Unclassified **AGR/CA/APM(2002)13/FINAL**

Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

15-Jan-2004

English - Or. English

DIRECTORATE FOR FOOD, AGRICULTURE AND FISHERIES
COMMITTEE FOR AGRICULTURE

AGR/CA/APM(2002)13/FINAL
Unclassified

Working Party on Agricultural Policies and Markets

RISK EFFECTS OF PSE CROP MEASURES

English - Or. English

JT00156747

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This paper is the second of a series of five papers on the measurement of decoupling under Activity 6 of the Programme of Work 2001-2002 of the Committee for Agriculture. Its main author is Jesús Antón from the OECD Directorate for Food, Agriculture and Fisheries. It follows the conceptual framework defined in [COM/AGR/APM/TD/WP(2000)14/FINAL] declassified in the 26-28 September 2000 session of the APM and the detailed project proposals defined in [AGR/CA/APM(2001)26] presented in the 30th session of the APM in November 2001. It presents the results of analysing the risk dimension of the PSE database and its application to measurement of the degree of decoupling using the PEM crop model.

This paper has been discussed at the Technical Meeting on Decoupling that took place in Paris on 21 May 2002 and in the Working Party on Agricultural Policies and Markets (APM) of the Committee for Agriculture at its 32nd Session (May 2002) and at its 34th Session (April 2003). The paper was declassified 22 December 2003 by written procedure.

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RISK EFFECTS OF PSE CROP MEASURES

Generally, all agricultural support measures have impacts on the returns from farming which, in turn, create incentives to produce more. But levels of support often fluctuate over time due, *inter alia*, to counter-cyclical features in the design of the policies, the political cycle and budget availability. These fluctuations are related to the fact that stabilisation of farm income is often cited as an objective of agricultural policies. If agricultural support reduces the variability of returns from farming, risk averse farmers will be better off and willing to produce more (Hennesssy, 1998).

The publication *"Market Effects of Crop Support Measure*s" OECD (2001*b*) measured the relative production and trade impacts of different Producer Support Estimate (PSE) categories using the PEM crop model. This estimation covered only the relative price effects of policies as defined in "*Decoupling: A Conceptual Overview"* OECD (2001*c*). This latter study identified other mechanisms through which policies could affect production decisions by farmers. Some of these mechanisms were related to risk and expectations. This current paper is a first attempt to estimate some of these risk-related effects of agricultural policies as classified in the PSEs. This is a relatively new area of research and, therefore, all the results have to be interpreted with caution. Specific conclusions about specific programmes would require more sophisticated empirical testing. All the results in this study are first approximations to the relative magnitude of these risk related effects.

The current study suffers from a number of limitations and weaknesses associated with the assumptions that needed to be adopted. They are discussed in more detailed in the main body of the text and can be grouped into three areas:

- Assumptions about risk. It is assumed that risk can be studied using farming revenue variability with no information on costs and other sources of income, and that the aggregate response of farmers can be reflected in a representative farmer risk aversion coefficient

- Assumptions about policy. The analysis relies on the policy information available in the PSE database and needs to make several simplifying assumptions: for instance, all risk reducing characteristics are summarised by the reduction in farm revenue variability and most of the analysis does not differentiate between different programmes classified under the same PSE category, but which may have different impacts on risk.

- Assumptions in the modelling framework. Product specific risk premiums are assumed to be able to capture the risk-related production response of farmers. All the limitations and caveats applicable to the PEM crop model (see OECD, 2001b) apply also to the parts of the analysis in this study that use this model.

The purpose of this study is to obtain a first estimate of the relative size of the risk related effects as compared to the better known price effects. It is not the intention to draw any conclusions about specific policy programmes. For that purpose the PSE database developed and updated by the OECD Secretariat, a risk version of the PEM crop model based on the standard model that was built in co-operation with some Member countries, and the structural database of the OECD, are used. The study is structured as follows:

- **Step 1. Measuring the reduction in income variability associated with each PSE category** (section 1).Gross farm revenue is used as a proxy for income and the limitations of this approach are discussed in detail. An indicator of farm revenue variability is developed and the impact of each PSE category on this indicator is estimated. This Index of Variation estimates *ex post* the inter-annual farm revenue variability for the period 1986-2001.

- **Step 2. Measuring the production impacts of PSE measures when including risk related effects** (section 2). The PEM crop model was modified to include risk effects on farmers' decisions. This required some information from the empirical literature about risk aversion, and from the OECD structural database. The risk premiums included are designed in a way which is compatible with the indexes developed in step 1. The results are presented in terms of production ratios including risk related effects and shares in total production impacts of price, insurance and wealth effects. Section 3 briefly looks at the dynamic impacts in world markets.

- **Step 3. Sensitivity analysis of the degree of decoupling** (section 4). There is already a systematic sensitivity analysis of production ratios of relative price effects in OECD (2001*b*) and in Dewbre *et al*. (2001). This section develops sensitivity analysis on the new parameters incorporated in the PEM model, related to both the insurance and wealth effects associated with risk.

The four crop commodities covered in the PEM model are covered in this study, that is, wheat, coarse grains, oilseeds and rice. The major commodity in each of the OECD countries represented in the PEM crops model (Canada, the European Union, Japan, Mexico, Switzerland and the United States) is selected. The approach to risk in this paper is commodity specific and it does not consider cross commodities linkages except through the input markets. This is consistent with the approach in the PEM model in which production functions are commodity specific. However, this approach has its limitations, particularly when dealing with payments that are not commodity specific (for instance programmes classified as payments based on historical entitlements). Some cross effects are implicitly but imperfectly captured by the implied cross supply elasticities in the PEM model. The time period covered is 1986-2001.

Section 1. Measuring the reduction in revenue variability associated with PSE measures

This section develops an ex-post analysis of the impacts of different PSE measures for crops on the risk faced by producers. The information available in the PSE database for the period 1986-2001 (OECD, 2002) is used to measure the revenue variability across these years. That is, the time series dimension of the database is exploited to analyse not only the amount of support in each year, but also how this amount is correlated with market revenue. The variability of gross revenue is used as an objective measurement of farming risk and the reduction in variability when each category of support is added is used as a measurement of the implied reduction in risk.

The method used consists of a statistical analysis of a group of time series related to the revenue received by producers of each commodity in each country. Since the PSE database has no information about costs or non-farm income, the analysis is limited to gross farm receipts. Therefore, the results in this section refer to gross farm revenue and not to the income of the farm households. The extent to which the results can be extrapolated to income depends on the correlation between gross farming revenue and net farm-household income. We have not found a consistent source of information on non-farm income. The information in the Economics Accounts of Agriculture (EAA) can be used to compare gross and net farm revenue. This shows that the variability of net and gross revenues is very similar, but data limitations do not permit a definitive conclusion on the extent to which the results would be modified if a more appropriate net income measure was used in the analysis (These issue is dealt with in some detail in Box 1).

Box 1. Gross revenue, transfer efficiency and net revenue in measuring income variability

The analysis reported in this paper uses gross revenue as a proxy for net revenue or income. Ideally, the variability faced by farmers would be best measured with respect to overall farm household net income. The variability of gross revenue may be different from that of net revenue because: *a)* there is no consideration of off-farm income as a source of increases or reductions in variability and *b)* no account is taken of the variability in the costs of production. On this latter issue, there is evidence (OECD, 2003a) that an important share of agricultural support does not reach the farmer's pocket. Transfer efficiency of a given measure is defined in OECD (2003a) as the ratio between its impact on farm income and its cost for consumers and taxpayers. Transfer inefficiencies arise because farmers incur additional costs and because of general efficiency losses. That is, other agents, such as land owners, capture part of the rents. Note, however, that this does not necessarily mean that the variability of support is also transferred to other agents. Both the farmer and the land owner have economic incentives to keep any counter-cyclical variability of support in the hands of the operator; this variability of support may reduce the variability of income of the farm operator, but it would potentially increase the income variability of the land owner. The extent to which this is the case should be proved empirically.

The OECD's Economics Accounts of Agriculture (EAA) contains aggregate information on farming costs that could help to explore the role of the variability of costs on income variability. A simple analysis of the correlation between gross and net revenues from the EAA for a set of ten OECD countries shows that correlation between these two series is always higher than 90% both in levels and in differences with the exception of Norway (Table Box 1). Such high correlations suggest but, of course do not prove, that results of the analysis on variability might not differ much when using net as compared to gross farm revenue. However, there remains the question of the degree to which variability of net *farm* revenue is correlated with that of net *farm household* income.*

Table Box 1: Correlation between Gross and net Agricultural revenue in the EAA

	Levels	Differences
Australia	0.98	0.96
Canada	0.96	0.90
EU15	0.99	0.98
EUR12	0.99	0.98
Japan	0.96	0.96
Korea	0.97	0.99
New Zealand	1.00	0.99
Norway	0.56	0.83
Switzerland	0.87	0.96
Turkey	0.99	1.00
United States	0.97	0.93

In summary, an appropriate analysis of income variability should be based on net farm household income, but data limitations do not permit this approach at this stage. A better understanding of the relationships among variability of gross revenue, net farm income and net farm household income may ultimately require more comprehensive and in-depth analysis based on micro data.

* An attempt was made to combine the PSE information and the net revenue information from the EAA in order to test whether the reduction in variability was different for gross and net revenue. This was done for the aggregate of all crops and for the whole agricultural sector for the United States. Support was shown to increase gross revenue variability and to have an smaller effect in reducing net revenue variability. The pattern was in general quite different from that shown in Table 1 in the main text. The results produced are explained by the different criteria used for counting market price support and aggregating commodities. The coverage of crops in the EAA is broader than in the PSEs, and market price support is already included in the EAA measurement of revenue.

The series used in the analysis for each commodity and country are the calculated farm revenue from different sources as classified in the PSE database:

- The revenue that farmers would have obtained if they had sold their crop at prevailing world prices (revenue from world prices).
- The revenue that the farmer actually earns from selling the crop at the domestic producer price (revenue from world prices plus revenue from market price support).
- The revenue from world prices plus payments based on output.
- The revenue from world prices plus payments based on area.
- The revenue from world prices plus payments based on historical entitlements.
- The revenue from world price plus payments based on inputs.
- The revenue from world prices plus payments based on input constraints, payments based on overall farm income and miscellaneous payments.
- The total revenue from the market and from government support: revenue from world prices plus total PSE.

All these series were expressed originally in national currency in nominal terms. Measuring variability requires making comparisons across time. Therefore the series were deflated with the corresponding consumer price index. Thus, all the series are expressed in national currency and represent farm revenue in real terms[1].

The methodology consists of calculating an index of variability of each deflated series in the list above and compare the corresponding index of variability with that of the first series in the list (revenue from world prices). The index is conceptually equivalent to Pearson's Coefficient of Variation[2] for a trended (non-constant mean) series and is calculated using the methodology defined in Cuddy and Della Valle (1978). This index will be referred to as "variability" in this paper. Additionally, a test for the significance of the reduction in variability was developed and applied to the series. The results of these comparisons of variability are summarised in Table 1. The numbers in this table represent the increase or decrease in variability induced by each type of support expressed as a per cent of the variability of market revenue at world prices. The technical details of this methodology are described in Annex 1 and Tables 1.1 to 1.3 in that Annex present the detailed results of the analysis. This methodology was first used in Box 2.2 in OECD (2003*b*).

Measuring the risk facing producers is not trivial. In this analysis, deviations from trend (in market receipts or receipts plus support payments) are used as a proxy for the real variability perceived by producers. A more theoretically satisfying approach would be to develop additional models to capture the individual sources of variation—prices, yields, and government payments—and then combine these in a composite measure. To do this would require specification and estimation of econometric models for each of these components, by country and commodity. The alternative chosen has the advantage of simplicity and transparency. However, it is recognized that the method is strictly appropriate only if trend values are a good representation of producer expectations.

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1. In previous versions of this paper, the series were expressed in real US dollar using the methodology defined by Bureau and Butault (OECD, 2000) and by Butault (OECD, 2001). Basically, the series were deflated using both the PPP (Purchasing Power Parity) index and the inflation rate in the United States. The results obtained did not greatly differ from those in Table 1.

2. The Coefficient of Variation is a measure of variability that is independent of the units in the series. It is equal to standard deviation over the mean.

The results of this analysis carried out for each PSE category of support have to be interpreted with caution. For instance, it is plausible that different measures within a single PSE category have very different impacts in reducing variability. This is particularly the case if one of the programmes has an explicit counter-cyclical design and the other is of an explicitly fixed nature. This situation is illustrated in Box 2 for market price support in Canada and payments based on historical entitlements in the United States.

Box 2. Reduction in variability: looking beyond the PSE categories

The results presented in Table 1 do not reflect the fact that different programmes inside the same PSE category may be designed differently. One programme may have an explicit counter-cyclical element while another may be fixed. In this case, the conclusions about the reduction in variability do not apply to the fixed payment programmes.

Payments classified as based on historical entitlements in the United States include two different components. First, the Flexibility Contract Payments or AMTA payments whose amount was fixed in the 1996 Farm Bill and maintained over the years. Second, the Market Loss Assistance (MLA) payments that were paid on an *ad hoc* basis starting in 1998 and with an explicit counter-cyclical dimension. Table Box 2 repeats the measurement of the reduction in variability for these two programmes. As expected, the AMTA payments have a much smaller impact in reducing variability than the MLA payments and neither presents a statistically significant negative covariance with market revenues (see Annex 1 for the description of the test). The reduction in variability is created by the MLA component of the historical entitlement payment and not by the fixed AMTA payments. However, this distinction may just be a technicality for farmers since the MLA payments were designed as an extension of the AMTA payments and paid on the same basis.

Table Box 2. Changes in variability and tests of signifficance. Two examples of different programmes inside a single PSE category

Payments based on Historical Entitlements in US (Coarse Grains)	
AMTA payments	-4%
Market Loss Assistance	-17%
Market price support in Canada (Wheat) with a policy break in 1995 (1)	
CWB pooling deficit	-22%*
Transportation subsidy (CROW)	-9%

* Covariance between market revenues and each type of support is negative with 5% signifficane.

