92</th>
<th>'89-91 average</th>
</tr>
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<tr>
<td>Common wheat</td>
<td>13422</td>
<td>12792</td>
<td>12572</td>
<td>12929</td>
</tr>
<tr>
<td>Durum wheat</td>
<td>2824</td>
<td>2956</td>
<td>3361</td>
<td>3047</td>
</tr>
<tr>
<td>Wheat</td>
<td>16246</td>
<td>15748</td>
<td>15933</td>
<td>15976</td>
</tr>
<tr>
<td>Rye and meslin</td>
<td>951</td>
<td>945</td>
<td>854</td>
<td>917</td>
</tr>
<tr>
<td>Barley</td>
<td>11764</td>
<td>11353</td>
<td>11231</td>
<td>11449</td>
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<tr>
<td>Oats/mixed cereals</td>
<td>1783</td>
<td>1500</td>
<td>1425</td>
<td>1569</td>
</tr>
<tr>
<td>Maize</td>
<td>3970</td>
<td>3497</td>
<td>3887</td>
<td>3785</td>
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<tr>
<td>Coarse grains</td>
<td>18468</td>
<td>17295</td>
<td>17397</td>
<td>17720</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>1660</td>
<td>2131</td>
<td>2453</td>
<td>2081</td>
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<tr>
<td>Soybeans</td>
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<td>664</td>
<td>481</td>
<td>592</td>
</tr>
<tr>
<td>Sunflower</td>
<td>2133</td>
<td>2651</td>
<td>2423</td>
<td>2402</td>
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<tr>
<td>Oilseeds</td>
<td>4425</td>
<td>5446</td>
<td>5357</td>
<td>5076</td>
</tr>
<tr>
<td>TOTAL</td>
<td>39139</td>
<td>38489</td>
<td>38687</td>
<td>38772</td>
</tr>
<tr>
<td>Maximum Area</td>
<td></td>
<td></td>
<td></td>
<td>35283</td>
</tr>
</tbody>
</table>

(*9% set-aside rate)


NOTE: base area is "the average number of hectares ... down to arable crops ... during 1989, 1990 and 1991", EC(1992b, p. 13, Article 2, para 2).
Annex 2. Derivation of Planted Area Elasticities with the Constant Difference of Elasticities (CDE) Functional Form

The CDE functional form requires that $H(\bar{P},X)$ - see (3) - be implicitly additive, i.e., that it be specified as:

$$H(\bar{P},X) = \sum_{i=1}^{n} H_i(\bar{P},R,X) = 1.$$  

where: $R$ is total revenue from all crop activities $= \sum_{i=1}^{n} \bar{P}_i \cdot A_i$.

Since $H(\bar{P},X)$ is homogeneous of degree 1 in prices, it can be normalised as:

$$H(Z,X) = 1,$$

where: $Z$ is a 1xn vector comprised of elements $Z_i = \frac{\bar{P}_i}{R}$.

The CDE implicit revenue function used to implement (A2.2) is specified as

$$\sum_{i=1}^{n} D_i \cdot Z_i^d \cdot X^{f_i d_i} = 1,$$

where: $d_i = 1 - a_i$;

$a_i$ (<<0 ∀ i) is a substitution parameter which ensures that the difference between substitution elasticities $\sigma_{gi}$ and $\sigma_{hi}$ are equal to the difference between the parameters $a_g$ and $a_h$;

$D_i$ (>>0 ∀ i) is a scale parameter which, when restricted to be nonnegative and nonzero ensures, with the negativity restriction on $a_p$ that $H$ will fulfill the regularity conditions required for duality; and

$f_i > 0$ is an expansion parameter (representing returns to scale = 1 for constant returns to scale).

The supply functions for planted area can be derived by applying Shephard's lemma to (A2.3); from these supply functions, elasticities of demand can also be derived. Specifically, the elasticities of planted crop areas consistent with (A2.3) are:

$$\xi_{ii} = r_i \cdot (2a_i - \sum_{k=1}^{n} r_k \cdot a_k) - a_i;$$

$$\xi_{ij} = r_j \cdot (a_i + a_j - \sum_{k=1}^{n} r_k \cdot a_k),$$
where: \( r_i \) is the revenue share \( \frac{\bar{p}_i \cdot A_i}{R} \).

