Kiel Institute of World Economics
Duesternbrooker Weg 120
24105 Kiel (Germany)

Kiel Working Paper No. 1016

Estimating the Aggregate Agricultural Supply Response: A Survey of Techniques and Results for Developing Countries

by
Rainer Thiele

December 2000

Estimating the Aggregate Agricultural Supply Response: A Survey of Techniques and Results for Developing Countries

Abstract

For many low-income countries, the impact of structural reforms on economic growth and poverty alleviation crucially depends on the response of aggregate agricultural supply to changing incentives. Despite its policy relevance, the size of this parameter is still largely unknown. This paper discusses the different approaches which may be employed to quantify the agricultural supply response. It turns out that none of these approaches is likely to deliver unbiased estimates. While in cross-country regressions the problem of unobserved country characteristics cannot be fully eliminated, time-series estimations tend to suffer from the Lucas critique. Any comprehensive empirical analysis should thus rely on more than one technique in order to check the robustness of results.

Keywords: agricultural supply response, cross-country regressions, Nerlove method, co-integration, dynamic general equilibrium analysis.

JEL–classification: C21, C22, D68, Q11

Rainer Thiele
Kiel Institute of World Economics
24100 Kiel, Germany
Telephone: 0431–8814215
Fax: 0431–8814500
E-mail: r.thiele@ifw.uni-kiel.de

For helpful suggestions I thank Rolf J. Langhammer and Rainer Schweickert. Financial support from the German Science Foundation (DFG) is gratefully acknowledged.

CONTENTS

I. THE ISSUE

One of the most influential policy prescriptions for low-income countries ever given by development economists has been to foster industrialization by withdrawing resources from agriculture (e.g. Lewis 1954). There is robust evidence that the majority of policy makers followed this prescription at least until the mid-1980s. The results of a comprehensive World Bank study (Krueger et al. 1992), for example, show for the period 1960–85 that in most countries examined agriculture was taxed both directly via interventions in agricultural markets and indirectly via overvalued exchange rates and import substitution policies (Table 1). The only exceptions from this finding were some middle-income countries, while the Sub-Saharan African sample countries appeared to be the heaviest taxers with total tax rates of about 50 percent. Whether the disincentives for agricultural production have continued to exist since the mid-1980s is not that obvious. On the one hand, most developing countries have adopted structural adjustment programs which explicitly aim at a removal of the direct and indirect discrimination against agriculture. But, on the other hand, it is known that many of these programs were not fully implemented, especially in Sub-Saharan Africa (Kherallah et al. 2000; Thiele and Wiebelt 2000; World Bank 1997). Hence, it seems safe to conclude that a certain degree of discrimination still prevails. The discrimination is probably compounded by poor public service delivery for rural areas (e.g. Platteau 1996), although this proposition has not yet been empirically validated.

Table 1 — Direct and Indirect Protection of Agriculture (period averages in percent), 1960–1985

Country	Direct Protection	Indirect Protection	Total Protection
Ghana	–26.6	–32.6	–51.6
Côte d'Ivoire	–25.7	–23.3	–49.0
Zambia	–16.4	–29.9	–46.3
Egypt	–24.8	–19.6	–44.4
Sri Lanka	–9.0	–31.1	–40.1
Thailand	–29.1	–15.0	–40.1
Dom. Rep.	–18.6	–21.3	–39.9
Pakistan	–6.4	–33.1	–39.5
Argentina	–17.8	–21.3	–39.1
Morocco	–15.0	–17.4	–32.4
Turkey	5.3	–37.1	–31.8
Colombia	–4.8	–25.2	–30.0
Philippines	–4.1	–23.3	–27.4
Chile	–1.2	–20.4	–21.6
Malaysia	–9.4	–8.2	–17.6
Brazil	10.1	–18.4	–8.3
Portugal	9.0	–1.3	7.7
Korea, Rep. of	39.0	–25.8	13.2
Sample Average	–7.9	–22.5	–30.3

Source: Schiff and Valdés (1992).