** Reduction of variance induced by the paiement is significative with 5% significance.

(1) Two sub-samples conwere considered for de-trending

Market price support in Canada also had two different components, one of which (the transportation subsidy CROW) was fixed. This subsidy was eliminated in 1995. The other component consisted of payments to cover the occasional deficits of the wheat pooling system run by the Canadian Wheat Board. The last time that a large deficit was financed by the Government was in 1990. This second component had an explicit countercyclical design. Reductions in variability in Table Box 2 are calculated breaking the sample* in 1995. The results show that the CROW subsidy had some impact in reducing variability, but this was much smaller than the financing of the pool deficits and was not statistically significant. There is currently no market price support for wheat in Canada. Therefore, the reduction in variability does not apply to current policies. The simulations for market price support in Canada are carried out in Section 2 with the only purpose of using them as a benchmark for comparison with the risk reducing impacts of other categories of support.

* Two sub-samples were considered with a breaking point in 1995. This methodology allows the policy break to be captured.

Most of the numbers in Table 1 are negative, meaning that for almost all countries/crops considered, almost all PSE categories of support reduce the variability of farm revenues[3]. Similar results were found in OECD (2003*b*) where the same methodology was applied to eleven OECD countries and ten PSE commodities. The covariance between market revenues and total support is significantly negative at 5% significance in three of the countries in Table 1. In some cases the reduction in the variance induced by different support measures is also statistically significant (see Annex 1 for a description of this test). However, for single PSE categories the reduction in variability and the degree of significance are smaller. There are two possible complementary explanations for this result: *1)* in general more support (across several PSE categories) allows for more reduction in variability; and *2)* there maybe some reduction in variability implemented across different PSE categories.

Results in Table 1 show that in most countries and for most commodities the total reduction in revenue variability is explained mainly by market price support. This is the category of support used most commonly used by governments to smooth the variability of domestic prices as compared to world prices in the period 1986-2001. This is the case for Canada (but only in the first half of the sample period), the European Union, Japan, México and Switzerland. The reduction in revenue variability from market price support is a measure of the lack of price transmission between world markets and domestic markets. This lack of transmission is potentially due to some explicit border mechanisms reducing price transmission - like the European Union’s variable export levies or subsidies in most of the sample years- or to tariff rate quotas for which the out-of quota tariff is not binding, or just prohibitive tariffs. Other factors such as exchange rate s and natural barriers may also play a role in price transmission.

Table 1. Percentage change in crop revenue variability by PSE Category (compared to variability from world prices) 1986-2001

Country	Canada	European Union	Japan	Mexico	Switzerland	United States
Commodity	Wheat	Wheat	Rice	Coarse Grains	Wheat	Coarse Grains
Market price support	-28%*	-60%**	-40%	-41%*	-30%	-2%
Payments based on output	-6%	0%	-20%	-2%	0%	-25%**
Payments based on Area	-17%	-8%	0%	0%	5%	-27%*
Payments based on Hist. Entitlements	20% (1)	0%	0%	5%	-18%	-20%**
Payments based on input use	-4%	-4%	-17%	-5%	-8%	-2%
Other payments	-4%	-5%	-6%	0%	-16%	0%
Total Revenues	-27%	-71%**	-46%	-45%*	-40%	-37%*

* Covariance between market revenues and each type of support is negative with 5% significance.

** Reduction of variance induced by the paiement is significative with 5% significance.

(1) This incrrease is due to a one-off compensation for the removal of transportation subsidy in 1995 and 1996

Other categories of support have much smaller impacts in reducing variability for all countries in Table 1 except for the **United States.** This country has not used market price support as its main instrument for farm revenue stabilisation in the crops sector. Payments based on output, area payments and payments based on historical entitlements have all played a role in reducing farm revenue variability. This is easy to explain for these three categories of support. The deficiency payment mechanism under “payments based on output” is explicitly a mechanism to truncate the lower part of the distribution of producer receipts per unit. Most emergency payments in the United States are classified under “payments

3. The only big positive numbers in Table 1 are due to high one-off payments in a single year like the compensation for the transport subsidy for wheat in Canada in 1995/96 classified as payments based on historical entitlements. In other cases, reforms creating big increases in a PSE category may also generate an *ad hoc* increase in the index of variability (for instance the movement towards area payments in Switzerland).

based on area" and, therefore, the support delivered by this mechanism is negatively correlated with farm revenue. Finally, the Production Flexibility Contract (PFC) payments based on historical entitlements have been supplemented since 1998 with the so-called market loss payments in years of low revenue.

Section 2. Measuring the production impacts of PSE measures when including risk related effects

A statistical indicator that uses the information in the PSE database is developed in Section 1 to measure risk reductions. The results show how different PSE categories affect the variability of farm revenue in each crop and country. There is statistical evidence in the period 1986-2001 confirming that different categories of support not only increased the average revenue, but also reduced the variability of this revenue. The next questions to be posed are the following:

- Do farmers take this information about reduction in revenue variability into account in their farming decisions?
- If so, how do they process this information and include it in their decision making?

This information about revenue variability in the past, at a detailed and individual level, is available to farmers for free: farmers know better than any other economic agents whether payments tend to be higher when market receipts are low. It seems reasonable therefore to assume that farmers will use this information when making production decisions. The answer to the second question requires more sophisticated assumptions. Farmers are not certain about how much they will receive in each form of support each year. Therefore, they need to form expectations about the amount of the payment, its variability and its correlation with market receipts. In some cases there is a publicly known payment implementation rule that determines the amount of the payment and farmers can directly use this information to estimate the expected level of support and the implied reduction in income variability[4]. However, in many other cases the amount of support is subject to *ad hoc* decision procedures and farmers need to infer the expected level and the associated reduction in variability. The work presented in this paper makes the simplest possible assumption applicable to all support categories: farmers form their expectations by looking at what has happened in the past in terms of support levels and revenue variability and extrapolating this information into the immediate future. Furthermore, given that the aggregate information available to us is only about support levels and average revenue variability, the assumption is made that this kind of aggregate information, as presented in Table 1, is what farmers use and process in their decision making.

Annex 2 explains how the PEM crop model has been adapted to include different assumptions about farmers' risk aversion (Box 1) and to take into account the information about revenue variability that has been analysed in Section 1. The links between agricultural policies, uncertainty and production developed here are inspired by Sandmo (1971) and Hennessy (1998) as explained in OECD (2001*c*). This approach does not account for the fact that countercyclical government support is not the only risk management strategy available. Other possibilities includes financial management, diversification of income sources, production techniques, marketing techniques, insurance markets and safety nets. These instruments are potentially more efficient in dealing with farming risk (OECD, 2000*b*). "Of course, if contingent markets are sufficiently rich, and if they are easy and cheap to use, then separability … will eliminate insurance and wealth effects" of agricultural support (Hennessy, 1998). If access to these markets is difficult or expensive, there will be scope for risk related effects.

4. For instance the rules applied to Loan programmes in the United States.

Box 3. Glossary of risk related terms
(based on OECD 2001*c*)

Risk aversion is a characteristic of individual preferences when decisions are taken in an environment with some uncertainty. An individual is risk averse if he prefers a sure income rather than a lottery with the same expected value. He is risk neutral if he is indifferent between the two (zero risk aversion). Absolute risk aversion is usually assumed to decrease with income (DARA assumption), meaning that if the individual becomes richer he will be more willing to take risks. Sometimes it is assumed that absolute risk aversion does not depend of income, that is, it is constant (CARA assumption). In this study we assume farmer's preferences can be represented as decreasing absolute risk aversion (DARA) preferences. However, in order to measure the dimension of risk-related impacts, the same simulations are made under the assumption of risk neutrality and risk aversion in either the form of CARA or DARA preferences.

All the results in this section are based on the idea that farmers dislike risk as measured by revenue variability. Under this assumption of risk aversion, farmers may be ready to accept lower profits if by doing so revenue becomes more stable or secure. Therefore, the uncertainty environment in which decisions are taken will affect production decisions.

In general, agricultural support induces farmers to increase production. The total change (*total effect*) in production induced by a single measure can be divided into at least three kinds of effects. The *price effect* measures the production change caused because that measure modifies the effective incentive price of the inputs or outputs. The *insurance effect* is the change in production caused by the reduction in the farm income variability that is attributable to the support measure. The insurance effect is zero if farmers are risk neutral. Finally the *wealth effect* is the change in production caused by the additional wealth created by the support measure, which may make the farmer less risk averse than otherwise.* The wealth effect would be zero if there is constant absolute risk aversion.

* This is only a risk-related wealth effect. Wealth effects can also arise due to other reasons such as constraints in capital markets (see OECD, 2001c).

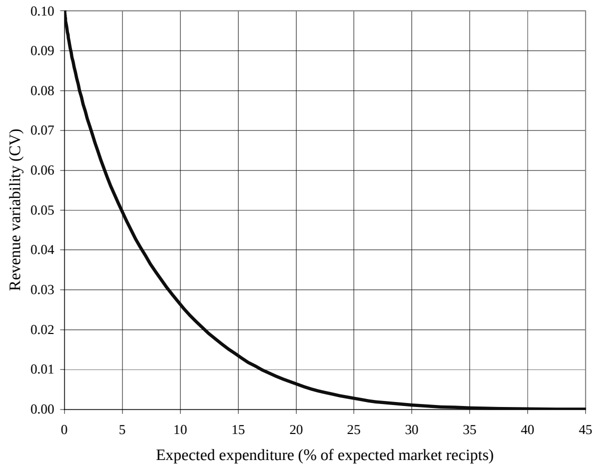
The basic idea in this analysis is to add an appropriate set of risk premia that are affected by support measures and farmers' decisions. The model needs two additional parameters: the ratio between farming receipts (or revenue) and farm household income that is obtained from the OECD structural database, and the relative risk aversion coefficient which is assumed at a base value of 2. This latter assumption lies within the range of estimates reported in the empirical literature (Annex 2). However, it is chosen for illustrative purposes , and in order to have a basis for sensitivity analysis. It is not claimed that this value of 2 is a good approximation of risk attitudes for all the commodities and countries considered in the analysis. Future research in this area could usefully concentrate on developing credible empirical estimates of risk attitudes. The purpose of this section is to estimate the production impacts of different categories of support in different countries when including risk related effects. The objective is to calculate the relative importance of price, insurance and wealth effects, and the degree of decoupling of different PSE categories when the risk dimension of support is incorporated.

For each PSE category, commodity and country there is an estimate of the impact of the measure in increasing the average revenue of farmers and reducing its variability for the period 1986-2001. The analysis estimates impacts of the main PSE categories for the main crop of each country (wheat in Canada, the European Union and Switzerland, coarse grains in Mexico and the United States and rice in Japan). In each case, we simulate a change in each PSE category that includes both an expected additional payment (or support) and an expected reduction in the variability of revenue. The simulations carried out create shocks that have two components: an increase in the amount of this type of support by a quantity equal to 10% of the mean support under this PSE category in 1986/2001; and a reduction in revenue variability equal to 10% of the impact of this type of support on the index of variability in 1986/2001. The shocks are defined as one tenth of the observed policy actions to avoid big shocks that are outside the appropriate range of the model.

There is an assumption of proportionality between expenditure and reduction in variability that is implicit in the design of the policy shocks. This proportionality is very unlikely to occur in reality. For instance, some agricultural programs have an explicit triggering mechanism which reduces the variability of the distribution of revenue by truncating the lower tail of the distribution. For these kinds of programs it can be shown that the first dollars spent have a much larger impact on revenue variability. The decreasing marginal impact of support expenditure on revenue variability is illustrated with an example in Figure 1 using the methodology developed by Chavas and Holt (1990). This decreasing marginal insurance effect would reinforce the decreasing marginal price effects that were discussed in OECD (2001*b*). However, in our simulation analysis we use stylised policies whose mechanism for reducing revenue variability is not explicitly modelled and we make a proportional change of both the mean and the coefficient of variation of revenue.

Figure 1. Expenditure and reduction of uncertainty under "truncating" programmes

An example using Chavas and Holt methodology assuming a normal distribution with CV=0.1



For each policy and country/commodity a set of nine different simulations was carried out. Simulations were made only for PSE categories having a relatively large impact in reducing revenue variability[5] as shown in Table 1. Each simulation imposes different assumptions about risk aversion and different combinations of shocks to the mean and to the variability of farm revenue. The results of these different simulations allow the insurance, wealth and price effects of policies to be isolated as explained in more detail in Annex 3. The price effect is estimated by simulating an increase in the amount of support with no change in variability under risk neutrality assumptions. The insurance effect is estimated by simulating a reduction in the variability of revenue with no change in the level of support under constant risk aversion (CARA) preferences. The total effect is estimated by simulating both the increase in the level of support and the reduction in variability under decreasing absolute risk aversion (DARA) preferences. Finally the wealth effect is estimated by simulated an exogenous change in income (a lump sum payment) equal to the estimated change in farm income due to that support measure. This simulation is also made under a DARA assumption. An extensive set of tables with some of the results of these simulations can be

5. Given the magnitude of the reductions in variability shown in Table 1, a double criterion was used to select the support categories: the statistical test of negative covariance being significant at 5% or a reduction in variability of at least 15%. Market price support was simulated in all cases to be used as the benchmark.

found in Annex 4. These results[6] are summarised in Tables 2A and 2B in the form of three types of indicators:

- ***Total Production ratios (TPR)***. Those ratios measure the degree of "coupling" with respect to production. The "Degree of Decoupling" (DD) can be calculated from them (OECD, 2001c): DD = (1-TPR). It is defined as the ratio of the impact on production per dollar of support in a given PSE category, to the impact per dollar of market price support given in the form of a single non-prohibitive tariff. This kind of market price support should allow for complete price transmission since it does not modify the variability of revenue measured by the coefficient of variation. Therefore, market price support with perfect price transmission is used as the reference for comparison and referred to as reference MPS* in this paper.[7] This method permits production ratios for market price support to be calculated. The production ratios for market price support can vary depending on the instruments used to support the domestic prices and they will be equal to one under risk neutrality (no risk related effect). Total production ratios are calculated under three different assumptions of risk behaviour as explained in Box 1: risk neutrality, CARA and DARA. This gives, respectively, the production ratio when only price effects are considered, when both price and insurance effects are included and when wealth effects are added to price and insurance effects.

