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The Declining Economic Importance of Agriculture

by

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As economic development proceeds, agriculture declines as a proportion of GDP. A number of theoretical explanations for this phenomenon have been advanced in the economic literature, but their relative historical significance has not been clear. This paper develops a methodology to analyse this issue and illustrates this methodology with time series data for Thailand. The study focuses on changes in the GDP shares of agriculture, manufacturing and services, and considers the implications of these changes for overall economic performance. Clarification of the respective roles of the major determinants of agriculture's secular decline is important both for historical understanding and for improved policy formulation.

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The Declining Economic Importance of Agriculture

1. Introduction

The transformation of agriculture from the dominant sector of relatively poor countries to a very small sector in the wealthiest countries is a central feature of economic development. Given the ramifications of this transformation, its causes and consequences have appropriately received enormous attention in the literature.

The literature has identified a number of economic forces contributing to agriculture's relative decline. They have included: (i) the effects that changes in income and population levels have on the demand for food relative to other goods and the resulting effects of these demand shifts on relative commodity prices; (ii) differences in the rates of technical change between sectors; (iii) changes in aggregate supplies of capital and labour in the economy and their resulting effects on industry structure; and (iv) the implications that adjustment costs and other impediments to factor movements have for the rates at which resource allocation will respond to the above determinants of agriculture's share.

While the causes of the decline in the agricultural sector are not generally policy variables, most of them are subject to policy influence. Price policy for the agricultural and industrial sectors appears to have a major impact on the relative prices of these goods and, in developing countries at least (Krueger, Schiff and Valdes 1988), a negative effect on agricultural output. Similarly, the level of the capital stock can be influenced by taxation and investment policies while the size of the labour force can be influenced by policies on immigration and fertility. The rate of technical change, especially in agriculture, can be influenced by policy towards research, extension and education.

Given the importance of these policy issues, information on the structural parameters which determine the effects of policy becomes a high priority. In the past, two major approaches have been used to analyse this process of structural change:

- (i) cross sectional econometric studies; and
- (ii) computable general equilibrium (CGE) models.

Cross sectional studies generally do not include an explicit role for price variables, and tend to be reduced-form in nature with the endogenous price variables substituted out. By contrast, relative prices play an important part in most analyses using CGE models.

CGE models can provide many insights into changes in the role of the agricultural sector, and have the advantage of allowing virtually any degree of disaggregation. However, they depend upon a large number of parameters for which few direct empirical estimates are generally available unless a large scale project involving the estimation of these parameters is undertaken for the particular country.

A CGE model allows a higher degree of disaggregation than would be achievable with direct estimation. However, direct estimation may be useful either as a complementary approach, or as an alternative where resources to construct a CGE model are not available.

In the quantitative component of this paper, we apply a three sector modelling technique to time series data for Thailand, a middle-income developing country where the process of structural change has been proceeding rapidly. In contrast with most other econometric studies of structural transformation and growth, the potential role of price changes is emphasized in this study. The approach is similar in principle to the 'Canadian' literature on modelling production by means of a GDP function (Kohli 1978; Diewert and Morrison 1987; Lawrence 1989).

A brief survey of the relevant literature is presented in the next section of the paper. Then, in section 3, the methodology is described. The data are then discussed in section 4. Results are presented in section 5. Finally we offer some tentative conclusions and proposals for future research.

2. Agriculture in Economic Development: Low productivity and relative decline

Economic thought on the role of agriculture in economic development has been dominated by two empirical observations. First, as economic growth proceeds, agriculture declines in economic importance relative to manufacturing and services. Second, at any stage of this growth process, resources frequently appear to be less productive in agriculture than in industry. The two phenomena are obviously connected. Higher economic returns to mobile factors of production in industry than in agriculture (the observed productivity difference) provide the economic incentive for their movement out of agriculture during the growth process (the observed secular decline of agriculture).

Economic policies toward agriculture have been influenced by the way these two phenomena have been interpreted. The decline of

agriculture relative to industry has been misinterpreted to mean that industrialization *causes* economic growth, rather than being a manifestation of it. The lower measured productivity of labour in agriculture has also been misinterpreted to mean that forced reallocation of resources from agriculture to industry will necessarily raise national income in the short term and promote growth in the longer term - a conclusion which ignores the economic forces responsible for the long-term persistence of productivity differentials.

We shall review the literature on these two phenomena in turn, taking agriculture's productivity first, followed by its relative decline.