The central question then is: to what extent does the discrimination against agriculture hamper economic development given that the sector accounts for a large share – one third on average, but sometimes over 50 percent – of total value added in low-income countries? The answer to this question crucially depends on whether a dynamic response of agricultural supply can be expected if incentives are changed to the better. Regarding the size of the agricultural supply response in developing countries, three different hypotheses have been put forward:

(i) Appropriate (direct and indirect) price incentives alone would foster agricultural development, i.e. the price elasticity of supply is high (e.g. Krueger et al. 1992);

(ii) Non-price factors, such as an unreliable rural infrastructure and limited access to credit, are the main bottlenecks for agricultural development, i.e. the supply elasticity with respect to non-price factors is high (e.g. Platteau 1996);

(iii) Natural conditions, such as low soil fertility and low and irregular rainfall, are the binding constraint for agricultural development, i.e. both the price elasticity and the non-price elasticity of supply are low, particularly in Sub-Saharan Africa (e.g. Bloom and Sachs 1998).

While the first two hypotheses suggest that the neglect of the agricultural sector could turn out to be a very costly choice,[1] the third hypothesis denies this, thus providing a rationale for an industrialization strategy.

Given the policy relevance of the agricultural supply response, there is surprisingly scant evidence on its size. As a result, the validity of the three hypotheses cannot be properly assessed. This paper attempts to take a first step towards filling the empirical gap by critically evaluating the approaches which may be employed to quantify the agricultural supply response. It discusses the scope of various time-series techniques (Sections II and III) and of cross-country regressions (Section IV). The ultimate objective of the paper is to provide a methodological framework for future empirical analyses.

II. THE NERLOVE-METHOD

The few existing empirical studies have largely concentrated on estimating the price elasticity of agricultural supply, i.e. they deal with hypothesis (i). In most cases, the so-called Nerlove-method (Nerlove 1979) has been employed. This method involves the estimation of a partial adjustment model of agricultural

---

1 The first two hypotheses may even be mutually reinforcing, implying that more favorable price incentives increase the impact of institutional improvements and vice versa (Schiff and Montenegro 1997).

production for one particular country. The supply function of the partial adjustment model has the general form

$$(1) \qquad \ln Q_t^* \quad = \quad a + b \ln P_{t-1},$$

where Q_t^* denotes desired output at time t and P_{t-1} the output price at time t–1. Furthermore , it is assumed that the dynamics of supply are captured by

$$(2) \qquad \ln Q_t - \ln Q_{t-1} \quad = \quad l\,(\ln Q_t^* - \ln Q_{t-1}),$$

where Q_t is actual output and l is the partial adjustment coefficient. According to equation (2), adjustment costs imply that the actual change in output between two periods is only a fraction of the change required to achieve the optimal output level Q_t^*. Substituting (2) into (1) and rearranging gives

$$(3) \qquad \ln Q_t \quad = \quad l a + l b \ln P_{t-1} + (1 - l) \ln Q_{t-1},$$

where λb and b are the short-run and long-run price elasticities of agricultural supply, respectively.

Variants of equation (3) are estimated in applications of the Nerlove-method. Frequently, the regressions contain additional control variables, such as a time-trend serving as a proxy for the impact of technological change on output. The overwhelming majority of the regression analyses based on the Nerlove-method obtain low, or even zero, long-run price elasticities of agricultural supply.[2] An illustrative example is the widely-cited study by Bond (1983). She estimates a significantly positive supply elasticity for only two out of nine Sub-Saharan African countries examined, and even for those two countries – Ghana and Kenya – the elasticity values are as low as 0.34 and 0.16, respectively. Price elasticities below 0.5 are also reported by Chhibber (1989) for India (0.39 – 0.43) and by Gafar (1997) for Jamaica (0.23). Reca (1980) reports somewhat higher estimates for Argentina (0.42 – 0.78). Both Chhibber and Reca additionally introduce one non-price variable into their regressions, with inconclusive results that do not allow an assessment of the validity of hypothesis (ii) stated above. While Chhibber estimates that in India the elasticity of aggregate output with respect to irrigation lies between 1.17 and 1.28, the Argentina study by Reca displays much lower values (0.11 – 0.19) with respect to credit availability.

