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Approximating supply response of a commodity with limited input data

The case of Australian bananas

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In numerous agricultural industries in Australia there is a paucity of data on levels of individual input use and prices paid by producers. This presents a major hurdle to obtaining rigorous estimates of producer responses in agricultural industries, particularly at a regional level. It is not surprising, then, that there has been relatively scant research in this area especially for smaller industries.

Yet producer responses to policy actions that affect prices received or cost of production is central to estimating the impacts on industries of such policies.

The Australian banana industry is an example where neither the time series data necessary for estimating grower responses nor the detailed cross sectional data on individual inputs are readily available to enable econometric estimation of producer response to price or cost changes.

In this paper a calibration method of a CES production function, based on cost shares of variable and fixed inputs in total production cost, is used to approximate regional supply elasticities for banana growers in Australia. Although this approach to estimation may not be the ideal, it appears to produce plausible results.

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Introduction

In a policy formulation context, prior knowledge of growers' supply response behavior is most relevant as it directly relates to the potential impacts of policies and actions that affect producer costs and prices. However, given the complex nature of supply in agriculture, empirical estimates of the supply relationships for agricultural commodities are generally fewer than those for demand response, and for many small industries are nonexistent.

Nevertheless, some measure of producer supply response is indispensable if the potential impacts of alternative policies or the adoption of new technologies on agricultural industries and the economy are to be properly assessed. Some studies use supply parameters obtained from the literature where they are available, while others have assumed a range of elasticities in the absence of previous estimates. James and Anderson (1998) assumed a range of long run supply elasticities (0.5, 1.0 and greater) for banana production in Australia. Although these extrapolations and assumptions for supply response parameters may be sufficient in informing policy decisions in some instances, they may not be in others — for example, where a policy impact is likely to be sensitive to small changes in supply elasticity.

In an attempt to obtain a reasonable quantitative estimate of the supply elasticities, while sidestepping the complexity and costs in time and resources associated with an econometric approach, a calibration procedure to approximate these elasticities from relative shares of primary inputs in a chosen production process is presented.

A constant elasticity of substitution (CES) production function was chosen to represent input relationships in the production process. This function can then be calibrated to cost shares in the base period assuming cost minimisation by producers in a competitive market who face fixed prices of variable inputs.

This procedure was applied to cost and price data for the Australian banana industry to approximate supply elasticities of banana growers nationally and at a regional level. The estimated supply parameters were then used to analyse potential impacts of a structural change that the industry might undergo as a result of the adoption of new cost saving production technology.

Calibrating for supply response

In the absence of econometric estimates of supply response parameters, a calibration procedure based on value shares of inputs in the cost production can be used to approximate supply elasticities.

However, by themselves, input cost shares do not contain any information on supply responsiveness to output price. Input cost shares for a base year only provide information that allows calibration of a production function.

The production responsiveness to output price depends on the general form of the production function; the particular parameters of that function with respect to returns to scale and substitution between inputs; the input cost shares in the base year; and the fixity of any inputs in the timeframe considered for the production response. For example, if the production function is constant returns to scale and all inputs are variable and available at prices that are independent of quantities used, then the supply elasticity is infinite. This is independent of any input cost shares. Another example, if the production function is CRS and CES with a given elasticity of substitution, and if — apart from one fixed input — all inputs are variable and available at prices that are independent of quantities used, then the supply elasticity depends on knowledge of the elasticity of substitution and the cost share of the fixed input.

The suggested alternative approach in this analysis is based on an assumed CES form of the production function with variable and fixed factors in both the short and the longer term.

In this approach, labor cost is used as a proxy for the variable cost of production, while capital and all other costs are taken as fixed in the short term.

In a two factor constant elasticity of substitution production function with labor as the variable factor (with share in total cost of θ_L) and with capital and other costs being the fixed factor (with share in total cost of θ_F), the sum of θ_F and θ_L equals 1. Assuming zero pure profit at equilibrium — that is, production costs per unit equate at the margin with the national producer price — an expression for the short run supply elasticity for a commodity produced in a sector or a region can be derived from the dual cost function as:

[1] $$\varepsilon = \frac{\sigma\theta_L}{1-\theta_L}$$

where σ is the elasticity of substitution. With σ equal to 1 in a Cobb-Douglas formulation, the elasticity expression becomes:

[2] $$\varepsilon = \frac{\theta_L}{1-\theta_L}$$

Variants of the derivation of the supply elasticity, based on a CES production function and using base year shares in production costs of variable and fixed factors, from the cost function are presented in Rutherford (2002), Horridge (2000) and Borrell and Hanslow (2004). That presented in Rutherford (2000) is provided in box 1.