2.1 Agriculture as a stagnant sector

In the 1950s and 1960s agriculture was commonly viewed as a backward and relatively stagnant sector whose main contribution to economic growth was to fuel the dynamic urban-based manufacturing and service sectors, particularly the former. Agriculture was seen primarily as a potential supplier of the food, labour and savings needed to promote urban-led growth. This was the perspective of the many studies prompted by Lewis (1954). Lewis himself had mentioned the simultaneous role of agricultural and industrial development but his emphasis was on the latter and this was even more true of the influential dual economy models which followed, especially Fei and Ranis (1964).

Lewis' analysis of 'surplus labour' in agriculture reinforced this view: workers could be relocated from agriculture to industry without loss of agricultural output. The source of Lewis' supposed surplus labour was not, as Jorgenson (1961) and Schultz (1964) assumed in their criticisms of Lewis, zero marginal productivity of labour in agricultural production, but the willingness of rural households to supply additional labour at a constant, but positive, supply price (Sen 1966; Lewis 1972). The impression remained that there was little to be lost from policies aimed at draining the agricultural sector of resources which could be used more productively elsewhere.

The import substitution-led recommendations of Prebisch (1950) and others also stressed the importance of manufacturing. Development required the transfer of resources from stagnant agriculture to dynamic manufacturing. Government policy should promote this process by protecting manufacturing in the early stages of industrialization. High tariff barriers against imported manufactured goods were seen as an appropriate way of achieving this end.

As Timmer points out, the central message of these theories was well received by such nationalist leaders of emerging third world nations as Sukarno, Nehru, Nkrumah and Nasser:

It is easy to see why agriculture was neglected as a source of growth in early strategies of economic development...It is the home of traditional people, ways and living standards - the antithesis of what nation builders in developing countries envisioned for their societies (Timmer 1988:289).

The Harris-Todaro model of rural-urban migration built on the dual economy foundations of Lewis and others but added an economic explanation for the coexistence of a low productivity agricultural sector and a high productivity urban industrial sector. Minimum wage regulations effective only in the urban sector prevented market wages there from declining to agricultural wage levels. The marginal productivity of labour thus remained higher in urban areas. Migrants from the rural to the urban sectors were participating in a search for rents - the difference between urban and rural wages. The competition for those rents produced a permanent pool of unemployed migrants in urban areas. These migrants from rural areas were induced to remain in urban areas, even when unemployed, because their presence there was a necessary condition for obtaining high-paying urban sector jobs when these became available (Harris and Todaro 1970).

The significance of the Harris-Todaro analysis was that although it retained the assumption of agricultural backwardness, it did not imply that public policies aimed at encouraging rural-urban resource transfers would necessarily promote growth. For example, subsidies to urban sector employment, such as protection of the domestic manufacturing sector, would increase the size of both the manufacturing workforce *and* the pool of unemployed. The net effect on the aggregate output of the economy was uncertain.

The Harris-Todaro analysis illustrates a crucial analytical point. While measured productivity differences between agriculture and industry are often large, policies aimed at forcing the transfer of resources from the former to the latter are not justified by this observation alone. The reasons for the persistence of the rural-urban productivity gap are central. The reason may lie in traditional sector dualism (Lewis 1954), modern sector dualism (Harris-Todaro 1970), or in costs of adjustment (Mundlak 1979, Cavallo and Mundlak 1982). The economic effects of policies directed at resource reallocation are very much dependent on the reasons for the continued existence of observed productivity differentials.

Not all analysts had supported a policy bias in favour of industry. Johnston and Mellor (1961) had stressed the importance of the

The policy implications of these two interpretations are quite different. Policies based on the first interpretation - those designed to extract resources from a stagnant agricultural sector - merely impoverish the rural population and frequently lead to food shortages. But policies based on new technology and market linkages with the rest of the economy create more opportunities for rural people than they destroy (Timmer 1989:291). These policies have been basic to the economic success of several East and Southeast Asian countries in the last two decades.

2.2 Agriculture as a Declining Sector

The empirical fact of agriculture's decline during economic growth is well known. Demand-side factors are its best understood causes. First, consider a closed economy. As income rises per head of population, at given commodity prices expenditure shifts towards services and manufactured goods relative to food, the phenomenon known as Engel's Law (Schultz 1953). If all sectors expanded output at the same rate, excess supply of food would result. The mechanism by which demand shifts affect industry outputs is thus changes in relative commodity prices. This same mechanism operates at a global level. Low expenditure elasticities of demand for food relative to other traded goods can be expected to result in declining international prices of food relative to other traded goods over time (World Bank 1982).

