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A Matrix Approach to Evaluating Policy: Preliminary Findings from PEM Pilot Studies of Crop Policy In the EU, the US, Canada and Mexico

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A MATRIX APPROACH TO EVALUATING POLICY: PRELIMINARY FINDINGS FROM PEM PILOT STUDIES OF CROP POLICY IN THE EU, THE US, CANADA AND MEXICO

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FOREWORD

This paper contains a description of, and results to date from, the Policy Evaluation Matrix (PEM) project. The project constitutes a joint effort by the Secretariat and a number of Member countries participating in a pilot project to develop a framework for quantifying effects of different types of farm support as measured by the PSE. Six Member countries are currently participating in the project: Canada, the European Union (represented by the EU Commission), Mexico, the United States and, most recently, Japan and Switzerland. Results to date come from analyses of some major programmes of crop support for the first four of the countries listed above. It was declassified in February 2000 under the responsibility of the Secretary-General.

Acknowledgements

This paper is based on work done by the PEM Work Group, a project team comprising staff from the Secretariat and the Member countries participating in the project. Members of this project team directly involved in the crop policy analysis and/or in the drafting of this report are listed below (the institutional affiliation may not be current):

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EXECUTIVE SUMMARY

The Producer Support Estimate (PSE) indicates the monetary value of transfers from consumers and taxpayers to agricultural producers resulting from policy measures that support agriculture. The Policy Evaluation Matrix (PEM) is a table showing the effects of changes in support on production, trade and economic welfare. This paper reports the results obtained to date from preliminary analysis which sought to test the practical feasibility of using the PSE as well as an economic model to quantify policy effects for the PEM.

The preliminary analysis focused on four *stylised* crop support measures -- market price support and three categories of budgetary payments based on, respectively, output, variable input use and area planted. The study examined the effects of selected support measures for three aggregate crops -- wheat, coarse grains and oilseeds -- in Canada, the United States, Mexico and the European Union.

The crucial question for analysis was: “how do the various forms of budgetary payments differ from market support and from each other in their effects?” The purpose of the project described in this paper is to develop an analytical framework within which we could pose and examine such questions by using both the information on support levels provided by the PSE and the key assumptions concerning relationships within and between factor and commodity markets.

The economic model used contains equations representing producer and consumer price response and the ‘incidence’ of support measures on prices. Following are key characteristics of the model and the way it was implemented in the analysis:

- The model is ‘partial equilibrium’ representing policy effects *only* for the three crops under study.
- The analysis is ‘comparative static’ in that policy effects are estimated by comparing prices and quantities before and after simulated policy changes but not their adjustment paths.
- The simulation results are ‘deterministic’ in that no account is taken of policy effects on risk.
- The model represents some, but not all, of the specifics of policy implementation across countries.

Findings obtained from the study are subject to several qualifications arising from: 1) uncertainty about the precise numerical values of key economic parameters; and 2) the assumptions necessary to represent the incidence of support measures in the model. Precise quantitative findings are sensitive to these assumptions. Results come from simulation analysis comparing the effects of ‘small’ equal PSE changes in support measures. These results are subject to the usual qualification that they may not provide the basis for conclusions about the effects of ‘large’ changes in support levels.

Bearing these caveats in mind, the main finding of this analysis is that, depending on the indicator, the effects of a given amount of support may differ substantially among the support measures used to provide that support. Area payments, even when assumed to be implemented with a requirement to plant, were found to be relatively more income efficient and less trade distorting than market price support, payments based on output, or payments based on variable input use. Payments based on variable input use were found to be the most inefficient and production distorting.

The effects of support given to producers in one country or region spill over to other countries or regions through trade and world market prices. In the analysis, there were substantially less spillover effects from area payments than for any other form of support studied. In some simulations, the spillover impacts of market price support, payments based on output, and payments based on variable input use were highly similar.

A Matrix Approach to Evaluating Policy: Preliminary Findings from PEM Pilot Studies of Crop Policy in the EU, the US, Canada and Mexico

I. Introduction

Agricultural policy in OECD countries has multiple objectives and governments use a wide variety of price and income support measures to pursue them. The mix of policy objectives and measures change over time due to changes in domestic policy priorities and to other factors such as the evolution of trade commitments.

Regardless of the objective, however, changing any given policy measure will usually have an impact on more than one outcome. Thus, in the same sense that, for example, changes in market price support may have environmental side effects, changes in environmental subsidies or taxes may have trade impacts. The challenge in evaluating the effects of policy change is to ensure a broad enough coverage of both the policy ***measures*** and the ***indicators*** of policy effects (Josling).

The Policy Evaluation Matrix (PEM) is a table presenting estimates of the impacts of various policy measures: market support, area payments, input subsidies, etc., on selected indicators of policy effects: production, trade, farm incomes, etc. The PEMs presented in this paper use column headings to denote different agricultural support measures and row labels to denote policy effects. The numbers in the cells of a PEM are estimates of the economic impacts and the commodity volume effects of changes in support measures.

The Producer Support Estimate (PSE) is the starting point for the analysis of the impact of policy measures for the PEM. The PSE data conveys two kinds of information necessary for PEM analyses. First, it indicates the level of monetary transfers, and changes over time of the level of these transfers, from consumers and taxpayers to farmers resulting from agricultural policies. Second, support estimates are classified according to the way the associated policy measure is implemented thereby highlighting the ‘initial incidence’ of the associated policy measure for analytical purposes.

There are eight main categories of the PSE: one for market price support and seven for different kinds of budgetary payments distinguished by implementation criteria. Within each of these ‘main’ categories there are sub-categories which identify more precisely the eligibility for receiving payment. Four crop categories of the PSE are featured in this analysis: 1) market price support 2) payments based on output 3) area payments and 4) payments based on variable input use.

A pilot project to test the feasibility of using the PEM approach in evaluating agricultural policy change is underway. It is comprised of six individual studies; one each for Canada, the European Union, the United States, Mexico, Japan and Switzerland. This paper consolidates findings to date from the first four of the studies. Japan and Switzerland have only recently joined the pilot study group and results from their analyses are not yet available. The primary focus of the work to date has been on policies providing support to wheat, coarse grain and oilseed producers in participating countries.

The long-term goal for the PEM is to analyse changes in all the main components of the PSE in terms of their quantitative impacts on a wide range of policy relevant outcomes: farm incomes, trade, taxpayer and consumer costs, farm employment and the environment. Ideally, the scope of coverage would be extended to include farm policy developments in all OECD countries and for all PSE commodities. The purpose of the pilot study is to test the feasibility of doing such analysis by focusing on a limited number of indicators, commodities and countries.

The greatest difficulty encountered in studying this feasibility has been to establish the validity of the economic model used to quantify policy effects for the PEM. Of particular concern is whether model estimates of policy effects will be valid for large changes in support measures. The concern arises firstly because demand and supply relationships in the model (as in all economic models) are derived from theory applied to evaluation of small 'marginal' changes in variables. Secondly, the numerical values of key economic parameters -- the supply and demand elasticities and the cost shares -- are assumed not to change regardless of the magnitude of the changes in support under study. These characteristics are generally interpreted to mean that this kind of model is better suited to analysis of small changes in support measures (Gardner, Piggott).

In practical terms, the key questions are:

- What is a [too] large change in a support measure?
- Is analysis of small 'at the margin' changes in support measures sufficiently interesting to provide policy relevant inferences about policy effects?
- Are the supply and demand elasticities and the factor shares appropriate for analysing large changes in support measures numerically greater or less than those appropriate for analysing small changes in policy measures?
- To what extent are results from analysis of large changes in policy measures biased, and in what direction is that bias?

The pilot study has not yet provided fully satisfactory answers to these questions and further analysis aimed at better addressing them is underway. Consequently, for the *qualitative* comparisons of policy measures reported in the main body of the paper, results are based on simulated changes in the percent PSE amounting to no more than 1%. The *quantitative* comparisons of policy measures reported in Annex 2 are based on simulated changes in the percent PSE of less than 1%. Care has been taken throughout the paper to indicate that findings and policy inferences flowing from those findings are based on simulated "small" changes in support measures. As such, it is not possible at this stage to generalise the results and conclude that they would equally apply to 'large' changes. With this caveat, the results provide information that, properly interpreted, might be of great interest to policy makers. The models developed for the pilot phase of the PEM project represent stylised versions of existing and hypothetical policies in the participant countries. The results provide useful information to policy makers about the *relative* effects of market price support and various kinds of budgetary payments. The sensitivity of the results to assumptions about the elasticity values or price responsiveness of supply and demand for inputs have been analysed in detail and also provide important information for policy makers.

In constructing the PEM models, two main kinds of assumptions were required: *1)* those relating to the basic structure of supply and demand response, the underlying data and the elasticities, and *2)* those relating to the primary incidence of support measures on prices and quantities. Economic theory and results of previous studies guided analysts' choices about the structure of the model, and the data and economic parameters to use. The classification of support measures in the PSE guided choices about their primary incidence.

This paper is comprised of four sections, in addition to the introduction, and three annexes. Section II provides an explanation of the basic analytical model used in the first phase of the work. Section III contains an explanation and graphical exposition of the main elements of the simulation analysis undertaken using this analytical model. This is followed by a presentation of some of the results of the analysis aimed at illustrating 'in-general' *qualitative* differences between generic versions of selected support measures (Section IV). The final section contains preliminary conclusions. The annexes contain results of the analysis that focused more specifically on *quantifying* the differences in policy effects between stylised versions of existing and hypothetical support measures in the study countries.

II. The modelling framework

i) General characteristics

Developing an appropriate modelling framework to estimate the elements of the PEM is one of the main working objectives of the pilot study. The modelling framework provisionally adopted for this phase of the work comes from an aggregate, partial equilibrium model of the farm sector elaborated in (Floyd) and (Gardner).[1] Both the way the model was specified and the way analysis was done closely follow applications found in Atwood and Helmers, Gunter *et al*, and in Hertel.

The type of analysis undertaken using this modelling framework has become known more generally as 'equilibrium displacement modelling' (Salhofer and Sinabell, Piggott, Cahill). In this framework, commodity supply is usually represented in terms of an aggregate production function and the associated factor demand and factor supply functions. Commodity demand and supply equations typically relate quantities and prices at the farm level, although several of the applications in the literature involve modelling sector-wide policy and market linkages (Alston). Normally, the functional relationships in the model are approximated with equations linear in elasticities and percentage changes in quantities and prices.

In doing policy analysis, supply and demand behavioural relationships are combined with the equilibrium requirements that supply must equal demand to simultaneously clear all markets. This system of equations is calibrated to replicate a given market situation -- actual prices and quantities observed in a particular 'base year', for example. A small change in the value of some exogenous policy parameter, e.g. an administered price, an area payment, or an input subsidy, is then introduced and the model used to calculate a new set of equilibrium values for all endogenous prices and quantities. This procedure is termed a 'policy experiment' or 'policy simulation experiment'.

Since all the supply and demand relations in the model are *approximated* with constant elasticity linear equations[2], policy experiments usually involve relatively small changes in policy variables. This is

1. In other work underway as part of the PEM pilot study, the feasibility of quantifying policy effects of interest using a general equilibrium model is being investigated. An important aim of that investigation is to produce estimates of policy effects obtained from a general equilibrium model to compare with estimates of those same policy effects obtained from the partial equilibrium models being used in this phase of the PEM work. Another aim is to obtain estimates of some policy effects, e.g. economy-wide employment impacts of farm policy changes, which cannot be obtained from models of partial equilibrium.

2. These type of equations provide log-linear approximations to the 'true' functional forms of the underlying production function, the associated factor demand equations and the equations of factor supply and commodity demand. The approximations would be better, especially for evaluating relatively large changes, if the underlying true production functions were of the constant elasticity of substitution form, and the factor supply and commodity demand equations were truly log linear (Gardner, 1987).

because the validity of the constant elasticity assumption can be brought into question when applying the model to the evaluation of a relatively large change in policy variables, e.g. the complete elimination of government support programs for agriculture. There is uncertainty over whether the elasticities of supply and demand appropriate for evaluating larger changes should be higher or lower than those appropriate for evaluating small changes. Annex 2 contains some results of sensitivity testing aimed at determining the effects on results of alternative settings of key supply and demand parameters.

The objective is to quantify effects of changes in selected components of agricultural support as measured by the PSE. More specifically, the aim is to quantify the effects of observed (or hypothetical) changes in the various components of the *PSE attributable to some explicit change in a given policy instrument*: an administered price, an output or input subsidy, or an area payment directly under the control of policy makers.[3] Most of the year over year changes observed in the PSE is due to change in variables such as exchange rates or world market prices over which farm policy makers have no control.

ii) The PEM crop model

PEM crop models are being developed for each of the countries participating in the project according to a common structure. Policy experiments are carried out using a model linking these individual country models (one each for Canada, the European Union, Mexico, the United States and a 'rest-of-world) through world price and trade effects. Each country module contains the equations needed to model supply and demand response, policy measures and prices for three crops: wheat, an aggregate of coarse grains, and an aggregate of oilseeds. In addition, with the exception of the rest of world module, there are equations representing demand and supply response and prices for at least four categories of inputs used to produce these crops. Annex 2 contains the documentation of the full version of this model.

In calculating costs and benefits of support, measure inputs were classified according to whether they were *supplied by* or *purchased by* farm households. Inputs supplied by farm households, e.g. land and farm household labour, are called 'farm owned'. In all study countries except Mexico[4], at least three kinds of inputs purchased by farm households were distinguished: fertiliser, hired labour and a residual aggregate, 'other purchased'.

A model representing this number of countries, policies, commodities and inputs constitutes too complex an analytical framework to represent graphically or to discuss in general terms. Likewise, analytical solutions derived from algebraic manipulation of the equation systems tend to be difficult to interpret and explain.[5] Accordingly, the following discussion highlights only the main features of the model: the structure of the most important equations, the representation of support measures and the key parameters. Annex 2 contains more complete documentation.

The discussion in the main body of the paper relies more on graphical exposition and illustrative numerical solutions to a representative one region, one output, and two input version. This simplified version is called the 'basic PEM model' and constitutes the common framework from which the more

3. This ties very closely the possible implementation of policy evaluation within the framework of the PEM to both the *classification* and the *decomposition* of observed changes in the PSE components.

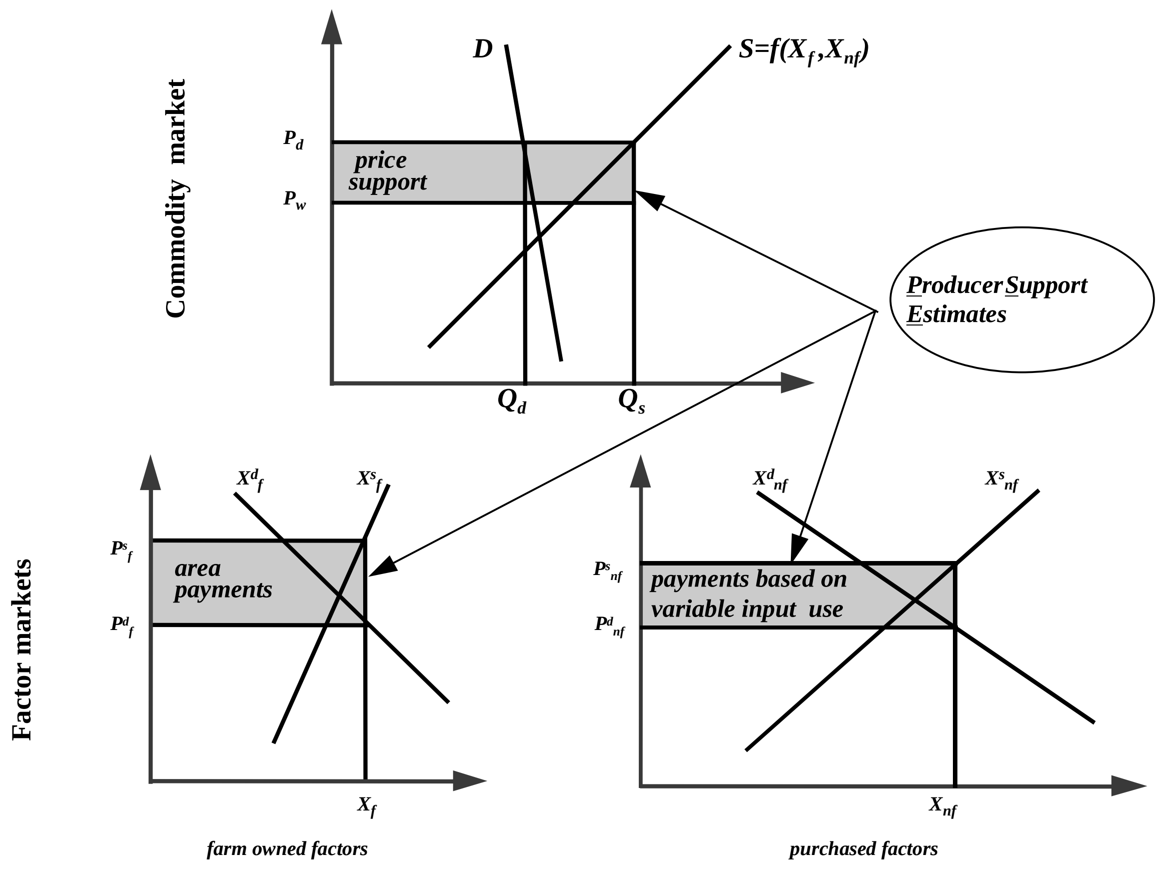
4 . Only two categories of purchased inputs are distinguished in the Mexico model, fertiliser and 'other purchased', because cost data for Mexico does not distinguish hired and farm family labour used on crop farms. On the other hand, nine individual categories of purchased inputs are distinguished in the US model.

5. In Gardner, Hertel, and Gunther, Jeong, and White there are some useful formulas derived from algebraic manipulations of models similar to the full PEM crop model, but containing generally fewer country, commodity, input and policy combinations.

detailed versions were developed. Annex 1 contains its documentation. Fortunately, one can obtain many of the more important policy insights from this simple version.

Imagine the one region being any one of the participant countries and one output, total crops. The two inputs are the aggregates: ‘farm owned’ and ‘purchased’. Figure 1 contains supply and demand diagrams illustrating the basic components of this representative model. The upper panel shows *commodity* supply and demand curves and the lower two panels show supply and demand curves for the two aggregated factors of production. The algebraic version of this simplified model presented in Annex 1 contains equations which correspond “one for one” (or as near as possible) to the supply and demand curves shown in the figure. The sections below contain general descriptions of market and policy components shown in the figure, but with the occasional reference to numerical simulation results obtained from using the *pro-forma* algebraic version.

Figure 1 - PEM crop model



Supply components

Crop supply is represented through a system of factor demand and factor supply equations. The factor demand equations reflect the usual assumptions of profit maximisation constrained by the production relationship and factor supply. Crop supply response corresponding to a medium term adjustment horizon of three to five years is reflected in the values assumed for the price elasticities of factor supplies and the parameters measuring the substitutability of factors in production as well as the factor shares.

The price elasticities of factor supply we used are plausible assumptions based on reviews of related work and theoretical considerations, rather than on specific econometric estimates. In making these assumptions we assumed no factor to be completely fixed in production of cereals and oilseeds, but we did assume crop land and the other farm-owned factors to be relatively more fixed (have lower price elasticities of supply) than the purchased factors. Likewise, no factor is assumed freely mobile, but purchased inputs are assumed relatively more mobile (a higher elasticity of supply) than the farm-owned factors. Analysis developed in Annex 2 illustrates the importance of these particular assumptions in explaining the differences in policy effects among policy measures. [6]

Commodity demand components

Demand equations in the PEM models relate domestic consumption of crop outputs to crop prices (at the farm level). Policy measures frequently result in similar changes in all crop prices occurring at the same time. This co-movement of prices may occur even when the policy measure is targeted directly to only one or two of the crops because wheat, coarse grain and oilseeds may be substitutes in *both* production *and* consumption.