Longer term supply response

With the passage of time, the supply of a commodity could be expected to become increasingly elastic as growers adjust a growing proportion of those costs that tend to be fixed in the short term. Much of the adjustment could be expected to be in material input and in the amount of capital invested in the production of the particular commodity. Reflecting this notion, a proportion of growers' real capital investment each year (assumed in this exercise to be equivalent to a declining balance depreciation rate) becomes variable in the following year.

The basic procedure used to estimate the supply elasticity in the short run is also followed in estimating the supply elasticity in the long run. Instead of the two-factor production function used in approximating short run supply elasticity, a three factor production function is used to derive long run supply response. As in [2] above, we assume a Cobb-Douglas specification for the production function, not only in the base year but in each subsequent year. While total cost remains the same, this is simply achieved by splitting the short run fixed cost into two components. One component, constituting capital investment and other material inputs, is variable in the long run; while the other, primarily land, is fixed both in the long and short run. Equation [2] could be rewritten for supply elasticity in each year as:

[3] $$\varepsilon_t = \frac{\theta_L + n\partial\theta_K}{\theta_F - n\partial\theta_K}$$

Or

$$= \frac{\theta_L + n\delta\theta_K}{\theta_D + \theta_K(1 - n\partial)}$$

Where θ_D and θ_K are the cost shares of land and capital respectively, which together equal θ_F; δ is the proportion of the capital share that will become variable each year; and *n* is the length of time period in years.

Box 1: Derivation of supply elasticity — Rutherford (2000)

Assume a CES production function in labor and capital. Output price at equilibrium is defined as $p = c(r, w)$; where w is the exogenous wage rate, r is the return to the fixed factor, capital. With zero profit, the underlying cost function is of the form:

$$c(r, w) = [\theta_F r^{1-\sigma} + \theta_L) w^{1-\sigma}]^{\frac{1}{1-\sigma}}$$

θ_F, θ_L and σ are as defined above. The product output q, the supply of the fixed factor $\overline{K}$, and the return to the fixed factor in the short term are linked by shepherd's Lemma such that:

$$q \frac{\partial c(r, w)}{\partial r} = \overline{K}$$

The calibration procedure, once values for cost shares and σ are known, constitutes solving for the supply elasticity, ε, at the benchmark equilibrium such that:

$$\varepsilon = \frac{\partial q}{\partial (p/w)} \frac{(p/w)}{q}$$

By choosing units of the fixed factor such that its price at the benchmark is 1, the fixed factor share also determines the factor supply:

$$\overline{K} = \theta_F \overline{q}$$

where the benchmark price of output is unity. If the ratio of output price and the price of the variable factor changes from its benchmark value, an expression for the return could be obtained by inverting the supply constraint for the fixed factor and substituting the equilibrium price for the cost function:

$$r = p\left(\theta_F q / \overline{K}\right)^{\frac{1}{\sigma}}$$

Substituting back into the cost function gives:

$$p^{1-\sigma} = p\left(\theta_F q / \overline{K}\right)^{\frac{1-\sigma}{\sigma}} + \theta_l w^{1-\sigma}$$

Or

$$q = \overline{K} \theta_F^{\frac{1}{1-\sigma}} [\theta_L (w/p)^{1-\sigma}]^{\frac{\sigma}{1-\sigma}}$$

Differentiating with respect to p and setting all prices equal to 1, we get an expression for short run supply elasticity for a commodity produced with a CES production function as:

$$\varepsilon = \frac{\sigma \theta_L}{1 - \theta_L}$$

With σ equal to 1 in a Cobb-Douglas formulation, the elasticity expression becomes:

$$\varepsilon = \frac{\theta_L}{1 - \theta_L}$$

Each year, the estimated elasticity is higher than in the preceding year as a result of a combination of increases in the share of variable costs and parallel reductions in the share of fixed costs. Theoretically, and in accordance with the assumption that land is also substitutable in production, all fixed factors could be varied at some point in the future, with the long run supply becoming perfectly elastic. Also, with the assumption of a variable factor in land, the estimated annual supply elasticities would be higher than those presented in this paper.