Since studies using the Nerlovian partial adjustment model have constantly produced low estimates of the price elasticity for developing countries from different regions and with different income levels, one might argue that the evidence is robust enough to suggest a rejection of hypothesis (i). This

---

2 Short-run elasticities will not be discussed here because the focus of the paper is on agriculture's contribution to economic development in the long run. Moreover, there is a general consensus that the short-run supply response is low because the use of primary factors, which usually account for 70 to 85 percent of the cost of agricultural production in developing countries (Binswanger 1993), cannot be changed instantaneously.

conclusion is, however, not justified due to a fundamental methodological weakness of the Nerlove-method, namely the modeling of the dynamics of supply which comes down to the crude decision rule that in each period a fraction of the difference between current output, Q_t, and long-run desired output, Q_t^*, is eliminated (see equation (2)). This simple adjustment mechanism can be derived from the minimization of a single-period quadratic loss function, assuming static expectations, i.e. no forward-looking behavior of agricultural producers (Nickell 1985). It is unlikely to capture the full dynamics of supply, thus biasing elasticity estimates downwards.

III. ALTERNATIVE TIME-SERIES APPROACHES

One direction that has been taken as a response to the limitations of the Nerlove-method is to use more sophisticated time-series techniques. The most important among these techniques – co-integration analysis and dynamic general equilibrium models – will be discussed in the following.

1. Co-Integration Analysis

The most straightforward way to overcome the restrictive dynamic specification of the Nerlove-model is to conduct a co-integration analysis. This approach does not impose any restrictions on the short-run behavior of prices and quantities. It only requires a co-movement of the two variables in the long-run. Formally, this implies that there is a linear combination of Q_t and P_t which is stationary even though both Q_t and P_t may be non-stationary. The long-run equilibrium relationship can be written as

$$(4) \qquad \ln Q_t = b \ln P_t + e_t ,$$

where the coefficient b measures the long-run supply elasticity, and where e_t is the residual which is stationary if, and only if, Q_t and P_t are co-integrated. The stationarity of e_t, and thus the existence of an equilibrium relationship, can be tested by means of time-series procedures such as the Augmented Dickey-Fuller (ADF) test.

If prices and quantities are co-integrated, then there exists an error-correction representation which incorporates both short- and long-run behavior. The error correction model (ECM) is given by

$$(5) \qquad \Delta \ln Q_t = \sum_{i=0}^{p} a_i \Delta \ln Q_{t-p} + \sum_{j=0}^{q} g_j \Delta \ln P_{t-q} - m e_{t-1} + u_t$$

$$\text{with } e_{t-1} = \ln Q_{t-1} - b \ln P_{t-1} .$$

The first two terms on the right-hand side of the ECM capture the short-run dynamic adjustment of quantities and prices, whereas the third term (the so-called error correction mechanism) measures the speed at which the system gets closer to the long-run equilibrium relationship, with the residual of the co-integrating regression (4) representing the divergence from equilibrium. If all coefficients a_i und g_j of the differenced variables turn out to be insignificant, the ECM reduces to a partial adjustment model, i.e. the latter is nested within the former.

The core advantage of the ECM over the partial adjustment model is that it is consistent with forward-looking behavior. As Nickell (1985) has shown, the ECM can be derived from the minimization of an intertemporal quadratic loss function. Moreover, with all variables being stationary, an estimation of the ECM avoids the problem of spurious correlations which may occur in OLS-regressions of the Nerlove-model if variables are non-stationary (Granger and Newbold 1974).