Moreover, depending on the degree to which crops are substitutes in demand, co-movement in their prices may lead to small 'net' changes in quantity demanded for any one crop and thus in their total. That is, the total demand for crops may be highly price inelastic. As will be seen later, this helps to explain some important similarities among estimated policy effects of different support measures.

Policy components

A critical consideration in modelling crop policy instruments for PEM purposes is 'initial incidence'. In other words, "which price is affected *first?*" Market price support has its initial incidence in commodity markets while area payments and subsidies to purchased inputs have their initial incidence in the associated factor markets, as depicted in Figure 1. Regardless of initial incidence, the price and quantity links in the model tie the factor and output markets together so that a change in a policy measure that affects any one of the crop or factor markets will end up having some effect on all of them.

Figure 1 shows how price wedges corresponding to unit market price support, area payments and subsidies to purchased inputs (reduction in input costs) were represented in the PEM crop models. The market price support wedge separates prices paid by domestic consumers to domestic producers, P_d, from the corresponding price on world markets, P_w. Similarly, area payments create a wedge between the price a farmer earns from using his land and other owned factors in crop production, P^s_f, and the return, P^d_f, those factors would earn in some alternative use. Finally, subsidies to purchased inputs create a difference between the price suppliers receive, P^s_{nf}, and the price farmers pay for them, P^d_{nf}.

In analysing the effects of market price support, no consideration was given to the specific trade or domestic policy instrument, or combination of them, actually creating the price wedge. Likewise, in analysing subsidies to purchased inputs (currently not a significant component of producer support in any

6. Although the own and cross-price elasticities of *crop* supply are not explicit parameters in the PEM crop models, their values can be calculated from knowledge of the elasticities of factor supply, factor substitution and factor shares. Table A2-3 contains the estimates of elasticities of crop supply for each of the participant countries calculated from 'middle-of-the-range' settings of the other supply parameters in the models.

of the pilot study countries), we did not distinguish the particular subsidy or tax instrument, or combination of them, actually used.[7]

As in any economic model of policy effects, it is difficult to represent the mechanisms of policy implementation and therefore 'incidence' in complete detail. As noted elsewhere, the choices we made were heavily influenced by the way support measures are classified in the PSE under the new system of classification. For the latter purposes, support measures are classified according to the main or primary condition that producers must meet in order to be eligible for the support. Usually, knowledge of the conditions of eligibility of a particular support measure, as revealed by its classification in the PSE, will be enough to infer its 'initial incidence'.

The clearest example, and overwhelmingly most important category, of crop support measures used in the pilot study countries in recent years is area payments. These were the central concern of the PEM crop policy analyses reported. Such payments *may* increase the rental rate received by a landowner for land used in crop production as compared to the rental rate that land would earn in other uses.

The "*may*" is an important qualification. In reality, as noted above, whether area payments encourage additional planting of cropland or not depends critically on how the program is implemented. In the PSE these payments are classified in one of two broad categories depending on whether they are based on historical or current plantings. In the PEM analyses done for this paper, area payments based on current plantings were assumed to have the same effect (on the returns to land used in crop production) as an equivalent increase in market returns to land. In reality, there are usually policy measures accompanying the area payments that mitigate their effects on plantings. These include payment limitations, set-aside requirements, voluntary set-aside and base area limitations.

The effects of changing one support measure could also depend on the level of support provided by other support measures. For example, the effects of an increase in area payments could be different depending on the pre-existing level of market price support. This difference arises because the induced changes in input and output depend on factor shares and elasticities. The values of these parameters, however, might be different under circumstances of high pre-existing support levels as compared to low pre-existing support levels. The current PEM model assumes constant factor share and elasticity values and does not capture these interactions.

As Figure 1 shows, the principal focus of PEM analyses was on the way support measures affect *prices* received and paid in farm commodity and factor markets. Support measures may have effects that show up not in terms of price changes in farm commodity or factor markets, but through other channels. The costs of program administration and taxation constitute one important example [OECD (1995), Moschini and Schokai].

In addition, the mere existence of a government backed program of pricing or area payments undoubtedly increases the sense of security of farm revenues and income, both in the minds of farmers and of people who lend money or extend credit to farmers. Given a farmer's specialised skills and the absence of perfect capital and information markets, this could lead to 'higher than otherwise' crop production, even for seemingly 'completely decoupled' support measures, while not having any observable direct effect on factor or commodity prices (Roberts, *et. al*., Gardner, ABARE.) Finally, payments made to farmers that are based on historical production or plantings might create an incentive to retain land in crop production to preserve entitlement rights to future program benefits.

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7. As noted above, all PEM crop models distinguish at least two categories of purchased inputs: fertiliser and 'other purchased'. In all but the Mexico model, hired labour is also accorded separate treatment. Nine individual input categories are distinguished in the US component.

In theory, all support measures have effects that do not show up directly in terms of price changes in commodity or factor markets. We did not attempt to quantify these 'non-price' impacts in developing the PEM analyses. The main focus of the PEM work is to compare support measures. An important question is thus, "to what extent are 'non-price' influences likely to be substantially different for different policy measures?" To the extent they are similar, we might safely ignore them in assessing the *relative* effects of various support measures.

III. Policy effects and graphical exposition of analysis undertaken

The table below lists the main indicators of policy effects (the row labels in the PEM tables) used in measuring the effects of policy changes.

Table 1. PEM indicators of policy effects

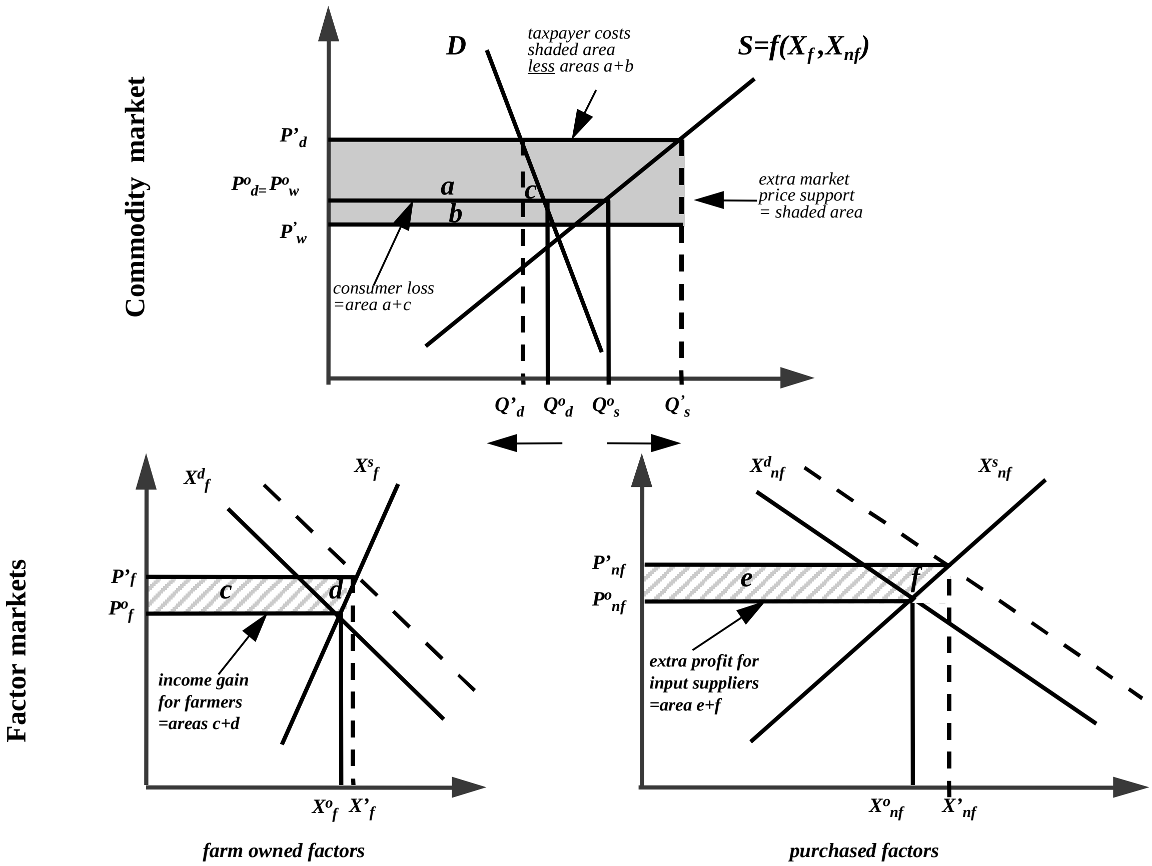
	Definition of measure
Taxpayer costs	Total change in government costs/receipts for: area payments, input subsidies, export subsidies and tariffs.
Consumer costs	Change in consumer surplus.
Farm household income	Change in returns above opportunity costs to land and other farm owned factors (net household income from farming).
Input suppliers profits	Change in returns above opportunity costs earned by suppliers of purchased factors.
Production	Change in volume of crop production.
Consumption	Change in volume of crop consumption
Net trade	Change in volume of net trade.
World market prices	Change in the traded price of individual commodities.

Figures 2 and 3 contain graphical representations of market equilibria 'before and after' hypothetical policy changes. We use the same frame as in Figure 1, but for expositional convenience assume in each case that support is increased in a situation where there was no support of any kind before. This simplification causes no problems in evaluating the *qualitative* effects of hypothetical changes in policy measures. Nevertheless, existing distortions do matter and cannot safely be ignored when trying to *quantify* policy effects in numerical analysis, as was done for the results reported in the Annexes.

...market price support

Figure 2 illustrates the analysis undertaken in assessing effects of market price support. Observe the upper panel of the figure showing commodity market impacts. For this illustration, assume a situation in which initially domestic price, P^0_d, and world price, P^0_w, are equal. Then, suppose a change in some market support instrument results in a price wedge, P'$_d$- P'$_w$, and an accompanying level of market price support of some given amount as indicated by the shaded area in the top part of Figure 2.

Figure 2 - Trade and income effects of market price support



The increase in crop production induced by the increased support is Q_s'- Q_s^o. The associated reduction in consumption is Q^0_d- Q'$_d$, with effects on net trade equals the difference between the implied quantity of exports after the change in support, Q'$_s$- Q'$_d$, less the implied quantity of exports before the policy change Q^0_s- Q^0_d . (This illustration assumes the country in question is an exporter both before and after the policy change.)

The increase in support is represented in the figure by the 'PSE rectangle' whose base is Q_s', and whose height is P'$_d$- P'$_w$. The area marked *a* and *c* shows the induced increase in consumer costs (reduction in consumer surplus). The induced increase in taxpayer costs to cover export subsidies is shown by the rectangle whose base is Q'$_s$- Q'$_d$ and whose height is P'$_d$- P'$_w$. The sum of taxpayer and consumer costs equals the whole of the shaded area measuring the change in support less the area marked *b*.

As shown in Figure 2, there are two price impacts of the increased market price support: the induced *increase* in the domestic price from P^0_d to P'$_d$, and the induced *decrease* in the world price, from P^0_w to P'$_w$. The relative magnitudes of these two price changes will depend on the size of the country in production and trade of the commodity in question.

Observe now the bottom part of Figure 2 showing associated factor market effects. The hypothesised increase in the producer price due to increased market price support translates into outward shifts in demand for both farm owned and purchased factors of production as shown by the dashed lines to the right of the demand curves labelled X^d_f and X^d_{nf} in the figure. This causes the quantities and prices of both factors to rise, the degree to which clearly depends on relative elasticities (slopes) of the factor supply schedules.

The areas marked *c* and *d* in the lower left hand panel of Figure 2 represent the impact of the supposed change in market price support on net incomes of farm households supplying the farm owned factors of production. Correspondingly, areas marked *e* and *f* in the lower right hand panel show increased profits for suppliers of purchased inputs. Which of these is the greater will depend on the elasticities of factor supply and substitution as well as on the relative importance of the factor bundles in crop production.

The *price* increase will always be the greater for the factor (or factor bundle) exhibiting the lowest supply elasticity, in this case the farm owned factor. However, this does not guarantee that the largest share of total benefits of support go to this factor since this depends on factor shares as well as elasticities. The essential point is that there will be some sharing of the economic benefits of increased support among these two groups of economic agents.

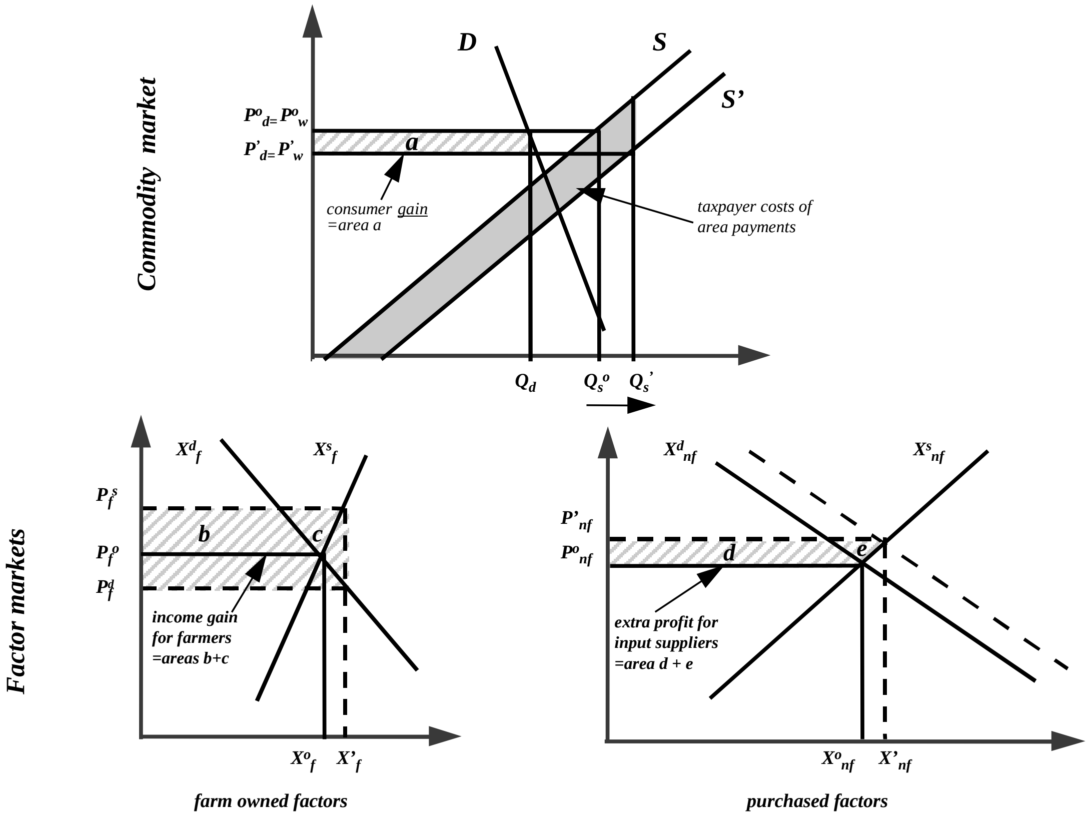
Illustrating the effects of market support for an importing country involves a straightforward adaptation of Figure 2. Except, in the case of an importing country, the consumer costs of a given increase in market price support are relatively much greater. Depending on the policy regime, such higher costs for consumers may be partially offset by an increase in tariff revenues. Mexico is a net importer of wheat, coarse grains and oilseeds. The EU is a net importer of oilseeds. The United States and Canada are net exporters of all three commodities. As shown below, the trading status of a country constitutes one of the factors explaining differences in incidence of policy effects.

...payments based on area planted

Suppose now that rather than providing the hypothetical increase in support as market price support, it is provided as a payment to land. Suppose further that the payment comes with a requirement to plant so that we can expect some induced increase in the area of land used in crop production to result. This payment drives a wedge between the effective rental rate received for land used in crop production and the associated rental rate charged (perhaps implicitly) for that land. This is depicted in the lower left hand panel of Figure 3 in terms of the price wedge, P^s_f - P^d_f . As compared to the initial equilibrium price, P^o_f , the equilibrium supply price for the farm owned factor rises to , P^s_f , while the equilibrium demand price falls to P^d_f. This leads to an increase in quantity of land and other farm owned factors demanded and used in crop production of (X'_f-X^o_f), which will be greater or less depending on the elasticity of supply of crop land reflected in the slope of the supply curve for farm owned factors. In turn, this increased factor use shows up as the rightward shift in the commodity supply schedule shown in the top portion of Figure 3, with associated increases in supply and net trade, equal (Q'_s- Q^0_s).

The increased supply results in some fall in world market prices. To the extent that the world market price falls, and to the extent that this price fall is transmitted to the domestic market, consumption of the commodity will increase. This is opposite the direction of change in consumption accompanying the increase in price support (Figure 2). That is, to the extent that the payment to land ends up (indirectly) affecting consumption at all, it will be to increase it. This is one reason to suspect that increased support made in the form of a payment tied to land would have less of an effect on trade than the same amount of support provided as market price support.

Figure 3 - Trade and income effects of area payments



Another reason, as noted above, has to do with the fact that the payment is a subsidy targeted to one factor of production -- land -- while market price support may be viewed as a subsidy spread more or less evenly across all inputs. The well founded suspicion that the former has less effect on output is based on the assumption that the elasticity of supply of land is less than the elasticity of the supply of non-land factors of production. It is shown in Annex 1 that this assumption alone is enough to ensure that the supply effect of the area payment will be less than that of market price support. This annex also contains an analysis of the sensitivity of estimated supply effects of area payments versus market support to alternative settings of these and other key parameters in the basic PEM model. (See Annex 1, in particular Figures A1 to A6.)

The increased support is traced out as the shaded area between the before and after commodity supply curves labelled S and S', respectively in the top panel of Figure 3. (Or, equivalently, the crosshatched areas in the lower left hand panel.) In this case, there is no distinction between the amount of support provided and the taxpayer costs of support. They are equal. If consumers are affected because of extra support provided as area payments it is through the induced *reduction* in market prices. The area marked '*a*' in the top panel of Figure 3 shows the amount of such potential gain. The income gain for farm households is the area '*b+c*' in the lower left panel of Figure 3, while area '*d+e*' in the lower right hand panel shows gains to input suppliers. Input suppliers gain, in this example, because the increase in commodity production creates additional demand for purchased inputs. This is represented as the rightward shift in the demand curve for purchased factors shown by the dashed line in the lower right hand panel of the figure.[8]

8. Notice the extra production constitutes only one of two channels through which suppliers of purchased inputs may be impacted by the area payments. Recall that we assume farm owned factors and purchased

There is again a sharing of the benefits of support amongst farm households and input suppliers, but this time farm households might be expected to get the lion's share. This result, like the result for commodity trade, also depends largely on the relative elasticity of supply of land. In general, as will be shown, there is a close, inverse relationship between the trade effects of a support measure and its income transfer efficiency. Schmitz and Vercammen use this to argue for using transfer efficiency as an empirical measure of trade distortion.