In some studies (Higgs 1986), the process is assumed to continue until all costs other than land become variable, with the ratio of these costs to the cost of land representing supply elasticity (ε_l) in the longer term. That is, as n increases, the term $n\delta$ goes to 1 and equation [3] is reduced to:

[4] $$\varepsilon_l = \frac{\theta_L + \theta_K}{\theta_D}$$

For the purpose of this analysis, a period of ten years was assumed to be sufficient to enable most of the adjustment in an industry to occur following a policy change or the adoption of new technologies that result in changes in prices or production costs. The estimated elasticity at the end of ten years can be assumed in most cases as reasonably representative of the longer term elasticity of supply in an industry.

Australian bananas: A case study

Because the Australian banana industry is located primarily in two main areas — north Queensland and the north coast of New South Wales — with quite different production environments, both national and regional supply elasticities for bananas were estimated. The estimated elasticities are expected to be useful in analysing the impacts of new technologies or possible policy actions on the industry. For example, analysis of policies affecting the cost structure of production, such as responses to disease outbreaks (cost increasing) or the adoption of (cost saving) technical changes would be facilitated.

The elasticities estimated in this study were used to assess the potential economic impacts of a cost saving technological change in the banana industry.

Overview of the Australian industry

Australian bananas are sourced from six producing regions in Queensland, New South Wales, Western Australia and the Northern Territory. Regional differences in climatic conditions, soil type and topography have contributed to variations in production and industry structure across the country.

Queensland is by far the largest producer of bananas, with average production of about 284 000 tonnes in 2001 and 2002. This output represented almost 85 per cent of total Australian production. The north Queensland area (around Tully and Innisfail) is the most dominant region of banana production in Australia, supplying around 80 per cent of national output.

The other 20 per cent of Australian banana production comes mostly from the coastal regions of northern New South Wales (the Tweed, Coffs Harbour, Byron, Lismore and Nambucca), south east Queensland, Carnarvon and Kununurra regions in Western Australia and the Darwin region in the Northern Territory. Of this group, New South Wales produces 60 per cent (around 12 per cent of national production.)

In the three years to 2002-03, Australia produced an average of around 310 000 tonnes of bananas a year, from about 12 000 hectares. Nationally, the average gross value of bananas produced in Australia in the three years to 2002-03 was an estimated $382 million a year at wholesale. After marketing costs are deducted, the growers' share, estimated at $277 million, represented nearly three quarters of this amount.

Industry costs structure at regional level

The Australian banana industry, like many other agricultural industries, has been undergoing significant structural change over recent years as holdings have become larger to take advantage of economies of size inherent in larger scale operations. Beneath the aggregate trends lies a wide disparity between regional banana industries.

Regional variations are evident in both the structure of production and the pace of consolidation within each industry. This is reflected in the average farm size and the number of banana growing establishments over time in each state. In 1997, the average bearing area of banana farms was 13 hectares in Queensland and 5 hectares in New South Wales. While the banana industries in all states have been restructuring toward larger size holdings, the greatest increases in farm size occurred in Queensland, where the average size of holdings by 2002 had increased by 76 per cent to 23 hectares. The rate of increase in the average size of farms in New South Wales was less than half the rate realised in Queensland.

An analysis of the banana industry in north Queensland (Department of Primary Industries 1999) provided detailed estimates of the investment required and the ongoing costs of banana growing. These estimates have been used in this study as the base for generating banana supply response parameters for Queensland and New South Wales. The supply response parameters presented in the next section are based on the assumption that the composition of total costs of production has remained largely within the range reported in the 1999 Queensland Department of Primary Industries study.

A survey of a sample of growers in Queensland and New South Wales for the period 1996–98 (Resource Consulting Services 1999) estimated labor cost in banana production in New South Wales at more than double that in north Queensland.

Based on the cost data presented in these studies, value shares of different input use in banana production for north Queensland and the rest of Australia (represented by New South Wales) regions were obtained (table 1).