As regards agricultural supply response, the only existing co-integration analysis has been carried out by McKay et al. (1999) for Tanzania. For food crops, McKay et al. obtain a price elasticity of supply that is close to unity (equations (1) and (2) in Table 2), and, by estimating significant coefficients for some differenced variables, they demonstrate that the dynamics of supply are more complex than suggested by the Nerlove-method (equations (3) and (4) in Table 2). The relatively high long-run supply elasticity for food crops does, however, not necessarily reflect a high aggregate agricultural supply response which would lend support to hypothesis (i). It may as well be the result of a substitution within agriculture between food crops and export crops.

While making use of the co-integration technique constitutes a substantial improvement compared to the less flexible Nerlove-method, both approaches share one major drawback in that they rely on a partial equilibrium analysis for the agricultural sector. In the long run, the dynamics of agricultural supply are likely to depend to a large extent on the ability of the sector to attract additional production factors from other sectors, an effect that cannot be captured in a partial equilibrium framework.

Table 2 — Short- and Long-run Supply Response of Food Crops in Tanzania, 1964–90

Explanatory Variables \ Dependent Variable	$\ln Q^f$ (1)	$\ln Q^f$ (2)	$\Delta \ln Q^f$ (3)	$\Delta \ln Q^f$ (4)
Constant	–0.31	–0.36		
$\ln P^f$	0.78			
$\ln P^e$	–0.93			
$\ln (P^f / P^e)$		0.92		
trend	0.02	0.02		
$\Delta \ln P^f$			0.37 (1.85)	
$\Delta \ln P^e$			–0.41 (–2.50)	
$\Delta \ln Q^f_{t-1}$			0.44 (2.18)	0.39 (2.08)
$\Delta \ln (P^f / P^e)$				0.39 (2.62)
$\ln e_{t-1}$			–0.72 (–3.13)	–0.72 (–3.44)

Note: f = food crops and e = export crops; figures in brackets are t-values; e_{t-1} denotes the lagged residuals of the co-integration regressions (1) and (2), respectively.

Source: McKay et al. (1999).

2. Dynamic General Equilibrium Models

To account for the effects of intersectoral factor movements on agricultural supply, dynamic general equilibrium models have been constructed which explicitly specify how production factors are accumulated over time and how they are allocated among different sectors of the economy (e.g. Coeymans and Mundlak 1993). These models distinguish three primary production factors – capital, labor and land. The capital stock K_t available for agricultural production in the current period equals the lagged capital stock K_{t-1}, diminished by depreciation at a given rate d_t, and augmented by the proportion Θ_t of total investment I_t that goes to agriculture:

(6) $$K_t = K_{t-1} \cdot (1 - d_t) + \Theta_t I_t \, .$$

The share of agriculture in total investment is assumed to be determined by the past allocation of investment, Θ_{t-1}, and the rate-of-return differential between agriculture and non-agriculture, r_{AG} / r_{NAG}.[3]

(7) $$\Theta_t = f(\underset{+}{\Theta_{t-1}}, \underset{+}{r_{AG} / r_{NAG}}),$$

[3] To keep the notation as simple as possible, the exposition here is confined to a two-sector economy. The model can easily be extended to the multisectoral case, as is done in all existing empirical applications.

where the plus-signs indicate a positive partial derivative of Θ_t with respect to the arguments.

Changes in the agricultural labor force L come about as a result of population growth and off-farm migration. The identity

(8) $$L_t = L_{t-1} \cdot (1 + n_t - m_t)$$

holds, where n_t is the exogenous population growth rate and m_t the share of the labor force that leaves agriculture in period t. Off-farm migration is specified along the lines of the classic Harris-Todaro model with the intersectoral income differential, W_{NAG} / W_{AG}, and the urban employment rate, U_{NAG}, as the main factors behind the decision to migrate:

(9) $$m_t = f(\underset{+}{W_{NAG} / W_{AG}}, \underset{-}{U_{NAG}})$$

Finally, the size of the cultivated area, A_t, is postulated to be affected by the real price of land, P_A / P, and the terms of trade of agriculture as measured by the intersectoral rate-of-return differential, r_{AG} / r_{NAG}. Constraints on the use of land, such as a lack of access to credit, may also be important. The respective equation can thus be written as

$$(10) \quad \underset{}{A_t} = f(\underset{+}{P_A / P}, \underset{+}{r_{AG} / r_{NAG}}, \underset{-}{R}),$$

where R denotes a vector of restrictions that limit the size of the cultivated area.