IV. Qualitative comparisons of support measures

Graphical analysis is helpful in illustrating differences in the channels through which support measures produce their effects and differences in the direction of impacts on selected outcomes. However, it is difficult to assess some of the more important qualitative differences in policy effects relying solely on graphical analysis. Table 2 below indicates differences in both the direction and the relative magnitude of effects of small changes in market price support, payments based on output, payments based on input use and payments based on area planted, for each of the PEM indicators featuring in this report. These results are derived from a set of policy experiments carried out using the basic PEM model. Annex 1 contains additional explanation of the simulation experiments.

Table 2. PEM qualitative rankings of alternative support measures for selected indicators

~Indicator~	~Support measure~			
	Market price support	**Payments based on output**	**Payments based on input use**	**Payments based on area planted**
Commodity market impacts:				
Production	+ +	+ +	+ + +	+
Consumption	-	+	+	+
Net trade (Prod^n-Cons^n)	+ + +?	+ +	+ + +?	+
World market price	- - -?	- -	- - -?	-
Economic costs & benefits:				
Taxpayers	-	- - -	- - -	- - -
Consumers	-	+ +	+ + +	+
Farm households	+ +	+ +	+	+ + +
Input suppliers	+ +	+ +	+ + +	+

Notes:
1. Comparisons were standardised on a given small increase in support.
2. A plus indicates a direct relationship between the support measure and the indicator, e.g. an increase in support of any kind increases farm household income. The number of pluses or minuses indicates, but is not meant to precisely quantify, relative rankings.

The analysis comprised repeated simulations with the model where in each simulation a small amount of extra support was provided by first one then another of the support measures. The simulation experiments were also repeated for alternative settings of key parameters in the model, utilising ranges of plausible values for them. Each cell in Table 2 contains one, two, or three plus '+' signs or, one, two, or three minus '-' signs. A plus sign in a particular cell indicates the estimated effect of the support measure (denoted by the associated column label) on the indicator of policy effect (denoted by the associated row

inputs are substitutes in production. (This must be the case when there are only two input categories.) In so far as production decisions are concerned, an area payment reduces the cost of land (rental rate) relative to non-land factors of production. If this were the only effect, the demand for purchased inputs would decline. The increased demand shown reflects a 'net' effect wherein this substitution effect is more than offset by the scale effect associated with increased production.

label) is positive. Observe, for example, the entry in the row labelled ‘Farm households’ in the column labelled ‘Market price support’. The plus signs indicate that an increase in market price support increases farm household income.

A minus sign in one of the rows measuring economic costs and benefits means that an increase in the associated support measure imposes a monetary cost on that group of economic agents. Correspondingly, a plus sign means that an increase in the associated support measure confers an economic benefit on that group of economic agents. A minus sign in one of the rows measuring quantity impacts means that an increase in support leads to a reduction in the associated volumes of supply or demand, and vice versa for a plus sign.

The number of pluses or minuses in the cells of a given row, from one to three, shows which support measures have the lesser and which the greater effects on the associated indicator. Compare the three pluses in the cell at the intersection of the ‘Market price support’ column and ‘Net trade’ row with the one plus in the ‘Payments based on area planted’ column of that same row. This indicates that the estimated net trade impact of the latter is systematically lower than that of market price support.

The same number of plus or minus signs appears in more than one column in some rows. In some, a question mark also appears. This indicates that the associated rankings of the support measures are not ‘robust’ for that indicator. An important case in point appears in the ‘Net trade’ row. Notice there are three pluses in both the ‘Market price support’ column and the ‘Payments based on input use’ (subsidies to purchased inputs) column. In most of the experiments, we found the trade impact of the same amount of support given as input subsidies to be greater than for market support. This is not, however, a completely general result as some combinations of parameter values market price support had the greater trade impact.

Although the analysis underlying results in Table 2 was not meant to give precise *quantitative* ranking of the effects of the policy measures on the various indicators, some important qualitative conclusions can be drawn from that analysis. We found that when comparing the effects of the small increases in the PSE measures we studied:

- the estimated effects on farm household income of a given amount of support provided in the form of payments based on area, even though tied to a requirement to plant, are systematically higher than for the other support measures.
- the estimated effects on farm household income of a given amount of support provided in the form of payments based on the use of purchased inputs are always lower than when that same amount of support is provided through the other measures.
- the estimated effects on production and on net trade of a given amount of support provided as a payment based on area are systematically lower than when that same amount of support is provided through any of the other support measures.
- estimated world market prices decline regardless of the form in which support is provided, but the decline is less for the area payments than for any of the other measures.
- in some comparisons the estimated effects of market price support, output price support and subsidies to purchased inputs on net trade were nearly the same. Differences in net trade effects among these three policy instruments arise mainly from differences in their induced effects on consumption. These differences will be less important the lower is the assumed elasticity of demand.

Taken together, these findings confirm that depending on the indicator, the trade and welfare estimated effects of a given amount of support differ depending on the support measure used to provide that support. But by how much? For example, is the trade effect of a given amount of market support two times, five times or ten times as great as that for area payments? In principle, this same type of question applies for every pairing of support measure and indicator shown in Table 2.

Answering such questions requires analysis with a more complete model of crop supply, demand and policy than that underlying the results reported in Table 2. The five-region PEM crop model introduced earlier was developed for that kind of analysis. Annexes 2 and 3 contain the documentation and some preliminary results from applying this model to an assessment of the effects of changes in the level of market price support and area payments provided to crop producers in the PEM pilot study countries.

V. Conclusions

Governments in OECD countries use a diverse mixture of policy measures to support farmers. The new OECD classification of the PSE groups transfers to farmers (from consumers and taxpayers) into eight main categories and eighteen sub-categories of support measures classified according to implementation criteria. Support provided by any one of these measures is likely to have consequences for more than one outcome of interest to policy makers.

The PEM arrays support measures and outcomes as column and row headings to make tables of policy effects. This paper contains a report of progress to date in developing such tables for crop policies in countries participating in the PEM pilot study. Findings reported in the main part of the paper focused on four of the stylised support measures belonging to the list of main categories of the PSE: market price support, payments based on output, payments based on (variable) input use and payments based on area planted.

In attempting to draw conclusions from PEM analyses it is important to bear in mind two of the caveats already noted in the above discussion. First, the empirical model developed for PEM analyses required assumptions of *plausible ranges* for key supply and demand parameters. The values of those parameters are subject to the usual qualification that they may be more appropriate for analysing ‘small’ as opposed to ‘large’ changes in policy measures (such as the complete elimination of all support).

Second, the basic PEM model represents support measures only in terms of their incidence on prices of commodities and factors. However, policies may produce effects through less direct channels. Farmers (and people who lend money or extend credit to farmers) might attach a different ‘certainty equivalence’ to a market induced change than to a policy induced change in their economic environment. For example, as compared to an equivalent increase in land rents caused by higher market prices, area payments might be seen as more of a ‘sure thing’ (having greater certainty equivalence). Similarly, an increase in market support associated with an increase in ‘guaranteed price’ might lead farmers to make production plans with more confidence than they would for the same expected increase in their market price. Moreover, as mentioned in the text, entitlements to support based on historical planting or production could provide an incentive for some farmers who would otherwise not plant to do so to ensure eligibility for the future.

Both these caveats would be of even greater concern if the aim of the analysis had been to quantify the *absolute* as opposed to the *relative* effects of policy measures. Fortunately, qualitative conclusions from some important comparisons among support measures are less vulnerable to the criticisms. For example, a key finding of the analysis was that the simulated small increases in coupled area payments had a smaller estimated impact on net trade than the same change in coupled market support. This finding hinges on the relative values of only two parameters in the model, the elasticity of supply of land and of non-land factors of production.

The study also found that the simulated small increases in payments based on area, even when assumed to increase the amount of land used in crop production, had a relatively greater effect on farm household income than any of the other support measures examined. The estimated distortions to production and trade associated with area payments could be reduced even further if they are ‘packaged’ with some other policy measures that frequently accompany them. These include voluntary and/or mandatory set-aside, payment eligibility based on historical plantings, equal payment rates regardless of the crop planted, and limitations on the size of the payments.

There has been a noticeable shift in recent years in the mix of policies used to support crop farmers in OECD countries, away from other forms of support and towards area payments. [OECD, 1999] The finding of a relatively higher income efficiency of area payments implies that this switch in policy mix may have increased net income of farm households, even when the overall level of support was declining. This is possible both because of the differing degrees of transfer efficiency of the support measures and because of the relative magnitude of their changes. Indeed, it seems likely that in some cases the ‘income compensation’ provided by area payments was substantially in excess of the ‘income loss’ associated with reductions in other forms of support.

Policy simulation results suggest that payments based on variable input use can be an especially inefficient way of transferring income to farmers. Simulated small increases in such payments were also found to have the greatest estimated effects on production and, in most simulations, the greatest estimated effects on net trade of the support measures studied. Perhaps these characteristics help to explain why payments based on variable input use no longer feature significantly in the programs of agricultural support in the study countries.

In some policy simulation experiments, the estimated net trade effects of the simulated small increases in market price support, output price support and subsidies to purchased inputs (but not area payments) were nearly the same. Typically, market price support requires border protection and the use of import tariffs and/or export subsidies. These trade measures are not essential accompaniments to output price support or subsidies to purchased inputs. In discussing trade policy for agriculture support associated with border protection is often distinguished from that arising from domestic subsidies (Sumner). Findings obtained in this study make clear that under ‘not implausible’ parameter assumptions, their effects on net trade may be highly similar.

Support for farmers in one country or region may significantly affect net trade and the economic well being of the farm sector in another country or region. Policy measures leading to identical changes in measured support, however, may differ greatly in these international spillover impacts. Estimated results obtained from the simulation analysis suggest that as compared to market support, area payments in one country or region, whether tied to a requirement to plant or not, lead to smaller production, trade and welfare impacts on other countries or regions. These results suggest that the observed change in policy mix in OECD countries away from market support towards area payments may have enhanced incomes of farm households in countries where such changes were implemented, while reducing the damage caused to farm household incomes in other countries. (These effects would be offset to the extent that the shift in the policy mix was accompanied by a discontinuation of area reduction programs.)

Although area payments were found to be a more efficient means of increasing farm household income, results developed in Annex 2 show that the benefits are almost exclusively in terms of higher returns to land. With due consideration to uncertainty about the life expectancy of the programs, the value of increased land rents will show up in higher valuations and selling prices of land. That is, such benefits will ultimately be extracted by landowners. Farm operators can benefit in the longer term only to the extent that they happen to own the land they farm. The greater the transfer efficiency of the payments, the greater the degree to which they may be capitalised into land values.

Furthermore, although estimated results suggest that area payments are *relatively* less production distorting than other forms of support they result in 'higher-than-otherwise' crop production. Enhancing the packaging of the area payments by linking them to a fixed historical period, eliminating requirements to plant, or introducing other refinements that ensure current production intentions are not directly affected would help to neutralise such effects. Limiting the time period during which such payments would be made would also facilitate reasonable adjustments by affected farms, while mitigating concerns with capitalization and any 'second level' distortions (associated with farmer perceptions of future payments/payment conditions, new investments in increased production capacity, etc.).

Such enhancements should be pursued. They would bring about further reductions in distortion at a relatively modest cost. Perhaps more importantly, they would remove further impediments to increased producer responsiveness to changing market signals and hence improved market income opportunities. Finally, such further actions would reduce the spillover effects that give rise to accusations of unfair trading practices and increased trade tensions and, ultimately, counter-measures that introduce further distortions.

Most policy measures have 'side-effects' and thus there are trade-offs to be considered in making policy choices. With the limited experience in development and application available at this time, the PEM approach to policy evaluation shows much promise as a means of studying the multiple impacts of policy change and informing those policy choices. Further development of the approach could complement the ongoing evaluation of agricultural policies based on the PSE by providing further insight into their domestic and external impacts.

Annex 1

The Basic PEM Model and Qualitative Findings

An equation version of the model of the farm sector depicted in Figure 2 of the paper is developed in Chapter 4 of Gardner's 1987 textbook. This same model appears in numerous other applications. In Chapter 3 of a textbook by Helmberger, there is a 'user-friendly' discussion of the Cobb-Douglas version. Hertel uses a version incorporating trade in much the same way as is done for the basic PEM model. Moreover, he applies the model to essentially the same questions addressed in the present analysis -- the production and trade effects of equal PSE changes in alternative support measures.

The basic model represents market equilibrium for one traded commodity and two non-traded inputs: a 'farm owned' bundle that includes land and farm household labour and a 'purchased' bundle that includes all inputs that farmers buy off the farm. Only two countries are considered: the home country and the rest of the world. Commodity and factors markets are assumed to be competitive; commodity producers are assumed to be identical, profit maximising firms.

Structural equations

There are six main categories of structural equations.

i) World demand and supply

Demand: $\%\Delta Qcr = e_{dr} * \%\Delta Pw$

Supply: $\%\Delta Qpr = e_{sr} * \%\Delta Pw$.

Qcr and Qpr denote, respectively, quantities consumed and produced in the rest of the world and Pw is the world price for the commodity with e_{dr} and e_{sr} representing the elasticities of commodity demand and supply in the rest-of-world.

(ii) Domestic factor supply functions and a domestic commodity demand function

Supply of farm owned inputs: $\%\Delta Xfs = e_f * \%\Delta Pfs$

Supply of non farm owned inputs: $\%\Delta Xnfs = e_{nf} * \%\Delta Pnfs$

Commodity domestic demand: $\%\Delta Qcd = e_{dd} * \%\Delta Pc$

Xfs and Xnfs represent, respectively, the quantity supplied of farm owned,

and of purchased inputs. Pfs and Pnfs are the corresponding prices. Qcd is the quantity of the commodity demanded domestically. Pc is the commodity price to be paid by domestic consumers; e_f and e_{nf} are the elasticities of supply of the farm owned and the purchased inputs, while e_{dd} is the elasticity of domestic demand for the commodity.

(iii) Factor demands and a zero profit equation

Demand for farm owned inputs: $\%\Delta Xf = \%\Delta Qpd - s_{nf} * \sigma * \%\Delta P_f + s_{nf} * \sigma * \%\Delta Pnf$

Demand for purchased inputs: $\%\Delta Xnf = \%\Delta Qpd + s_f * \sigma * \%\Delta Pf - s_f * \sigma * \%\Delta Pnf$

Zero profit condition: $\%\Delta Pp = s_f * \%\Delta Pf + s_{nf} * \%\Delta Pnf$

Xf and Xnf denote the quantity demanded of farm owned and purchased inputs. Pf and Pnf are the corresponding prices; s_f and s_{nf} represent the share of each kind of input in total costs, with s_f =(1- s_{nf}) and σ is the elasticity of factor substitution. Pp is the price received by domestic producers and Qpd is domestic production. The zero profit condition reflects the requirement that the total value of production must be equal to the total of payments to factors of production.

(iv) Price equations incorporating the policy instruments

Domestic producer commodity price: Pp = Pw * (1 + *mps* + *ops*)

Domestic consumer commodity price: Pc = Pw * (1 + *mps*)

Farm owned input supply price: Pfs = Pf * (1 + *dp*)

Purchased input supply price: Pnfs = Pnf * (1 + *is*)

In the model producer output, prices may differ from the world price due to two different policy measures: market price support, labelled *mps*, and payments based on output, labelled *ops*. Note that the consumer price equation contains only the market price support wedge. Demand and supply prices for the farm owned factor differ due to payments coupled to their use, labelled *dp* in the equation. Likewise, demand and supply prices for purchased factors will differ due to payments based on their use, labelled *is* in the equation. These will be subsequently referred to as ‘direct payments’ and ‘input subsidies’ respectively. All policy variables are defined here as percentage rates.

(v) Market clearing equations

Farm owned factor market equilibrium: Xf = Xfs

Purchased factor market equilibrium: Xnf = Xnfs

Commodity market equilibrium: Qcr = Qpr + Qx, with Qx = Qpd-Qcd

Where Qx is the total commodity exports from the home country to the rest of the world.

(vi) Cost & welfare equations

Besides the structural equations, the basic PEM model also includes a number of equations used to calculate the economic impacts of changes in support measures. All such measures are in terms of level changes in the variables, denoted by the Δ (rather than %Δ) symbols used in the equations below.

Consumer surplus: $\Delta CS = Qcd * \Delta Pc + 0.5 * \Delta\, Qcd * \Delta Pc$

The symbol ΔCS denotes net change in total domestic consumer surplus. Other variables are as defined above.

Change in taxpayer costs:	$\Delta TAX = mps * Qx * Pw + ops * Qpd * Pp + is * Xnfs * Pnf + dp * Xfs * Pf$
Change in farm income:	$\Delta FI = \Delta(Xf * Pfs) / (1 + e_f)$
Change in input supplier profits:	$\Delta IR = \Delta(Xnf * Pnfs) / (1 + e_{nf})$

Some general results

The following section of the paper contains an explanation of how the above model was used to simulate hypothetical changes in policy measures under alternative assumed values for the various parameters. However, it is possible to obtain some important initial insights into the relative effects of policy measures without plugging in actual numerical values. Gardner derives a number of formulas useful for such purposes from algebraic manipulation of the symbolic version of the equation system.

We shall use two of Gardner's formulas to investigate 'in-general' differences between the production and trade effects of a market price support that is coupled to production and a direct payment that is coupled to use of a farm owned factor such as land. Recall from above that the symbol *mps* is used for a given percentage rate of price subsidy and *dp* for a percentage rate of direct payment (where the latter percentage is measured with respect to total farm factor earnings, not total revenue). Gardner gives formulas (pp. 107 and 112) for calculating the percentage production impacts of production and input subsidies. The two of interest for this study are (using the labelling scheme defined above):

For market price support,

A.1 $\%\Delta Qpd = (e_{dt} * [e_f * e_{nf} + \sigma * (s_f * e_f + s_{nf} * e_{nf})] / D) * mps$. (See Gardner, p 112, equation 4.36)

For direct payment,

A.2 $\%\Delta Qpd = (sf * edt * ef * (enf + \sigma) / D) * dp$. (See Gardner, p 107, Table 4.2.)

The symbol e_{dt} refers here to the 'total' (domestic plus export) demand facing the home country. (This is an explicit parameter in Hertel's variant of the model.) The symbol D is the determinant of the coefficient matrix for the model. Neither of these two need concern us. This is because both appear in the same way in both equations and the relationship to be derived is based on a ratio of the two equations.

Notice that the equations measure the 'percentage' effect on production of a 'percentage' rate of support provided by one or another of the support measures. In the analysis so far the focus has been on comparing a given and equal change in the 'level' of the support measures. Thus, the first step is to calculate percentage changes giving the same amount of change in support. Denoting totals of support with capital letters, the change in amounts of support provided by the two measures is:

A.3 ΔMPS = *mps* * Pp * Qpd

A.4 ΔDP = *dp* * Pf * Xf

Standardising to achieve the same change in level of direct payment as in market price support gives,

A.5 *dp* * Pf * Xf = *mps* * Pp * Qpd, or

A.6 *dp* = *mps* * Pp * Qpd / (Pf * Xf).

Noting that the farm factor share is,

A.7 s_f = Pf * Xf / Pp * Qpd.

This leads to,

A.8 $dp = mps / s_f$.

This gives the following equation for the percentage increase in production due to that percentage increase in direct payments.

A.9 $\%\Delta Qpd = [s_f * e_d * e_f [(e_{nf}+\sigma)] / D] * mps / s_f$

Simplifying,

A.10 $\%\Delta Qpd = [e_d * e_f [(e_{nf}+\sigma)] / D] * mps.$

Now, we obtain the 'relative' production effect of direct payments versus market price support by taking the ratio of the last equation to the very first one in this section giving,

A.11 $ratio = e_f [(e_{nf}+\sigma)] / [e_f * e_{nf} + \sigma * (s_f * e_f + s_{nf} * e_{nf})]$

The first interesting feature of this formula is that it contains only parameters from the supply equations, none from the demand side. (This despite the fact that the equations we started with were derived from a market equilibrium model in which all quantities and prices are endogenous.) That is, the relative *production* effects of (an equal amount of) payments based on use of a factor of production and market support depend only on the technical characteristics of commodity supply.