- ***Production Ratios by type of effect***. These ratios compare the relative production impact due to each kind of effect for a given PSE category as compared to market price support. That is, we measure the production impact per dollar through insurance effects of a given PSE category, and then calculate the ratio of that impact to the impact through insurance effects of market price support. Production ratios are then calculated for the price effects, the insurance effects and the wealth effects.

- ***Shares of price, insurance and wealth effects in total production impacts***. For a given PSE category the total production impact is disaggregated into the three effects being measured: price, insurance and wealth effects. These shares can differ from one PSE category to another and from one country to another. If a measure is applied in a way that directly reduces revenue variability, insurance effects will have a larger share in total impacts. If a measure is very efficient in transferring income to farmers, it will have a larger share of wealth effects[8].

The total production ratio for **market price support** in the European Union is 1.12 when all three effects are considered (price, insurance and wealth effects under DARA). This means that due to the way price support was provided, producer price variability was reduced and production was 12% higher than if no such effects had existed. The share of price effects is 82%, compared to 17% for insurance effects and 1% for wealth effects. Total production ratios of price support are higher in Canada (1.62) and the United States (1.29) and lower in other countries (1.15 in Mexico, 1.15 in Japan and 1.19 in Switzerland).The large figure in Canada can be explained by the strong counter-cyclical nature of the one of the programmes under market price support (the payments to cover the deficit of the price pooling system in the first half of the sample period): lower price support is provided but it is more targeted to reduce revenue variability. However, this result for Canada does not apply to current policies as explained in Box 2. Wealth effects of market price support tend to be very small due to the low transfer efficiency of this kind of support (OECD

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6. Results in Annex 4 are presented together with some sensitivity analysis for different values of the main risk related parameters. The values presented in Tables 2A and 2B correspond to results calculated for the base values for the risk-related parameters.

7. The market price support impacts used as reference MPS* do not include insurance and wealth effects.

8. See OECD (2001*d*) for an analysis of transfer efficiency of different PSE measures.

2003). They are more important in Canada because transfer efficiency is higher, which, in turn, is due to the lower initial level of support.

Table 2A. Production ratios and isolated insurance and wealth effects, 2001

	Market Price Support	Payments based on Output	Payments based on Area	Payments based on Historical Entitelments
CANADA (Wheat)				
Total Production Ratios				
Under no Risk Aversion	1.00	n.c.	0.46	n.c.
Under CARA	1.51	n.c.	0.81	n.c.
Under DARA	1.62	n.c.	0.95	n.c.
Production Ratios by type of effect				
Price	1.00	n.c.	0.46	n.c.
Insurance	1.00	n.c.	0.71	n.c.
Wealth	1.00	n.c.	1.02	n.c.
Share in total production impacts				
Price effect	0.56	n.c.	0.42	n.c.
Insurance effect	0.29	n.c.	0.33	n.c.
Wealth effect	0.15	n.c.	0.25	n.c.
THE EUROPEAN UNION (Wheat)				
Total Production Ratios				
Under no Risk Aversion	1.00	n.c.	0.20	n.c.
Under CARA	1.12	n.c.	0.25	n.c.
Under DARA	1.12	n.c.	0.26	n.c.
Production Ratios by type of effect				
Price	1.00	n.c.	0.20	n.c.
Insurance	1.00	n.c.	0.22	n.c.
Wealth	1.00	n.c.	1.73	n.c.
Share in total production impacts				
Price effect	0.82	n.c.	0.77	n.c.
Insurance effect	0.17	n.c.	0.17	n.c.
Wealth effect	0.01	n.c.	0.06	n.c.
JAPAN (Rice)				
Total Production Ratios				
Under no Risk Aversion	1.00	1.50	n.c.	n.c.
Under CARA	1.15	3.52	n.c.	n.c.
Under DARA	1.15	3.53	n.c.	n.c.
Production Ratios by type of effect				
Price	1.00	1.50	n.c.	n.c.
Insurance	1.00	9.26	n.c.	n.c.
Wealth	1.00	n.c.	n.c.	n.c.
Share in total production impacts				
Price effect	0.81	0.42	n.c.	n.c.
Insurance effect	0.18	0.58	n.c.	n.c.
Wealth effect	0.00	0.00	n.c.	n.c.

The total production ratio for **payments based on output** is more sensitive to the insurance effects, increasing from 1.13 under risk neutrality to 1.62 under DARA in the United States. This means that payments based on output have an impact on production that is 62% higher than the reference MPS*. The corresponding figure is 253% higher in the case of Japan, which shows that when output support is provided in a risk reducing manner, it can have an impact on production that is much larger than the price support used as a reference. The production ratios by type of effect show how output payments have a price effect which is similar to that of MPS in the United States (1.13) and higher in Japan (1.50). But output payments have an insurance effect which is almost twice that for price support in the United States and nine times higher in Japan. The share of insurance effects for output support is 31% in the United States and 58% in Japan. As expected, wealth effects of output payments are not very large.

Table 2B. Production ratios and isolated insurance and wealth effects 2001

	Market Price Support	Payments based on Output	Payments based on Area	Payments based on Historical Entitelments
MEXICO (Coarse grains)				
Total Production Ratios				
Under no Risk Aversion	1.00	n.c.	n.c.	n.c.
Under CARA	1.12	n.c.	n.c.	n.c.
Under DARA	1.15	n.c.	n.c.	n.c.
Production Ratios by type of effect				
Price	1.00	n.c.	n.c.	n.c.
Insurance	1.00	n.c.	n.c.	n.c.
Wealth	1.00	n.c.	n.c.	n.c.
Share in total production impacts				
Price effect	0.84	n.c.	n.c.	n.c.
Insurance effect	0.12	n.c.	n.c.	n.c.
Wealth effect	0.05	n.c.	n.c.	n.c.
SWITZERLAND (Wheat)				
Total Production Ratios				
Under no Risk Aversion	1.00	n.c.	n.c.	0.01
Under CARA	1.03	n.c.	n.c.	0.14
Under DARA	1.09	n.c.	n.c.	0.15
Production Ratios by type of effect				
Price	1.00	n.c.	n.c.	0.01
Insurance	1.00	n.c.	n.c.	3.22
Wealth	1.00	n.c.	n.c.	0.94
Share in total production impacts				
Price effect	0.89	n.c.	n.c.	0.03
Insurance effect	0.04	n.c.	n.c.	0.60
Wealth effect	0.08	n.c.	n.c.	0.37
THE UNITED STATES (Coarse grains)				
Total Production Ratios				
Under no Risk Aversion	1.00	1.13	0.50	0.03
Under CARA	1.29	1.62	0.68	0.29
Under DARA	1.29	1.62	0.70	0.30
Production Ratios by type of effect				
Price	1.00	1.13	0.50	0.03
Insurance	1.00	1.75	0.63	0.88
Wealth	1.00	1.25	2.26	2.60
Share in total production impacts				
Price effect	0.77	0.68	0.70	0.11
Insurance effect	0.22	0.31	0.26	0.79
Wealth effect	0.01	0.01	0.04	0.10

Payments based on area were found to have lower impacts on production than market price support when measuring only relative price effects as in OECD (2001*b*). However, including the risk related effects can reduce the difference between the production impacts of area payments and those of market price support. This is the case in the United States and Canada where the programs classified as area payments have a clear counter-cyclical design. The production ratios of area payments when including risk related effects are 0.70 in the United States and 0.95 in Canada, compared to 0.50 and 0.46 under risk neutrality. Even if the European Union's payments based on area have no counter-cyclical design, the total production ratio slightly increases when risk effects are included. The production ratios by type of effect show that both price and insurance effects on production are larger for market price support than for area payments. However, wealth effects of area payments can be twice as large as for market price support due to their higher transfer efficiency.

One of the most important changes in the estimated total production ratio when including risk effects is found for **payments based on historical entitlements** in the United States and Switzerland. The ratio for price effects increases by a multiple of ten when risk effects are included. However, the ratios remain low at 0.30 and 0.15, respectively. This is mainly due to the high insurance effects which represent 79% of the total production impacts in the case of the United States. The counter-cyclical nature of part of these payments in recent years is at the origin of these results. In the case of the United States this reflects the existence of two different programmes under the category "payments based on historical entitlements". As shown in Box 2, the risk reduction effect is mainly due to the Market Loss Assistance payments and not to the AMTA fixed direct payments. The historical entitlements payments in Switzerland also have a relatively large insurance effect that represents 60% of total production impacts and increases the total production ratio form 0.01 under risk neutrality to 0.15 under DARA.

Section 3. Measuring the impacts on world market price variability

Tables 2A and 2B show how the "risk reducing" nature of most PSE categories is estimated to make an important contribution to the impact on domestic production. More production in the protected country means less production somewhere else. However, there is another dynamic spill-over effect associated with this reduction of farm revenue variability. The risk reduction for domestic producers means that the variability of revenues associated with shocks in the world markets is not transmitted to domestic producers. This lack of transmission makes excess supply in the protecting country more rigid and the required adjustment in world markets larger. That is, reducing revenue variability for domestic producers accentuates the variability of prices in the world market, creates inefficiencies in the production adjustment process and creates more pressure for counter-cyclical policies. This section uses the PEM model to estimate this impact on world price variability.

Table 3 illustrates the impact of partially isolating domestic producers from world price variability. The PEM model is modified to include partial price transmission between world markets and farmers' revenues. Only some fraction of the variation of world prices around its expected value is assumed to be transmitted to farmers. This fraction is calculated[9] using the indicators of reduction in variability developed in Section 1 and quantified in Table 1. The indicator used for the variability of world prices is the Coefficient of Variation of each crop price in the world market using data from the PSE database. The PEM crop model is shocked with stochastic exogenous shifts in the supply of the rest of the world. The quantity shocks in the supply for each crop are assumed to be normally distributed and calibrated in a way that, as a result of the shocks, the simulated coefficients of variation of prices are equal to those observed in the period 1986-2001 when partial price transmission existed. Then one hundred stochastic shocks are applied with different versions of the model. Six different versions are used, with one country at a time allowing complete price transmission. In the final version, complete price transmission is assumed for all six countries. After each set of stochastic shocks, the variability of world prices is measured across these simulations in order to quantify the change in the variability of world prices attributable to partial price transmission in each country.

The results in Table 3 suggest that allowing complete price transmission in the European Union may reduce the variability of world wheat prices from 0.25 to 0.16. Partial price transmission in the United

9. The fraction F applied to each commodity and country is calculated from the per cent reduction in variability (RV) created by market price support (on the demand side) and by all support measures (on the supply side): F = (1-RV)

States may also have relatively large impacts on the price variability of most commodities. The impact of the combined effect of permitting complete price transmission in all the six OECD countries in the PEM crop model could reduce the variability of world wheat prices by 45%, while the corresponding reduction is 32% for coarse grains, 23% for oilseeds and 21% for rice.

Table 3. Does policy increase world price volatility?

	Wheat	**Coarse Grains**	**Oilseeds**	**Rice**
Observed data 1986-2001: CV with partial price transmission in all countries	**0.25**	**0.19**	**0.17**	**0.25**
CV with complete price tranmision only in:				
The European Union	0.16	0.15	0.15	0.23
Switzerland	0.25	0.19	0.17	0.25
Japan	0.25	0.19	0.17	0.25
Canada	0.24	0.18	0.17	0.25
Mexico	0.25	0.18	0.17	0.25
United States	0.21	0.15	0.14	0.21
CV with complete price transmision in the six countries	**0.14**	**0.13**	**0.13**	**0.20**
Reduction in variability when allowing complete price transmission	45%	32%	23%	21%

The imperfect transmission of world market price fluctuations into domestic farm revenues is not only due to policy. The exercise in Table 3 illustrates the order of magnitude of the dynamic effects associated with risk reducing policies. The estimate is based on observed transmission in the period 1986-2001, which could differ from current price transmission due to market conditions or to policies. Therefore results in Table 3 have to be interpreted as merely indicative of the order of magnitudes of these effects. Stabilising domestic farm revenue has some elements of a prisoner's dilemma: revenue variability increases everywhere if each government tries to reduce internal variability unilaterally. Farmers and consumers in countries that do not stabilise farm prices and revenues face larger price variability and, through these negative insurance effects, reduce production.

Section 4. Sensitivity analysis of the production impacts

The results in Section 2 show that, according to the simulations carried out with the PEM crop model, the effects associated with risk can be non-negligible. Table 4 compares these results with other results in the literature for the Loan deficiency payments in the United States. Our estimates of the share of the insurance and wealth effects are the smallest out of the four studies, including the analysis of the 2002 US Farm Bill published in the Monitoring and Evaluation report (OECD, 2003*c*). This can be explained by the choice of the risk related parameters: the coefficient of relative risk aversion of 2 considered in this paper is low compared to what is used in the other studies (Annex 2) and to the specific way in which the risk premiums have been introduced. In OECD (2003*c*) the risk premiums were calculated in an exact manner following the implementation rules of the programme, while in this study a general formulation of the risk premiums has been applied to all PSE categories. This general formulation used here generates relatively smaller risk related impacts. The selected ratio between farming receipts and farm household income may also affect the differences in the results in Table 4.

