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Abstract:

Administered commodity price schemes in developing countries have proved ineffective in raising farmers' incomes and price stabilisation through futures markets is increasingly advocated as the alternative policy objective. A potential difficulty is that farmers tend not to hedge extensively, even in developed countries where access to futures markets is long established. Explanations for this reticence are examined here with context provided by the Mexican hedging programme, which incorporates financial incentives to spur adoption. Applying representative data for corn to a well-known analysis of the hedging decision suggests that limited participation may reflect rational calculation rather than farmer 'inertia'. A policy implication is that permanent access subsidies are difficult to justify from the national perspective.

Keywords

Farmers, hedging incentives, subsidies, Mexico.

1. Introduction

Expanding trade and international financial integration during the 1980s prompted a fundamental change in policy perspectives on primary commodity dependence in developing countries. From the 1950s, international agreements that aimed directly to influence prices had been motivated by the perception both that commodity exporters were confronted by a secular deterioration in their terms of trade and that the characteristic volatility of prices was harmful to their development aspirations (Larson *et al*, 1998). Individual initiatives in producer countries also led to the institution of a range of national schemes, including buffer stocks, price stabilisation funds (or variable tariffs) and marketing boards (Knudsen and Nash, 1990). Sharing the motivations that had prompted the international agreements, these national programmes were often to fail under similar pressures of budgetary strain and over-production.

While the possibility of using futures markets as an alternative to buffer stock arrangements had been raised earlier (McKinnon, 1967), the view that policy should focus on price risk management, rather than manipulation of their average levels, gained increasing acceptance from the mid-1980s (Varangis *et al*, 2002). Alongside theoretical work that contributed to this change in perspective a number of applied studies have simulated the potential gains from using commodity futures-type contracts to manage price risks confronting producers (for example, Faruquee *et al*, 1997).

Although helping to consolidate the conclusion that risks should be managed through commodities futures markets, such simulations assume crucially that farmers will actually choose to hedge their crops in this way when the opportunity is presented to them. In practice, however, and even in the more sophisticated commercial markets, relatively few farmers appear to hedge using market instruments (Gardner, 2000). If a number of reasons may explain this finding (collectively termed 'inertia' below), a practical implication is likely to be that large-scale adoption of hedging by farmers will require a degree of public financial inducement. This was the conclusion reached by the Mexican authorities in launching their innovative crop hedging facility in 1994. The present examination of its application to the country's staple corn production therefore attempts to illuminate a policy issue with potentially general relevance to developing economies.

Following a brief review of the provisions of the Mexican scheme below, the first analytical objective is to establish a social benefit-cost framework for evaluating the introduction of a subsidised programme in which hedging charges are paid to a foreign futures exchange. The central assumptions in developing this perspective are that farmers do not have access to hedging opportunities prior to the scheme's introduction and that inertia requires some public subsidy of the hedging costs in order to achieve widespread participation. While the first assumption reflects the Mexican environment prior to 1994, the validity of the second is investigated in the next stage of the analysis. Whereas the social benefit-cost exercise yields an evaluation of the degree of inertia (foregone hedging gains) necessary in order to justify premium subsidies, the subsequent use of income mean-variance analysis provides a yardstick for comparison by estimating the likely actual gains to farmers from crop hedging.

Application to the case of corn suggests that the inertia needed for subsidisation to be socially worthwhile would be substantial, whereas the private income insurance benefits are probably sufficiently modest for the subsidies to have a material influence on the decision to participate. The implication that high participation rates may only be achieved at net social cost is then taken up in the context of experience so far with the Mexican programme. Policy implications of the finding that inertia is a less likely explanation for limited up-take than modest perceived net benefits from hedging are discussed in conclusion. It is argued that an open-ended subsidy programme is unlikely to be worthwhile in light of the results presented.

2. The ASERCA futures scheme

The Mexican programme administered by the government department ASERCA[1] was created in 1994 to facilitate access by farmers to futures and futures options contracts traded on the Chicago, Kansas City and New York Boards of Trade and the Chicago Mercantile Exchange. The stated purpose was to help producers to reduce risk related to adverse agricultural price movements and thereby to motivate them to increase production. Under its provisions, growers may acquire commodity futures, futures

[1] The Spanish name of the scheme is 'Subprograma de apoyos directos a cobertura de precios agricolas'. It is part of 'Apoyos y servicios a la comercializacion agropecuaria (ASERCA)'. The latter is a Mexican Federal Government Department within the Secretariat of Agriculture and Rural Development. The scheme's web page is http://www.sagarpa.gob.mx

options and synthetic options contracts with a fifty per cent federal subsidy on option prices. Both call and put options are eligible although in practice almost all of the contracts outstanding are put options on futures (referred to as futures options). The scheme has become increasingly comprehensive in terms of the crops eligible for hedging and its approved budget for the years 2002-3 was approximately $U.S 22.5 million[2].