We know from the related discussion in the text that to the extent that market price support and payments based on factor use affect consumption (through their effects on commodity prices), those effects will be of the opposite sign: market price support negative, direct payments positive. This is useful because if we can establish the general conditions under which a payment based on factor use is less production distorting than a market price support, we can readily establish that under those conditions such a payment is even less trade distorting.

An important general result referred to in the main text is that the production effect of a area payment will be less than that of a market price support so long as the elasticity of supply of the farm owned factor is less than that of the purchased factor. To illustrate this compare the top and bottom parts of the equation as follows:

A.12 $e_f\,[(e_{nf}+\sigma)] \overset{?}{<} [e_f{*}e_{nf}+\sigma{*}(s_f{*}e_f+s_{nf}{*}e_{nf})]$

A.13 $e_f{*}\sigma \overset{?}{<} \sigma{*}(sf{*}e_f+s_{nf}{*}e_{nf})$

A.14 $e_f \overset{?}{<} (s_f{*}e_f+s_{nf}{*}e_{nf})$.

Recalling that,

A.15 $s_f + s_{nf} = 1.0$

A.16 $s_f{*}e_f+s_{nf}{*}e_f \overset{?}{<} s_f{*}e_f+s_{nf}{*}e_{nf}$

A.17 $s_{nf}{*}e_f \overset{?}{<} s_{nf}{*}e_{nf}$

A.18 $e_f \overset{?}{<} e_{nf}$.

This establishes the condition under which the production effect (and, by extension, the trade effect) of a given amount of support provided as a payment coupled to use of a farm owned factor will be less than that of a coupled market price support. This will be so as long as the elasticity of supply of the farm owned, e.g. land, is less than that of purchased factors, e.g. fertiliser.

Put the other way round, a given amount of support provided as a subsidy to a factor of production will have a greater impact on output than an output price subsidy if the factor receiving the subsidy is in relatively elastic supply. This combined with typically low elasticities of farm commodity demand leads to the general tendency, shown in Table 2 of the text, for subsidies to purchased inputs to also be more *trade* distorting than price support.

A close look at the formula *A.11* (labelled *ratio* above) reveals that there are only two situations in which the production effects of market support and direct payments would be equal: if their supply elasticities are equal ($e_f = e_{nf}$) or if the elasticity of substitution were zero ($\sigma = 0$). As noted in the text, most studies have found or assumed elasticities of farm owned factor supply, such as land, that are substantially less than those found or assumed for purchased factors, such as fertiliser. In addition, most studies have found or assume that, in the aggregate, factors of production may be substituted in response to relative price changes (Abler).

Numerical simulation for qualitative analysis

Further insights into the relative effects of support measures and, especially, the robustness of qualitative rankings of their effects were obtained through numerical simulation of the basic PEM model. The combinations of parameter values used in doing the simulation experiments were drawn from the following ranges of parameters judged ‘plausible’ for agriculture in the aggregate on the basis of available empirical evidence. (Floyd, p.155, discusses practical considerations to be taken into account in choosing such parameters.)

Table A1-1. Elasticity values in the basic PEM model

Three values for the elasticity of factor substitution:					
σ	0.25	0.5	1.0		
Three values for the Farm owned factor share:					
S_f	0.1	0.2	0.5		
Five set of values for the factor supply elasticities:					
e_f	0.1	0.2	0.4	0.1	0.4
e_{nf}	1.0	2.0	3.0	3.0	1.0

For each one of the forty-five combinations of parameters possible, four simulation experiments were performed. In each experiment a given, small amount of extra support is provided by one or another of four policy measures: market price support, output price support, payment based on use of farm owned factor and payment based on use of a purchased input. Results for each type of support for the various indicators were then compared. Table 2 in the main text summarises the regularities in the relative effects of policy measures that were found in making those comparisons.

Figures 1 to 6 depict main findings for the relative production effects of market support and area payments. Figures 1 and 2 compare their estimated effects at alternative settings of the elasticity of substitution. A different assumption on factor supply elasticities is done for each figure as specified in their headings. Figures 3 and 4 compare the production effects of the support measures for different values of the factor supply elasticities; a different value of the elasticity of substitution is used in each figure. Finally, Figures 5 and 6 show estimated effects of the two policy measures at different values of the factor shares.

The height of bars in the figures reflect changes in the magnitude of estimated production effects for two support measures at different settings of the parameters while the ratio of their effects is shown by line graph. When this ratio equals one the policy measures have equal production effects. From the discussion above, this happens when either: a) the elasticity of substitution equals zero (Figures 1 and 2) or b) the elasticity of supply of the farm owned factor is the same as that of purchased factors (Figures 3 and 4).

Figure A1: Sensitivity of estimated production effects to alternative values of the elasticity of substitution when efs=0.4; enfs=1 and Sf=0.2

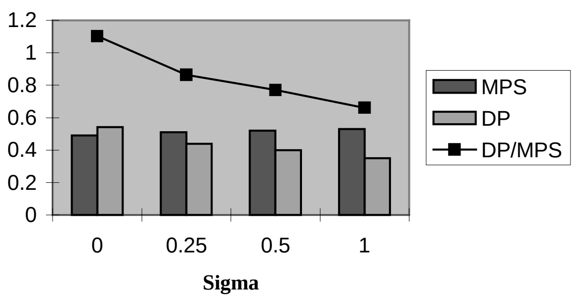


Figure A2: Sensitivity of estimated production effects to alternative values of the elasticity of substitution when efs=0.2; enfs=2 and Sf=0.2

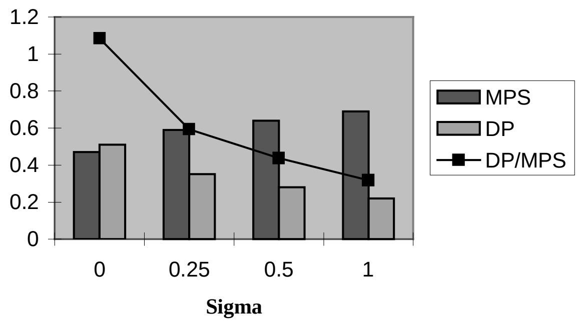


Figure A3: Sensitivity of estimated production effects to alternative values of the factor supply elasticities when Sigma=0.5 and Sf=0.2

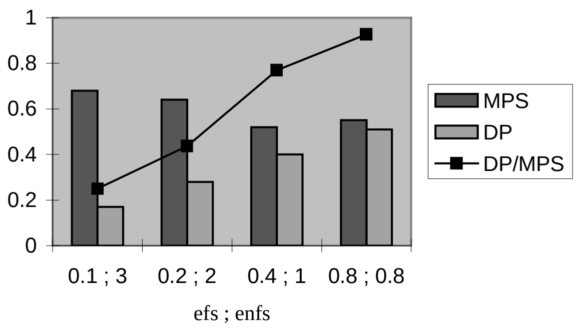


Figure A4: Sensitivity of estimated production effects to alternative vlues of the factor supply elasticities when Sigma=0.25 and Sf=0.2

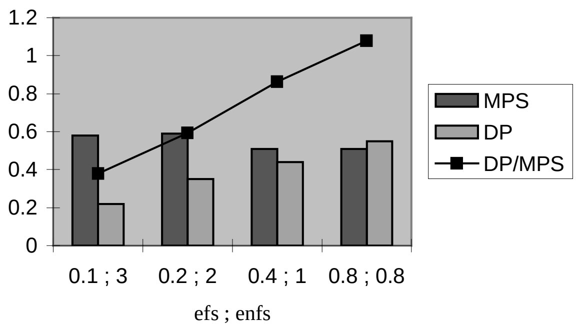


Figure A5: Sensitivity of estimated production effects to alternative values of the farm owned factor share when Sigma = 0.5; efs=0.2; enfs=2

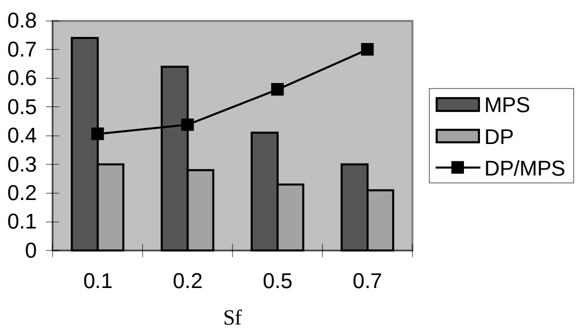
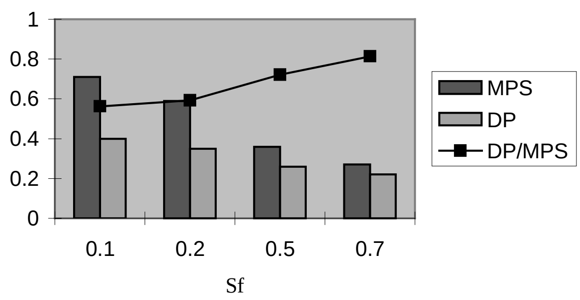


Figure A6: Senstivity of estimated produciton effects to alternative values of the farm owned factor share when Sigma = 0.25; efs=0.2; enfs=2



Annex 2

The Five-Region Version of PEM and Preliminary Numerical Results

The basic PEM model described in Annex 1 served as the common foundation on which the 'country modules' of the five-region PEM model were built. Each of these components has the same kind of production, consumption, price and policy equations as in the basic PEM. Moreover, key assumptions about the incidence of policy made for the basic PEM (in terms of price wedges in product and factor markets) were retained in the individual country components.

The main difference between the basic PEM model and the individual components of the five-region version is the wider coverage in the latter of product and factor markets. To extend this coverage, however, required a much greater specificity in the parameter assumptions: the factor shares and the supply and demand elasticities.

This annex begins with some discussion of the factors considered in choosing plausible values, and ranges of plausible values, for the supply and demand elasticities used. The final section contains preliminary numerical results from policy simulation analyses and related discussion.

Supply and demand elasticities in the five-region model

Supply components

Crop supply is represented through a system of factor demand and factor supply equations. The factor demand equations reflect the usual assumptions of profit maximisation constrained by the production relationship and factor supply. Crop supply response corresponding to a medium term adjustment horizon of three to five years is reflected in the values assumed for the price elasticities of factor supplies and the parameters measuring the substitutability of factors in production. In theory, the longer the period allowed to adjust factor supplies and combinations following a permanent change in expected prices, the greater that adjustment would be. However, the degree to which this applies is different depending on the parameter. For example, the difference between the long run and short run elasticity of land supply is likely to be smaller than that for purchased factors or for farm labour. Likewise, elasticities of factor substitution, which depend to some degree on advances in technology occurring over the longer term, might be expected to evolve more slowly than other supply parameters.

An important consideration in modelling the demand and supply of inputs used in crop production is the degree to which they are specific to any one or the other of the crops produced. In principle, some factors of production may be specific to the crop for which they are used; for example, certain individual items of fixed capital may be necessary for each one of the crops produced. Moreover, there is regional specialisation in production with associated costs to factor mobility among regions. [See Abler and Shortle (1997), p. 48.] At the other extreme, there are factors of production that can be used just as easily for one crop as for another. In principle, given quantities of these inputs would be re-allocated without cost amongst crops with changes in relative returns.

In modelling demand and supply of cropland, we adopted an approach that distinguishes land use by crop. This approach recognises that although any one of the three crops may be grown on the same hectare of land, some land is better suited for one crop than for another and thus land rental rates can differ across commodities (Orazem and Miranowski). Following Abler and Shortle, we model this less than perfect substitutability using commodity specific land supply equations containing both own and cross-price elasticities.

A similar 'commodity specific' distinction was made in modelling the demand and supply of the aggregate factor -- 'other farm owned'. This factor comprises (mostly) farm household labour and management. However, we assume in this case a complete specificity in that no substitution in use of this factor among crops is allowed. We did not distinguish supply of any of the purchased factors on a commodity basis, assuming thereby a perfect substitutability in their use amongst crops in response to changes in relative prices.

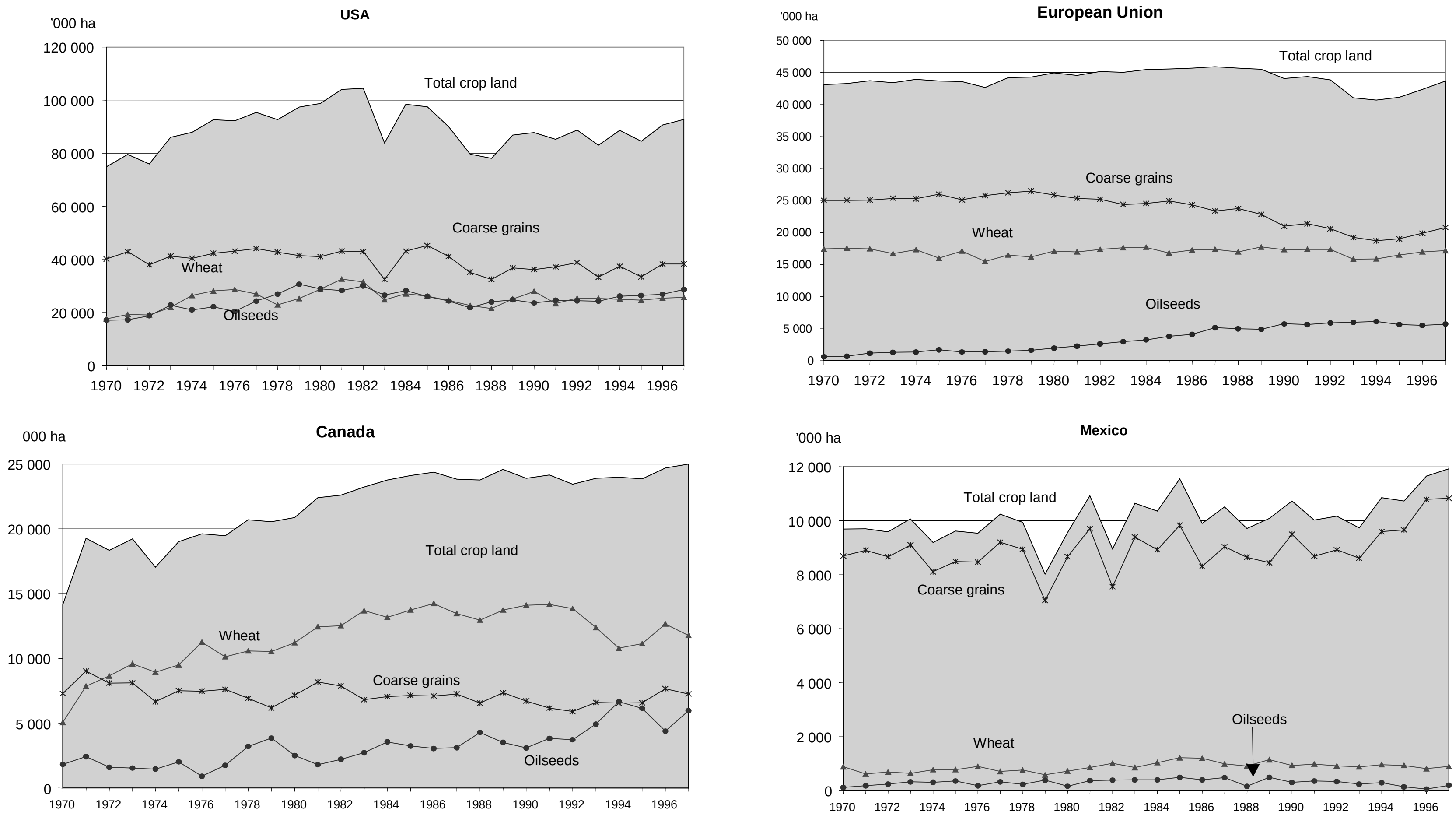
...the elasticity of supply of cropland

The elasticity of supply of cropland measures the proportional change in area planted to a particular crop in relation to a proportional change in the returns to land. In general, the adjustment in the area of land planted to a particular crop following a change in returns will comprise two effects: a scale effect and a substitution effect. The scale effect reflects adjustment in the *total* cropland brought about by the change in overall returns to cropping while the substitution effect reflects the re-allocation among alternative crops which occurs with the change in relative returns to individual crops.

Most economists would agree that the supply elasticity of total cropland is low (Floyd). The widely accepted belief that the benefits of farm support accrue predominantly to landowners rests on the assumption that the elasticity of supply of land is lower than the elasticity of supply of non-land inputs (see Gardner pp. 100-101). Indeed, in related studies of the effects of agricultural policies, e.g. Hertel, Helmberger, Gunter, *et al*, Abler and Shortle (1992, 1997) and Cahill, total cropland is often assumed to be completely fixed in crop production (but with varying degrees of substitutability among crops).

Panels 1 to 4 in Figure A2-1 display trend lines showing for the period 1970 to 1997 the area planted to wheat, coarse grains and oilseeds in the European Union (EU15), the United States, Canada and Mexico respectively. These trend lines reveal some changes over time, not only in the allocation of land among the three crops, but in their totals as well.

Figure A2-1: Evolution of land use in PEM pilot study countries, 1970 to 1996



The magnitude of these changes is relatively small, however, and there is no evident persistence in the overall trends for any one of the countries or commodities (except possibly coarse grains versus oilseeds in the European Union). Moreover, at least some of the year to year variation is probably due more to other factors, such as weather conditions at planting time, than to changes in relative prices and rental rates. For the United States and the European Union, some of the year over year changes must be attributed to the occasional programs of voluntary and mandatory area set-aside.

In their recent econometric study of crop area response in the United States, (Lin, *et al*) estimated own and cross elasticities of area response for wheat, maize, soybeans, rice and cotton. In a similar study, (Hussein, *et al*) estimate area response elasticities for major crops in Australia.[1] In neither study are there estimates of elasticities of area response for the particular commodity aggregates used in the PEM crop models. However, it is possible to use the information that is reported in these studies to calculate estimates corresponding to PEM crop definitions. Table A2-1 contains the results.

Table A2-1. Cropland supply elasticities for the United States and Australia from recent studies

United States	*% change in area due to a 1% change in price of:*		
	Wheat	Coarse Grains	Oilseeds
Wheat	0.36	-.19	-.02
Coarse Grains[2]	-0.04	0.30	-0.24
Oilseeds	-.01	-.14	0.27
Total Crops		0.09	
Australia			
Wheat	0.34	-0.06	0.00
Coarse Grains	-0.02	0.08	-0.01
Oilseeds	-0.26	-0.18	0.69
Total Crops		0.22	

Note from the table that own elasticities of land supply are generally in the range 0.1 to 0.4. (The main exception is oilseeds in Australia, but oilseed area constitutes only a small percentage of cropland use there.) Cross elasticities all fall in the range -0.3 to 0.0. The elasticity estimates reported in these two studies are closely related to but are not defined in exactly the same way as those needed for the PEM crop models. In both studies, the elasticities are measured with respect to *crop prices* whereas the land elasticities in the PEM crop models refer to changes in returns to land (implicit rental rates). Generally, land supply elasticities defined with respect to returns to land would be lower than those defined with respect to output price.[3]

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1. Published studies reporting econometric estimates of land supply elasticities based on recent data are rare. There are land supply equations for several OECD countries in Aglink. The elasticities used in Aglink equations are generally from unpublished analyses done using data that is now several years old. Nonetheless, the elasticities are generally in the same range as those in the two studies cited here.