In addition to tracing intersectoral factor movements, a further characteristic of the dynamic general equilibrium models is that they endogenize the choice of techniques. The underlying assumption is that at any point in time not all producers adopt the best available technology. The implemented technology depends on the available technology (*AT*), on incentives (*IN*) such as prices, and on constraints (*CON*) such as weather conditions. These variables are exogenously given to the farmers. The production relationship can then be written as a Cobb-Douglas function[4] where the parameters are a function of the exogenous determinants, that is

$$(11) \quad \begin{aligned} \ln Q_t &= b_0(AT, IN, CON) + b_1(AT, IN, CON)\ln K_t \\ &\quad + b_2(AT, IN, CON)\ln L_t + b_3(AT, IN, CON)\ln A_t . \end{aligned}$$

Applications of this kind of dynamic general equilibrium models proceed in two steps. First, a number of parameters, such as those of the migration equation (7) and the production function (11), have to be estimated. The parameter estimates can then be used as an input for simulations of changes in agricultural prices.

---

4 If indicated by empirical evidence, other types of production technology may be chosen as well, e.g. a CES function.

Two studies along these lines have been carried out for Argentina and Chile. The results point to long-run price elasticities of agricultural supply of about unity, i.e. they provide support for hypothesis (i), but the strong response is only realized after a considerable adjustment period (Table 3). Moreover, the estimates for the two middle-income countries cannot easily be transfered to poorer economies where institutional constraints are likely to be more pronounced. A further case study for the Punjab in India by McGuire and Mundlak (1992), which employs the choice-of-technique approach while retaining a partial equilibrium framework, obtains a price elasticity of 0.8. Since this elasticity is higher than those found in most conventional partial equilibrium analyses, the study provides a first indication that by specifying endogenous technology adoption one may capture an important part of the supply response.

Table 3 — Simulated Price Elasticities of Supply for Argentina and Chile

Year	Price Elasticity of Supply	
	Argentina	Chile
5	0.43	0.58
10	0.51	1.01
20	0.99	1.18

Note: The simulations for Argentina cover the period 1913–84, those for Chile the period 1962–82.

Source: Mundlak et al. (1989); Coeymans and Mundlak (1993).

In sum, the explicit consideration of factor movements and technology choice definitely constitutes an advantage of dynamic general equilibrium models. This advantage has to be weighed against one serious disadvantage, namely the high requirements in terms of data and modeling efforts. Whether, on balance, model simulations are to be prefered over co-integration regressions can only be decided case by case, e.g. depending on data availability in the respective country. A common problem of both approaches is that they may suffer from the Lucas-critique. In particular in case of radical policy shifts, as for instance in Chile in the 1970s, one cannot expect parameters to be unaffected. A credible reform should reduce insecurity and thereby lead to a stronger response of economic actors. This implies that all time-series approaches are likely to understate the true agricultural supply elasticity.

IV. CROSS-COUNTRY REGRESSIONS

Beside the application of more sophisticated time-series approaches, the second major response to the limitations of the Nerlove-method has been to estimate the supply elasticity for a cross-section of countries rather than for single countries over time. If the focus is on the long-run response of agricultural supply, this approach has the advantage that prices obtained from cross-country data tend to reflect different price regimes while prices obtained from time-series data are to a large extent drawn from a given price regime, mainly reflecting short-run fluctuations around the mean. Cross-country regressions should thus deliver higher long-run elasticity estimates than time-series analyses. In the most widely-cited empirical cross-country study, Peterson (1979) clearly confirms this proposition. For a sample of 53 developed and developing countries, he obtains an aggregate price elasticity of supply that lies significantly above unity (equations (1) and (2) in Table 4).