Table 4. Shares of risk related effects of US deficiency payments according to different studies

	Price Effects	Insurance Effects	Wealth Effects
Hennessy (1998) [1]	21%	66%	14%
Mullen et Al (2001) [1]	26%	65%	9%
OECD (2003) for corn	30%	70%	
This study	66%	33%	1%

[1] Calculated from the results presented in each studies

Results in Section 2 are sensitive to the assumptions about the risk related parameters. Do the results change with these assumptions? In order to answer this question, systematic sensitivity analysis has been carried out for the risk related parameters in the PEM crop model following the methodology developed in Davis *et al.* (1998) and Griffiths *et al.* (2000) and already used in OECD (2001*b*). The two parameters under study are the relative risk aversion coefficient and the ratio between farming receipts and farm household income. The information in the empirical literature and in the OECD databases allows plausible ranges for the main parameters to be determined. These are summarised in Annex 2. Methodological explanations concerning the sensitivity analysis are presented in Annex 4. The sensitivity analysis is carried out in two phases, with most of the analysis concentrated on the risk aversion coefficient. Phase 1 undertakes the sensitivity analysis with respect to the relative risk aversion coefficient, the rest of the parameters being held constant at their base values. Phase 2 also allows the ratio farming receipts/farm household income to be stochastic, the rest of the parameters being held constant. The detailed results of this sensitivity analysis[10] are presented in the tables and figures in Annex 4.

The **sensitivity analysis of the relative risk aversion coefficient** shows that the insurance effects of all policies are very sensitive to the value of this parameter. As shown for the United States in Figure 4.1 of Annex 4, the price effects on production are not affected by the risk aversion parameter. However the insurance effect of market price support varies from zero (since zero risk aversion is the lower bound) to more than half of the price effects when risk aversion is at the highest part of the range (5). The relationship between the risk coefficient and the insurance effect is almost linear as shown in that figure.

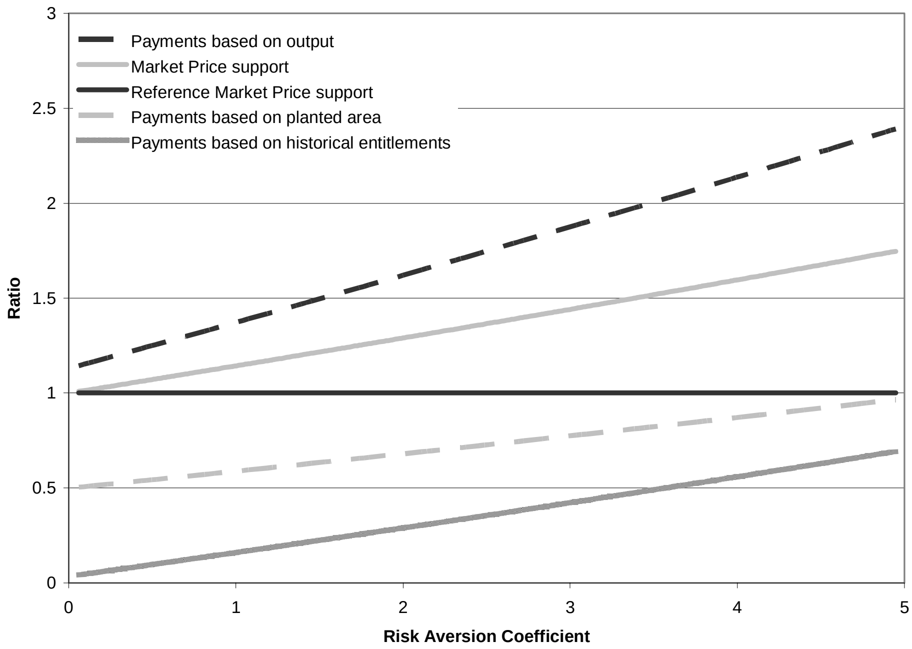
In the range of plausible risk aversion values considered, insurance effects may become larger than price effects for PSE categories that are counter-cyclical (for instance, payments based on output or deficiency payments), or specially in categories that also have lower price impacts (for instance, payments based on historical entitlements). For high levels of risk aversion, all PSE categories considered can have insurance effects that represent more than a third of the total production effects.

Wealth effects are larger the larger the risk coefficient, but they remain very small (below 10% of the total impact even in extreme cases) for the less transfer efficient PSE categories, that is, market price support and payments based on output. However, they may be as large as 42% of the total impact of payments based on historical entitlements in Switzerland because these payments are more transfer efficient.

10. A hundred stochastic parameter values, with six types of simulations for each of up to four PSE measures considered, six countries and the two phases of the sensitivity analysis, generated a total of 15 600 simulations.

How does the risk aversion coefficient affect total production ratios? This is a critical parameter in the model for which there is little empirical evidence. Figure 2 illustrates the sensitivity of total production ratios with respect to the value of the risk aversion parameter. Four PSE categories in the United States are shown as an example. Incorporating risk effects tends to increase the relative production impacts of all types of support. The production effects of payments based on output, area payments and payments based on historical entitlements increase compared to those associated with market price support. Figure 2 shows no line crossing, denoting no change in the ordering of production impacts of PSE categories. However, area payments and payments based on historical entitlements reduce the gap between their production impacts and market price support.

Figure 2. Sensitivity of total production ratios in the United States with respect to risk aversion (coarse grains, 2001)

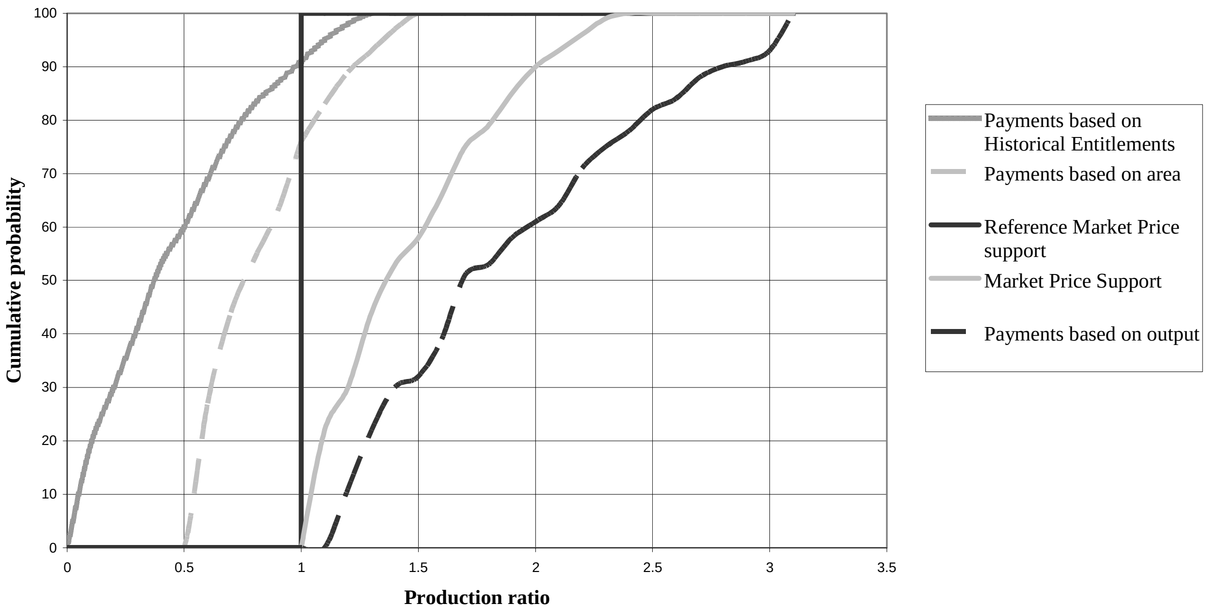


The **sensitivity analysis with respect to both risk-related parameters** (risk aversion coefficient and the ratio farm receipts/farm household income) at the same time provides a wider degree of variability of the production impacts. When a low value of the risk aversion parameter is combined with a low value of the income parameter, the result is smaller insurance and wealth effects. On the contrary, when both parameters have high values, insurance and wealth effects are larger. Therefore, the range of all indicators when both parameters are changed simultaneously as shown in the tables of Annex 4 widens as compared to the sensitivity analysis of risk aversion only.

It is plausible therefore that payments based on area have a total production ratio up to 1.46 in the United States, that is 46% higher than the reference market price support MPS* (Annex Table 4.6B). The highest production ratio for the payments based on historical entitlements is 1.2 in the United States (Annex Table 4.6B). These high ratios are due to the greater importance of insurance and wealth effects and correspond to extreme but plausible cases. However, those effects also operate, to a lesser extent, for market price support. Therefore, the ratio of the production impacts of land based PSE measures compared to price support are smaller when risk effects are considered. But the difference is still non-negligible as shown in Figure 2. Figure 3 represents the cumulative distribution of total production ratios for each PSE category in the United States. The fact that the distribution lines in this figure do not cross each other means that for any hypothetical value of the production ratio, the percentage of stochastic cases having smaller production ratios always follows the same ordering across the four PSE categories[11]: output payments, market price support, area payments and payments based on historical entitlements. These distributions also show that for plausible values of the parameters the production impacts of all categories of support can be higher than the reference market price support MPS*. That is insurance and wealth effects for policy measures may — in some cases — be as large as the relative price effects. The percentage of stochastic cases in which payments based on historical entitlements have an impact on production larger than the reference market price is only 9%.

Figure 3. Cumulative distribution functions of total production ratios under DARA in the United States (Coarse grains, 2001)

Result after 100 simulations for each category with stochastic values for both risk related parameters



Conclusions

Standard statistical methodologies analysing the variability of the PSE time series for the period 1986-2001 show that some PSE categories for most crops and OECD countries reduce the variability of total receipts faced by farmers. This means that most forms of agricultural support are provided in a counter-cyclical manner, due to explicit, implicit or *ad hoc* mechanisms of agricultural policy design. Countries with low levels of support also have very low levels of risk reduction. These results — already obtained in a general analysis for most countries, commodities and PSE categories in OECD (2003*b*) — were confirmed in this study for a group of OECD countries and crops.

The PSE category that is most generally found to reduce risk is market price support, which often reduces the variability of farming revenue by half. If market price support was provided through fixed and non-prohibitive tariffs, one could expect perfect price transmission to occur and no reduction in revenue variability. The fact that sometimes market price support is, or has been, provided through variable measures, tariff rate quotas or prohibitive tariffs, or that it is accompanied by some intervention in the domestic markets, can facilitate the smoothing of farm revenue through price support measures.

11. This comparison is an extrapolation of the concept of first degree stochastic dominance that is usually applied in the theory of choice under uncertainty. See for instance Chapter 3 in Just and Pope (2002) for a definition.

Other PSE measures have also been found to reduce the variability of farming revenue. In some countries payments based on historical entitlements, payments based on area and payments based on output are found to have had a counter-cyclical effect. However, the risk reducing impact of the different PSE categories cannot be generalised across countries. That is, the specific manner in which the payments are decided is crucial for the risk reduction impacts of the different PSE categories. Furthermore, the PSE classification by itself does not allow different risk reduction impacts of different measures within the same PSE category to be distinguished. More information is needed to make a more precise estimation of the risk related effects of specific policy measures. The risk analysis developed in the Analysis of the US 2002 Farm Act in OECD (2003*c*) is an example of progress in that direction.

A new version of the PEM crop model that incorporates risk premiums and the impact of risk reducing policies has been used to measure the production impacts associated with risk reduction. The results of this analysis should be considered as indicative only. The results show that for some OECD countries the risk related effects of PSE measures are potentially important. Using plausible values for the risk related parameters, it is found that the insurance effects associated with market price support represent more than 20% of the total effects in most countries. The share of the insurance effects of counter-cyclical payments based on output may be more than 30% of the total impact on production. Finally, for payments with very small price effects, the insurance effects may dominate the production impacts: for example, 75% of the production impacts of historical entitlements may be due to risk reduction effects.

Wealth effects are found to be small for support categories with low levels of transfer efficiency like market price support and payments based on output. However these wealth effects can become more relevant for more transfer efficient forms of support such as area payments or payments based on historical entitlements. For instance, wealth effects are estimated to represent up to 36% of the total production impacts in some cases. Nevertheless total effects are found to be smaller than those of market price support.

Since most PSE categories of support reduce farming revenue variability, the risk related effects can potentially exist for all types of support. Production impacts of all forms of support are larger when farmers are risk averse than when they are not. However, there seems to be evidence of differences in the relative importance of these effects across categories of support and across countries. The categories of support that are used with clear counter-cyclical design or with large transfer efficiency have much larger relative insurance and wealth effects.

The systematic sensitivity analysis carried out using Montecarlo simulations, further emphasises the fact that the risk related effects of PSE measures could be important. Insurance effects can dominate the total production impacts in some cases under plausible assumptions about the parameter values. Full time and more risk averse farmers have larger insurance and wealth effects than farmers whose main income is from an off-farm source and who are risk neutral. The ordering of the production impacts of different PSE measures found in OECD (2001*b*) is not modified by the incorporation of risk as in the current study . However, the differences in the production impacts between market price support and policy measures based on land can be narrowed when risk effects are included.

Stabilising farm revenue is sometimes presented as an objective of agricultural support measures. This study shows that it is difficult to do this without having effects on production even if less production distorting measures are used. Furthermore, counter-cyclical measures may prevent farmers from using other instruments for risk management and may discourage the development of appropriate markets for those instruments[12]. Finally, counter-cyclical measures that prevent price transmission to domestic markets may accentuate the volatility of world market prices.

12. See OECD 2000*b* “Income Risk Management in Agriculture” for alternative income risk management mechanisms for farmers.

Annex 1.

Measuring the reduction in revenue variability

The main technical problem posed in Section 1 was designing an index of variability that took into account the fact that there is a trend to many of the farm revenue time series. Using a standard deviation or a coefficient of variation to estimate the variability across years in a trended series would lead to an overestimation of such variability. Cuddy and Della Valle (1975) developed a general technique to calculate this variability that has been adopted in this study. Their index of variation (CCV) is expressed as follows:

$$CCV = CV\sqrt{1-\overline{R}^2}$$

CV is the coefficient of variation of the original trended series and $\overline{R}^2$ is the adjusted coefficient of multiple correlation of a log linear estimation of the trend[1]. If the trend is able to predict exactly all the values in the series, then $\overline{R}^2$ will be equal to one and the index of variation CCV will be zero. Some difficulties were found in Mexico due to the fact that their series are distorted by the devaluation of the peso in 1994. Their results must be interpreted with caution.