2. The Lin, *et al*, study reported elasticities of wheat and of soybean (oilseeds) supply with respect to selected coarse grain prices. However, the study did not report elasticities of supply of any coarse grain except for maize. Those are the estimates reported here.

3. This can easily be verified using formulas found in Gardner, p. 99, Table 4.1. The proof requires only one assumption, that the own elasticity of land supply be less than the own elasticity of supply of non-land

Some programs of government support result in payments based on the area of land planted to a specific crop. Other types of programs may require that the land remain in production but do not specify which one of a selected group of crops must be planted. Still other types of programs require that land be retained in a productive or approved conservation use, but impose no conditions impinging on a producer's decisions about what to plant.

The elasticity of land supply appropriate to modelling policy effects will, in general, be different depending on these aspects of program implementation. As noted above, because land can be substituted among competing uses the elasticities of land supply for any individual crop are higher than for any aggregation of them. Moreover, the more crops there are in an aggregate, the lower is the elasticity of supply of that aggregate. The elasticity of supply of total crop plus pasture land is less than the elasticity of supply of crop land, which is in turn less than the elasticity of supply of, for example, wheat land.

This hierarchy of elasticities implies a certain hierarchy of policy effects for different support measures. For example, area payments that require planting of a particular crop might be expected to have a greater impact on the planting of that crop than area payments which only require planting of one of several 'eligible' crops. Similarly, payments conditional only on a requirement that land remain in agricultural use might be expected to have less of an effect on plantings than payments which require planting, whether of a particular crop or one from a list of eligible crops. These refinements are not yet fully reflected in the PEM crop models.

...the elasticity of supply of farm labour

In other studies, farm labour is sometimes assumed in perfectly elastic supply, sometimes in perfectly inelastic supply, and sometimes between these two extremes. The elasticity of supply of farm labour will be different for different lengths of run and for different definitions of farm labour employed: farm household labour, hired labour or both. Most labour used in producing wheat, coarse grains and oilseeds in the pilot study countries is farm household labour. The share of total costs represented by hired labour is less than 3 per cent on average across countries and crops (see Table A2-2). Moreover, it seems likely that hired labour used in crop production can more readily be increased or reduced with changes in economic circumstances than can farm household labour.

In the very short run, farm households may have limited opportunities for adjusting to changes in their economic circumstances. Adjustments such as entering or leaving farming, re-allocating work time between farm and off-farm work, or shifting between work and leisure time, making it likely that, over this length of run, farm household labour is locked into farming activities, having a zero or near zero elasticity of supply. All these possibilities for adjustment, however, must be considered if the horizon being considered is sufficiently long run. Thus, over a long enough period of adjustment it is probably safe to assume, as is frequently done, that farm household labour is in completely elastic supply.

For a medium term adjustment horizon, however, neither of these assumptions will do. We assumed a range for the elasticity of supply farm household labour of 0.2 to 0.4. Hertel used in his study an elasticity of supply for this factor of 0.5. In keeping with the treatment of hired farm labour as a 'purchased input', the range of elasticity estimates used for this factor (and for all other categories of purchased inputs as well) was 1.0 to 4.0.

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factors as an aggregate, an assumption that would seem representative of crop production in OECD countries.

...the elasticity of supply of purchased factors

In other studies, purchased inputs are usually assumed in completely elastic (fixed price) supply to the agricultural sector. The explanation for assuming high to infinitely high elasticities of supply for these factors is that, over the long term, the energy and materials used in the production of farm inputs can probably be increased or decreased with little effects on prices of those raw materials. See, for example, Abler and Shortle (1991). This seems plausible given that the agricultural share of the total market for these raw materials, mostly traded on international markets, is trivially small.

The inputs purchased by farmers comprise not just the raw materials required for their manufacture, however, but also a range of services: processing, transportation, distribution and marketing to make them available for use on farms. The provision of those services requires investment in capital specific to agriculture. The existence of capital, specific and fixed, in the industries supplying inputs to crop producers means that, at least in the medium term, supplies cannot be readily and fully adjusted to changes in relative prices and returns.

...factor substitution

We assume that purchased inputs may be substituted for farm owned inputs in response to relative price changes. The degree of such substitutability is represented in terms of assumptions about the elasticity of factor substitution. Unitary elasticities of factor substitution, the Cobb-Douglas assumption, imply *constant factor cost shares*. Zero elasticities of substitution imply *constant factor proportions*, i.e. constant input-output coefficients. It seems the great majority of past studies of agricultural adjustment at the regional or national level have been based on models assuming at least some degree of substitutability among aggregate factors of production. Moreover, most of those studies adopted the Cobb-Douglas unitary elasticity of substitution assumptions. (See Floyd, p.155 and Helmberger, p 47.)

Both Gardner (pp. 113-114) and Hertel (p. 563) consider the implications of different assumptions about substitution elasticities when calculating policy effects.[4] In a yet to be published study on the topic, David Abler of Pennsylvania State University reviewed a large number of published and unpublished econometric analyses aimed at estimating elasticities of substitution for aggregate agricultural production functions. He summarised his results using a classification of aggregate factors similar to the one used in this paper. The median of the estimates of the so-called 'Allen Elasticities of Substitution' ranged from 0.19 to 0.87, depending on the factor pairing. We estimated results using a range of values of 0.2 to 1.0 for this parameter.

...factor shares

There are three input categories common to all countries and products: land, other farm owned, fertiliser and other purchased inputs. However, the European Union and Canada cost functions also include hired labour. The United States cost functions contain those four plus five additional purchased inputs. Numerical estimates of factor shares used in the model are based on results from surveys of costs of production done in participant countries. For the United States and Mexico, published data are available to

4. However, in both cases the discussion is in terms of a single output production function. The existence of multiple outputs, each utilising a different factor mix, constitutes an additional source of factor substitution in response to relative price changes. This means that the elasticity of substitution characterising an aggregate such as total crops should be ***greater*** than the elasticities of substitution characterising the technology of the individual crops comprising that aggregate.

estimate crop specific cost shares. For the European Union and Canada the publicly available data refer to ‘whole farm’ costs. In these cases special analyses were done to produce the crop specific estimates shown in Table A2-2. In each case, the category ‘other farm owned’, comprising returns to farm household labour, management and non-land permanent capital, was calculated residually.

Table A2-2. Wheat factor shares

	European Union	*United States*	*Canada*	*Mexico*
Land	0.14	0.21	0.21	0.24
Other Farm Owned	0.14	0.23	0.22	0.13
Hired labour	0.05	0.04	0.001	
Fertilisers	0.14	0.11	0.10	0.09
Irrigation		0.01		
Chemicals		0.06		
Energy		0.08		
Interest		0.05		
Insurance		0.05		
Other Purchased	0.53	0.17	0.47	0.55
Coarse grain factor shares				
Land	0.18	0.21	0.19	0.27
Other Farm Owned	0.02	0.21	0.23	0.17
Hired labour	0.06	0.02	0.001	
Fertilisers	0.14	0.15	0.12	0.16
Irrigation		0.00		
Chemicals		0.07		
Energy		0.06		
Interest		0.06		
Insurance		0.07		
Other Purchased	0.60	0.14	0.46	0.40
Oilseeds factor shares				
Land	0.18	0.27	0.22	0.30
Other Farm Owned	0.17	0.23	0.13	0.09
Hired labour	0.06	0.03	0.003	
Fertilisers	0.16	0.05	0.11	0.02
Irrigation		0.00		
Chemicals		0.11		
Energy		0.04		
Interest		0.07		
Insurance		0.09		
Other Purchased	0.43	0.12	0.54	0.60

…crop supply elasticities

Although the own and cross-price elasticities of crop supply are not explicit parameters in the PEM crop models, their values can be calculated from knowledge of the elasticities of factor supply, factor substitution and factor shares. The relevant formulas are available in Gardner. Table A2-3 contains the estimates of elasticities of crop supply for each of the participant countries, calculated from 'middle of the range' settings of the other supply parameters in the models.

Table A2-3. Crop Supply Elasticities

	European Union	*United States*	*Canada*	*Mexico*	*Rest of the world*
Wheat	*~% change in quantity supplied due to a 1% change in price~*				
Wheat price	1.42	1.01	1.12	1.43	0.14
CG price	-0.59	-0.29	-0.18	-0.55	-0.04
Oilseed price	-0.08	-0.18	-0.29	-0.10	-0.02
Coarse grains					
Wheat price	-0.63	-0.11	-0.25	-0.15	-0.04
CG price	1.85	0.95	1.24	0.76	0.10
Oilseed price	-0.13	-0.18	-0.30	-0.10	-0.02
Oilseeds					
Wheat price	-0.29	-0.10	-0.33	-0.29	-0.07
CG price	-0.43	-0.26	-0.25	-0.25	-0.04
Oilseed price	1.25	0.98	1.40	1.50	0.15

Commodity demand components

Demand equations in the individual country components of the PEM model relate domestic consumption of crop outputs to crop prices (at the farm level). These demand equations incorporate substitutive and complementary price relationships among the various crops. Own and cross price elasticities used in these equations were obtained from the Aglink model, which distinguishes demand for crops for food use from demand for livestock feed. No such distinction is made in the current version of the PEM models, and thus the PEM crop demand equations represent *totals* of food and feed uses. Aggregated demand elasticities were calculated accordingly. Table A2-4 contains the results.

Table A2-4. Crop Demand Elasticities

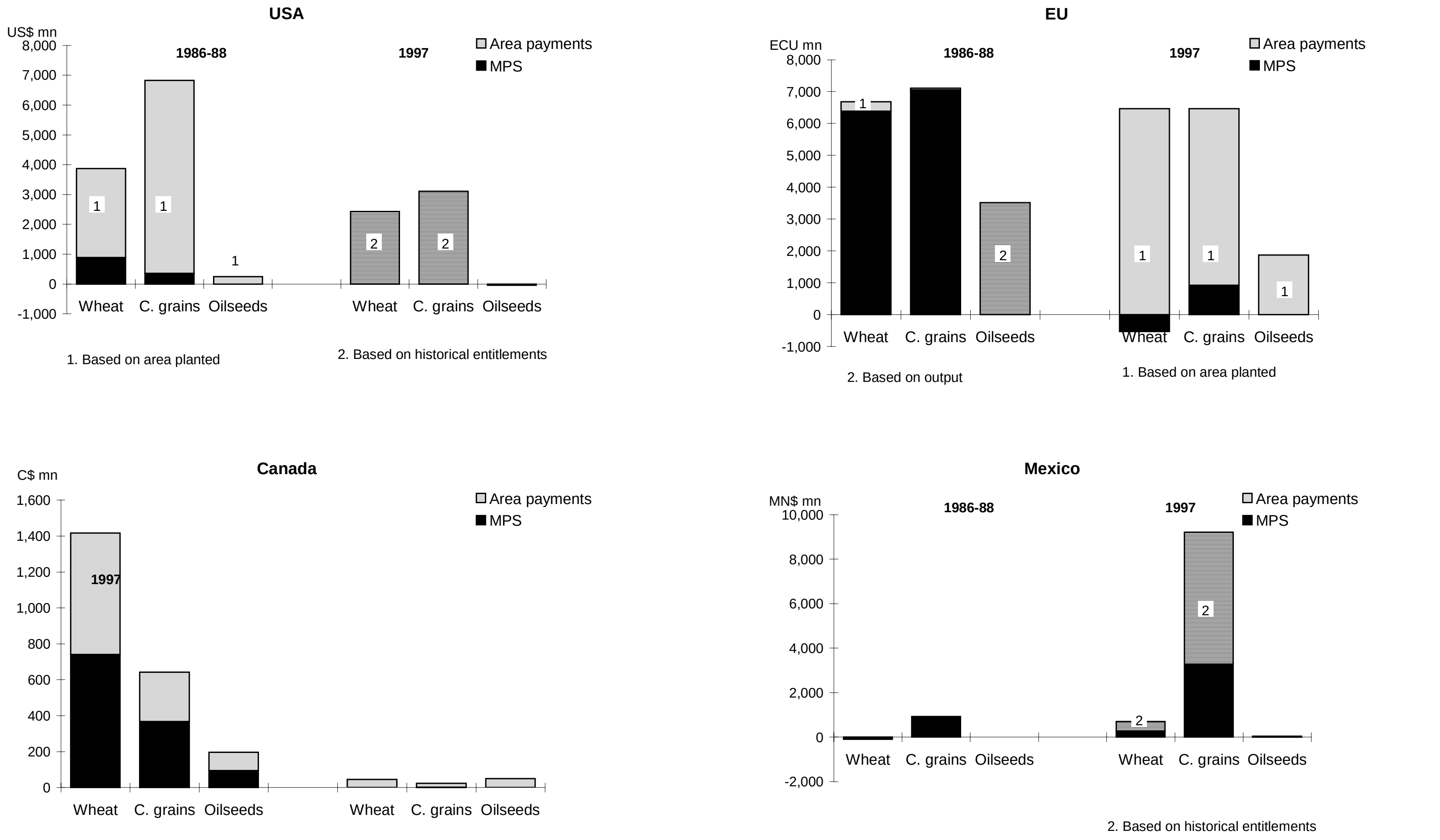
	European Union	*United States*	*Canada*	*Mexico*	*Rest of the world*
Wheat	*~% change in quantity demanded due to a 1% change in price~*				
Wheat price	-0.46	-0.60	-0.52	-0.55	-0.13
CG price	0.30	0.42	0.23	0.34	0.05
Oilseed price	-0.05	0.09	0.18	-0.03	0.00
Coarse grains					
Wheat price	0.15	0.07	0.10	0.08	0.07
CG price	-0.27	-0.15	-0.12	-0.13	-0.19
Oilseed price	0.05	-0.01	-0.03	0.01	-0.02
Oilseeds					
Wheat price	-0.02	0.08	0.50	-0.05	0.01
CG price	0.03	0.01	-0.19	0.20	0.01
Oilseed price	-0.17	-0.17	-0.31	-0.22	-0.37

Preliminary findings from policy simulation analysis

Policy experiments and base period

Market price support and area payments constitute the two most important components of support provided to crop producers in the PEM study countries. Figure A2-2 shows the evolution of these two components of support for wheat, coarse grains and oilseeds in the United States, the European Union, Canada and Mexico from average levels, 1986-88 to 1997. These data reveal substantial changes in both the amount and, especially, in the mix of support provided by these two measures.

Figure A2-2. Evolution of producer support in PEM pilot project study countries, 1986-8 to 1997



The base period for policy experiments was 1997, meaning that equations were calibrated on data measuring production, consumption, factor expenditures, prices and support levels in that year.[1] In 1997, area payments were far and away the dominant source of support to crop producers in the pilot study countries. A comparatively small amount of support was provided in the form of market price support to wheat and coarse grain producers in the European Union, and generally smaller amounts of support were provided in the form of reduction in input costs in all participant countries (OECD, 1998).

Accordingly, the focus of policy experiments was principally on the instruments and incidence of the various programs of area payments. Two types of stylised area-based payments were used for the policy experiments: an area payment with and an area payment without a planting requirement. It should be noted again, however, that neither of these alternatives completely captures the features of existing programs of area payments.

In addition, an experiment was undertaken in each case to evaluate effects of a hypothetical increase in generic price support for *cereals*. (There are no programmes of market price support for oilseeds in place in any of the study countries, nor has this form of support featured significantly in the past for any of them.) Results from the market price support experiments serve mainly to provide a basis for comparison of simulation experiments done to evaluate effects of area payments. It is recognised that the way the particular programs used to provide market price support might differ greatly from country to country. These differences are ignored for now.

Each policy experiment comprised an *increase* in the level of support provided producers by one or the other of the support measures for one or another of the participant countries. The monetary amount, in $US, of the experimental increase was the same for area payments as for market price support, but different among the countries. To calculate the amount of the experimental increase in support level for each country we applied a common percentage, approximately 0.2 per cent, of the 1997 value of total producer receipts, inclusive of area payments. (This leads to increases in the percent PSE for crops in each of the countries also equal approximately 0.2 per cent.) These calculations resulted in experimental changes in support levels, in $US million, for each of the countries as follows:

United States	100
European Union	82
Mexico	9
Canada	12

Sensitivity testing undertaken with the PEM crop models revealed no significant differences in the absolute magnitudes of effects for experimental *decreases* in support levels. However, some aspects of actual policy design may result in an asymmetry of policy effects depending on the amount of the change in support. An important example is noted in the discussion of the evaluation of EU area payments below.

Estimated ‘per dollar’ effects of a given change in the amount of support provided by one or another program will not, in general, be the same as the ‘per dollar’ effects of a larger or smaller

1 . Other base years were used in earlier phases of the analysis. Base year choice is important because of changes over time in both the levels and the composition of support. However, base year is much less important in comparing the effects of experimental changes in support levels, the main focus of the analysis here. That is to say, the commodity and economic effects of a given change in any category of support is not particularly sensitive to the base period chosen.

experimental change in support. Moreover, the degree of this non-linearity of effects is different depending on the support measure used. (The estimated effects for area payments being considerably less scale dependent in this sense than the estimated effects for market support.) There are, as well, the uncertainties discussed earlier concerning the validity of the various elasticities for ‘large’ as opposed to ‘small’ changes in support levels.

The potential asymmetry of effects of increases versus decreases in support levels and the uncertainties about small versus large changes in policy measures are important issues. They are ignored for now, but require further consideration in order to apply PEM analyses to the evaluation of changes in support levels revealed in the evolution of PSE’s.

i) Factor supply parameters and the <u>relative</u> effects of support measures

The estimated results from policy simulation experiments were obtained using the (country and commodity specific) estimates of crop demand elasticities and the (country, commodity and factor specific) input cost shares reported in the above tables. However, the particular values of the elasticities of factor supply and of substitution used had to be chosen from ranges of values for these parameters that could be judged ‘plausible’ based on the limited information available on them.

In each policy simulation experiment, the ‘package’ of these parameters used was the same for all countries in the model. That is, we did not distinguish elasticities of factor substitution or supply by either country or commodity. These ‘common’ elasticity ranges are summarised in Table A2-5.

Table A2-5. Ranges of elasticities of factor supply and substitution used in the five-region PEM

Elasticities of factor supply:	**Bottom of range**	**Top of range**
Land ‘own-price’	0.4	0.8
Land ‘cross-price’	-0.1	0.0
Purchased	1.0	4.0
Elasticity of factor substitution	0.2	1.0

Set 1 ***Set 2***

A central feature of the PEM analysis has been to compare the production, trade and economic effects of support measures. Theoretical analysis developed in Annex 1 established that the relative effects of market support and area payments depends mainly on the *relative* values of factor supply elasticities and the substitution elasticities. The key findings were that the effects of area payments and market support are more similar: a) the more similar are the elasticities of supply of land and non-land factors of production; and b) the smaller is the elasticity of factor substitution.

Correspondingly, the differences in the effects of the two support measures are greater: a) the greater is the difference between the elasticity of supply of land and non-land factors of production and b) the greater the elasticity of substitution. Thus, any empirical findings concerning the relative effects of support measures (and the policy inferences flowing from them) hinge critically on the particular pairing of numerical values of factor supply and substitution elasticities chosen from the ranges shown in the Table A2-5.

The set of elasticities in Table A2-5 that would be expected to yield estimates of policy effects most *similar* between market support and area payments is: land ‘own-price’ 0.8, land ‘cross-price’ 0.0, purchased 1.0, and an elasticity of substitution of 0.2. Note these are the values of land supply elasticities from the *top of the range,* and the values of purchased factor supply elasticities and the elasticity of substitution from *the bottom of their respective ranges*. Call this group of parameters *set one*.