The scheme is available to qualifying[3] producers and exporters with the rules for qualification seeking to ensure that the motive for participation is crop hedging, rather than speculation. Although some rolling of futures and futures options contracts is permitted, for instance, the nine-month limit imposed on the hedging period reflects the objective of risk management on a crop by crop basis. With paperwork between the scheme and the futures exchanges administered through the central offices in Mexico City, farmers deal directly with the scheme's regional subsidiaries where monitoring seeks to ensure that the volumes hedged do not exceed the anticipated crop. When gains are realised from exercising, the farmer's initial share of the option premium is reimbursed. The authorities then recoup up to the full amount of the initial subsidy with any remaining profits remitted to the grower. To limit further the potential costs of the premium subsidies, farmers are required to purchases option contracts with a strike price at, or closest to, the prevailing futures price.

[2] Corn, rice, wheat, sorghum, soya (beans and oil), cotton, coffee, orange juice, live cattle and hogs were eligible at this time (ASERCA, 2003, p 49).

[3] The qualification process is performed in the scheme's subsidiaries in different regions or Mexican states.

In the case of the staple crop, the average number of corn hectares and tons insured under the scheme in the four years 1997-2000 was 38,687 and 200,796 respectively (ASERCA, 2002). Reflecting the more general pattern referred to above, and up to six years after introduction, these magnitudes confirm the limited extent of farmer participation. The average number of corn hectares and tons in Mexico for the same four years was respectively 7.6 and 18.2 million (*ibid*), suggesting that the area and quantity insured amounted to around one per cent of the total. Nevertheless, while the averages quoted above are representative of the annual insured magnitudes over 1997-2000, the number of hectares (tons) covered expanded markedly to 135,950 (750,859) in 2001 (ASERCA 2003, pp. 48-58). With little accompanying change in the national area and production aggregates, the implied relative increase in hedging activity is reflected in the 263 per cent rise in the number of contracts, from 1631 in 2000 to 5,912 in 2001. The rise in the number of participating producers from 1,549 in 2000 to 4,632 in 2001 represented a roughly comparable gain of two hundred per cent (*ibid*). Albeit from a small base, therefore, and as the scheme has become more established, these latest figures indicate the potential for wider participation. Against this background, the approach adopted for the social evaluation of the programme's subsidy regime is presented below.

3. Optimal crop hedging and the net resource cost of premium subsidies

3.1 Price risk and the production-hedging decision

The analysis concerns the production response of a representative farmer to the introduction of a previously unavailable crop hedging opportunity. Inertia that would otherwise prevent this response is then invoked to provide a possible rationale for public subsidy of the insurance services purchased. Considerable simplification is achieved if it is also assumed that there is no production uncertainty and that all hedging is undertaken with a simple futures contract. Although not reflective of the Mexican case, where futures options are involved, the figures used in the analysis refer to the estimated cost of the put contracts that are, in fact, typically purchased. Since production uncertainty and the option component should both enhance further the attraction of hedging to farmers, it will be noted later that these simplifications tend to bias the analysis in favour of subsidisation.

The chosen output (Q) will be sold either at the spot price prevailing at the time of harvest (Q_s) or at the futures price quoted for the relevant interval (Q_f) at the time of planting:

$$Q = Q_s + Q_f \tag{1}$$

The part of the crop quantity (Q_s) that will be sold at the future spot price is assumed to be ƒ0 in order to rule out speculative futures commitments by the farmer. While this assumption would seem compatible with basic risk aversion, it also reflects the fact that speculative commitments are specifically excluded under the scheme[4]. As a small producer, the farmer must accept for unhedged output the world price prevailing at harvest time (a horizontal demand curve is assumed), implying that net revenue will be subject to random disturbances as follows:

[4] Eligible ‘qualified producers’ are prohibited from using the scheme for speculative purposes.

$$\tilde{\pi} = P_f Q_f + \tilde{P}(Q - Q_f) - c(Q) - (p - s)Q_f, \tag{2}$$

where P_f, representing the futures price, is known to the farmer at the time of planting, in contrast to the future spot price $\tilde{P}$ at harvest, which is not. Production is subject to a rising cost curve $c(Q)$ and hedging is undertaken at a known transaction cost (p) net of subsidy (s), yielding $(p\text{-}s)Q_f$ as the net (private) cost of hedging.