Table1: Input cost shares in banana production, New South Wales and north Queensland

		New South Wales	North Queensland
Unit cost = price	$/t	946	946
Cost shares			
Labor	%	46	20
Plantation management	%	21	41
Capital	%	7	17
Land	%	21	16
Other	%	05	6

Method and analysis

To estimate potential economic consequences of technical or regulatory actions for a domestic agricultural industry, such as the banana industry, it is necessary to first determine plausible demand and supply parameters for the Australian market. In addition, a number of market variables are needed. These include current prices and quantities in the domestic market and potential post-policy prices.

The situation against which the impacts were measured is represented by the current market equilibrium. That is, prevailing quantities and prices in the domestic market in the absence of policies and technologies were used as the base against which changes resulting from a possible structural change were assessed.

Estimates of supply and demand parameters together with market variables for the banana industry were used in a partial equilibrium model to estimate the potential economic impacts of a change in production structure (quantities, prices and welfare, as deviations from the current 'no change' situation).

Supply response estimates

With Australian banana growing concentrated in two main regions (north Queensland and New South Wales) the responses of each region's producers to changes in either prices received or costs of production would likely differ, reflecting different production structures in the regions. This means that potential impacts of similar policy actions or technological changes would also be different.

To gauge differential regional impacts, production response parameters in north Queensland and New South Wales (the latter representing production elsewhere in Australia as well) were derived. Supply elasticities were estimated by substituting factor shares in table 1 for the relevant parameters in the calibration procedure outlined earlier.

Labor costs were used as a proxy for the variable costs of production, while capital and other costs (including land and management) were taken to represent fixed costs. The supply elasticity for each time period at the national level was obtained from the regional estimates, each weighted by the corresponding region's share of national production.

The estimates of supply elasticity over time are presented in table 2. In the short term (the first year), banana supply in north Queensland is estimated to be less responsive to price changes than is supply in New South Wales (and the rest of Australia). A 10 per cent change in the price received by banana growers is estimated to result in a 2.7 per cent change in the same direction in the volume of bananas produced in north Queensland, and a 9.3 per cent change in the volume of the fruit produced in New South Wales. For Australia as a whole, supply is estimated to change by 3.2 per cent for a 10 per cent change in price.

Over the longer term (greater than ten years), the responsiveness of supply to a sustained change in prices received is estimated to be much greater. For a sustained 10 per cent change in the farm price of bananas, the volume of the fruit produced in north Queensland is estimated to change by 11.3 per cent in the same direction over the longer term. The change in supply is estimated to be 17.5 per cent in New South Wales and 12.3 per cent for Australia as a whole. The greater responsiveness of supply over the longer term reflects the fact that producers are more willing and better able to adjust

the amount of resources devoted to a farm activity the longer that the changed market environment persists.

Table 2: Supply elasticities for Australian bananas [a]

Year	New South Wales	North Queensland	Australia
1	0.93	0.27	0.32
2	1.02	0.35	0.40
3	1.12	0.44	0.50
4	1.23	0.54	0.61
5	1.32	0.63	0.71
6	1.41	0.73	0.80
7	1.49	0.82	0.91
8	1.58	0.92	1.01
9	1.66	1.03	1.12
10	1.75	1.13	1.23

a Percentage change in the volume of bananas produced following a 1.0 per cent change in the price received by growers.

Demand for bananas

Although it is generally understood from previous empirical evidence that demand for bananas is price inelastic, no recent estimates of the price elasticity of demand in the Australian market are available. Stuckey and Anderson (1974) estimated a price elasticity of demand for bananas in Australia of –0.39. In estimating the welfare effects of allowing banana imports into Australia, James and Anderson (1998) argued that it was possible that demand had become more responsive to price changes since the earlier study, owing to the increasing availability and range of food substitutes. Reflecting this view, the authors used a price elasticity of demand of –0.5 in their 1998 analysis.