Parameters \( a_i \) are obtained via calibration. This is done by providing the own-price elasticities to the following system of equations (which combine equations (A2.4a in matrix form):

\[
(A2.5) \quad -\xi = \tilde{R} \cdot A,
\]

where: \( \xi \) is an \( 1 \times n \) vector comprised of elements \( \epsilon_{ii} \);

\( \tilde{R} \) is an \( n \times n \) matrix with elements \( (1-r_i)^2 \) on the diagonal and \( r_i r_j \) on the off-diagonal; and

\( A \) is an \( n \times 1 \) vector of the parameters \( a_i \).

Note that \( X \) (the input aggregate) is excluded from expressions \((A2.4a - A2.5)\) because it does not affect the elasticities or other parameters due to the assumption of joint technology.

Parameters \( a_i \) may be solved by inverting \( \tilde{R} \) (providing this matrix is non-singular):

\[
(A2.6) \quad A = -\tilde{R}^{-1} \cdot \xi,
\]

Then, the parameters \( a_i \) can be used to compute a theoretically consistent set of planted area cross-elasticities \( \xi_{ij} \) using \((A2.4b)\). The data and calculations used to accomplish this are given in Tables A2.1 and A2.2, along with the full set of planted area elasticities computed.
Annex 2. Calibration of EC Acreage Elasticities using CDE Revenue Function

Table A2.1 Basic data

<table>
<thead>
<tr>
<th>crop</th>
<th>revenue share (ri)</th>
<th>wt</th>
<th>cg</th>
<th>rp</th>
<th>sb</th>
<th>sf</th>
</tr>
</thead>
<tbody>
<tr>
<td>wheat (wt)</td>
<td>0.46</td>
<td>0.297</td>
<td>0.180</td>
<td>0.033</td>
<td>0.008</td>
<td>0.027</td>
</tr>
<tr>
<td>coarse grains(cg)</td>
<td>0.40</td>
<td>0.180</td>
<td>0.365</td>
<td>0.029</td>
<td>0.007</td>
<td>0.023</td>
</tr>
<tr>
<td>rapeseed (rp)</td>
<td>0.07</td>
<td>0.033</td>
<td>0.029</td>
<td>0.659</td>
<td>0.001</td>
<td>0.004</td>
</tr>
<tr>
<td>soybeans (sb)</td>
<td>0.02</td>
<td>0.008</td>
<td>0.007</td>
<td>0.001</td>
<td>0.966</td>
<td>0.001</td>
</tr>
<tr>
<td>sunflower (sf)</td>
<td>0.06</td>
<td>0.027</td>
<td>0.023</td>
<td>0.004</td>
<td>0.001</td>
<td>0.687</td>
</tr>
<tr>
<td>sum</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
 inv[R]: \text{inverse of } [R] \\
\begin{array}{cccccc}
\text{wt} & \text{cg} & \text{rp} & \text{sb} & \text{sf} \\
4.829 & -2.370 & -0.107 & -0.022 & -0.082 & -0.680
\end{array}
\]

\[
\text{ wg} = \text{inv} [R-I] \times [-E] \\
\begin{array}{cccccc}
\text{wt} & \text{cg} & \text{rp} & \text{sb} & \text{sf} \\
-2.370 & 3.916 & -0.040 & -0.008 & -0.031 & -0.750
\end{array}
\]

\[
\text{ sb} = \text{inv} [R-I] \times [-E] \\
\begin{array}{cccccc}
\text{wt} & \text{cg} & \text{rp} & \text{sb} & \text{sf} \\
-0.107 & -0.008 & -0.000 & 1.036 & -0.000 & -0.666
\end{array}
\]

\[
\text{ sf} = \text{inv} [R-I] \times [-E] \\
\begin{array}{cccccc}
\text{wt} & \text{cg} & \text{rp} & \text{sb} & \text{sf} \\
-0.082 & -0.031 & -0.001 & -0.000 & 1.131 & -0.700
\end{array}
\]

\[
\text{ sum} = -1.23
\]