A test of significance has been constructed to evaluate whether or not the covariance between each support measure and market revenue is significantly negative **(Test 1)** and whether the reduction of variance induced by each type of support is significant **(Test 2)**. The tests are applied on the correlation coefficient between payments and the series of market revenues corrected by the CPI and detrended. They are Pearson's correlation tests which assume normal distributions for all the series (the series of real, world market price revenue, X, and the series of different types of support Y).

The starting point is the expression for the variance:

$$V(X+Y) = V(X) + V(Y) + 2\,\mathrm{cov}(X,Y)$$

- **Test 1:** The covariance between each support measure and market revenue is equal to or greater than zero (H_0^1) versus this covariance is significantly negative (H_1^1)

1. A complete analysis of the estimated trends and the potential need to divide the series into two sub-samples was undertaken. However most of the Chow tests did not provide neat cut-off points, introducing some arbitrariness in the choice of these cuts. In order to gain transparency, it was decided to eliminate them from most of the calculations of the CCV. Breaks were used for the application of the statistical test whenever a given category of support switched over time from zero to positive (or *vice versa*) due to the introduction of a new programme.

The population correlation is equal to:

$$\rho = \frac{\text{cov}(X,Y)}{\sqrt{V(X)V(Y)}}$$

Test 1 is equivalent to test $\boxed{\rho \geq 0 \text{ (} H_0^1\text{) versus } \rho < 0 \text{ (} H_1^1\text{)}}$. It is known that sample variances (denoted with an S compared to population variances denoted with σ) $S^2{}_x = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2$ have Chi-Square distributions:

$$\frac{(N-1)\times S^2{}_x}{\sigma_x{}^2} \sim \chi^2_{N-1}$$

The sample covariance is defined as:

$$S_{XY} = \frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})(y_i - \bar{y})$$

And the Pearson correlation coefficient r in the sample is:

$$r = \frac{S_{XY}}{\sqrt{S_X^2 S_Y^2}}$$

The sample variance of r is known to be equal to:

$$S_r^2 = \frac{1-r^2}{N-2}.$$

where r^2 is the coefficient of determination (the shared variance between variables) and N-2 is the number of degrees of freedom of r. When H_0^1 is true, the sampling distribution of r is normal and so symmetric around 0. Then the following student statistic can be used:

$$t = \frac{r}{S_r} = \frac{r}{\sqrt{1-r^2}}\sqrt{N-2}$$

Under H_0^1, t follows a t distribution with N-2 degrees of freedom. So the independence of variables is rejected when:

$$\frac{r}{\sqrt{1-r^2}}\sqrt{N-2} \leq t_{N-2}(c)$$

Where "c" is the significance level of the test. In the case of the one-sided test applied in this study, H_0^1 is rejected at 5% significance if:

$$\frac{r}{\sqrt{1-r^2}}\sqrt{N-2} \leq -2.1$$

Test 2: The reduction of variance induced by the payments is not significant (H_0^2) versus the reduction of variance is significant (H_1^2)

This test corresponds in fact to testing $\boxed{H_0^2\ V(X+Y) \geq V(X) \text{ versus } H_1^2\ V(X+Y) < V(X)}$.

$$
\begin{aligned}
V(X+Y) < V(X) \quad &\Leftrightarrow V(X) + V(Y) + 2\operatorname{cov}(X,Y) < V(X) \\
&\Leftrightarrow V(Y) < -2\operatorname{cov}(X,Y) \\
&\Leftrightarrow V(Y) < -2\rho\sqrt{V(X)V(Y)} \\
&\Leftrightarrow \sqrt{\frac{V(Y)}{V(X)}} < -2\rho \\
&\Leftrightarrow \rho < -\tfrac{1}{2}\sqrt{\frac{V(Y)}{V(X)}}
\end{aligned}
$$

We define $\rho_{test} = -\tfrac{1}{2}\sqrt{\frac{V(Y)}{V(X)}} \leq 0$.

So, we can in fact test: $\boxed{\rho \geq \rho_{test} \text{ (} H_0^2\text{) versus } \rho < \rho_{test} \text{ (} H_1^2\text{)}}$.

We can only have a reduction in variance (H_1^2 in test 2 true) when the covariance between each support measure and market revenue is significantly negative (and then H_1^1 of test 1 is true). This means that the test of reduction of variance may be interpreted as an extension of the test of negative covariance in the following sense: If H_0^2 is rejected in test 2, then H_0^1 will also be rejected in test 1.

Under H_0^2, the sampling distribution of the Pearson correlation coefficient r is very skewed. This problem is minimised through the use of Fisher's transformation from r to Z. Fisher's transformation is appropriate when the number of observations in the sample N is greater than 10 (which is the case here). The transformed Z is calculated as:

$$Z = \tfrac{1}{2}\ln\left(\frac{1+r}{1-r}\right)$$

The sampling distribution of Z is approximately normal. (NB: The approximation to the normal improves as the absolute value of ρ becomes smaller and as the sample size becomes larger).

The variance of the sampling distribution of Z is $V(Z) = \tfrac{1}{N-3}$.

We define an analogous Fisher's Z transformation for the tested value $Z_{test} = \tfrac{1}{2}\ln\left(\frac{1+\rho_{test}}{1-\rho_{test}}\right)$.

As Fisher transformation is a growing function, we can in fact test

$$\boxed{Z \geq Z_{test} \text{ (} H_0^2\text{) versus } Z < Z_{test} \text{ (} H_1^2\text{)}}$$

To perform it, we use a Z-test statistic which is normally distributed under H_0^2

$$Z_{stat} = \frac{Z - Z_{test}}{\sqrt{V(Z)}} = \frac{Z - Z_{test}}{\sqrt{1/N-3}} \sim N(0,1) \text{ (under Ho).}$$

So the reduction in variance is accepted when:

$$(Z - Z_{test})\sqrt{N-3} \leq N^{-1}(c)$$

Where "c" is the significance level of the test.

In the case of the one-sided test applied in this paper, H_0^2 is rejected at 5% significance if:

$$(Z - Z_{test})\sqrt{N-3} \leq -1.96$$

Tables 1.1 to 1.3 in this annex provide numerical results for PSEs for the period 1986-2001 and the variability of the corresponding farm receipts as measured by the standard deviation and the index of variability CCV. Percentage reductions in variability only are presented in Table 1 in the main text, with the results of the statistical test of significance. In all the tables, six pairs of country / main crop commodity are considered: European Union / wheat, Canada / wheat, Japan / rice, Mexico /coarse grains, Switzerland / wheat and United States / coarse grains.

Given that world prices of crops often fluctuate together, it is known that risk reducing payments provided to one crop may reduce variability of receipts of other crops. This point is especially relevant for payments that do not require production of a specific crop, as is often the case for payments based on historical entitlements. However, this paper does not incorporate these risk-cross effects of policies.

Table 1.1. Average Producers' receipts form the market and from support measures 19876-2001
(mn of real national currency units of 1996)

Country **Commodity**	Canada Wheat	European Union Wheat	Japan Rice	Mexico Coarse Grains	United States Coarse Grains	Switzerland Wheat
Value of production at						
World Prices	3 549	10 456	537	10 432	22 219	153
Market Price Support	477	4 355	2 297	3 619	208	318
Payments on Output	141	20	122	75	1 106	0
Payments on Area	390	3 709	0	6	3 391	30
Payments on Hist. Entitle.	111	19	0	1 274	1 528	17
Payments on Inputs	139	465	100	952	768	14
Other Payments	110	374	72	6	460	22
All support	4 916	19 399	3 127	16 364	29 681	553

Table 1.2. Standard Deviation of Producers' receipts when adding support to world prices (de-trended series)
(mn of real national currency units of 1996)

Country **Commodity**	Canada Wheat	European Union Wheat	Japan Rice	Mexico Coarse Grains	Switzerland Wheat	United States Coarse Grains
Value at World Prices	771	2 089	106	2 846	27	3 350
+ Market Price Support	633	1 172	327	2 247	57	3 305
+ Payments on Output	757	2 093	105	2 812	27	2 646
+ Payments on Area	712	2 592	106	2 851	34	2 823
+ Payments on Hist. Entitle.	951	2 083	106	3 356	24	2 866
+ Payments on Inputs	769	2 087	105	2 945	27	3 398
+ Other Payments	766	2 059	113	2 844	26	3 428
+ All support	779	1 108	327	2 466	58	2 814

Table 1.3. Coefficient of Variation *Cuddy-Delavalle* of Producers' receipts when adding support to world prices
(mn of real national currency units of 1996)

Country **Commodity**	Canada Wheat	European Union Wheat	Japan Rice	Mexico Coarse Grains	Switzerland Wheat	United States Coarse Grains
Value at World Prices	0.22	0.21	0.20	0.28	0.18	0.16
+ Market Price Support	0.16	0.08	0.12	0.17	0.13	0.15
+ Payments on Output	0.21	0.21	0.16	0.28	0.18	0.12
+ Payments on Area	0.19	0.19	0.20	0.28	0.19	0.11
+ Payments on Hist. Entitle.	0.27	0.21	0.20	0.30	0.15	0.12
+ Payments on Inputs	0.22	0.20	0.17	0.27	0.17	0.15
+ Other Payments	0.22	0.20	0.19	0.28	0.15	0.16
+ All support	0.16	0.06	0.11	0.16	0.11	0.10

Annex 2.

Including risk in the PEM modelling framework

This annex explains the technical details and the empirical information used to calibrate the PEM model to measure risk-related effects. It is divided into three parts. First, appropriate analytical expressions are found to calculate risk premiums in the PEM model. Second, information about how to estimate exogenous off-farm income is presented. Finally, the literature on farmers' risk aversion is briefly revisited. The last two parts provide the basis for the base values and ranges for the parameters needed in the calibration of the model and the sensitivity analysis of the results.

Calculating risk premiums

Let us assume a production function for the representative producer of each commodity that is independent. The inter-linkage between commodities occurs in the input markets where scarce inputs have to be allocated among commodities as in the PEM model (OECD, 2001b). We define total income of the representative farmer (farm household income) of a given commodity as a random variable with the following form:

$$\tilde{Y} = \tilde{R} - TC(\overline{Q}) + \tilde{B} + O \qquad [1]$$

with:

$$\begin{array}{ll} \tilde{R} = \tilde{P} * \tilde{Q} & \text{Market receipts, assuming } E[\tilde{R}] = \overline{P} * \overline{Q} \text{ or } \mathrm{Cov}(\tilde{P}, \tilde{Q}) = 0 \\ CT(\overline{Q}) & \text{Cost function} \\ \tilde{B} & \text{Budgetary payments received by the farmer} \\ O & \text{Off-farm income of all kinds} \end{array} \qquad [2]$$

The main implicit assumptions in this modelling framework are the following:

- The costs of the inputs and the production process are not sources of uncertainty[1].
- Off- farm income is not a source of uncertainty. It is an exogenous variable in the model. This rules out the possibility of interaction between off-farm income and production at the farm level.
- Each commodity is analysed independently, which does not allow the diversification of production as a risk management tool to be captured.

A risk averse farmer is assumed to maximised the "certainty equivalent" of that income. Using the mean-variance approach to expected utility[2] (see chapter 6 in Newbery and Stiglitz 1981, Coyle 1992 and

1. This assumption avoids congruence problems in supply and demand determined from duality as shown in Pope and Just (2002).

1999, Mullen 2001and Mullen *et al*. 2001*a* and 2001*b*) we can calculate a “certainty equivalent” income as:

$$\hat{Y} = E\left[\tilde{Y}\right] - \frac{1}{2}\alpha * V[\tilde{Y}] \quad \text{With constant absolute risk aversion } \alpha \text{ under CARA assumptions}$$
$$\hat{Y} = E\left[\tilde{Y}\right] - \frac{1}{2}\frac{\rho}{\overline{\overline{Y}}} * V[\tilde{Y}] \quad \text{With constant relative risk aversion } \rho \text{ under DARA assumptions} \qquad [3]$$

Each type of support will affect the expected income in a different way. We assume that each PSE category affects different incentive prices in the input or output markets as established in the framework of the PEM model. That is, market price support and payments based on output directly increased the producer expected price, area payments create a gap between the supply and demand price of land, and input payments create a price gap (see OECD 2001*b* for more details). For convenience, to illustrate the risk premiums, we assume here that $\partial E\left[\tilde{Y}\right] / \partial\overline{Q} = \overline{P} - C'$, that is the marginal increase in expected income is equal to the difference between the expected incentive price and the marginal cost. However, in the PEM model that is applied for all simulations in this paper, policy shocks directly affect this derivative.

The first order condition of maximising [3] takes the following form:

$$\overline{P} * [1 - \theta] = C'$$

Where θ is the risk premium with the following form :

$$\theta = \frac{\alpha}{2 * \overline{P}} \frac{\partial V\left[\tilde{Y}\right]}{\partial \overline{Q}} \quad \text{Under CARA assumptions}$$
$$\theta = \frac{\partial V\left[\tilde{Y}\right] / \partial \overline{Q}}{\overline{P} * E\left[\tilde{Y}\right] * \left[\frac{2}{\rho} + CV\left[\tilde{Y}\right]^2\right]} \quad \text{Under DARA assumptions} \qquad [4]$$

In the present study specific implementation criteria for each type of support are not used. Therefore, an assumption is made about $\frac{\partial V\left[\tilde{Y}\right]}{\partial \overline{Q}}$. To make the problem tractable it is assumed that farmers are not able to change the coefficient of variation (CV) of farming revenue. This assumption follows the underlying hypothesis that the coefficient of variation of farming revenue represents the risk related policy variable followed by governments[3]. Governments are assumed to be able to generate exogenous shocks to this CV.