In choosing an appropriate demand elasticity to use in the present study, several other studies of demand were examined. It was found that demand for bananas in other developed countries also appears to be largely inelastic. Gaviria (2002) and the University of Florida (2002) estimated the demand elasticity for bananas in a number of countries and regions. For example, estimated demand elasticity for the United States was –0.85 and –0.41 in the two studies respectively. For the purposes of the present study, a price elasticity of demand of –0.60 was assumed for bananas in Australia — that is, for a 10 per cent change in the price of bananas, consumption will change by 6 per cent in the opposite direction. The demand elasticity chosen is a little higher than that assumed by James and Anderson, but is consistent with their view of increasingly elastic demand over time, and approximately midway between the two estimates for the United States.

Effects of a technical change

Using the above parameters, a scenario was constructed for the banana industry in Australia to illustrate the potential effects of a hypothetical change in production costs. The scenario simulates the effect of a shift in supply, emanating from a cost saving technological change, other factors remaining constant. Implications of a 10 per cent shift in supply as a result of a resource augmenting technological change were assessed. Current prices and quantities (benchmark) as well as the assumed supply shift are presented in table 3.

Table 3: market quantities and prices prior to a regulatory policy or a technical change

Pre policy equilibrium quantity	kt	290
Producer price/cost	$/tonne	946
Supply shift from a cost reducing technical change	%	10

The standard functions for supply and demand are expressed as

[4] $$Q_S = \alpha P_p^{\varepsilon}$$

[5] $$Q_D = \beta P_c^{\eta}$$

where Q_S and Q_D are quantities supplied and demanded respectively, P_p and P_c are producer and consumer prices, ε is the price elasticity of supply and η the price elasticity of demand. α and β are constants.

At market equilibrium, the quantity supplied equals quantity demanded and the price paid by consumers and that received by producers are equated at the market clearing level. In the base equilibrium:

[6] $$Q_0 = \alpha P_0^{\varepsilon} \quad \text{(Supply)}$$

$$= \beta P_0^{\eta} \quad \text{(Demand)}$$

With the proportional shift in supply (denoted as *k*), the new equilibrium quantity is given by:

[7] $$Q_1 = (1+k)\alpha P_1^{\varepsilon} \quad \text{(Supply)}$$

$$= \beta P_1^{\eta} \quad \text{(Demand)}$$

where Q_1 and P_1 are the equilibrium quantity and price after the technological change. From equation [7], α and β can be computed in terms of equilibrium price and quantity as:

$$\alpha = \frac{Q_1}{(1+k)P_1^{\varepsilon}} \quad , \quad \text{and}$$

$$\beta = \frac{Q_1}{P_1^{\eta}}$$

Substituting the value for α in the supply and for β in the demand function of [6] yields:

[8] $$Q_0 = \frac{Q_1}{(1+k)P_1^{\varepsilon}} P_0^{\varepsilon} = \frac{Q_1}{P_1^{\eta}} P_0^{\eta}$$

Or $$\frac{Q_1}{(1+k)P_1^{\varepsilon}} P_0^{\varepsilon} = \frac{Q_1}{P_1^{\eta}} P_0^{\eta}$$

Rearranging [8] gives:

[9] $$P_1 = P_0 (1+k)^{\frac{1}{\eta-\varepsilon}}$$

And, with the right hand term of [8] equal to Q_0, yields:

[10] $$Q_1 = \left(\frac{P_1}{P_0}\right)^{\eta} Q_0$$

Once the new equilibrium prices, and thereby quantities, are determined following a technical change, this information could be used to estimate the potential impact of the technology on producers and consumers.

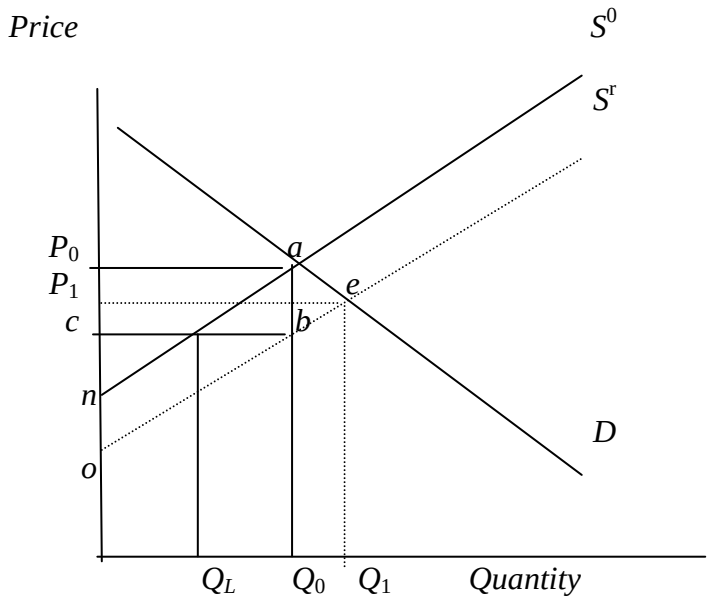
Distribution of benefits from technology induced supply shifts