Table A2.2 determination of the matrix of compensated crop area elasticities

<table>
<thead>
<tr>
<th>([E]_{ij})</th>
<th>(wt)</th>
<th>(cg)</th>
<th>(rp)</th>
<th>(sb)</th>
<th>(sf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(wt)</td>
<td>0.680</td>
<td>-0.546</td>
<td>-0.072</td>
<td>-0.013</td>
<td>-0.048</td>
</tr>
<tr>
<td>(cg)</td>
<td>-0.628</td>
<td>0.750</td>
<td>-0.066</td>
<td>-0.012</td>
<td>-0.044</td>
</tr>
<tr>
<td>(rp)</td>
<td>-0.447</td>
<td>-0.357</td>
<td>0.830</td>
<td>-0.005</td>
<td>-0.020</td>
</tr>
<tr>
<td>(sb)</td>
<td>-0.356</td>
<td>-0.278</td>
<td>-0.022</td>
<td>0.666</td>
<td>-0.009</td>
</tr>
<tr>
<td>(sf)</td>
<td>-0.376</td>
<td>-0.296</td>
<td>-0.026</td>
<td>-0.003</td>
<td>0.700</td>
</tr>
</tbody>
</table>

Note: the diagonals are assumed levels. Off diagonals are computed using (A2.4b). Revenue share data are derived with information given in Table 1.
Annex 3. Estimation of Yield Trend Elasticities

In order to implement the model (equations (12) (13) and (14), it is necessary to obtain values for the yield trend elasticities (defined in expression (10)). Here, following an approach used by Guyomard et al (1991, p. 126), the yield trend elasticities are 'estimated' using average yield and price growth data (for each crop over the period 1980-1991). This is done by rearranging expression (8) as:

\[
\frac{dY_i}{Y_i} = \xi_i \frac{dP_i}{P_i} + \xi_i \frac{dW}{W} + \xi_i \frac{dt}{t}
\]

where: \( \frac{dY_i}{Y_i} \) is the average annual yield growth rate of crop \( i \), 1980-1991 ; 
\( \xi_i \frac{dP_i}{P_i} \) is the elasticity of yield to input price (\( =\xi_i \frac{dP_i}{P_i} = 0.25 \)); and 
\( \frac{dP_i}{P_i} \) is the average annual growth rate of producer price of crop \( i \) (1980-1991).

Rearrangement of A3.1 allows us to estimate the trend elasticities (where the average \( dt/t = 1 \) and can be dropped):

\[
\xi_i = \frac{dY_i}{Y_i} - \xi_i \frac{dP_i}{P_i} - \xi_i \frac{dW}{W}
\]

The average growth rates of yields and prices - derived with the data in Table A3.1 - are given in Table A3.2. Yield growth averaged between 1.6% per annum for coarse grains to 5.8% per annum for soybeans over the period 1980-1991. The average annual growth rate of producer prices for the same period ranged between 0.7% for wheat to 3.8% for sunflower.

Estimated yield trend elasticities are given in the third to last row of Table A3.3. These range between 2.5% per year for coarse grains to 6.4% per year for soybeans. Yield trend elasticities are also estimated for the more recent period 1986-1991. This is done because, as the second to last row of Table A3.3 indicates, autonomous yield growth slowed in the latter years of the 1980's (with the largest reduction for wheat - see last row - and the smallest for sunflower. This second set of results is useful to determine how measured decoupling rates change when yield elasticities change (see fn. 13 in main text).
Table A3.1. EC Yield and Price Data