---

2. This approach can be derived from a Taylor series quadratic approximation of the true expected utility function as shown in Chapter 6 of Newbery and Stiglitz, 1981. Note that under Decreasing Absolute Risk aversion (DARA) the assumption of constant relative risk aversion is made.

3. Other alternative assumptions could be made. In the case on the Analysis of the FSRI Act in the United States in OECD (2003c), the implementation criteria of the loan rate programmes and the countercyclical programmes allowed the corresponding derivatives to be constructed without further assumptions.

$$V[\tilde{Y}] = [\bar{R}+\bar{B}]^2 * \left(CV[\tilde{R}+\tilde{B}]\right)^2$$
$$\frac{\partial V[\tilde{Y}]}{\partial \bar{Q}} = 2 * E[\tilde{R}+\tilde{B}] * \bar{P} * \left(CV[\tilde{R}+\tilde{B}]\right)^2 \qquad [5]$$

Substituting [5] into [4] gives the following expressions for the risk premiums[4]:

$$\theta = \alpha\left(\bar{R}+\bar{B}\right) * CV\left[\tilde{R}+\tilde{B}\right]^2 \qquad \text{under CARA}$$
$$\theta = \frac{1}{\frac{1}{2} * \frac{\bar{R}+\bar{B}}{\bar{Y}} + \frac{1}{\frac{\bar{R}+\bar{B}}{\bar{Y}} * \rho * CV\left[\tilde{R}+\tilde{B}\right]^2}} \qquad \text{under DARA}$$

Therefore, under the assumptions stated above, the PEM model can be recalibrated including these endogenous risk premiums in the corresponding supply equations. For that purpose, the following additional information is required:

- Total farming receipts, their coefficient of variation and an estimate of α in the case of CARA.
- Total farming receipts, their coefficient of variation, total farm household income and an estimate of ρ in the case of DARA.

The total farming receipts $\left(\bar{R}+\bar{B}\right)$ for each commodity and country is available in the PSE database and the corresponding coefficient of variation CV has been calculated in Section 1 of the main text. When simulating a policy change we will assume that both farming receipts and the coefficient of variation can be exogenously affected by support measures.

Equation [5] represents the main assumption on the linkage between policy and risk premiums. It is a mere approximation of reality but which fits well with the PEM modelling framework, the data available and the variability analysis in Section 1 of this study. In the work that the OECD has carried out on analysing the 2002 US Farm Act, a similar methodology was developed, but an exact formula for the derivative of the variance with respect to Q was obtained (see Annex 5 in OECD (2003b) and Anton and LeMouel (2003)). This was possible because both Loan Deficiency payments and Counter-Cyclical payments have well defined rules stating their exact impact on the variability of farming revenue. In that study it was obtained that counter-cyclical payments have about two-thirds of the risk impact on production that loan deficiency payments have for the same level of loan rate and target price. This proves that the risk related impact of different policy instruments can differ depending on the implementation. However, these risk reduction impacts of policy measures are often due to *ad hoc* decisions that are not represented in the implementation rules of the programmes. The methodology developed in this study allows one to make a rough estimate on the magnitude of these impacts.

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4. Be aware that we express the risk premiums in terms of the coefficient of variation of farm revenue that is related with the coefficient of variation of income in [4] by the following expression:

$$CV[\tilde{Y}] = \frac{[\bar{R}+\bar{B}]}{E[\tilde{Y}]} * CV[\tilde{R}+\tilde{B}]$$

Estimating farm household income

In order to **estimate total farm household income** the information in the PSE database is not enough. Some information about costs and off-farm income is also required. This information is taken from the OECD structural database. Table 2.1 is built up from information in OECD (1999). The information needed is the ratio Gross output / Total income, which is equivalent to our ratio between farming receipts and farmers' household income $\frac{\overline{R}+\overline{B}}{\overline{Y}}$. The information available is not sufficiently detailed. Not all the countries in the PEM model have information in the structural database;, and in all cases we have an estimation for one year and all farms[5], but not for each of the years in our 1986-2001 sample nor for the different specialised crop farms. For the US, Canada, Switzerland and Japan the all farms average in Table 2.1 is used. Since we have no estimation for Mexico, the estimate for the United States is used. In the European Union, the figure for Denmark is used.

Table 2. Table 2.1. Distribution of income components by quartiles based on gross sales, in selected OECD countries (average per farm represented)

(Average per farm represented)

	Australia	Canada	Denmark	Japan	Netherlands	Switzerland	United States
Year	1999/2000	1998	1996/97	1994	1999	1995	2000
Unit	'000 AUD	'000 CAD	'000 DKK	'000 JPY	'000 NLG	'000 CHF	'000 USD
All farms							
A-Gross farm receipts	226	122	819	4,025	491	200	77
B-Total income of farm households	73	51	527	7,094	82	67	62
Ratio A/B	3.10	2.41	1.55	0.57	5.96	2.99	1.24
First quartile (25% smallest farms, based on gross sales)							
A-Gross farm receipts	49	27	68	566	119	115	3
B-Total income of farm households	29	51	328	6,321	46	52	61
Ratio A/B	1.69	0.53	0.21	0.09	2.55	2.20	0.05
Fourth quartile (25% largest farms, based on gross sales)							
A-Gross farm receipts	549	306	2,339	11,283	1,130	314	277
B-Total income of farm households	149	56	990	8,147	138	83	71
Ratio A/B	3.69	5.44	2.36	1.38	8.18	3.78	3.90
Crop farms							
A-Gross receipts from crops (1)	301	74	n.c.	n.c.	279	n.c.	101
B-Gross farm receipts	403	105	n.c.	n.c.	327	n.c.	134
C-Total income of farm households	118	54	n.c.	n.c.	56.26	n.c.	58.44
Ratio A/C	2.56	1.38	n.c.	n.c.	4.96	n.c.	1.72
Ratio B/C	3.42	1.96	n.c.	n.c.	5.82	n.c.	2.29

n.c.: not calculated.

1. Without program payments in Canada and the US.

The ratio varies substantially depending on farm size. The smallest farms (those in the first quartile) have a lower ratio indicating high levels of off-farm income. On the other hand, big farms in the fourth quartile have a larger ratio indicating that most of the income comes from farming. The estimated wealth

5. In the OECD (1999) publication only the rates for all farms are available. The structural database already includes calculated ratios for crop farms, which would be more appropriate for the PEM crops modelling framework. However, there is not a consistent calculation for different quartiles.

and insurance effects will be larger when off-farm income is small. Information about the ratios in the first and last quartiles is used to build the parameter ranges when doing sensitivity analysis in Section 3. The ratios farming receipts/farm household income is used in the model to estimate off-farm income which, thereafter, is assumed to be exogenous to the model.

Estimating farmer's risk aversion

The available **information about the risk aversion coefficients** is even more scarce and depends on empirical work. Moreover, many empirical studies make estimates of the risk aversion coeficicients whose relationship with the absolute risk aversion coefficient α depends on the functional forms used in each study. The relationship with the relative risk aversion coefficient ρ additionally requires information about farm household income, which very often is not available. The empirical evidence required refers to this ρ coefficient which has the advantage of being non-dependent on the specific units used to measure prices, quantities and income. Therefore, it is comparable across studies.

Young (1979) categorises the methods of measurement of risk aversion into three groups: direct elicitation of utility functions (DEU), experimental methods (EM) and observed economic behaviour (OEB). The DEU process consists of interviewing farmers to determine their preferences among risky alternatives for hypothetical gains and losses. The EM process consists of observing farmers' preferences in choosing among real risky prospects offered to farmers in an experimental setting, where monetary payoffs are made after the farmers make their decisions. The OEB method consists of econometrically estimating risk attitude parameters reflected in observed farming decisions, such as choices on input levels and crop acreage mix. Only the OEB method is based on revealed behaviour of farmers facing real farming decisions. Some estimations based on OEB are made by calibrating analytical models (CAL) to a few observational data, without using formal statistical econometric procedures.

Table 2.3. includes a list of studies dealing with the measurement of farmers' risk aversion. A majority of the studies use data sets from the United States, but there are also studies on Norway and Israel. Most recent studies use the OEB methodology as it has the advantage of measuring from observed relevant decisions rather than from *ad hoc* decision problems producers are confronted with. Although some studies estimate that some individual farmers in their sample are risk lovers, all studies find that most of the farmers are not risk lovers. Furthermore, all estimations across a sample or an aggregate data set conclude a risk averse behaviour. Most of the studies find that absolute risk aversion decreases with wealth (DARA). However, many studies do not estimate a coefficient of relative risk aversion.

Table 2.2. Selection of empirical estimates of farmers' Arrow-Pratt coefficient of relative risk aversion

	Min	Max	Mean
Econometric estimates			
Brink and McCarl, 1978	0.0	2.0	1.0
Chavas and Holt, 1990	1.4	7.6	4.5
Lence, 2000	1.1	1.1	1.1
Lien, 2002	0.1	10.8	2.2
Love and Buccola, 1991	2.4	18.8	10.6
Saha, Shumway, and Talpaz, 1994	3.8	5.4	4.6
Mean	1.5	7.6	4.0
Mean (eliminating the extrems)	1.2	6.4	3.1
Calibrations			
Hennessy, 1998			4.7
Mullen, 2001			2.1

The estimated values of the relative risk aversion coefficient vary significantly across studies, with values ranging from zero to 19. There are very few studies that have specific estimates of the Arrow-Pratt coefficient of relative risk aversion for OECD farmers and we have found only six published econometric studies. These are summarised in Table 2.2. Given the variability of the results in Table 2.2, it is difficult to decide the appropriate value for this parameter. Any methodology to choose a range of values is arbitrary. Most of the studies present a range between a minimum and a maximum. A procedure similar to that described by K. Salhofer in Annex 3 of OECD (2001) is followed here. In order to avoid extreme values or outliers, the lowest and largest values are eliminated and an average is calculated for the remaining values as shown in Table 2.2. This would give a mean of 3.1 and a range of [1.2, 6.4]. It was decided to move the range to [0,5] and fix a base value of 2 in order to reduce the probability of over-estimating risk-related effects. These are the base values of the relative risk aversion coefficient and the range used in baseline estimations and sensitivity analysis in this paper. Saha *et al.* (1994) estimate a larger risk aversion coefficient for larger farms. However, the estimates are not significantly different from each other at 95%. The same results are found in Sckokai (2003).

Table 2.3. Risk Attitudes of Farmers: Results of Empirical Studies

Journal	Source	Description of producers	Measurement method[1]	Dates of data	Sample Size	Risk Attitudes	Effect of Wealth	Risk Aversion
JARE	Bard and Barry, 2001	Illinois farmers	DEU – interval method	1998	81 farmers	>50% averse	Not evaluated	Non estimated
AJAE	Brink and McCarl, 1978	Midwest grain farmers	OEB – compared profit max. vs. utility max. in QP model	1974-75	38 farmers	66% averse, 34% neutral, 0% loving	Not evaluated	[0 , 1.95]
AJAE	Chavas and Holt, 1990	U.S. corn and soybean sectors	OEB – model based on acreage allocations	1954-85	Aggregate – used national data	Averse	DARA	Non estimated
REA	Chavas and Holt, 1996	U.S. corn and soybean sectors	OEB – model based on acreage allocation	1954-85	Aggregate – used national data	Averse	DARA	[1.4 , 7.6]
AJAE	Collins, Musser, and Mason, 1991	Oregon grass seed growers	DEU – estimated utility functions	1973-75	37 farmers	16-32% averse, 38-52% neutral, 30-32% loving	Not evaluated	Non estimated
WJAE	Halter and Mason, 1978	Oregon grass seed growers	DEU – estimated utility functions	1973-75	44 farmers	About equal across averse, neutral, loving	Not evaluated	Non estimated
Mimeo	Hildreth and Knowles, 1982	Minnesota cattle producers	DEU – estimated various utility functions	1976-77	13 farmers	85% to 8% averse, varies by functional form;	DARA	Non estimated
AJAE	King and Oamek, 1983	Eastern Colorado wheat farmers	DEU – interval approach	1982?	10 farmers	30% averse, 70% mixed	No clear relationship	Non estimated
AJAE	Lence, 2000	U.S. agricultural sector	OEB – model based on asset allocations	1966-94	Aggregate – used national data	Averse	DARA imposed	1.1
AJAE	Lin, Dean, and Moore, 1974	California crop farmers	OEB – compared utility max and profit max	1973?	6 farmers	50% averse, 33% neutral, 17% mixed	Not evaluated	Not estimated
AJAE	Love and Buccola, 1991	Iowa corn and soybean farmers	OEB – estimated using FOC for input choices in utility max model	1964-69	264 farmers in 3 counties – data aggr. by county	Averse for all 3 counties	CARA imposed	[2.4 , 18.8]
SJAE	Ramaratnam, Rister, Bessler, and Novak, 1986	Texas grain sorghum farmers	DEU – estimated various utility functions	1983	26 farmers	100% to 73% averse, varies by functional form;	Varies with functional form	Non estimated
AJAE	Saha, Shumway, and Talpaz, 1994	Kansas wheat farmers	OEB – estimated using FOC for input choices in utility max model	1979-82	15 farmers (observations aggregated)	Averse	DARA	[3.8 , 5.4]
Mimeo	Schurle and Tierney, 1990	Kansas crop and livestock farmers	DEU – interval method	1989?	90 farmers	80% averse, 2% neutral, 18% loving	Not evaluated	
NCJAE	Tauer, 1986	New York dairy farmers	DEU – interval method	1983	72 farmers	34% averse, 39% neutral, 26% loving	Group test: dec. aversion	Non estimated
AJAE	Thomas, 1987	Kansas crop and livestock farmers	DEU – interval method	1986?	30 farmers	20% averse, 13% loving,67% mixed	Generally dec. aversion	Non estimated
WJAE	Wilson and Eidman, 1983	Minnesota swine producers	DEU – interval method	1980?	45 farmers	42% averse, 36% neutral, 22% loving	33% dec., 21% cons., 18% incr., 28%	Non estimated
AJAE	Kumbhakar, 2002	Norwegian salmon farmers	OEB - model	1992	216 farmers	averse	Not evaluated	0.05
Mimeo	Gómez-Limón, Riesgo and Ariza, 2002	Northern Spain Crop producers	OEB - multicriteria decision model	2001?	52 farmers	45% neutral, 55% averse	DARA	> 6 for 41% of farmers
AE	Lien, 2002	Norwegian farms	OEB - non parametric	1993-98	2136 observations	averse	DARA	[0.08 , 10.8], mean 2.21
AJAE	Hennessy, 1998	Iowa corn producers	CAL - aggregate data	1996		averse	DARA	4.7
Mimeo	Mullen, 2001	Kansas Wheat farmers	CAL - aggregate data	1998		averse	DARA	2.1
AE	Bar-Shira, Just and Ziberman, 1997	Israel co-operative farmers	OEB - land allocation model	1973-82	101 farmers	averse	DARA	0.61
EI	Saha, 1997	Kansas Wheat Farmers	OEB - inputs allocation	1979-82	15 farmers	averse	DARA	Non estimated
AE	Fienerman and Finkelshtain, 1996	Northern Israel farmers	OEB - factors determining risk aversion	1967?	180 farms	averse	DARA	Non Estimated
AJAE	Pope and Just, 1991	Idaho potato producers	OEB - aggregate supply	1950-87		averse	DARA - CRRA	Non Estimated

[1]DEU = direct elicitation of utility, OEB = observed economic behavior, CAL = calibration of theoretical model,

Annex 3.