Re-arranging (2) with the addition and subtraction of $\overline{P}(Q - Q_f)$ (where the bar denotes the farmer's *expected* price) yields the following:

$$\tilde{\pi} = \overline{P}Q - c(Q) - (p - s)Q_f + (P_f - \overline{P})Q_f + (\tilde{P} - \overline{P})(Q - Q_f) \tag{3}$$

Expected net revenue and its variance (assuming no production uncertainty) will therefore be:

$$\overline{\pi} = \overline{P}Q - c(Q) - (p - s)Q_f + (P_f - \overline{P})Q_f, \tag{3a}$$

$$\sigma_\pi^2 = \sigma_P^2 (Q - Q_f)^2. \tag{3b}$$

The assumption of exponential utility implies maximisation of the following objective function after substitution for the expectation and variance of returns from above:

$$Max_{Q,Q_f}\left(\overline{\pi} - \frac{\lambda}{2}\sigma_\pi^2\right) = \overline{P}Q - c(Q) - (p - s)Q_f + (P_f - \overline{P})Q_f - \frac{1}{2}\lambda(Q - Q_f)^2\sigma_P^2 \tag{4}$$

This is the objective function suggested by Anderson and Danthine (1980, 1981) for our simplified case where only one futures contract maturing at harvest time is assumed (implying that the variances of the futures and the spot price at harvest are the same). The first order conditions are:

$$\frac{\partial u}{\partial Q} = 0 = \overline{P} - \frac{\partial c}{\partial Q} - \left[\lambda \sigma_P^2 \left(Q - Q_f\right)\right], \tag{5}$$

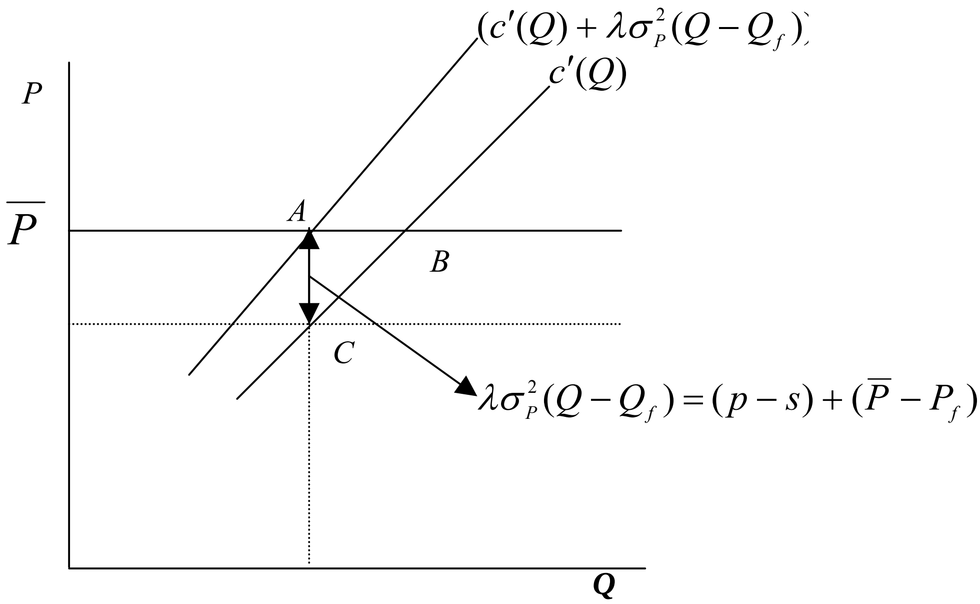
$$\frac{\partial u}{\partial Q_f} = 0 = P_f - \overline{P} - \left(p - s\right) + \left[\lambda \sigma_P^2 \left(Q - Q_f\right)\right], \tag{6}$$

Contrary to the normal theoretical prediction under conditions of optimal complete hedging, equation (5) implies that the risk aversion coefficient (λ) will be involved in determining the chosen level of output. While reflecting the prohibition against 'over' hedging assumed in the Mexican case, (that is, $Q_s f 0$) the simplification facilitates a focus on the production consequences arising from the *introduction* of a new hedging opportunity as will be emphasised below. More conventionally, risk aversion is also present in the marginal hedging calculation described in equation (6), although it is equally clear that the extent of hedging may not be determined critically by this characteristic. Given the farmer's own expected price, the futures price may exceed it by enough effectively to 'pay' (prospectively) for the contribution made to the hedging cost *(p-s)*. From this point all output would be hedged, irrespective of the size of the risk aversion coefficient (λ). As has been argued elsewhere, the critical consideration in the hedging decision may therefore be the relationship between the futures price and the farmer's personal expectations for the cash price at harvest (Harwood *et.al.* 1999).