In general, producers supply more of a commodity at higher prices and/or if improvements in production technology result in a lower cost of production. For ease of presentation, supply and demand schedules are taken to be linear in this section (rather than the nonlinear form in the preceding section) in the constant elasticity specification.

Initially, farmers produce along the supply curve S^0 in figure 1. D represents the domestic demand curve for the product. The intersection of the two curves, S^0 and D,

determines equilibrium market quantity and price before adoption of the cost saving technology, at Q_0 and P_0 respectively.

Figure 1: **Technology induced supply shift**



Technology adoption causes a shift in the supply curve from S^0 to S^r, but the demand curve remains at D — that is, for the case represented in figure 1, the innovation generates cost reductions but has no impact on product quality or other demand shifting factors.

Falls in prices caused by increased supply result in more of the product being demanded (along the downward sloping demand curve). The new market price is determined, at P_1, by the intersection of demand curve D and the new supply curve S^r. Cost savings per unit of production from adopting the technology are represented by *ab*, the vertical distance between the two supply curves, or by P_0c on the price axis. In comparison, the market price has fallen by P_0P_1. For producers, the fall in prices as a result of increased supply is more than compensated for by the decline in unit cost of production, indicating that not all cost savings are passed on to consumers.

In figure 1, producer surplus before and after the supply shift is represented by the area of triangles P_0an and P_1eo respectively. The change in producer surplus following the technological change is the difference between the areas of the two triangles (P_1eo less P_0an). With P_0c equals *ab* equals *on*, it follows that P_0an and *cbo* are equal. Therefore, the change in producer surplus is equal to P_1eo less *cbo*, or the area bounded by P_1ebc in the diagram. That is, producers receive a net gain of P_1c per unit of production up to

Q_0 and half that amount per unit for additional supply ($Q_1 - Q_0$). The change in producer surplus in each time period is calculated as:

$$\Delta PS = (K + P_1 - P)[Q_0 + 0.5(Q_1 - Q_0)] \text{ , or}$$

$$\Delta PS = 0.5(K + P_1 - P)(Q_0 + Q_1)$$

where P_1 is the equilibrium price with technology, P_0 is the equilibrium price without technology, Q_1 is the equilibrium quantity with the technology and Q_0 is the equilibrium quantity prior to the technical change. *K* translates the quantity shift into a per unit cost reduction along the price axis (Hafi, Reynolds and Rose 1995) — that is, the vertical shift in supply (= $ab = P_1c$) and can be approximated by:

$$K = \frac{k \times P_0}{\varepsilon} \quad *$$

where, as earlier defined, *k* is the percentage shift in supply quantity and ε the elasticity of supply.

Consumer gains are mainly driven by the fall in prices and higher consumption, with total gains represented by the area P_0aeP_1.

$$\Delta CS = (P_0 - P_1)[Q_0 + 0.5(Q_1 - Q_0)]$$

Or $$\Delta CS = 0.5(P_0 - P_1)(Q_0 + Q_1)$$

---

* As price and production costs equalise in equilibrium, a change in either has similar but opposite effects on the quantity supplied. From the diagram, the change in quantity and price (cost) can be related as:

$$\frac{Q_0 - Q_L}{Q_0} = \frac{P_0 - c}{P_0} \times \varepsilon$$

but $(Q_0 - Q_L)/Q_0$ equals the shift in supply, *k*, and $P_0 - c$ equals the reduction in unit cost, *K*. Substituting in the above equation gives:

$$K = \frac{k \times P_0}{\varepsilon}$$

The welfare impacts of equivalent rightward and leftward shifts in the supply curve would be similar in absolute magnitude (but of opposite signs), given the symmetry of response to movements in prices. That is, the above analysis is equally applicable to an upward shift in supply as a result of higher costs of production (for example due to pest or disease establishment) but with producers and consumers experiencing welfare losses instead of the gains they would achieve with a similar downward shift in the curve.