How insurance and wealth effects are estimated

Annex 2 explains how risk was incorporated in the PEM model. This paper seeks to decompose the effects of policy changes in the three components: price effects, insurance effects and wealth effects as defined in OECD (2001). For each PSE category in each country, policy shocks have been related to observed PSE data: the average level of support in the period 1986-2001 (tables in Annex 1) and the average reduction in variability, as shown in Table 1 in the main text.

A set of nine different simulations is carried out for each PSE category. Each PSE category for each country and commodity is characterised by a shock with two components: first, an increase in the level of that type of support equal to 10% of the increase in the mean revenue that appears in Table 1.1; and, second, a reduction in the index of variability of farm revenue equal to 10% of the reduction in the variability of revenue that appears in Table 1. In some simulations only the mean is increased, while in others only the CV is reduced in order to insulate the impacts of each of the components (price versus risk-related effects). Simulations are also carried out doing both at the same time. Additionally, some simulations are carried out with a lump sum payment that is equal to the estimated increase in farm income associated with each type of support, which allows the wealth effects to be insulated. Different assumptions about the risk preferences of the farmer are imposed in the different simulations. The purpose of doing this set of simulations is to isolate the price, insurance and wealth effects of policies. Table 3.1. defines the nature of the shocks and risk preferences assumed in each simulation denoted by a capital letter from A to I. For instance, simulation "D" was carried out under CARA preferences and the complete policy shock was included (increase in the level and support or mean and reduction in the variability or CV).

Table 3.1. Set of simulations carried out for each PSE category

Risk	**No risk**	**C. A. R. A.**			**D. A. R. A.**				
Name of simulation	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Included shocks	Mean	Mean	CV	Mean CV	Mean CV	+ LS*	Mean - LS*	CV - LS*	Mean CV - LS*
Risk modelisation	Risk neutral	CARA	CARA	CARA	DARA	DARA	DARA	DARA	DARA

* LS = Lump sum comensation. Lumps sum compensation is equal to the farm income increased obatined in simulation E

The focus of this study is on the production effects on the main crop of each country. This impact on production is estimated in each simulation described in Table 3.1. Comparing these estimates allows the insurance and wealth effects to be estimated in the different ways which are described in Table 3.2. These are the kind of methods already used in the empirical literature [Hennessey (1999) and Mullen *et al.* (2001)]. The production effects in simulation "A" under risk neutrality are the standard relative price effects. Production effects in simulation "D" under CARA include both price and insurance effects, but not wealth effects. However those wealth effects are captured n simulation "E" carried out under DARA. Simulation "C" isolates the insurance effects of policies by applying a shock to the coefficient of variation, but not to the mean revenue, under CARA assumptions. Simulation "F" isolates the wealth effects by creating a shock that consists of a theoretical lump sum payment that affects only the overall income of the farmer under DARA assumptions. However, insurance and wealth effects can also be calculated as residual effects as the differences of production impacts (D-A) and (E-D), respectively.

Table 3.2. Alternative possibilities to isolate the insurance and wealth effects

	1	2	3	4	5	6	7
Price Effect	A	A	B	B	G	G	G
Insurance Effect	C	D-A	C	D-B	H	H	I-G
Wealth Effect	F	E-D	F	F	F	E-I	E-I
Total effect	E	E	E	E	E	E	E

The distribution of the total effect among the price, insurance and wealth effects is sensitive to the way they are calculated. However, simulations were carried out proving that results do not differ substantially when using any of the alternative seven insulation strategies defined in Table 3.2. In general those effects that are calculated as a residual seem to be underestimated. In order to avoid this bias the estimation of price insurance and wealth effects is done according to method 1 in Table 3.2. Under this method, the sum of the three different production effects does not add to the total effect, even if the difference is rather small.

Therefore, price effects are estimated by simulating a shock in the level of each category of support under risk neutrality assumptions (simulation A). Insurance effects are calculated by simulating a shock on the reduction of the variability under CARA preferences (simulation C). Wealth effects are estimated by simulating a lump sum shock affecting income under DARA preferences (simulation F). The total effect is obtained by shocking both the level of support and the variability of revenue under DARA preferences (simulation E).

Annex 4.

Sensitivity analysis of the results of measuring the production impacts when including the insurance and wealth effects

This annex includes more detailed information on the methodology and the results of the sensitivity analysis. Simulations are carried out with the PEM risk crops model calibrated with different parameter values for the risk related coefficients. The sensitivity analysis is presented in the form of the minimum, maximum and mean values of each indicator when the simulation is repeated 100 times for different stochastic independent values of the risk related parameters. The values of the parameters are drawn from independent uniform distributions. The ranges for these distributions are obtained from the plausible minimum and maximum values obtained from the analysis of empirical data and literature as shown in Annex 2: the first and fourth quartiles values of the farming receipts / household income ratios in each country (when available in Table 2.1) and a range [0,5] for the risk aversion coefficient.

The results of this sensitivity analysis are presented in two parts. First, information on production ratios and shares of each type of effect are shown in Table 4.1 to 4.6. Secondly, Figures 4.1 and 4.2 illustrate some results from the sensitivity analysis in a graphical manner.

The policy simulations are designed as an increase of 10% in the level of this type of support and a reduction of 10% of the revenue variability assigned to that PSE category as described in the main text. For each policy considered the results of simulations A, C, D, E and F in Table 3.1. are used to estimate the impact of each simulation on production (in million tons) of the main commodity. These production impacts are used to calculate production ratios and shares of each type of effect.

Results and sensitivity analysis of production ratios and shares of each type of effect

The **total production ratios** are calculated and reported in the Tables 4.1 to 4.6. Unity minus each of these ratios corresponds to the concept of “degree of decoupling” as defined in Cahill (1997), Moro and Sckokai (1998), and OECD (2001*c*). The production ratio is the ratio of the production effect of one dollar spent in a given PSE category with respect to the production effect of the same dollar spent as market price support (MPS). These ratios were already used to present the results of the PEM crop model in OECD (2001*b*) and in Dewbre *et al.* (2001). In this study we have not only the relative price effects of different PSE categories, but also the insurance and wealth effects. This allows a specific **production ratio by type of effect** with respect to MPS for each of the three effects covered by the modelling framework to be measured: price effects, insurance effects and wealth effects. However, for the total effect of a given PSE category, the price effect impact of MPS with complete price transmission becomes the denominator. We can thus calculate a total production ratio for MPS that is different from one, capturing the insurance effects of the price support measures. In the same set of tables, the results are presented in terms of the **share of the price, insurance and wealth effects** in the total production impact. These shares were calculated according to methodology number 1 in Table 3.2.

Table 4.1. Production ratios and shares of insurance and wealth effects

Wheat in Canada (2001)

(results after 100 stochastic simulation - Canada - 2001)

	Sensitivity to Risk Aversion $\xi \sim U(0,5)$			Sensitivity to both Risk Aversion and off-farm income		
	Mean	Min	Max	Mean	Min	Max
Market Price Support						
Total Production Ratios						
No risk (A)	1.000	1.000	1.000	1.000	1.000	1.000
CARA (D)	1.754	1.007	2.837	5.359	1.000	211.248
DARA (E)	1.781	1.009	2.554	1.605	1.000	2.556
Production Ratios by type of effect						
Price effects (A)	1.000	1.000	1.000	1.000	1.000	1.000
Insurance Effects (C)	1.000	1.000	1.000	1.000	1.000	1.000
Wealth Effects (F)	1.000	1.000	1.000	1.000	1.000	1.000
Share in total production impacts						
Price effects (A)	0.538	0.270	0.991	0.500	0.005	1.000
Insurance Effects (C)	0.305	0.006	0.496	0.404	0.000	0.997
Wealth Effects (F)	0.156	0.003	0.234	0.096	-0.019	0.231
Payments based on area planted						
Total Production Ratios						
No risk (A)	0.459	0.459	0.459	0.459	0.459	0.459
CARA (D)	0.983	0.463	1.735	3.895	0.459	186.255
DARA (E)	1.068	0.466	1.642	0.911	0.459	1.634
Production Ratios by type of effect						
Price effects (A)	0.459	0.459	0.459	0.459	0.459	0.459
Insurance Effects (C)	0.713	0.713	0.713	0.715	0.713	0.887
Wealth Effects (F)	1.004	0.897	1.163	1.000	-1.207	1.374
Share in total production impacts						
Price effects (A)	0.423	0.180	0.983	0.411	0.002	0.999
Insurance Effects (C)	0.340	0.010	0.515	0.440	0.000	0.999
Wealth Effects (F)	0.237	0.007	0.310	0.148	-0.029	0.315

Table 4.2. Production ratios and shares of insurance and wealth effects

Wheat in the European Union (2001)

(results after 100 stochastic simulation - European Union - 2001)

	Sensitivity to Risk Aversion $\xi \sim U(0,5)$			Sensitivity to both Risk Aversion and off-farm income		
	Mean	Min	Max	Mean	Min	Max
Market Price Support						
Total Production Ratios						
No risk (A)	1.000	1.000	1.000	1.000	1.000	1.000
CARA (D)	1.154	1.006	1.306	1.134	1.001	1.446
DARA (E)	1.157	1.006	1.310	1.136	1.001	1.446
Production Ratios by type of effect						
Price effects (A)	1.000	1.000	1.000	1.000	1.000	1.000
Insurance Effects (C)	1.000	1.000	1.000	1.000	1.000	1.000
Wealth Effects (F)	1.000	1.000	1.000	1.000	1.000	1.000
Share in total production impacts						
Price effects (A)	0.797	0.644	0.990	0.822	0.547	0.998
Insurance Effects (C)	0.194	0.010	0.338	0.169	0.002	0.419
Wealth Effects (F)	0.009	0.000	0.017	0.008	0.000	0.034
Payments based on area planted						
Total Production Ratios						
No risk (A)	0.201	0.201	0.201	0.201	0.201	0.201
CARA (D)	0.259	0.204	0.315	0.251	0.202	0.368
DARA (E)	0.276	0.204	0.349	0.267	0.202	0.435
Production Ratios by type of effect						
Price effects (A)	0.201	0.201	0.201	0.201	0.201	0.201
Insurance Effects (C)	0.220	0.220	0.221	0.220	0.220	0.221
Wealth Effects (F)	1.696	1.537	1.883	1.725	1.439	1.899
Share in total production impacts						
Price effects (A)	0.739	0.562	0.985	0.774	0.439	0.998
Insurance Effects (C)	0.192	0.011	0.322	0.168	0.002	0.367
Wealth Effects (F)	0.069	0.004	0.116	0.059	0.000	0.194

Table 4.3. Production ratios and shares of insurance and wealth effects

Rice in Japan (2001)

(results after 100 stochastic simulation - Japan - 2001)

	Sensitivity to Risk Aversion $\xi \sim U(0,5)$			Sensitivity to both Risk Aversion and off-farm income		
	Mean	Min	Max	Mean	Min	Max
Market Price Support						
Total Production Ratios						
No risk (A)	1.000	1.000	1.000	1.000	1.000	1.000
CARA (D)	1.187	1.005	1.371	1.237	1.010	1.871
DARA (E)	1.189	1.005	1.374	1.239	1.010	1.857
Production Ratios by type of effect						
Price effects (A)	1.000	1.000	1.000	1.000	1.000	1.000
Insurance Effects (C)	1.000	1.000	1.000	1.000	1.000	1.000
Wealth Effects (F)	1.000	1.000	1.000	1.000	1.000	1.000
Share in total production impacts						
Price effects (A)	0.788	0.635	0.992	0.770	0.430	0.984
Insurance Effects (C)	0.210	0.008	0.363	0.229	0.015	0.576
Wealth Effects (F)	0.002	0.000	0.002	0.001	-0.006	0.004
Payments based on output						
Total Production Ratios						
No risk (A)	1.504	1.504	1.504	1.504	1.504	1.504
CARA (D)	4.071654	1.573	6.604	4.765109	1.644	13.472
DARA (E)	4.068	1.573	6.586	4.732	1.644	13.106
Production Ratios by type of effect						
Price effects (A)	1.504	1.504	1.504	1.504	1.504	1.504
Insurance Effects (C)	9.256	9.254	9.257	9.256	9.254	9.262
Wealth Effects (F)	-0.756	-6.158	2.371	72.677	-366.534	7106.563
Share in total production impacts						
Price effects (A)	0.425	0.222	0.955	0.437	0.111	0.912
Insurance Effects (C)	0.576	0.045	0.781	0.566	0.088	0.916
Wealth Effects (F)	0.000	-0.003	0.001	-0.003	-0.027	0.001