3.2 Premium subsidies and 'break-even' production

From the public policy viewpoint the net resource implications of the hedging subsidy may be clarified by reference to Figure 1, which provides a diagrammatic representation of the first order conditions specified in equations (5) and (6). To delay consideration of the participation decision it is accepted initially that farmer inertia requires a subsidy inducement to achieve up-take. It is also assumed that only one type of crop is grown, although reference will be made later to the important question of the production alternatives facing the farmer.

Figure 1 representation of equilibrium



With a linear marginal cost curve, Figure 1 depicts the 'risk adjusted' curve that is implied when the risk aversion coefficient and price variance are both constant. To derive a comparative measure of the public benefits and costs of participation subsidies, two 'polar' equilibrium positions might be identified from the figure. Initially cut off from futures markets, the farmer's 'risk-adjusted' cost curve would lie above the 'technical' schedule (c'(Q)) by the distance AC (equal to $(\lambda\sigma_P^2 Q)$). Production at A would be below the technical optimum represented by B with the implied surplus of price over marginal cost compensating the overall price risk.

In the opposite case, the producer might be offered hedging facilities with a one hundred per cent subsidy to cover any associated costs. Should the expectation of the price at harvest not exceed the current futures price ($\overline{P} \square P_f$), the decision under the assumed absence of output uncertainty would be to hedge the entire crop and for production to approach B, the technical optimum. Comparison could then be made between the 'social' value of the extra output and the budgetary cost of the one hundred per cent subsidy to cover the entire (enhanced) crop[5]

This calculation may be expressed in terms of a 'break-even' quantity of increased production, defined as that which would have equivalent net value over resource cost at world prices (the area ABC) to the subsidy outlays (covering payments made to the

[5] In principle, with a premium subsidy of 'only' fifty per cent and with a coincidence between expected and futures prices for corn, some of the crop may be left unhedged. Evaluation of the remaining risk $(\lambda\sigma_P^2(Q-Q_f)^2)$ would be balanced against the premium cost saving from bearing it (p-s)(Q – Q_f). In practice, with a simple futures contract, partial hedging would more plausibly reflect a futures price that was low relative to the farmer's expectations.

foreign futures exchange). Measuring the price elasticity of supply from a pre-scheme point like C in Figure 1, and setting the premium subsidy at fifty per cent to reflect the Mexican case, it is shown in Appendix A that the required proportional increase in output may be expressed as follows:

$$\overset{0}{Q} = \frac{\frac{p}{P'} + \sqrt{\left(\frac{p}{P'}\right)^2 + \frac{4p\varepsilon}{P'}}}{2}. \tag{7}$$

The break-even percentage quantity increase ($\overset{0}{Q}$) therefore depends positively on the transaction premium (p, expressed here as a percentage of the anticipated price for corn after deduction of the subsidy paid by the scheme P^t) and the supply elasticity (ε, reflecting the slope of the marginal cost schedule in Figure 1). Whereas Mexican data did not permit direct estimation of the production elasticity, a proxy for the former parameter may be derived in the case of corn. Using seasonally adjusted monthly data (constructed from daily quotes as explained in Appendix B) a put option premium series based on contracts approaching expiration 'near to the money' yielded an average value of approximately ¢US14 per bushel between January 1995 and September 1999. This estimate of the average put premium was around five per cent of the mean futures price of ¢US277 per bushel over the same interval and is taken as the relevant transactions cost here.

Drawing on the empirical literature, a range of plausible values for the production elasticity is employed and it appears that the broad conclusions of the analysis are not critically dependent on this magnitude. Reflecting the importance of substitutability in production, empirical studies generally confirm that individual crop elasticities exceed those for overall agricultural production. Rambaldi and Simmons, for example, obtained a value of 1.2 for Australian wheat (2000). Even in poor agricultural areas crop elasticities can be quite high, with values for one Indian region varying between 0.25 to 0.77 per cent (reported by Binswanger, 1989). In a more recent result for a location nearer the present case, Lopez and Ramos estimated a price elasticity of supply for corn in Ecuador (0.25) at the lower end of this range (1998).

As the hedging facility is available for all major crops under the Mexican programme, it is further probable that the relevant supply curve for the analysis would more closely resemble that for agricultural output as a whole, rather than for an individual crop. A general conclusion, suggested for instance by Binswanger's survey, is that this value tends to lie between 0.1 and 0.2 in the short term (*op.cit* Table 2). In the light of these findings, Table 1 reports the quantitative implications of inserting the above option premium estimates, and three assumed values for the production elasticity (1.3, 0.7 and 0.25), into Equation (7). On the assumption that take-up requires a fifty per cent subsidy the estimates in the first row are of the (proportional) increase in production that would be necessary socially to justify support when set at that rate.