<table>
<thead>
<tr>
<th>Year</th>
<th>yield (tonne/ha): Yi</th>
<th>producer price (ECU/tonne): Pi</th>
<th>nominal input price index: 1985=100</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>wheat</td>
<td>egrain</td>
<td>rapeseed</td>
</tr>
<tr>
<td>1979</td>
<td>3.61</td>
<td>3.60</td>
<td>2.20</td>
</tr>
<tr>
<td>1980</td>
<td>3.93</td>
<td>3.85</td>
<td>2.68</td>
</tr>
<tr>
<td>1981</td>
<td>3.72</td>
<td>3.61</td>
<td>2.22</td>
</tr>
<tr>
<td>1982</td>
<td>4.05</td>
<td>3.89</td>
<td>2.58</td>
</tr>
<tr>
<td>1983</td>
<td>4.00</td>
<td>3.72</td>
<td>2.17</td>
</tr>
<tr>
<td>1984</td>
<td>5.12</td>
<td>4.49</td>
<td>2.80</td>
</tr>
<tr>
<td>1985</td>
<td>4.68</td>
<td>4.38</td>
<td>2.83</td>
</tr>
<tr>
<td>1986</td>
<td>4.62</td>
<td>4.16</td>
<td>2.83</td>
</tr>
<tr>
<td>1987</td>
<td>4.54</td>
<td>4.35</td>
<td>3.14</td>
</tr>
<tr>
<td>1988</td>
<td>4.78</td>
<td>4.60</td>
<td>2.82</td>
</tr>
<tr>
<td>1989</td>
<td>4.86</td>
<td>4.51</td>
<td>2.96</td>
</tr>
<tr>
<td>1990</td>
<td>5.14</td>
<td>4.37</td>
<td>2.86</td>
</tr>
<tr>
<td>1991</td>
<td>5.36</td>
<td>4.70</td>
<td>3.05</td>
</tr>
</tbody>
</table>

Source: yield and output price data: OECD
Table A3.2 Calculated Growth Rates: yield, price

<table>
<thead>
<tr>
<th>Year</th>
<th>wheat</th>
<th>grain</th>
<th>rapeseed</th>
<th>soybeans</th>
<th>sunflower</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>9.1%</td>
<td>6.9%</td>
<td>21.6%</td>
<td>56.6%</td>
<td>4.1%</td>
</tr>
<tr>
<td>1981</td>
<td>-5.4%</td>
<td>-6.3%</td>
<td>-17.1%</td>
<td>10.5%</td>
<td>-5.3%</td>
</tr>
<tr>
<td>1982</td>
<td>8.7%</td>
<td>7.8%</td>
<td>16.2%</td>
<td>3.0%</td>
<td>33.2%</td>
</tr>
<tr>
<td>1983</td>
<td>-1.2%</td>
<td>-4.5%</td>
<td>-15.0%</td>
<td>17.1%</td>
<td>-3.1%</td>
</tr>
<tr>
<td>1984</td>
<td>28.2%</td>
<td>20.7%</td>
<td>28.8%</td>
<td>3.2%</td>
<td>17.0%</td>
</tr>
<tr>
<td>1985</td>
<td>-8.7%</td>
<td>-2.3%</td>
<td>0.9%</td>
<td>12.5%</td>
<td>-0.0%</td>
</tr>
<tr>
<td>1986</td>
<td>-1.3%</td>
<td>-5.1%</td>
<td>0.3%</td>
<td>16.9%</td>
<td>9.3%</td>
</tr>
<tr>
<td>1987</td>
<td>-1.7%</td>
<td>4.6%</td>
<td>10.8%</td>
<td>-0.5%</td>
<td>18.5%</td>
</tr>
<tr>
<td>1988</td>
<td>5.2%</td>
<td>5.7%</td>
<td>-10.2%</td>
<td>-2.0%</td>
<td>1.8%</td>
</tr>
<tr>
<td>1989</td>
<td>1.6%</td>
<td>-2.0%</td>
<td>4.8%</td>
<td>1.0%</td>
<td>-9.6%</td>
</tr>
<tr>
<td>1990</td>
<td>5.8%</td>
<td>-3.3%</td>
<td>-3.2%</td>
<td>-1.2%</td>
<td>-1.5%</td>
</tr>
<tr>
<td>1991</td>
<td>4.3%</td>
<td>7.7%</td>
<td>6.8%</td>
<td>0.3%</td>
<td>1.2%</td>
</tr>
</tbody>
</table>

*Yield growth: dYt/Yt = (Yt(1980)-Yt(1979))/Yt(1979). Similarly for Pi.

* maximum and minimum yield change removed from average, to remove obvious 'outliers'.