Likewise, the set of elasticities in Table A2-5 that would be expected to yield estimates of policy effects most *different* between market support and area payments is: land ‘own-price’ 0.4, land ‘cross-price’ -0.1, purchased 4.0 and an elasticity of substitution of 1.0. That is, the values of land supply elasticities from the bottom of the range and the values of purchased factor supply and elasticity of substitution from the top of their respective ranges. Call this group of parameters *set 2.*

These were the sets of factor supply and substitution elasticities used in estimating ranges of policy simulation results. Thus, for each experimental change in support, two policy experiments were done. One used the set 1 elasticities of factor supply and substitution the other used set 2. Column headings of results presented in the tables below are labelled accordingly.

ii) European Union

... policy characteristics

The main policy instruments used in the arable crop regime of the European Union are area payments for both cereals and oilseeds and, for cereals, market price support. The latter is in the form of a guaranteed intervention price, which sets a floor for the domestic market, accompanied by border measures, i.e. tariff rate quotas, import tariffs, export refunds (or, sometimes, export taxes). For oilseeds, no intervention or border measures exist.

The system of guaranteed prices with the associated tariffs and export subsidies (or taxes) to a large degree isolates EU producers and consumers of cereals from variations on the associated world markets. This feature constitutes an important difference between the European Union and the other pilot study participants. It is of somewhat less importance in evaluating the ‘home country’ effects of changes in support measures that are the subject of this section. But it is an obviously important element in explaining differences in the international spillover effects of policy changes that are the subject of the next section.

A supply management element for the crop regime is added in the form of a mandatory set aside, the rate of which is set annually depending on market conditions. Small producers are exempted from the set-aside requirement resulting in a difference between the level at which policy makers set this parameter and the *effective* rate of set-aside. For the 1997/98 season, the former was 5 per cent and the latter approximately 3.5 per cent. There are also programs of *voluntary* set aside. Depending on the region, a certain percentage of the area eligible for planting may be left unplanted and the producer still receives the area payments.

EU area payments are fixed on a per hectare basis based on historical regional yields. This, effectively, de-links them from yield decisions in the sense that a producer cannot affect the size of the payment by changing yields and therefore has no incentive to expand yields beyond what market conditions would dictate. However, although there is a global limit on total outlays, each producer receives payments on the actual area planted and the area set aside. If regional ‘base’ area plantings are exceeded, proportional reductions in the payment rate are applied to keep outlays within their global limit.

Except for land obligatorily or voluntarily set aside, producers are required to plant their eligible base area to receive payment. This requirement means that such payments constitute an incentive to plant so long as the relevant portion of the base area is not (or would not be) fully utilised in the absence of the payments. Once the base area is fully used, the incentive effect is substantially mitigated by the global limit on payments and the proportionate decrease in payment rate which would accompany over planting of the aggregate base area. Base areas are set regionally. The incentive effect is also mitigated by the possibility of voluntary set-aside. In practice there has been no systematic over or under planting of base area.

This combination of a planting requirement and, in effect, a planting restriction introduces some uncertainty about the effects of hypothetical 'small' changes in area payments such as those under study. There are two dimensions to this uncertainty. First, there exists the asymmetry between the expected effects of an increase as opposed to a decrease. In particular, once the base area is fully utilised further increases in payment rates would be expected to have limited effects on plantings.

Similarly, a 'small enough' reduction might have no effects either. This would be the result if all producers found that after a small change in support they could still cover their costs of planting with a combination of market receipts and payments. For a 'large enough' reduction though some producers would find it unprofitable to plant their marginally productive land which would lead to an under planting of the base. We assume that the experimental change in support would be sufficient to cause a move along the crop land supply curve as dictated by the elasticities of crop land supply discussed earlier.

In estimating the effects of EU area payments reported in Table A2-6 some of the specific aspects of program implementation were embodied in the model. These included: 1) zero price transmission for cereals, 2) area payments which are fixed on a per hectare basis, 3) conditional on a set-aside requirement, and 4) subject to a global limit on outlays. Other specific aspects of program implementation, such as voluntary set-aside, were not incorporated in the version of the model used for this first phase of the analysis.

...estimated results

Table A2-6 contains estimated results showing commodity market impacts of EU support. Look first at the entries showing effects on production volumes for wheat, coarse grains and oilseeds respectively. The estimated production increase for cereals caused by the extra support given in the form of area payments is about one half the effect of the same amount of support given in the form of market price support using set 1 factor supply elasticities. The estimated production effects of area payments are less than one-tenth the effect of market support using set 2 elasticities.

Table A2-6. Estimated range for the commodity market impacts of extra producer support in the EU

	Initial level	*Change due to $US82 mil additional support as:* market support		area payments	
Impacts on volume of:	**~thousand tonnes~**	**set 1**	**set 2**	**set 1**	**set 2**
Production:					
wheat	94752	108	293	55	21
coarse grains	98342	174	424	92	36
oilseeds	14305	-18	-40	8	3
Consumption:					
wheat	78969	-31	-25	0	0
coarse grains	80134	-44	-36	0	0
oilseeds	28836	5	4	1	0
Net trade:					
wheat	15783	139	318	55	21
coarse grains	18207	218	460	92	36
oilseeds	-14530	-23	-44	7	2
Impacts on world prices of:	**~$US/tonne~**				
wheat	124	-0.12	-0.17	-0.05	-0.01
coarse grains	96	-0.07	-0.09	-0.03	-0.01
oilseeds	238	-0.04	-0.05	-0.05	-0.01

The effects of the extra market price support on EU production of oilseeds are negative. There are two factors at work here: 1) higher cereal prices within the European Union and 2) lower world and, therefore, EU market prices for oilseeds. Recall that the experimental increase in market price support applies only to cereals. In the European Union, the effect is to increase the relative returns to cereal production and a corresponding shift out of oilseeds production. Outside the European Union, the opposite would be expected. Extra EU cereal production leads to lower world prices of cereals relative to oilseeds and thus to increased world oilseeds production. The latter, in turn, causes world market prices of oilseeds to decline. We assume these lower prices are passed through to EU producers, further increasing the relative attractiveness of cereals versus oilseeds returns for EU crop producers.

Consumption effects are relatively small, regardless of the support measure or the crop. Accordingly, the relative effects of the support measures on net trade are approximately the same as for production. These results are mirrored in the results in the last row of Table A2-6 showing estimated effects of the two support measures on world market prices of the three commodities. The simulated impacts of extra EU market support on cereal prices are more than twice the effect of the same amount of support provided as area payments using set 1 elasticities and more than ten times as high using set 2 elasticities. (Because extra market support was applied only to cereals while area payments were applied to oilseeds as well, differences in oilseeds price impacts are not especially meaningful.)

Table A2-7 contains estimates of economic impacts of extra EU support. Consumers pay the larger share of the costs for that form of support because market support raises internal prices. Taxpayers are affected in that both the unit rate of export subsidy and the volume of exports that must be subsidised rises with the increased market support. Taxpayers pay the entire costs of the area payments, plus a little extra. The extra arises because area payment also lead to an increase in export subsidies.

Table A2-7. Estimated range for the economic impacts of extra producer support in the EU

	Change due to $US82 mil additional support as:			
	market support		*area payments*	
~million $US~	**set 1**	**set 2**	**set 1**	**set 2**
Taxpayer costs	16	16	84	82
Consumer surplus	-50	-40	1	0
Farm household income	22	23	43	60
…of which land rent	*15*	*16*	*39*	*60*
Input supplier profits	31	22	14	1

Farm households gain the greater share of the estimated benefits of extra support regardless of the support measure used. However, their gain is at least twice as great when the support is provided in the form of area payments rather than as market support, regardless of which set of factor supply elasticities are used.

Note, however, that the gain in farm household income from area payments is almost entirely due to the estimated increase in land rents, assuming all land rents go to farm households. Similar findings were obtained for programs of area payments operating in the other study countries. An implication is that the primary beneficiaries of these area payments are land *owners*. Land *users* (farm operators) benefit only to the extent that they own the land they farm (Shertz and Johnson).

iii) United States

... policy characteristics

No programs of market price support were operating in the United States during 1997, the base year for this analysis. In earlier years, wheat producers were provided market price support through expenditures under the Export Enhancement Program. Producers of wheat and other cereals can also receive output price support under one or another of the provisions of commodity loan rate programs administered by the Commodity Credit Corporation. In some preliminary analysis for the paper, the estimated production, trade and income effects of these two forms of support were found to be quite similar, albeit with different distribution of costs between consumers and taxpayers. To maintain comparability with the analysis done for the European Union, the focus is on results obtained from a hypothetical increase in market price support provided to both wheat and coarse grain producers.

A form of area payments is made to US crop producers under the Federal Agricultural Improvement and Reform (FAIR) Act based on their historical participation in government programs of area payments for crops. The payments are independent of farm prices and production and, while producers must comply with conservation and planting requirements (i.e. cropland must be kept in agricultural or related uses), no crop production is required.

Support provided under the FAIR Act might affect crop production a) if payments result in some crop land being kept in agricultural or related uses which would otherwise be diverted to other uses, and b) if that land is actually planted to crops. However, these potential linkages were not represented in the current versions of the PEM crop models. As currently designed, these models permit only one of two assumptions. Either the payments have no effects whatsoever on current planting and production decisions, or they affect such decisions in the same way as open ended subsidies to area planted with an associated planting requirement.

No simulation analysis is needed to estimate policy effects under the first of these assumptions. Since the extra $US 100 million of support has no estimated effects on production, consumption or trade, the associated taxpayer costs, the increase in farm household income and the part of the latter going to land rent should all three equal exactly $US 100 million. The tables below contain the estimated results obtained treating the FAIR Act payments as subsidies to current planting. However, these results need to be interpreted keeping in mind the stylised nature of this policy representation.

...estimated results

Table A2-8 contains results showing estimated commodity market effects of support given US crop producers. Production and trade effects of extra cereal market price support are greater for coarse grains than for wheat, reflecting the relative importance of the two crops in the United States. As for the EU results, oilseeds production declines with the simulated increase in cereal market price support. As compared to the results for the European Union, the net trade impacts of extra US market price support are somewhat less and the world price effects somewhat greater. (This holds even after accounting for the slightly greater amounts of extra support in the US experiment.)

Table A2-8. Estimated range for commodity market impacts of extra producer support in the US

			Change due to $US100 mil additional support			
		Initial	*market*		*area payments (*)*	
Impacts on volume of:		**~thousand**	**set 1**	**set 2**	**set 1**	**set 2**
Production						
	wheat	68697	71	142	56	16
	coarse grains	262538	228	368	112	37
	oilseeds	73577	-31	-51	37	19
Consumption						
	wheat	35471	-15	-14	0	0
	Coarse grains	207501	-17	-10	16	5
	oilseeds	48115	8	7	1	1
Net						
	wheat	33226	85	156	56	16
	coarse grains	55036	245	378	96	32
	oilseeds	25463	-39	-58	36	18
Impacts on world prices of:		**~$US/tonne**				
	wheat	124	-0.15	-0.20	-0.11	-0.03
	coarse grains	96	-0.15	-0.19	-0.09	-0.02
	oilseeds	238	-0.01	-0.02	-0.16	-0.05

* Assumes payments coupled to area planted

To a large degree, the explanation lies in the fact that when market support is increased in the European Union, the United States absorbs some of the world market price impact through reduced production and higher consumption. When US market support is increased, however, there is no pass through of world market prices to EU producers and consumers of cereals and thus no absorption. In terms of the usual two-region trade model, this aspect would be revealed as differences in the elasticities of the excess demand confronting the two regions: those facing the European Union being somewhat greater (in absolute value) than those facing the United States. This important asymmetry features again in results presented later showing ‘spillover’ effects of policy changes.

Table A2-9 contains results of calculations of economic impacts for the United States. The overall consumer plus taxpayer cost of a given amount of *measured* market price support is somewhat lower than for area payments because increases in market support lead to reductions in world market prices and because those price changes are transmitted to US consumers. Of course, the gain in farm household income due to an increase in area payments is substantially greater. Importantly, however, in both cases this constitutes a gain that comes in the form of extra land rents.

Table A2-9 Estimated range for the economic impacts of extra producer support in the US

Set of parameters:	*Change due to $US100 mil additional support as:*			
Short run	*market support*		*area payments(*)*	
~million $US~	**set 1**	**set 2**	**set 1**	**set 2**
Taxpayer costs	28	29	100	100
Consumer surplus	-34	-24	29	9
Farm household income	27	22	42	71
…of which land rent	*10*	*11*	*31*	*71*
Input supplier profits	20	28	11	-1

* Assumes payments coupled to area planted

iv) Mexico

... policy characteristics

The main policy mechanisms under which cereal producers in Mexico can receive market support are tariffs applying to wheat and a tariff rate quota applying to maize. PROCAMPO is the main program of area income payments to cereals and oilseeds producers. Payments made under this program are granted to farmers who actually cultivate the land, being owners or renters, individuals or corporations. To be eligible, land must have been cultivated with maize, beans, wheat, sorghum, rice, soybeans, safflower, cotton or barley in any crop season over the three years prior to August 1993.

Since the beginning of this program there has been a high degree of freedom in the use of land receiving PROCAMPO payments. As of 1996, land can be devoted to any crop, livestock, or forestry activity, or placed in an improved environmental program. In any of these cases, land can receive the same area payment. However, the land may not be left idle except if registered under an environmental program operated by the Ministry of Environment. When registering for a PROCAMPO payment, farmers are requested to declare the intended use of land for the next crop season.

As for the US FAIR Act payments, support provided via PROCAMPO payments can affect production of a particular crop only in the case where payments result in some land being used in producing that crop which would otherwise be abandoned entirely. In evaluating them, as was done for the United States, the only case examined is the one assuming that eligibility for payments is based on a requirement to plant.

...estimated results

Results showing commodity market impacts of extra support in Mexico are in Table A2-10. The pattern of production effects for cereals are similar to that obtained for the United States, reflecting the predominance of coarse grains in the crop mix in both regions.

Table A2-10 Estimated range for the commodity market impacts of extra producer support

	Initial	Change due to $US9 mil additional support: market		area	
Impacts on volume of:	**~thousand**	**set 1**	**set 2**	**set 1**	**set 2**
Production					
wheat	3636	5	12	3	2
coarse grains	24407	24	54	24	9
oilseeds	176	0	0	1	0
Consumption					
wheat	5126	-1	-1	0	0
coarse grains	28671	-4	-4	0	0
oilseeds	3702	2	2	0	0
Net					
wheat	-1490	-6	-13	-3	-2
coarse grains	-4264	-28	-58	-23	-9
oilseeds	-3526	2	2	-1	0
Impacts on world prices of:	**~$US/tonne**				
wheat	124	-0.01	-0.01	-0.01	0.00
coarse grains	96	-0.01	-0.01	-0.01	0.00
oilseeds	238	0.00	-0.01	-0.01	0.00

* Assumes payments coupled to area planted

Table A2-11 contains estimates of economic impacts of extra support provided in Mexico. Because Mexico is a net importer of wheat, coarse grains and oilseeds there are important differences in the magnitude and incidence of both the costs and benefits of market support as compared to either the United States or the European Union. A unit increase in market support has a greater than one unit effect on consumer costs in Mexico as consumers must pay the resulting higher domestic prices on both all of production and all of imports.

Table A2-11. Estimated range for the economic impacts of extra producer support in Mexico

		Change due to $US9 mil additional support as: market support		area payments*	
	~million $US~	**set 1**	**set 2**	**set 1**	**set 2**
Taxpayer costs	-1.1	-1.1	-0.6	9.6	9.1
Consumer surplus	-10.1	-10.1	-10.5	0.3	0.1
Farm household income	4.9	4.9	6.0	5.7	6.9
…of which land rent	*2.2*	2.2	3.6	*4.0*	*6.8*
Input supplier profits	2.9	2.9	2.1	1.9	0.2

* Assumes payments completely coupled to area planted

On the other hand, taxpayers are seen to actually gain in consequence of the additional market support provided cereal producers in Mexico. This reflects the value of additional tariff revenues resulting from reductions in world market prices and assumed to be captured by the government.

The gain in farm household income due to increased market support in Mexico is greater than was the case for either the European Union or the United States. The explanation is that the farm income share of total revenue is higher in Mexico. Crop production in Mexico, especially for coarse grain, is both more land extensive and labour intensive than is the case for the other regions.

Nevertheless, area payments are still seen to deliver gains in farm household income much more efficiently than market support. Notice once again, however, that these gains are almost exclusively in terms of increases in land rents.

v) Canada

... policy characteristics

In contrast to the other PEM participant countries, there were no programs in place under which crop producers in Canada could receive market price support in 1997, the base year. The main support program in effect is the Net Income Stabilisation Account (NISA) which provides matching grants and an interest subsidy to farm savings in a program account.

This matching grant is based on farm revenue (up to a specified cap) and thus has some elements of output support, since at least some participants in the program can increase their matching grant by increasing production. Once the revenue cap is reached, no further funds can be generated from the program by increasing output and payments received above that limit are additions to farm income. Under the new PSE classification, the totality of NISA payments are allocated to the category ‘Based on Farm Income’.

The NISA program is a ‘whole-farm’ program, however, and, despite some trial efforts to do so, it was not possible to model policy effects attributable uniquely to the three crop aggregates under study. Such analysis must await a more complete representation of Canadian farm production and policy. Instead, as was done in the early phases of the PEM work, two policy experiments were undertaken aimed at revealing the differences in ‘generic’ or classical forms of market price support and payments based on area.

...estimated results

Table A2-12 and A2-13 contain, respectively, the estimated commodity market impacts and economic impacts of extra support provided crop producers in Canada. Although the policy experiments for Canada are similar to those done for the other countries, care should be taken in making comparisons. First, as noted above, the experiments are entirely ‘in the abstract’. Second, the total amount of support provided to Canadian crop producers is comparatively much less than that provided to crop producers in the United States, Mexico or the European Union. Consequently, a given increase in support may result in a greater proportional change in prices of crops and of inputs for Canada than for the others.

Table A2-12 Estimated range for the commodity market impacts of extra producer support in Canada

		Change due to $US11 mil additional support			
	Initial	*market*		*area*	
Impacts on volume	**~thousand**	**set 1**	**set 2**	**set 1**	**set 2**
Production					
wheat	24400	52	120	23	14
coarse grains	20659	49	126	19	13
oilseeds	9101	-10	-24	13	7
Consumption					
wheat	7214	-5	-5	1	0
coarse grains	18808	-2	-3	0	0
oilseeds	6122	2	2	0	0
Net					
wheat	17186	57	126	22	13
coarse grains	1852	51	129	19	13
oilseeds	2979	-12	-26	13	7
Impacts on world prices	**~$US/tonne**				
wheat	124	-0.05	-0.08	-0.03	-0.01
coarse grains	96	-0.02	-0.03	-0.01	-0.01
oilseeds	238	0.00	0.00	-0.03	-0.01

Table A2-13. Estimated range for the economic impacts of extra producer support in Canada

	Change due to $US11 mil additional support as:			
	market support		*area payments*	
~million $US~	**set 1**	**set 2**	**set 1**	**set 2**
Taxpayer costs	6	7	11	12
Consumer surplus	-5	-6	1	0
Farm household income	6	8	7	9
…of which land rent	*2*	*4*	*4*	*9*
Input supplier profits	3	3	3	0

vi) Spillovers

The individual country studies comprising the PEM pilot project focused mainly on developing indicators showing domestic effects of alternative support measures. This section contains results from analysis aimed at estimating effects of policy change in one country or region on outcomes in another country or region, i.e. the international spillovers of policy measures.