TABLE 1
'REQUIRED' INCREASE IN CORN PRODUCTION UNDER ALTERNATIVE SUPPLY ELASTICITY AND PREMIUM SUBSIDY ASSUMPTIONS

Assumed price elasticity	$\varepsilon = 1.3$	$\varepsilon = 0.7$	$\varepsilon = 0.25$
Critical quantity increase (1)	0.29	0.22	0.14
Marginal risk evaluation (1)	0.18	0.24	0.36
Critical quantity increase (2)	0.2	0.15	0.1
Marginal risk evaluation (2)	0.13	0.18	0.28

Calculations use Equation 7 inserting mean values (1995:1 to 1999:9) of $\rho = 14$ and $P' = 277$ (both in ¢ per bushel). Calculation (1) assumes a 50 per cent subsidy of the premium whereas (2) sets the subsidy at 25 per cent on average (see text).

These production increases correspond to the distance AB in Figure 1. Using the relevant elasticity values, the same results may be expressed in terms of the analogous vertical distance AC. The diagram shows that this represents the marginal cash value to the farmer of the risk being borne with the initially unhedged crop. The relevant magnitudes are reported in the second line of Table 1 and, expressed as a fraction of the observed price (P'), range from nearly 18 to 36 per cent. The intuition behind these results is that subsidies could be socially worthwhile if farmers are characterised either by a high underlying supply response (offsetting modest risk aversion), as in the first column, or by high underlying risk aversion (offsetting a comparatively low supply response), as in the third. Expressed equivalently, scheme benefits would be at their maximum when inertia would otherwise discourage participation by highly risk-averse farmers faced with elastic technical conditions of supply.

The alternative calculations reported in the third and fourth rows of the table recognise that the premium subsidy is only paid in full under the Mexican scheme when the futures options are not exercised. A natural assumption might be that this situation would arise for approximately fifty per cent of transactions over the course of a number of years. In practice, over the period 1995-99, the scheme recouped around sixty-five per cent per year of its subsidy outlays. The additional calculations in the table therefore insert into Equation (7), after minor modification, the assumption that the effective subsidy is 25 (rather than fifty) per cent.

As would be expected, the break-even production increases are now lower and range from 10 to 20 per cent. Again expressed as a fraction of the observed price, the marginal risk evaluation ranges between 13 and 28 per cent. When these new values are compared with the (unsubsidised) premium to price fraction of five per cent it is clear that inertia would need to be a major impediment, under any plausible supply elasticity, for premium subsidies to be both necessary and self-financing in the sense defined by Equation (7). If farmers were as risk averse before the scheme as these calculations suggest, their incentive to participate after its introduction would be thought sufficiently powerful to obviate the need for subsidy. While the subsidy could be necessary to encourage participation if the farmer's evaluation of risk approximated that suggested by the premium, the net public resource cost must then be positive.

While the analysis leading to this rather stark conclusion was based on a simple futures hedge, it may be supported further by reference to the characteristic use of put options in the Mexican programme. The additional options feature must enhance the attraction of a crop hedging facility and, since the actual net premium costs to the farmer have been incorporated in the analysis, further strain on the inertia interpretation of low participation rates is therefore implied. To return more directly to the participation issue, therefore, the role of inertia is confronted below with the alternative view that farmers make rational decisions with respect to hedging and that cost is critical to determining the level of involvement.

4. Inertia, calculation and the take-up issue

Should unfamiliarity and inertia explain restricted hedging activity the same farmer psychology would also help to justify its encouragement through a premium subsidy. Nevertheless, the calculations presented in Table 1 show that the necessary inertia would have to be considerable and the plausibility of this explanation against the alternative that farmers perceive the benefits from hedging to be low should be considered. Particularly severe inertia is implied, for instance, in the high pre-scheme valuations of risk reported in the third column of Table 1. They arise in the context of a modest supply response and there is reason to doubt whether this combination would arise in practice. Should the hedging programme cover all major crops, as in the Mexican case, its introduction could produce a small supply response for any one commodity as the estimate assumes. The implication that farmers are able to grow more than one crop, however, also suggests that the private benefits of hedging might be meagre. Diversified production provides some natural hedging against individual price shocks - a consideration suggesting that risk sensitivity in these circumstances need not be especially high.