For an individual trading country this analysis changes, but only slightly. For given rates of domestic trade taxes and subsidies, international prices determine the relative domestic prices of traded goods such as food and manufactures. For a small country these relative traded goods' prices are independent of domestic demand conditions, but the level of these prices relative to those of non-traded goods, such as services are affected by domestic demand. Services typically have expenditure elasticities of demand greater than unity (Anderson 1988), implying that the aggregate of all other goods - i.e. traded goods - has an expenditure elasticity below unity. This reasoning is thus consistent with the observed decline of traded goods prices relative to non-traded goods as economies develop (Kravis and Lipsey 1988; Falvey and Gemmell 1989).

In summary, as incomes rise the demand-side forces we describe will lead to a decline in agricultural product prices relative to prices in general. Falling agricultural prices relative to other goods will reduce agriculture's share of GDP in two ways. First, provided GDP is measured at current prices, even if industry output levels were constant, agriculture's measured share of GDP would fall. Second, in

simultaneous development of agriculture and industry, a view also emphasized by Schultz (1953) and Jorgenson (1961). Johnston and Mellor listed five roles for agriculture in the development process:

- (1) increase the supply of food for domestic consumption;
- (2) release labour required for the industrial sector;
- (3) increase the size of the market for domestic manufactured goods;
- (4) release domestic savings for investment in industry; and
- (5) earn foreign exchange.

As Myint (1975) pointed out, the domestic interdependence stressed by the first four roles reflects a closed economy perspective. Only the fifth, foreign exchange earnings, reflects the role of international trade. In this respect the Johnston-Mellor framework reflects the influence in the 1950s and 1960s of the Indian model - in which the size of the domestic economy is so great as to minimize the relative importance of foreign trade (Timmer 1988).

Since the 'green revolution' experiences of the late 1960s onwards it has no longer been possible to characterize agriculture as being inherently stagnant. The historical record has shown conclusively that when profitable opportunities exist, even illiterate farmers will innovate, confirming the earlier thesis of Schultz (1964). The importance of public investment in agricultural technology and infrastructure has now been recognized in the economic development literature and although urban bias remains a central characteristic of the policies of most low income countries (Lipton 1976) the academic support for these policies has crumbled. Despite this, the view persists in popular thinking that agriculture is an inherently backward corner of the economy whose main role in development is as a reservoir of underemployed resources usable for urban-based development.

Reynolds (1975) distinguishes between static and dynamic interpretations of agriculture as a 'resource reservoir'. The 'static' view coincides with the simple dual economy models described above. It is through appropriate public policies that a stagnant agricultural sector may be squeezed of resources - food, labour and savings - without significant cost in terms of agricultural output but with substantial benefit in terms of industrial output. The 'dynamic' view, which roughly characterizes the present state of thought, is that in an economy where agricultural output is rising as a consequence of technical change and investment 'part of the increment in farm output and income is available for transfer to non-agriculture' (Reynolds 1975:14-15).

response to the relative price changes, resources will move away from agriculture towards other sectors where their returns are greater.

Differences in rates of technical change between sectors will also contribute to changes in the composition of GDP. If, as is widely thought, the rate of technical change is relatively slow in agriculture for developing countries (Chenery and Syrquin 1986:74), then this would directly contribute to a decline in the share of agriculture in the economy.

Another possible influence on the size of the agricultural sector is changes in the total supply of labour and capital in the economy. If the factor intensities of the agricultural sector and other sectors differ, then Rybczynski's theorem (Rybczynski 1955) would lead us to expect that changes in factor supplies will induce changes in the output mix. In particular, if agriculture is more labour intensive than the rest of the economy, then capital accumulation will cause agriculture's output to fall absolutely. Strangely, outside general discussions in textbooks on international economics and a passing reference in Anderson (1988:198), we are aware of no systematic discussion of this possible source of agriculture's relative decline.

Finally, we must recognize dynamic factors which will influence the rate at which restructuring occurs. The relative decline of the agricultural sector is almost certain to require the physical movement of factors. The rate of resource movement will depend upon physical adjustment costs (Mundlak 1979; Cavallo and Mundlak 1982), psychic adjustment costs (Tweeten 1979:180) and institutional impediments to structural adjustment such as those giving rise to either traditional sector dualism (Lewis 1954) or modern sector dualism (Harris and Todaro 1970).