Results

Producer gains were estimated at different supply elasticities, assuming a 10 per cent shift in supply resulting from instantaneous adoption of a technological change. The elasticities correspond to those reported in table 2 for New South Wales and North Queensland.

It is evident from table 4 that, with a given shift in supply, the lower the producer response the higher the economic gains will be and vice versa.

Table 4: Economic effects of a 10 per cent shift in supply, with a demand elasticity of –0.6

	Producer benefit			Consumer benefit
Year	**New South Wales**	**North Queensland**	**Australia**	
	million	million	million	million
1	0.3	31.4	31.7	27.2
2	0.1	22.1	22.2	26.3
3	0.1	16.0	16.1	24.0
4	0.1	12.1	12.1	22.1
5	0.1	9.6	9.7	20.5
6	0.1	7.9	7.9	19.1
7	0.1	6.5	6.6	17.8
8	0.1	5.5	5.5	16.7
9	0.1	4.6	4.7	15.7
10	0.1	4.0	4.1	14.7

Like any adjustment, however, technology adoption occurs only gradually with full adoption expected to be realised only in the long run. With inelastic supply response for bananas in the short term, it is more likely that the estimated high benefits (lower elasticities) will be partly offset by lower rates of adoption in the short term.

Although the price elasticity of demand is assumed to remain constant, consumer surplus is also estimated to be lower the higher the supply elasticity, owing to the latter's influence on the equilibrium price. Moreover, simulating the scenario with a

lower price elasticity of demand resulted in lower producer gains and higher consumer benefits (table 5) compared with those realised under a more elastic demand.

Table 5: Economic effects of a 10 per cent shift in supply, with a demand elasticity of –0.3

	Producer benefit			Consumer benefit
Year	**New South Wales**	**North Queensland**	**Australia**	
	million	million	million	million
1	−1.0	25.6	24.6	40.0
2	−1.1	16.8	15.7	38.0
3	−0.9	11.8	10.9	33.5
4	−0.7	8.7	7.9	29.7
5	−0.6	6.8	6.2	27.0
6	−0.5	5.4	4.9	24.6
7	−0.4	4.4	4.0	22.6
8	−0.3	3.7	3.3	20.8
9	−0.3	3.1	2.8	19.2
10	−0.2	2.6	2.4	17.8

Concluding remarks

In general, the uptake of technological innovations in production systems is not costless and accordingly the rates of adoption differ among producers depending on their ability and preparedness to adopt the new technology. Although the production sector would, in aggregate, benefit from a cost reducing technical change, there are likely to be losers and winners among individual producers or producer groups. The losers may include two main groups:

- Those who, because of the nature their production structure or for some other reason, are unable to adopt the cost reducing new technology. With product prices now lower following technology adoption elsewhere, this group still incurs the pre-technology cost of production.
- The second group constitutes those with low adoption rates compared with the industry average. Producers in this category are likely to experience a loss if their adoption rates of the technology (and consequently declines in unit costs) were too low to offset the general declines in market prices as a result of higher supply. This is demonstrated by results for New South Wales.

In summary, it has been shown that, following input augmenting technical change in production of agricultural commodities, aggregate gains to producers and consumers depend importantly on the magnitudes of the price elasticities of supply and demand. The relationship is such that the lower the supply elasticity and the higher the elasticity of demand the greater are the producer gains and the lower the gains to consumers.

A main conclusion that could be drawn from this information is that prior knowledge of supply and demand parameters could be a crucial element in allocating funds for research and development. It would be more feasible for industries' and growers' representative groups to direct a major part of their productivity enhancing research toward products with inelastic supply and more elastic demand. In contrast, there seems to be a strong case for government contributions to research and development for commodities with relatively higher supply elasticities and/or lower elasticities of demand, reflecting larger consumer gains that could be obtained from improvements in the production process.

It must be noted that in conducting cost benefit analysis to determine the feasibility of a technical innovation, the cost of research and development of the technology needs to be taken into account.

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