The more favourable case from the viewpoint of the scheme might be envisaged from the individual crop example in Figure 1. At this level, a key determinant of supply response will be the opportunity cost of increasing yields as resources are switched from alternative crops. A farmer for whom crop specialisation is potentially worthwhile will presumably face a relatively small opportunity cost in these terms. Specialisation, however, leads to increased exposure to price risk and suggests that the hedging facility would then be willingly adopted. Tentative evidence will be provided below that these were, indeed, the characteristics of farmers who have adopted the Mexican scheme.

While these examples suggest that hedging subsidies may be of limited value to a diversified farmer, and unnecessary for a specialised producer, a more formal argument deriving from the equilibrium position depicted in Figure 1 provides insight into the farmer's likely evaluation of the hedging opportunity. Evidence on the probable (actual) evaluation of risk by a commercial farmer lacking access to futures markets (as distinct from the break-even marginal risk evaluations in Table 1) could be compared with the cost of the market hedge. Inertia would suggest a substantial excess of the former over the latter. A yardstick measure for the farmer's cost of risk deriving from equation (4) above is as follows. From the exponential utility function assumed in the specification of that equation the coefficient of relative risk aversion (R) may be defined conventionally as:

$$R = \lambda \pi \qquad (8)$$

The objective function in equation (4) implies that the farmer maximises expected income with a deduction for the cost of risk:

$$Max\left(\bar{\pi} - \frac{\lambda}{2}\sigma_{\pi}^{2}\right) \equiv Max(\bar{\pi} - \rho) \qquad (9)$$

Using these definitions, the relative cost of risk may be expressed as a fraction of expected net income as follows:

$$\frac{\rho}{\bar{\pi}} = \frac{R}{2}\frac{\sigma_{\pi}^{2}}{\bar{\pi}^{2}} = \frac{R}{2}(v)^{2} \qquad (10)$$

Whereas the earlier analysis implicitly assumed that farmers were characterised by constant *absolute* risk aversion, a more general assumption in the literature is of constant *relative* risk aversion with the coefficient (R) thought empirically to be around two. If this typical value is adopted, the relative cost of risk as defined in equation (10) is equal to the square of the coefficient of variation (v) for a farmer depending for all income on a single crop (Kletzer *et.al.*, 1992). Continuing to abstract from quantity variability, the coefficient of variation for the monthly spot price of corn over the period between January 1991 and July 2001 was approximately 24 per cent - implying a relative cost of risk of 5.7 per cent (of expected income). This estimate is both very much lower than any of the break-even marginal risk evaluations reported in Table 1 and strikingly close to the fraction of the futures price typically represented by the (unsubsidised) premium cost reported earlier. As an alternative to explanations related to inertia these calculations suggest that relatively low up-take of a hedging programme might be linked more to the comparatively marginal benefits anticipated from participation. The subsidies would therefore encourage involvement but the production consequences would be unlikely to offset appreciably the cost of the programme.

Whereas the analysis has cast doubt on the case for subsidisation in the context of the introduction of a hedging scheme, the facility in itself could yield important benefits if it were to replace the alternative of crop diversification for farmers otherwise inclined to specialise. The rather indirect evidence gathered below suggests that this may have been an aspect of the introduction of the Mexican programme.

5. Participating farmers: who hedges?

Setting aside the unfavourable social benefit-cost assessment, the estimated private benefit from hedging suggests that the subsidy element of the programme is likely to be important in determining the degree of participation by farmers. With recent data suggesting a quickening of interest it is worthwhile to enquire into the context of this hedging activity. While reference has been made to the small fraction of Mexico's corn crop that is currently hedged it is necessary to qualify somewhat the impression of the scheme's marginal role in the country's agriculture.

The Mexican crop is dominated by white corn destined for human consumption, with the typical fraction recently reported to be around 95 per cent (ASERCA 2003a). Nevertheless the yellow variety is in increasing demand, primarily for animal feed, and around eighty per cent of the output of this variety concentrated in the north of the country. The northern states of Baja California, Guanajuato, Jalisco, Nayarit, Sinaloa, Sonora, South Baja California, Tamaulipas and Veracruz, are distinguished from the rest in containing most of the irrigation-dependent commercial farms (SAGAR, 1999). This feature is important in accounting for their relatively high productivity. Against an overall national corn yield of 2.58 metric tons per hectare in 2000-2002, the yield in these states (weighted by hectares harvested) was 3.8 (calculated from Zahniser and Coyle, 2004, Appendix Table 2). ASERCA data, moreover, indicate that approximately 70 per cent of participating producers over the period 1994-9 were located in the northern states. The contrast with this relatively dynamic setting is provided at the national level by the typical farm of less than five hectares, where only nine per cent have access to irrigation (*ibid* p.6).