Table 4 — Estimates of Cross-Country Aggregate Supply Functions

Explanatory Variable	(1)	Research Included (2)	Research and Irrigation Included (3)
Price	1.66 (11.80)	1.27 (6.47)	0.97 (3.62)
Precipitation	0.30 (2.18)	0.29 (2.19)	0.37 (2.84)
Research/ha		0.12 (2.84)	0.22 (2.98)
1968–70 Dummy	0.38 (2.64)	0.30 (2.15)	0.22 (1.49)
Irrigation/ha			0.84 (0.39)
R^2	0.61	0.65	0.71

Note: Equations (1) and (2) are from Peterson (1979); figures in brackets are t-values; the functional form is log-linear; the estimation method is instrumental variables; data for 53 developed and less developed countries, at two time points, 1962–64 and 1968–70, are included.

Source: Chhibber (1989).

Peterson's results might have turned the consensus view among agricultural economists against the elasticity pessimism that prevailed following earlier studies based on the Nerlove-model. But, from the very beginning, his regressions were criticized for having omitted important control variables, such as various non-price factors (e.g. irrigation, infrastructure, credit) and agroclimatic variables (soil fertility, rainfall). If these omitted variables are positively correlated with the price variable, the coefficient of the latter will be biased upwards. According to Chhibber (1989), who conducted an extensive sensitivity analysis, the estimated supply elasticity is indeed very sensitive to the inclusion of different sets of control variables. While remaining significant and higher than in most time-series applications, the estimated coefficient always dropped below unity when additional non-price factors were included. Adding an irrigation variable to Peterson's specification, for example, reduced the price elasticity to 0.97 (equation (3) in Table 4). Binswanger and Rosenzweig (1987) have shown that even by including ten measured attributes of agroclimate and public investment the correlation of the explanatory price variable with unobserved country characteristics cannot be fully eliminated, pointing towards an inherent upward bias in price elasticities estimated from cross-country data.

Overall, due to their two counteracting properties – a more accurate tracing of long-run regime shifts, on the one hand, and the omitted-variable bias on the other hand – cross-country regressions have not been able to resolve the debate on the size of the long-run agricultural supply elasticity.

V. CONCLUDING REMARKS

This paper has evaluated the various approaches that are available to quantify the aggregate agricultural supply response in developing countries. As a main result, it turned out that the Nerlove-method, which hitherto has been applied in most instances, is inappropriate when it comes to estimating the long-run supply elasticity because it specifies the dynamics of supply in a too restrictive way. Among the remaining approaches – co-integration analysis, dynamic general equilibrium models, and cross-country regressions – no definite ranking can be established. All of them have their distinctive weaknesses. In cross-country regressions, the problem of unobserved country characteristics cannot be fully eliminated, biasing estimates upwards. Time-series analyses tend to suffer from the Lucas-critique, biasing estimates downwards. Comparing the two time-series techniques, the very high requirements of dynamic general equilibrium models in terms of data and modeling efforts have to be weighed against the fact that co-integration analyses neglect the impact of intersectoral factor movements on agricultural production.

As a consequence of these various problems, there has not yet emerged a consensus view on the size of the price elasticity of agricultural supply. The possible effects of institutional and natural constraints on agricultural supply are even less known as they have barely been subjected to empirical scrutiny.

With respect to future empirical applications, the findings of this paper point towards the need to carry out both time-series and cross-country studies in order to obtain upper and lower bounds for the agricultural supply response and to check the robustness of results. Moreover, future analyses should avoid the narrow focus on price incentives that characterizes most existing studies by carefully accounting for relevant non-price factors and climatic variables. A research approach along these lines seems to be the most promising way to arrive at a proper assessment of the three hypotheses mentioned at the outset of the paper.

REFERENCES

Binswanger, H.P. (1993). Determinants of Agricultural Supply and Adjustment Policies. In: F. Heidhues and B. Knerr (ed.), *Food and Agricultural Policies under Structural Adjustment*. Proceedings of the 29th Seminar of the European Association of Agricultural Economists. Frankfurt a.M.