Table A3.3. Calculation of Yield Trend Elasticity
(Annual Price-Independent Yield Growth)

<table>
<thead>
<tr>
<th>Year</th>
<th>wheat</th>
<th>grain</th>
<th>rapeseed</th>
<th>soybeans</th>
<th>sunflower</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980-1991</td>
<td>2.5%</td>
<td>1.6%</td>
<td>3.2%</td>
<td>5.8%</td>
<td>4.2%</td>
</tr>
<tr>
<td>1985-1991</td>
<td>0.8%</td>
<td>0.8%</td>
<td>1.5%</td>
<td>3.9%</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

*Yield trend elasticity:
1. EYt(1980-1991) = 0.036
2. EYt(1986-1991) = 0.015
ratio: 2 vs 1
Annex 4. A Survey of Decoupling Definitions

The following is a number of definitions of decoupling drawn from the surveyed literature:

1) "The concept of reducing or eliminating trade-distorting subsidies but allowing for government programmes which are neither output nor trade-distorting is called 'decoupling' " (Weiss (1992, p.1));

2) "Policies which result in production ... levels which are the same as those which would occur in the absence of support are termed decoupled" (Roberts and Andrews (1991, p. 204));

3) "Decoupled program payments...provide to farmers income support that is independent of what or how much is produced... As used in the various debates, decoupling is not always a well-defined concept [my emphasis]" (McIntosh and Shumway (1991, p. 299));

4) "Over time, the term 'decoupling' has taken on several different connotations and definitions [my emphasis]. The term has even been used in reference to any government program which does not distort trade...For this paper however, we limit use of the term to direct payments to farmers. If neither implementation nor removal of a payment has any impact on production, the payment is fully decoupled. One can also think of partially decoupled programs in which the link between program payments and output is partially broken" (Magiera and Dixit (1991, p. 1));

5) "Although various definitions have been attempted [my emphasis] of the term 'decoupling', there is no ambiguity about its essential meaning ....[which is to] break the link between the provision of income assistance to farmers and the latter's production decisions" (Warley (1988, p. 1));

6) "we will define decoupling in the following way: ...when any form of public financial support ... received by an agricultural producer [has] ... no direct connection with, or ... direct influence in the allocation of resources ... devoted to a particular commodity" (Gilson (1988, p. 5));

7) "In general, the term refers to the concept of transferring income to farmers with a production neutral, and presumably trade neutral, effect. Because the term has often been used without precise definition, some confusion has arisen over its relationship to various forms of agricultural subsidy programs...[my emphasis]" (Carr and Rossmiller (1988, p. 136))

8) "[decoupling is] where government support provided to farmers is unrelated to specific farm commodities and their levels of production...Other analysts have suggested many other definitions that are different from that proposed here[my emphasis]" (Finkle and Furtan (1988, p. 149));

9) "One of the predominant themes which has surfaced from these papers has been the lack of consensus among authors in establishing a uniform definition of 'decoupling'[my emphasis] .... With these features in mind the following definition of decoupling is submitted as a candidate for consensus:

Decoupling means restructuring the criteria by which farmers receive government support in such a way that payment entitlements are as unrelated as possible [my emphasis] to classifications of specific commodities and their levels of production, or production practices related to such commodities and their levels of production" (Finkle and Cameron (1988, pp. 158-159)); and
10) "Decoupling means to remove income support from production decisions and to permit free market
determination of commodity prices. Payments to farmers should not be linked to production" (Rausser, G. C. and Foster, W.E. (1987, p. 18)).

Discussion

None of these references provide a formal definition for the term partial decoupling - only Josling and
Mariani do this (more or less - see my discussion of this, p. 2 in main text). Instead, most look at how total
decoupling can be achieved. In this regard, many define decoupling as support which is unrelated to levels of
production. With this type of definition, it can be said that the EC's compensatory payments are perfectly decoupled
a priori, since the payment does not depend on the level of production of any crop, merely that the crop be planted.

I instead choose the middle ground and use definition (2) above, adapting it to the case of compensatory
payments. The definition of partial decoupling that I use is also flexible enough to encompass 'total' decoupling
(DRate = 1) or no decoupling (DRate = 0), as well as any point in between.