White corn production is clearly a subsistence crop for many producers and the comparative lack of attraction of hedging for this group is unsurprising. Much of its production is for own consumption and, where commercial output is involved, the available instruments are for the yellow variety. Basis risk of this type was not considered in the analysis above and its presence would, *ceteris paribus,* be expected to reduce the attractiveness of hedging for farmers with a marketable surplus of white corn. Adopting the extreme assumption that this consideration would prevent all participation by farmers of white corn, the earlier estimate that hedging covered approximately one per cent of national corn output in the late 1990s could imply that more than 20 per cent of the yellow crop was so insured.

This estimate must be regarded as highly tentative in the absence of relevant data but the general implication that the main beneficiaries from hedging subsidies are the relatively prosperous commercial farmers in the northern yellow corn regions raises the question of the motivation for the programme. Some insight is available from the trends summarised in Figure 2, which reports FAO[6] data for total corn production and imports (right vertical scale) in metric tons over the years 1980-2002.

FIGURE 2

The implementation of the NAFTA treaty in January 1994 marked (together with the introduction of the scheme) the beginning of a period of stagnation following the production expansion that had occurred after 1989. While imports have proved erratic, their main feature is their increased relative importance in the NAFTA years. Representing approximately 15 per cent of domestic production in 1994-5, the figure has risen subsequently to around 30 per cent. Despite this significant development, it is striking that the cost advantage of US farmers has not led to a reduction of Mexican production below its 1994 levels. The explanation for this resilience appears to lie in the transitional provisions of the NAFTA treaty and in the associated support measures introduced by the Mexican authorities.

Reflecting its importance in the country's agriculture the 14-year transitional period to the full introduction of free trade in corn on January 1st 2008 was the longest in the agreement, (Zahniser and Coyle *op.cit.* p.2). The transition regime involved an initial

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[6] FAOSTAT data 2004
http://apps.fao.org/faostat/collections?version=ext&hasbulk=0&subset=agriculture

2.5 million ton import quota (for 1994), which was scheduled to rise by three per cent per year until the 2008 deadline. Nevertheless, the authorities have often chosen to permit larger import volumes in order to supplement inadequate domestic production (*ibid* p.4).

Whereas the free trade provisions of NAFTA have been delayed, the authorities were required at the outset to eliminate guaranteed prices for corn and other staples. In their place, the government has instituted the Programmme of Direct Support for Agriculture (PROCAMPO). Under these provisions, farmers receive direct cash payments per hectare of 'eligible' land (that used for crop production in the crop cycle 1990-93) (*ibid.* pp.7). Although PROCAMPO is the most expensive of the support measures, others supplement it and it is probably in this political light that the (relatively minor) hedging subsidies should be seen. Zahniser and Coyle note, for instance, that 38 per cent of the Direct Support Subprogramme (relating to marketing costs) went to farmers in the northwestern state of Sinaloa. The state produces 42 per cent of the corn grown on irrigated land in Mexico and farms have comparable production technology to those in the USA (pp.8-9). Since such support relates to commercial, rather than subsistence activity, the beneficiary bias of this programme may well reflect that arising from the hedging subsidies.

Conclusions

The general conclusions from this analysis of the Mexican hedging programme are readily summarised. Low utilisation appears not to reflect (irrational) inertia on the part of farmers that prevents major (private and public) gains from being realised. A conventional approach to their measurement revealed instead that hedging costs were quite close to the farmers' estimated 'price' of risk bearing, even for specialised growers. While subsidies clearly improve the position of these individuals, and their participation has been increasing accordingly, they do not yield an equivalent increase in production gains. More specifically, the price of risk estimate was substantially below that which would be 'necessary' to produce these gains after the introduction of the scheme.

Commercial farmers most in a position to benefit from the subsidy scheme (and to raise output as a result) are increasingly making use of it. Located mainly in the northern states, a practical implication of the analysis is that the subsidies have amounted to cash support for this relatively favoured group. Poorer farmers concentrated in the southern states, by contrast, have been largely bypassed, as also appears to be the case with other marketing-related supports. While programmes aimed directly at the needs of small growers would seem more appropriate in principle, the apparent political imperative to support domestic production in the presence of rising import penetration has tended to bias support in favour of larger commercial units. It should, of course, be stressed that part of this need arises because of the substantial aid provided by the US authorities to corn farmers in that country.

A final dimension of the hedging programme, as part of a much wider framework of cash transfers in Mexico, presents a less familiar aspect of agricultural support policies in international terms. The introduction of the NAFTA regime was followed at the end of 1994 by the Tequila crisis and the subsequent collapse of domestic bank intermediation. Farming was adversely affected by these developments and it has been suggested that, for instance, PROCAMPO payments act to support agricultural activity in these circumstances (Sadoulet *et.al.* 2001). From a similar perspective, it might be expected that farmers without access to credit would need to insure their cash flows from the current crop in order to underwrite subsequent production expense. If so, the hedging programme is substituting for the lack of domestic financial support. The re-establishment of bank lending could help to offset the political difficulty of ending the hedging subsidy programme.