Binswanger, H.P., Y. Mundlak, M.C. Yang, and A. Bowers (1987). On the Determinants of Cross-Country Aggregate Agricultural Supply. *Journal of Econometrics* 36: 111–131.

Bloom, D.E., and J. Sachs (1998). Geography, Demography, and Economic Growth in Africa. *Brookings Papers on Economic Activity* 2: 207–273.

Bond, M.E. (1983). Agricultural Response to Prices in Sub-Saharan African Countries. *IMF Staff Papers* 30: 703–726

Chhibber, Ajay (1989). The Aggregate Supply Response: A Survey. In: S. Commander (ed.), *Structural Adjustment and Agriculture: Theory and Practice in Africa and Latin America*. London.

Coeymans, J.E., and Y. Mundlak (1993). Sectoral Growth in Chile: 1962–82. International Food Policy Research Institute, Research Report 95. Washington, D.C.

Gafar, J.S. (1997). The Supply Response of Aggregate Agricultural Output in Jamaica. *Agricultural Economics* 16(3): 205–217.

Granger, C., and P. Newbold (1974). Spurious Regressions in Economics. *Journal of Econometrics* 2(1): 227–238.

Kherallah, M., C. Delgado. E. Gabri-Madhin, N. Minot, and M. Johnson (2000). The Road Half Travelled: Agricultural Market Reform in Sub-Saharan Africa. International Food Policy Research Institute, Food Policy Report 10. Washington, D.C.

Krueger, A.O., M. Schiff, and A. Valdés (1992). *The Political Economy of Agricultural Pricing Policies: A World Bank Comparative Study.* Baltimore.

Lewis, W.A. (1954). Economic Development with Unlimited Supplies of Labour. *Manchester School* 22: 139–191.

McGuirk, A.M., Y. Mundlak (1992). The Transition of Punjab Agriculture: A Choice of Techniques Approach. *American Journal of Agricultural Economics* 74: 133–143.

McKay, A., O. Morissey, and C. Vaillant (1999). Aggregate Supply Response in Tanzanian Agriculture. *The Journal of International Trade and Economic Development* 8: 107–124.

Mundlak, Y., D.F. Cavallo, and R.A. Domenech (1989). Agriculture and Economic Growth in Argentina: 1913–84.International Food Policy Research Institute, Research Report 76. Washington, D.C.

Nerlove, M. (1979). The Dynamics of Supply: Retrospect and Prospect. *American Journal of Agricultural Economics* 1: 874–888.

Nickell, S. (1985). Error Correction, Partial Adjustment and all that: An Expository Note. *Oxford Bulletin of Economics and Statistics* 47: 119–129.

Peterson, W.L. (1979). International Farm Prices and the Social Cost of Cheap Food Policies. *American Journal of Agricultural Economics* 61: 12–21.

Platteau, J.-P. (1996). Physical Infrastructure as a Constraint on Agricultural Growth: The Case of Sub-Saharan Africa. *Oxford Development Studies* 24: 189–219.

Reca, L.G. (1980). Argentina: Country Case Study of Agricultural Prices and Subsidies. World Bank Staff Working Paper 386. Washington, D.C.

Schiff, M., and C. Montenegro (1997). Aggregate Agricultural Supply Response in Developing Countries: A Survey of Selected Issues. *Economic Development and Cultural Change* 45: 393–410.

Schiff, M., and A. Valdés (1992). *The Political Economy of Agricultural Pricing Policy, Vol. 4: A Synthesis of the Economics in Developing Countries*. Baltimore.

Thiele, R., and M. Wiebelt (2000). Sind die Anpassungsprogramme von IWF und Weltbank gescheitert? Eine Bestandsaufnahme der Erfahrungen von zwei Jahrzehnten. Kiel Institute of World Economics. Kiel Discussion Papers 357. Kiel.

World Bank (1997). *Adjustment Lending in Sub-Saharan Africa: An Update.* Washington, D.C.