Support in one country or region affects outcomes in another country or region through the impacts on trade and world market prices. But the effects will be different among countries depending on: 1) the degree to which world market prices are transmitted to producers and consumers, 2) the commodity mix of the price changes as compared to the commodity mix of production, and 3) the factor mix of production.

In order to reduce the number of combinations of countries, policy measures and indicators to be evaluated, the analysis focused on comparing effects on just two of the indicators: net trade and farm household income. Furthermore, results are presented showing effects of hypothetical increases in support for only two support measures, market price support and area payments, in only two of the participant countries, the United States and the European Union. To further facilitate comparisons, the same monetary change in support level -- $US100 million -- was used for both policy measures in both regions. For these purposes, the ‘coupled version’ of US area payments was used. Finally, the simulation analysis was done using ‘middle of the range’ values for the elasticities of factor substitution and supply.

Table A2-14 contains results showing the differential effects of the two support measures on *cereals net trade*. Increases in EU market price support are seen to have much greater estimated net trade impacts in both the European Union and in the other countries than EU area payments. The same finding applies in comparing US market price support and US area payments.

Notice, however, the asymmetry between the effects of market support in the European Union and the United States. Although a given increase in EU market support has quite significant estimated negative impacts on net trade in cereals in all the other countries, the effects of the same increase in US market support are quite different. Importantly, the increased market support in the United States has almost no impact at all on EU trade and correspondingly even greater impacts on the other countries. This reflects the fact that there is no transmission of world market price changes into the European Union so the other countries must absorb a greater share of the increase in cereal exports from the United States.

Table A2-14 Estimated spillover impacts of support in the EU and US on wheat and coarse grains net trade

	impact of $US100 mil additional support as:			
	EU mps	*EU dp*	*US mps*	*US dp*
on net exports from:		**~'000 tonnes~**		
European Union				
wheat	237	24	1	3
coarse grains	361	44	0	3
United States				
wheat	-88	-9	101	20
coarse grains	-227	-27	275	39
Mexico				
wheat	5	1	3	0
coarse grains	10	1	20	4
Canada				
wheat	-47	-6	-39	-9
coarse grains	-31	-4	-60	-10

Table A2-15 contains results making clear that the greater the positive income impact of a given support measure in the country implementing that support, the less is the negative spillover on other countries. Notice the asymmetry between the effects of market support in the European Union and the United States. A given increase in EU market support is seen to have a quite significant impact on US farm household income. However, because once again there is no transmission of cereal market prices, the same increase in US market support has zero impact on EU farm household income.

Table A2-15. Estimated income spillover effects of producer support in the EU and the US

	impact of $US100 mil additional support as:			
	EU mps	*EU dp*	*US mps*	*US dp*
on farm household income in:		**~$US million~**		
European Union	31	72	0	-1
United States	-29	-4	28	66
Mexico	-2	0	-3	0
Canada	-5	-1	-5	-2

Annex 3

Policy Mix and 'Packages' of Changes in Policy Instruments

Background

In the initial phases of the PEM pilot study, two kinds of analysis for which the PEM framework might prove useful were distinguished. One was called 'indicative' analysis, the other 'impact' analysis. Indicative analysis meant evaluating the effects of hypothetical one-by-one marginal changes in individual policy measures. Impact analysis meant evaluating the net impact of a package of policy changes all occurring at the same time, such as might be revealed looking at a time series of PSE data.

The main focus of analytical efforts so far has been on indicative analysis. It is the simplest kind of analysis possible within the PEM framework and constitutes an essential first step in understanding how policy measures differ in their effects on trade and welfare.

Moreover, the results obtained in doing this kind of analysis seem important in their own right. Some of the findings, the relative trade effects of area payments versus price support for example, will be the same whether the evaluation is of the impacts of the two measures changing one at a time or of both changing at the same time. Since those results are important and controversial it is essential to achieve some degree of understanding and acceptance of them, keeping the analysis as simple as possible.

The second kind of application originally contemplated for the PEM -- impact analysis -- permits evaluation of the net effects of actual (real-world) policy developments in a way not possible with indicative analysis. Applying the PEM in this way may also help in providing partial insights into other critical questions being addressed in the pilot study, such as to what extent the framework may be useful for quantifying the effects of relatively large changes in support measures.

This annex contains results of analysis undertaken to illustrate how the PEM framework might be employed in doing impact type analysis. The example chosen is the package of policy changes that occurred in the EU in 1992. That package included some relatively large changes in producer and consumer prices and in area payments. As noted elsewhere in the paper and annexes 1 and 2, key supply and demand parameters in the PEM crop models are constants. There is less confidence in their validity for evaluating policy changes resulting in large changes in prices than for evaluating policy changes resulting in small changes in prices.

The policy package

The 1992 reform of the EU's Common Agricultural policy resulted in simultaneous changes in four policy instruments:

1. A reduction in cereals intervention prices leading to a reduction in producer prices
2. Elimination of oilseeds deficiency payments
3. Imposition of area set aside requirements
4. Introduction of area payments.

The table below contains averages of cereal producer prices, direct payments and set aside percentages for selected years before and after the implementation of these changes.

Table A3-1. Annual averages of EU support measures before and after policy change[1]

Cereal producer price:		1988-92	1993-97
		ECU/tonne	
	Wheat	176	140
	Coarse grains	167	136
Set aside:		*%*	
	Cereals	0	11.4(8.0) [2]
	Oilseeds	0	12.4 (8.7)[2]
		1988-92	1995-1997[4]
Annual Payments: [3]			
		Million ECU	
	Wheat	490	6253
	Coarse grains	32	5316
	Oilseeds	2955[5]	2273

Notes

1. *Sources*: OECD (1997), *Agricultural Policies in OECD Countries: Monitoring and Evaluation* 1997, EDP; AGLINK database.

2. The numbers in parentheses are the 'effective' rates of set-aside. These were the estimates actually used in the simulation experiments. These were calculated using an area 'slippage' factor of 0.3 taken from AGLINK. This factor reflects the exclusion of selected producers from the set aside requirement. It is measured as:

Area slippage = 1- (% reduction in area planted / % 'required' set aside).

3. Annual payments for oilseeds for 1988-92 were in the form of output based deficiency payments. Annual payments for all crops for 1995-97 were in the form of area payments.

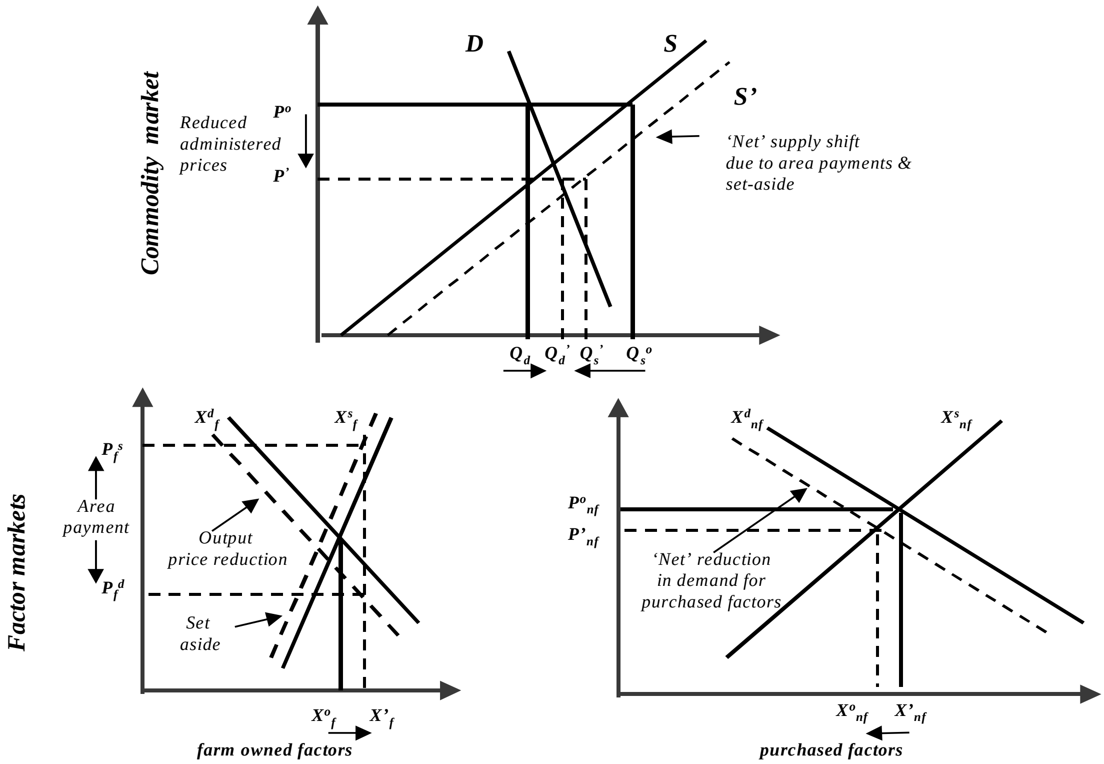
4. It was necessary to use a different range of years (1995-97) for area payments than for the other policy measures (1993-97) because of the change in the composition of the EU after 1994. The PEM crop models are calibrated to do analysis of EU-15 totals.

5. Total for EU-12. The three countries that became members of the EU in 1995 produced relatively very small quantities of oilseeds 1988-92.

Graphical analysis

Figure A3-1 illustrates qualitative impacts on some commodity and factor market outcomes that might be expected to result from such a package of policy changes. The upper panel of the figure compares before and after equilibrium in the representative commodity market, the lower two panels the before and after equilibrium in the two factor markets. Solid lines depict the 'before' policy change situation and the dashed line the 'after'.

Figure A3-1 Trade and income effects of change in policy mix



In the commodity market, the price reduction by itself leads to lower production and higher consumption. However, the production impact is offset by the outward shift in the supply schedule due to the area payment, even after accounting for the set aside.

The most complicated pattern of changes occurs in the market for farm owned factors, shown in the lower left-hand panel of the figure. There are leftward shifts in both the factor demand and the factor supply curves, offset by movements along them. The leftward shift in the demand schedule is due to the reduction in output price. (The same occurs with the demand for purchased factors.) The leftward shift in the supply schedule for farm owned factors reflects the impact on supply of land of the set aside requirement. Finally, the wedge which area payments drive between the supply and the demand price for that factor bundle leads to movements along both curves. As shown, the net effect of the combination is to increase equilibrium quantity of farm factor use (and reduce that of the purchased factor).

The pattern of impacts shown in the figure -- net reductions in production, net trade and purchased factor use, net increases in consumption and farm owned factor use -- are by no means general results. There exist combinations of reductions in prices and increases in payments that result in net changes all in the opposite direction to those shown. However, as the analysis in the main text illustrates, the pattern of impacts shown in the figure is that which would be expected if: a) there was no net change in level of support or, b) the reduction in market support more than offset the increase in direct payments. It is shown in the next section that the estimated net effect on the total PSE of the combination of changes in policy measures revealed in Table A3-1 is slightly positive.

Simulation experiments

A sequence of policy simulation experiments was undertaken to evaluate the net effects of the above package of policy changes using the stylised versions of EU policies contained in the PEM crop model. Recall the base year data in the model is from 1997 and all supply and demand elasticities are meant to correspond to a 'medium-run' adjustment horizon. Similar to the indicative analysis, the current version of the model does not capture any changes in parameters caused by the interactions of different policy instruments.

It was assumed that the differences in five-year averages shown in the above table indicate the 'medium-run' changes in policy measures resulting from the policy changes implemented after 1992. The PEM crop model was used to estimate the effects of reversing those changes, using the 1997 base year data as the starting point.[1] Table A3.2 contains the results for crop production, consumption and net trade. The first column of numbers shows estimated impacts of the price reduction components of the package, the second column shows estimated impacts of the area payments alone, the third column contains estimated impacts of area payments and set aside combined, and the fourth column contains estimated 'net' impacts of the entire package.

The estimates in Table A3-2 indicate the amount by which selected indicators of policy effects: production, consumption, net trade and so on, are higher/lower than they *otherwise would have been*. There is no way of knowing for sure what the values of any of those indicators 'would otherwise have been'. We can only construct hypothetical 'scenarios'.

One possibility would be the average values before the policy changes were implemented, i.e. a 'no-change' scenario. This seems unlikely, however, as there are many other variables besides policy variables which have an impact on production and whose averages would have changed between 1988-92 and 1993-97.

Another candidate, somewhat more appealing, would be a 'constant-policy' projection scenario for 1992-96 obtained from a model such as AGLINK or GTAP. Unlike the PEM, these models do contain many of the more important non-policy variables determining EU crop quantities and prices. Such an alternative deserves further consideration.

The scenario chosen for present purposes was to use simple trend lines fitted to data for the period before the policy changes were introduced (1979 to 1991) and then extrapolate those trends over the period following the implementation of the policy changes (1993 to 1997). That is to say, a 'trend will continue' scenario. Undoubtedly, some elements of the long-term development of EU crop production and consumption -– the growth in productivity of cropland due to technical progress for example -- can be predicted accurately using simple trend extrapolation.

1. An alternative would have been to create a 1988-92 base period and then introduce the policy changes in the way they actually occurred. This introduces the complications of the 1995 change in the composition of the EU. There is no reason to expect the results would be much different, but perhaps it should be done as a check.

Figures 1 to 3 display the data and the trends for production, consumption and net trade, for wheat, coarse grains and oilseeds respectively. The data for the period before 1992 fall generally slightly above and below the trend line. There is, however, a certain consistency in the pattern of data relative to trend after 1992.

Wheat, coarse grain and oilseed production levels are generally below the trend line in the post 1992 period. Wheat and coarse grain consumption are both above their respective trend line, while oilseed consumption is, on average, below its trend. Reflecting these patterns, the values of net trade for all three commodities are all below trend in the five years after 1992.

To what extent does this pattern of departures from trend correspond to the pattern of policy effects predicted by the PEM crop model? The next to last column in Table A3-2 contains the latter. The last column contains averages of differences from trend of the actual data over the period 1993 to 1997. There is a close correspondence among model predictions of the direction of policy effects and the direction of departures from trend. There is a less closer correspondence in the magnitudes of effects. Model predictions for wheat and oilseeds are of similar magnitude to departures from trend, but this is not so for coarse grains.

Table A3 - 2 Estimated net commodity impacts, in the EU, of 1992 changes in EU policy

	Model based estimates of net impacts of:				
	Reducing prices and deficiency payments only	*Area payments only*	*Area payments plus set-aside*	*Entire package*	*Actual as compared to trend*
Impacts on volume of:		**~million tonnes~**			
Production:					
wheat	-16.6	6.4	4.3	-12.3	-11.0
coarse grains	-24.7	12.9	8.2	-16.5	-5.0
oilseeds	-7.4	0.7	0.4	-7.0	-5.0
Consumption:					
wheat	3.3	0.0	0.0	3.3	8.0
coarse grains	4.3	0.0	0.0	4.3	9.0
oilseeds	-0.9	0.1	0.1	-0.8	-1.0
Net trade:					
wheat	-20.0	6.4	4.3	-15.6	-19.0
coarse grains	-29.0	12.9	8.2	-20.8	-14.0
oilseeds	-6.5	0.6	0.3	-6.2	-4.0

A particularly interesting question concerning policy changes occurring in the EU after 1992 is, "how much of the 'net' reduction in estimated production attributable to the overall package is due to the effects of the set-aside requirement as compared to the other components?" The first two columns of Table A3-3 contain the model-based estimates of 1) the percentage reduction in production due to the entire package of changes in support measures, and 2) the percentage reduction in production caused by set-aside.

According to the model, area set-aside alone caused reductions in wheat, coarse grain and oilseed production of between 2 per cent and 5 per cent. Notice in Table A3-1 that the average effective rate of set-aside was 8.0 percent for cereals and 8.7 per cent for oilseeds. As stated in footnote 2, the effective rate in that table is one which reflects an adjustment for so-called "area slippage", mainly due to the exclusion of some producers from the requirement to set aside land. What then explains the difference between the average effective rate of set-aside of around 8 per cent and an average estimated production effect attributable to set aside of only around 3 per cent?

Table A3-3 Estimated production effects of set-aside.

	Model based		*Departure from trend*	
	Total package	*Set-aside contribution*	*Total*	*Set-aside contribution*
Impacts on volume of:	~ % ~		~ % ~	
Production:				**??** *'but less than:*
wheat	-11%	-2%	-11%	-8%
coarse grains	-15%	-5%	-6%	-8%
oilseeds	-33%	-2%	-28%	-9%

This is explained by yet another form of slippage associated with area restrictions -- production slippage. In theory, a producer faced with a restriction on the use of land will have an incentive to make adjustments in his output and input mix so as to minimise the effects of that restriction on the optimal level of output. These adjustments mean that any given percentage reduction in area will lead to a less than proportional reduction in production. Production slippage is measured as:

Production slippage = 1 - (% change in production / % 'effective' set aside).

In discussing the former program of area payments and set aside in the United States, Gardner (p. 60) cites an estimate of production slippage for wheat of 0.35. This would mean, for example, that for those producers obliged to set aside land, a 10 per cent set aside requirement would yield only a 6.5 per cent reduction in their production. (Thus an even smaller percentage reduction in the total of their production plus that of producers not obliged to set aside.)

There are several ways producers may respond to an area restriction that would lead to their having a less than proportional effect on production. These include:

1. Setting aside the least productive land.

2. Increasing the intensity of non-land factors of production on any given crop.

3. Changing the mix of crops produced towards the most land-intensive ones.

The area slippage percent is a parameter in the PEM crop models but the production slippage factor is not. This is because the latter is automatically accounted for. In the policy simulation experiments an imposed restriction on plantings leads to (endogenous) changes in relative factor and output prices and to associated changes in output and factor combinations. The production slippage implicit in the results in Table A3-3 are 0.75, 0.38 and 0.77 for wheat, coarse grains and oilseeds respectively. (Calculated using the above formula, the numbers in the second column of Table A3.3 and the corresponding effective rates of set aside from Table A3-1.)

The third column of Table A3-3 contains "departure-from-trend" estimates of production effects, also converted to percentages. It is impossible to glean from the historical data the exact contribution of the set-aside as compared to other factors influencing EU crop production during the period 1993 to 1997. However, allowing for an even modest degree of production slippage, the percentage reductions are (on average) somewhat greater than would be anticipated considering the potential effects of the set aside alone.

Table A3-4 contains estimates of the net economic impacts of the EU policy changes. The first row shows model estimates of the effects of the various changes in policy measures on the total PSE for the three crop commodities. As noted earlier, these estimates indicate only a slight net increase overall. This contrasts quite dramatically with the changes in commodity volumes shown in Table A3-2 and with estimated changes in other indicators in Table A3-4. Policy effects clearly depend on both the magnitude and the mix of changes in policy measures.