Appendix A: derivation of the break-even quantity expression (Equation (7)

The expected crop price received by the farmer, P', will equal the expected market price less a (net of subsidy) fraction, $0<\alpha<1$, of the option premium, p. That is: $P' = \overline{P} - \alpha p$. The farmer's supply elasticity is defined in relation to a point like C in Figure 1:

$$\varepsilon = \frac{\left(P' - \Delta P\right)}{Q_1 - \Delta Q} \times \frac{\Delta Q}{\Delta P}, \text{ or } \varepsilon \Delta P = \frac{\left(P' - \Delta P\right)}{\left(Q_1 - \Delta Q\right)} \times \Delta Q\,.$$

Defining, $\overset{0}{Q} = \dfrac{\Delta Q}{\left(Q_1 - \Delta Q\right)}$, it follows that $\varepsilon \Delta P = \left(P' - \Delta P\right)\overset{0}{Q}$ and therefore

$\Delta P = \dfrac{P'\overset{0}{Q}}{\left(\varepsilon + \overset{0}{Q}\right)}$. Similarly, $\Delta Q = \overset{0}{Q}\left(Q_1 - \Delta Q\right)$, and $\Delta Q = \dfrac{\overset{0}{Q}\,Q_1}{\left(1 + \overset{0}{Q}\right)}$.

Defining area of triangle *ABC* in Figure 1 as $A = \frac{\Delta P \Delta Q}{2}$ and substituting the above expressions for changes in price and quantity:

$$A = \frac{P' \overset{0}{Q}}{\left(\varepsilon + \overset{0}{Q}\right)} \times \frac{\overset{0}{Q} Q_1}{\left(1 + \overset{0}{Q}\right)} \times \frac{1}{2},$$

A positive social return requires:

$\frac{P' Q_1 \overset{0}{Q}{}^2}{2\left(\varepsilon + \overset{0}{Q}\right)\left(1 + \overset{0}{Q}\right)} \geq (1-\alpha) p \left(Q_1 - \Delta Q\right)$, where the right side is the value of the subsidy paid by the scheme for the pre-scheme crop. Substituting out ΔQ from this inequality using the identity $\Delta Q \equiv \frac{Q_1 \overset{0}{Q}}{(1 + \overset{0}{Q})}$ yields, with use of the quadratic formula:

$$\overset{0}{Q} = \frac{(1-\alpha)p}{P'} + \left\{ \left[\frac{(1-\alpha)p}{P'} \right]^2 + \left(\frac{2(1-\alpha)p\varepsilon}{P'} \right) \right\}^{1/2}$$

For a subsidy of fifty per cent, (1-α)=0.5, this expression becomes Equation (7) in the text. The alternative estimates in Table 1 were for a value of (1-α)=0.25.

Appendix B: data sources and procedures

Spot and futures corn prices: The data used were seasonally adjusted monthly averages derived from daily quotes on the Chicago Board of Trade and originally supplied by the Futures Industry Institute. Data from this source for the period 01/01/1995 to 31/09/1999 were also used to construct a series for put option prices. An interpolation methodology was required in order to avoid the discontinuities problem that tends to arise when time series for futures prices must be based on different contracts (Wei and Leuthold: 1998).

Interpolation procedure for futures prices

In order to avoid such unrealistic estimated futures price 'jumps', daily synthetic futures prices for a constant time to maturity were created. The procedure involves interpolation from the futures prices quoted for two contracts with the closest maturities to either side of the desired constant value (set at 91 days)[7].

Futures option put premium series

Monthly put prices were calculated from CBOT-supplied daily prices for near-to-expiration futures options (puts) taking at-the-money (or closest to at-the-money) values. The futures (put) option strike price was therefore matched against the futures price of the futures contract closest to maturity to ensure that the option was at-the-money (equal) or the closest to at-the-money (almost equal). When the option was fifteen trading days close to expiration the put premium was obtained from the next (in calendar) futures option contract. This was intended to avoid volatility bias due to the time to expiration phenomenon (Figlewski: 1997).

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[7] The futures contracts for corn have the following delivery months: March, May, July, September and December.

A detailed explanation of the interpolation and seasonal adjustment procedures employed in the research underlying this study is available from the authors on request.

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FIGURE 2: MEXICAN CORN PRODUCTION AND IMPORTS