Table 4.4. Production ratios and shares of insurance and wealth effects

Coarse Grains in Mexico (2001)

(results after 100 stochastic simulation - Mexico - 2001)

	Sensitivity to Risk Aversion $\xi \sim U(0,5)$			Sensitivity to both Risk Aversion and off-farm income		
	Mean	Min	Max	Mean	Min	Max
Market Price Support						
Total Production Ratios						
No risk (A)	1.000	1.000	1.000	1.000	1.000	1.000
CARA (D)	1.152	1.001	1.323	1.215	1.001	1.946
DARA (E)	1.185	1.002	1.371	1.230	1.001	1.568
Production Ratios by type of effect						
Price effects (A)	1.000	1.000	1.000	1.000	1.000	1.000
Insurance Effects (C)	1.000	1.000	1.000	1.000	1.000	1.000
Wealth Effects (F)	1.000	1.000	1.000	1.000	1.000	1.000
Share in total production impacts						
Price effects (A)	0.807	0.645	0.998	0.763	0.410	0.998
Insurance Effects (C)	0.136	0.002	0.250	0.159	0.002	0.467
Wealth Effects (F)	0.057	0.001	0.105	0.078	0.000	0.161

Table 4.5. Production ratios and shares of insurance and wealth effects

Wheat in Switzerland (2001)

(results after 100 stochastic simulation - Switzerland - 2001)

	Sensitivity to Risk Aversion $\xi \sim U(0,5)$			Sensitivity to both Risk Aversion and off-farm income		
	Mean	Min	Max	Mean	Min	Max
Market Price Support						
Total Production Ratios						
No risk (A)	1.000	1.000	1.000	1.000	1.000	1.000
CARA (D)	1.039	1.000	1.082	1.041	1.001	1.107
DARA (E)	1.105	1.000	1.195	1.107	1.002	1.230
Production Ratios by type of effect						
Price effects (A)	1.000	1.000	1.000	1.000	1.000	1.000
Insurance Effects (C)	1.000	1.000	1.000	1.000	1.000	1.000
Wealth Effects (F)	1.000	1.000	1.000	1.000	1.000	1.000
Share in total production impacts						
Price effects (A)	0.868	0.758	1.000	0.865	0.709	0.998
Insurance Effects (C)	0.044	0.000	0.085	0.046	0.001	0.104
Wealth Effects (F)	0.087	0.000	0.156	0.089	0.001	0.187
Payments based on historical entitlements						
Total Production Ratios						
No risk (A)	0.006	0.006	0.006	0.006	0.006	0.006
CARA (D)	0.173	0.007	0.337	0.180	0.009	0.408
DARA (E)	0.177	0.007	0.344	0.184	0.009	0.423
Production Ratios by type of effect						
Price effects (A)	0.006	0.006	0.006	0.006	0.006	0.006
Insurance Effects (C)	3.154	2.839	3.418	3.140	2.636	3.419
Wealth Effects (F)	0.957	0.850	1.058	0.961	0.848	1.092
Share in total production impacts						
Price effects (A)	0.057	0.011	0.874	0.050	0.009	0.615
Insurance Effects (C)	0.581	0.081	0.604	0.589	0.257	0.648
Wealth Effects (F)	0.362	0.045	0.401	0.361	0.128	0.423

Table 4.6A. Production ratios and shares of insurance and wealth effects

Coarse Grains in the United States (2001)

(results after 100 stochastic simulation)

	Sensitivity to Risk Aversion $\xi \sim U(0,5)$			Sensitivity to both Risk Aversion and off-farm income		
	Mean	Min	Max	Mean	Min	Max
Market Price Support						
Total Production Ratios						
No risk (A)	1.000	1.000	1.000	1.000	1.000	1.000
CARA (D)	1.368	1.009	1.747	1.508	1.006	2.828
DARA (E)	1.363	1.009	1.720	1.456	1.006	2.313
Production Ratios by type of effect						
Price effects (A)	1.000	1.000	1.000	1.000	1.000	1.000
Insurance Effects (C)	1.000	1.000	1.000	1.000	1.000	1.000
Wealth Effects (F)	1.000	1.000	1.000	1.000	1.000	1.000
Share in total production impacts						
Price effects (A)	0.743	0.560	0.991	0.705	0.333	0.993
Insurance Effects (C)	0.246	0.009	0.418	0.274	0.006	0.609
Wealth Effects (F)	0.012	0.000	0.023	0.021	0.000	0.057
Payments based on output						
Total Production Ratios						
No risk (A)	1.129	1.129	1.129	1.129	1.129	1.129
CARA (D)	1.751	1.144	2.391	1.986	1.139	4.207
DARA (E)	1.735	1.144	2.330	1.886	1.139	3.312
Production Ratios by type of effect						
Price effects (A)	1.129	1.129	1.129	1.129	1.129	1.129
Insurance Effects (C)	1.752	1.750	1.753	1.751	1.744	1.754
Wealth Effects (F)	1.265	1.138	1.356	1.207	0.000	1.433
Share in total production impacts						
Price effects (A)	0.662	0.453	0.987	0.631	0.248	0.991
Insurance Effects (C)	0.326	0.013	0.525	0.350	0.009	0.699
Wealth Effects (F)	0.012	0.000	0.022	0.019	0.000	0.054

Table 4.6B. Production ratios and shares of insurance and wealth effects

Coarse Grains in the United States (2001)

(results after 100 stochastic simulation)

(Million of Tons)	Sensitivity to Risk Aversion $\xi \sim U(0,5)$			Sensitivity to both Risk Aversion and off-farm income		
	Mean	Min	Max	Mean	Min	Max
Payments based on area planted						
Total Production Ratios						
No risk (A)	0.499	0.499	0.499	0.499	0.499	0.499
CARA (D)	0.729	0.504	0.966	0.816	0.502	1.637
DARA (E)	0.747	0.505	0.990	0.823	0.502	1.464
Production Ratios by type of effect						
Price effects (A)	0.499	0.499	0.499	0.499	0.499	0.499
Insurance Effects (C)	0.630	0.629	0.631	0.630	0.627	0.631
Wealth Effects (F)	2.214	1.863	2.706	2.008	0.001	2.706
Share in total production impacts						
Price effects (A)	0.681	0.478	0.988	0.644	0.260	0.993
Insurance Effects (C)	0.276	0.011	0.450	0.294	0.007	0.598
Wealth Effects (F)	0.044	0.002	0.072	0.062	0.000	0.145
Payments based on historical entitlements						
Total Production Ratios						
No risk (A)	0.034	0.034	0.034	0.034	0.034	0.034
CARA (D)	0.358	0.042	0.692	0.482	0.040	1.650
DARA (E)	0.365	0.043	0.688	0.453	0.040	1.236
Production Ratios by type of effect						
Price effects (A)	0.034	0.034	0.034	0.034	0.034	0.034
Insurance Effects (C)	0.879	0.878	0.880	0.880	0.878	0.884
Wealth Effects (F)	2.558	2.208	3.049	2.333	0.000	3.040
Share in total production impacts						
Price effects (A)	0.149	0.044	0.803	0.171	0.017	0.871
Insurance Effects (C)	0.753	0.176	0.842	0.716	0.129	0.846
Wealth Effects (F)	0.098	0.022	0.114	0.113	0.000	0.202

Sensitivity analysis of production impacts and production ratios with respect to the risk aversion coefficient: a graphical illustration

The example of the results for coarse grains in the United States is used to illustrate the sensitivity of the results with respect to different values of the risk aversion coefficient. The results for production impacts are shown in Figure 4.1 and for production ratios in Figure 4.2. Production impacts through insurance effects are very sensitive to the value of the risk aversion coefficient. However, the relative production impacts captured in the production ratios in Figure 4.2 are much more stable regardless of the assumed level of risk aversion.

Figure 4.1. Sensitivity analysis of production effects per dollar of support in the United States (Coarse grains, 2001)

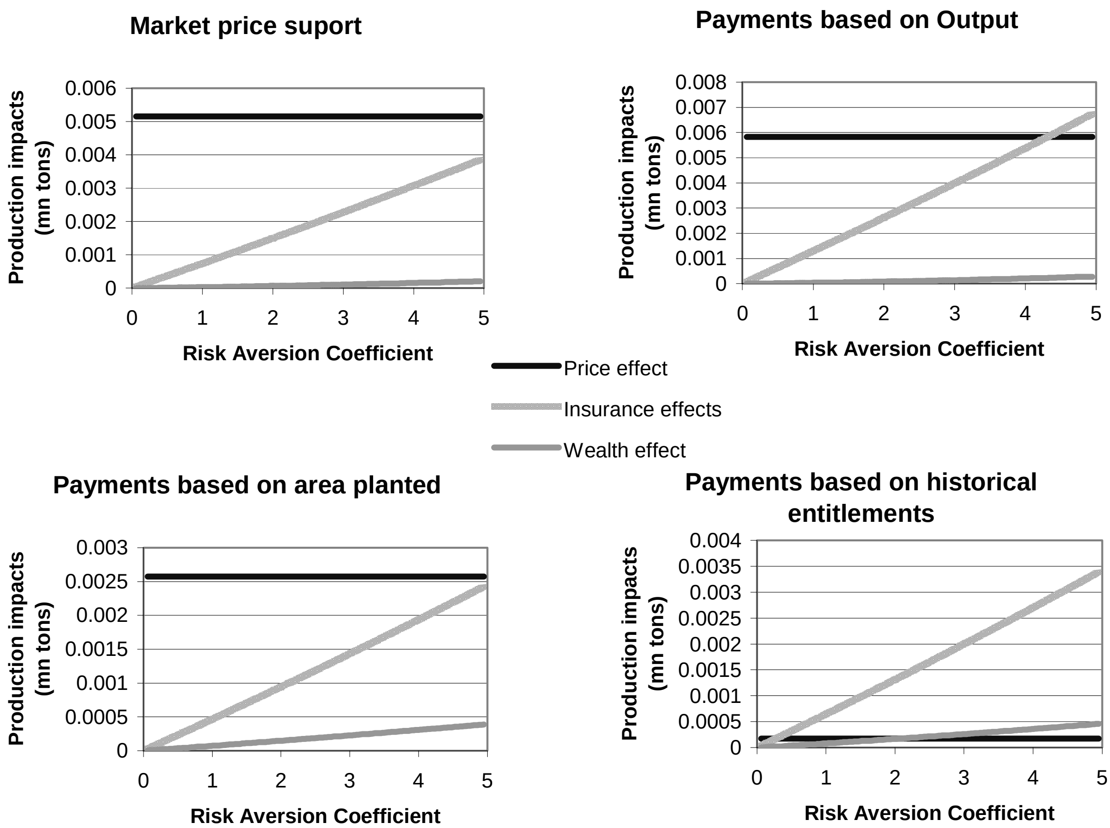
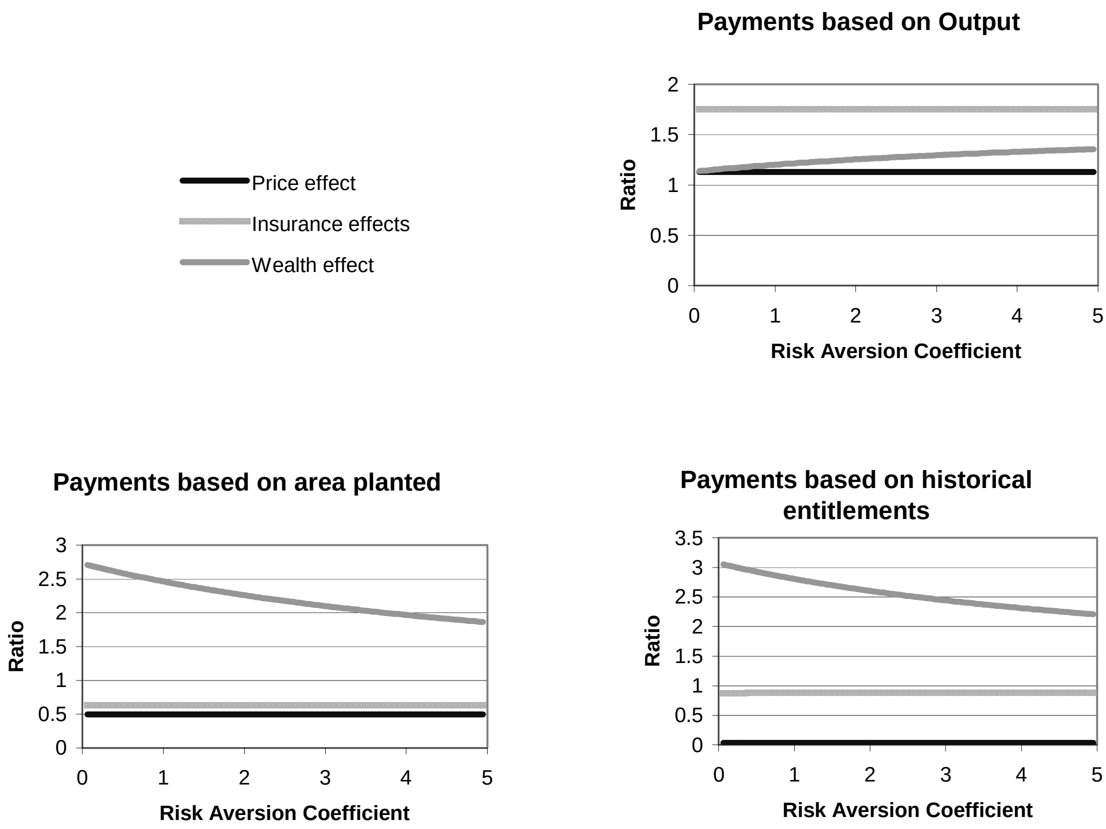


Figure 4.2. Sensitivity analysis of production ratios by type of effect in the United States (Coarse grains, 2001)



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