Table A3-4 Simulated net economic impacts, in the EU, of 1992 changes in EU policy mix

	Net impacts of:			
Net impacts on:	*Reducing prices and deficiency payments only*	*Area payments only*	*Area payments plus set-aside*	*Entire package*
		~billion $US~		
Producer Support Estimate	-15.3	16.8	16.0	0.7
Taxpayer costs	-7.9	16.1	15.6	7.7
Consumer surplus	5.4	0.1	0.1	5.4
Farm household income	-5.8	11.0	11.0	5.2
…of which land rent	*-3.6*	*10.7*	*10.8*	*7.2*
Input supplier profits	-4.2	1.0	0.6	-3.6

Observe the row labelled ‘Farm household income’. The first column of that row shows the estimated income loss EU farm household would have suffered from the price reduction component of the package of policy changes. The third column shows the estimated net income gain from the area payment/set aside component and the final column the net impact for the entire package. These numbers indicate an over-compensation in terms of farm household income of approximately $US5.2 billion, comprising a loss of $US5.8billion from the price reductions component of the package and an $US11.0 billion gain from the direct payment/set aside component.[2]

Table A3-5 contains estimates of the net impacts of the package of EU policy changes on the United States, to illustrate international spillover effects. Note the row labelled ‘Farm household income’. The first column of that row shows the estimated income gain US farm households would have experienced from the price reduction component of the package of EU policy changes. The third column shows estimated net income loss from the area payment/set aside component and the final column the net impact for the entire package. These numbers indicate a net income gain for US farm households from the entire package amounting to approximately $US2.7 billion, comprising a gain of $US3.5 billion from the price reductions component and a $US0.8 billion loss from the direct payment/set aside component.

Table A3-5 Simulated net economic impacts, in the US, of 1992 changes in EU policy mix

	Net impacts of:			
Net impacts on:	*Reducing prices and deficiency payments only*	*Area payments only*	*Area payments plus set-aside*	*Entire package*
		~billion $US~		
Taxpayer costs	0.1	0.0	0.0	0.1
Consumer surplus	-3.7	1.2	0.8	-2.9
Farm household income	3.5	-1.1	-0.8	2.7
…of which land rent	*1.7*	*-0.5*	*-0.4*	*1.3*
Input supplier profits	2.5	-0.8	-0.6	2.0

2. Notice that compensating at a rate of e.g. fifty per cent, of the estimated reduction in the PSE (0.5 * 15.3 = $US 7.7 billion) would still have left EU farm households with an estimated net income gain of (7.7 - 5.8 = $US 1.9 billion) from the overall package of policy changes.

Comparing results for the EU and the US suggests that farm households in both regions gained overall from the package of EU policy changes. These results further suggest that such 'win-win' possibilities for farm households in the two regions may exist wherever there is an opportunity for substituting relatively more trade distorting for less trade distorting forms of support[3].

This first attempt at an impact analysis shows that the PEM framework has the potential to evaluate the net impact of changes in a set of policy instruments. The analysis also identifies additional trade-offs not revealed by the indicative analysis of a single instrument. Similar to the indicative analysis, the impact analysis represents stylised versions of policies subject to the limitations of the model framework.

The package of policy changes evaluated comprised some relatively large changes in policy instruments. Despite this, model predictions of the direction of policy effects on production and consumption accord well with the direction of effects revealed by simple trend analysis of actual data. There is a weaker correspondence of the predicted magnitudes of policy effects and the departures from trend revealed in the data. In making simple comparisons of model predictions with variations from trend there is the risk that changes in non-policy factors rather than the changes in support measures could explain the departures from trend observed in the actual data.

3. Note, however, the findings for farm household income reported in the middle columns of the two tables. These findings provide an indication of the relative costs and benefits of changing just the area payment and set-aside components of the EU support package. A policy change would mean one or the other groups of farm households would lose from a policy change. For example, a decrease in area payments of a given magnitude would lead to a proportionally much greater loss for EU farm households than would be the gain to US farm households.

Figure A.3-2. EU15 wheat production, consumption and trade - 1979 to 1997

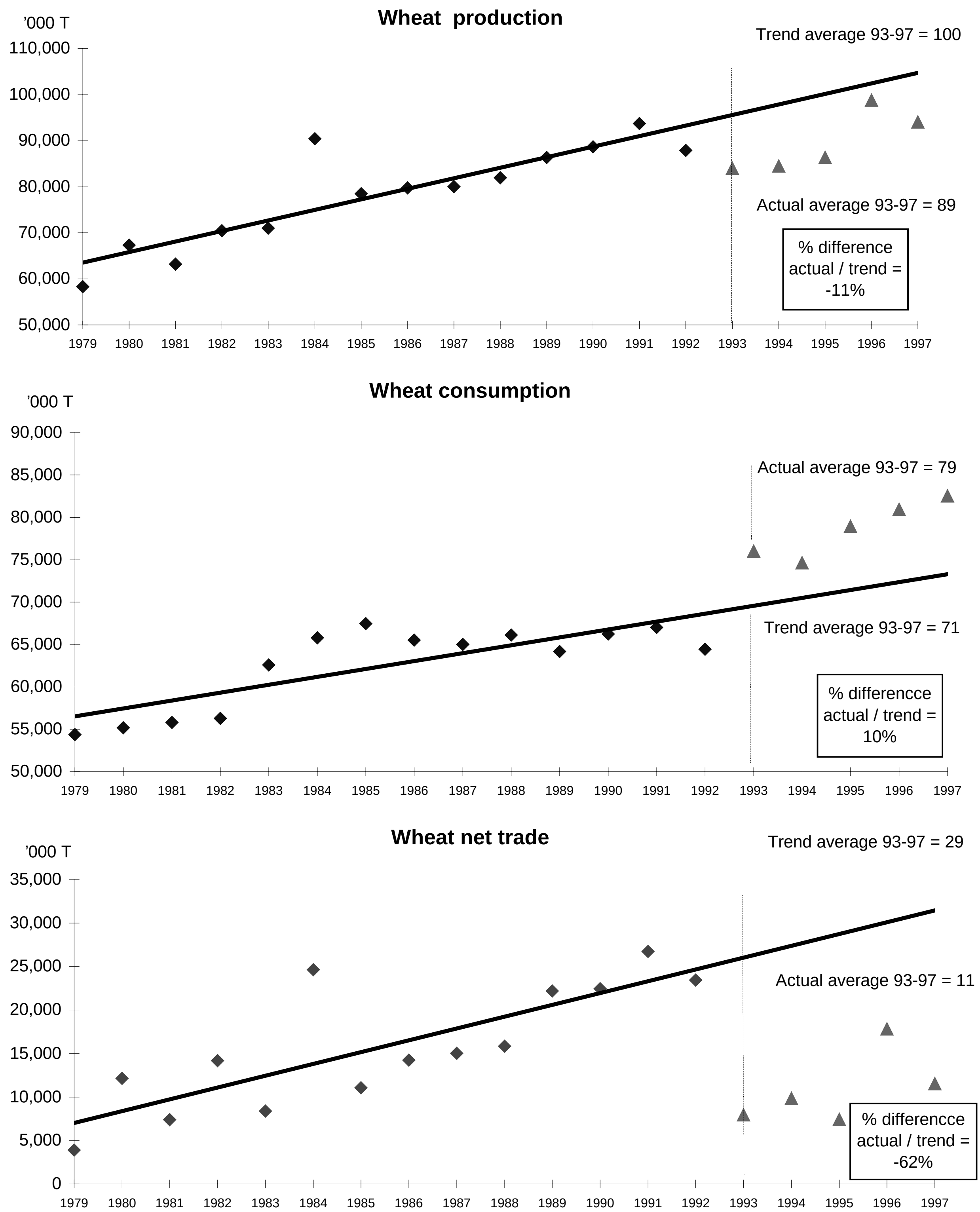
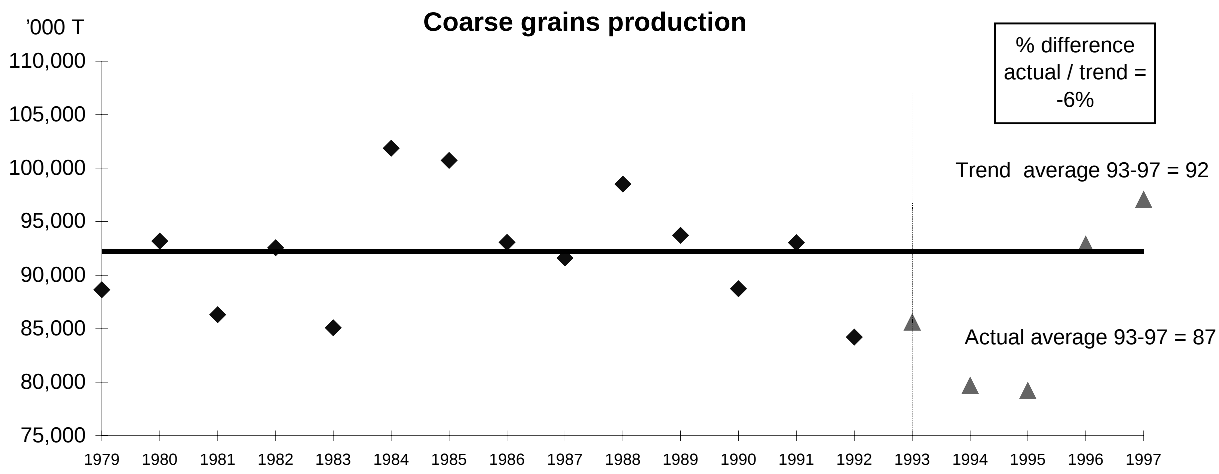
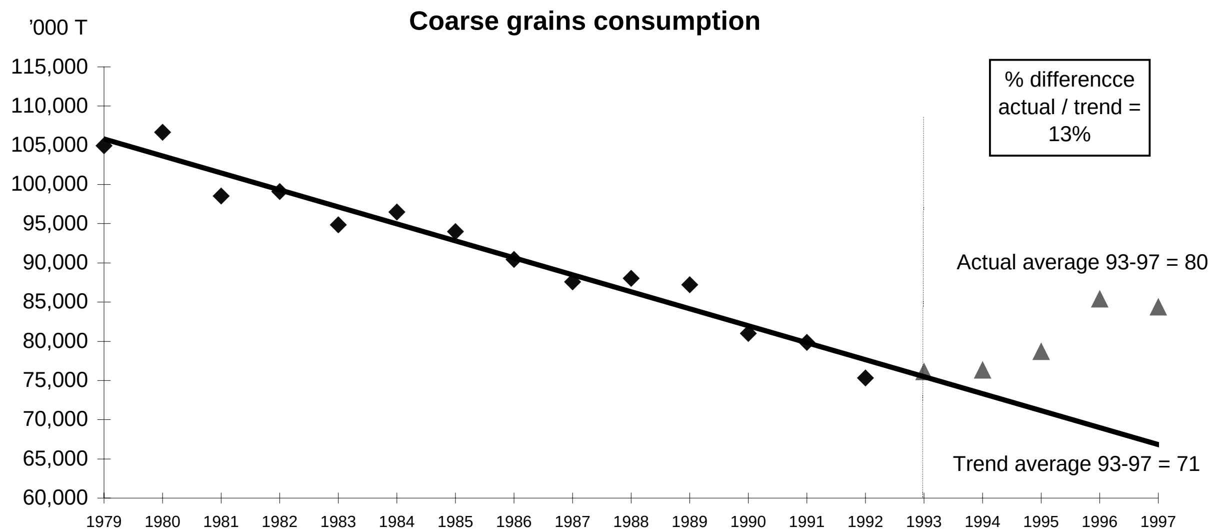


Figure A.3-3. EU15 coarse grain production, consumption and trade - 1979 to 1997





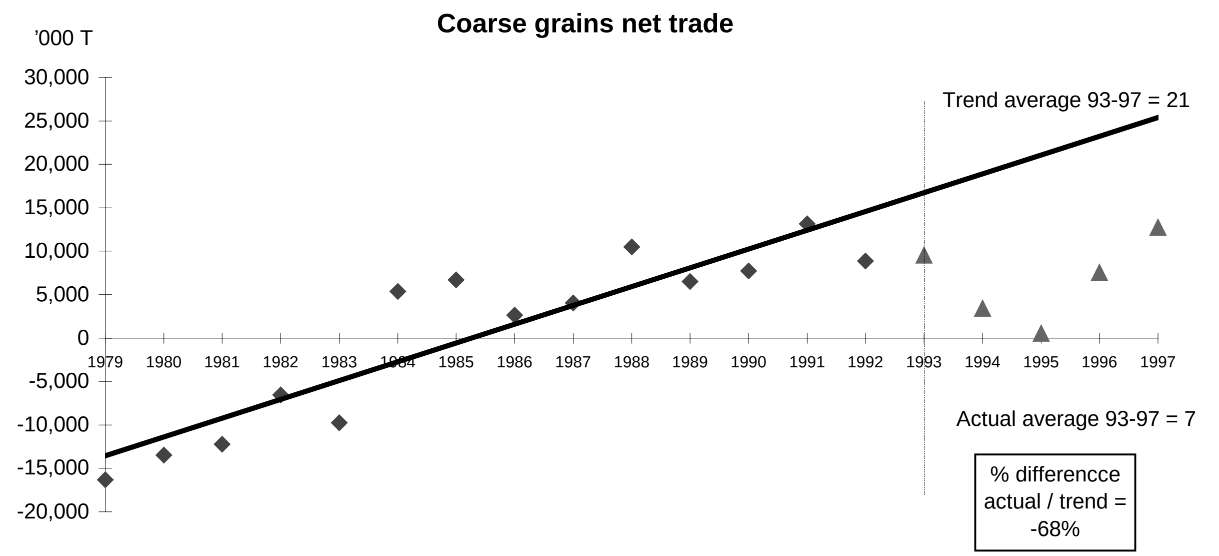
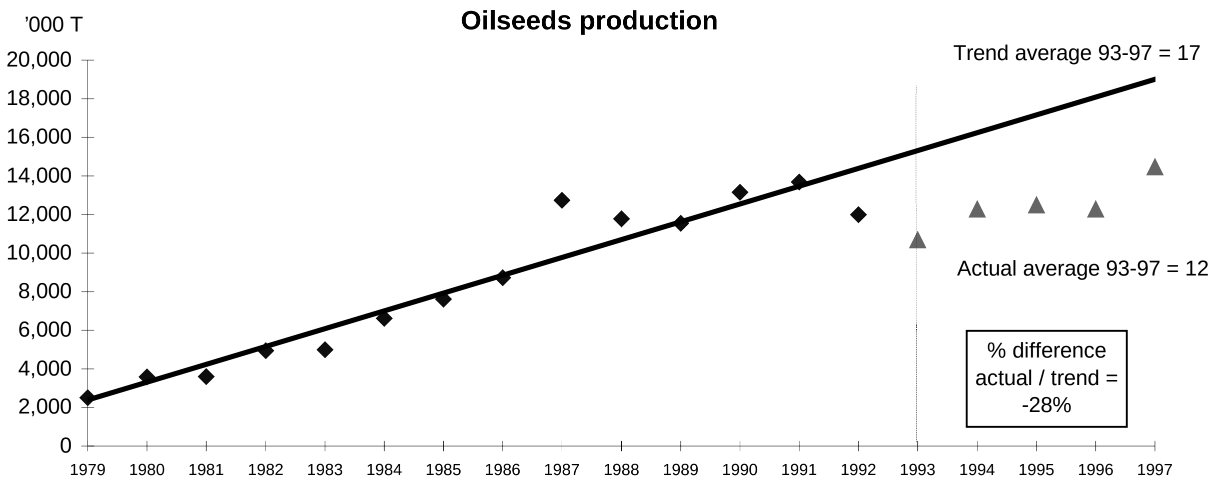
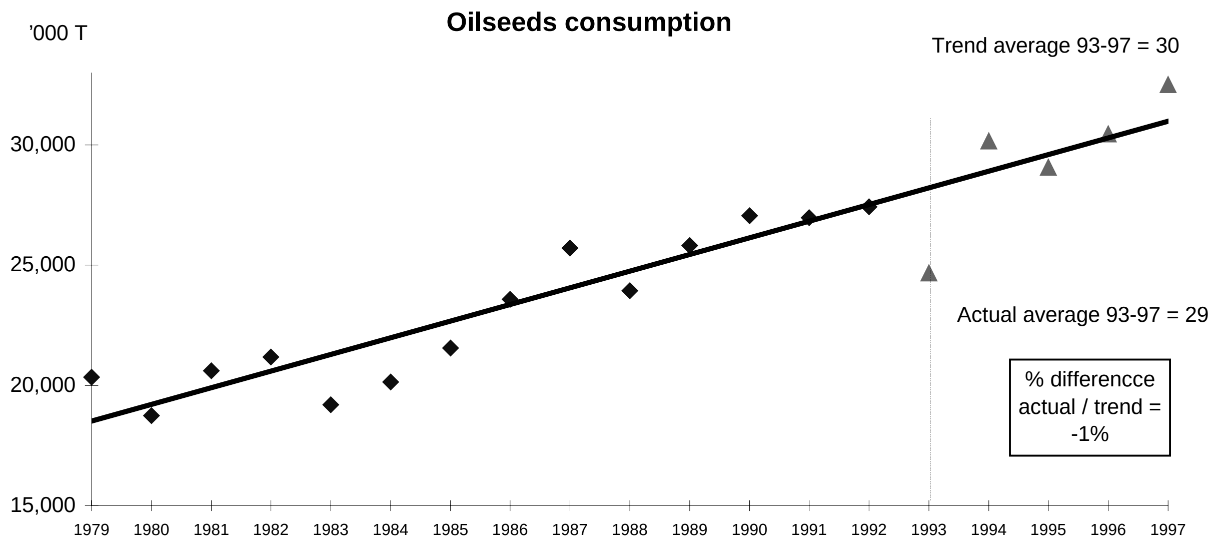
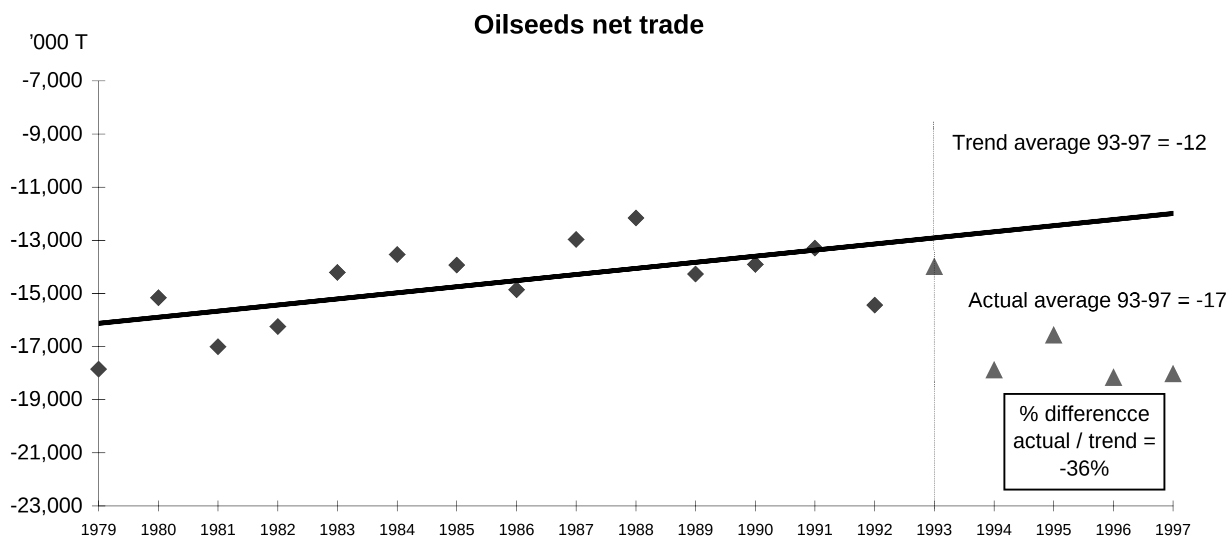


Figure A.3-4. EU15 oilseeds production, consumption and trade - 1979 to 1997







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