We have thus distinguished three major sources of agriculture's decline: changes in relative commodity prices; differential rates of technical change; and factor accumulation. The rate at which agriculture declines will also depend on costs of adjustment, among other forces.

3. Methodology

The process described in the literature surveyed above is fundamentally general equilibrium in character, depending upon both demand and supply side influences. To make the present paper manageable, however, we focus entirely on the production side, taking output prices as given. This provides an initial basis for evaluating the relative importance of output price effects and other effects. The

results of this analysis will also help to determine whether the empirically difficult step of incorporating endogenous price determination is warranted. If, for instance, it emerged that historical output price effects were very small, then a major effort to incorporate endogenous price behaviour would probably not be worthwhile.

The major proximate determinants of the size of the agricultural sector identified in Section 2 were: output prices, factor endowments, and technical change.

The challenge in this paper is to model the response of the agricultural sector to these determinants. To our knowledge, direct estimates of the output price effects in an economy-wide context, with explicit recognition of the distinct role of the manufacturing and services sectors, have not yet appeared in the literature. Prices do not appear explicitly in the Chenery *et al.* (1986) cross-sectional reduced-form model, and the manufacturing and services sectors are aggregated into a single composite sector in the Cavallo and Mundlak (1982) study of agriculture in the open economy.

The approach used in this study is based on time series data for an individual country. Time series data are required to capture the dynamics of adjustment resulting from factors such as adjustment costs, information and implementation lags. Pooling of data across countries to increase the sample size could be investigated in subsequent work, although such pooling would be conditional on tests of cross-country parameter equality.

Static models are not likely to be adequate for the problem at hand given the likely importance of lags in adjustment. However, since the major focus of interest is in the long-run structural parameters, an approach which readily allows these parameters to be estimated was required. Development of the methodology for the study required consideration of both the long-run structure and of the dynamic specifications and behavioural properties of the data. Each of these issues is now discussed in turn.

3.1 Long run structure

The analysis considers three major sectors - agriculture, manufacturing and services - utilizing capital, labour and a changing level of technical knowledge. This technology can be characterized by the implicit function:

$$H(A, M, S, K, L, T) = 0 \quad (1)$$

where: A is agricultural output; M is manufacturing output; S is services output; K is the capital input; L is the labour input; and T is an index of technology. Given the focus of interest in this study, the sectoral output variables must be treated as endogenous. By contrast, the input variables can be treated as exogenous to the economy, or at least predetermined for statistical purposes.

A popular modern approach to characterizing a technology is the dual approach under which the technological parameters are inferred from the properties of a profit function subject to certain regularity conditions. Of the generally used dual functional forms (see Diewert and Wales 1987), only the translog function seems suitable, since it is the only one which does not impose input-output separability (Lopez 1985). It also has the convenient property that its first derivatives with respect to output prices are the value shares of each output, the variables of prime interest in this study.

In the initial analysis undertaken for this study, the long run technology was therefore characterized using a translog short-run profit function, where profit is the total return to primary factors in the economy, or GDP. While rarely used previously to characterize the sectoral composition of output, this approach is consistent with the profit functions used in a large number of studies focusing on import demand and export supply (for example, Kohli 1978; Nakamura 1986; Diewert and Morrison 1988; Lawrence 1989).

Some of the regularity properties required for the translog function to characterize the technology can be imposed and tested during the estimation process. Thus, the condition that the profit function be homogeneous of degree zero in prices can be imposed and tested. The symmetry condition can readily be imposed and tested. The adding-up condition that the estimated profit shares add to total profit is routinely imposed in the estimation process. The necessary condition that the profit function be convex in output prices presents more of a difficulty. Convexity can be imposed at a point, such as the sample mean, using a Choleski decomposition as suggested by Lau (1978) or Diewert and Wales (1987) but is difficult to impose globally.

The economically relevant parameters of the technology, such as the elasticities of transformation and substitution can be calculated from the estimated parameters of the Translog function and the budget shares using well known formulae (Diewert 1974).

3.2 Dynamics

Because of adjustment costs, incomplete information and implementation lags, the economy will clearly not be in long-run equilibrium at any particular time. Clearly, some mechanism is required to define how the economy deviates from its long-run equilibrium.

One such specification is provided by the multivariate partial adjustment or flexible accelerator model utilized by Upsavada and Ball (1988). In this model, the target variables adjust partially towards their desired long-run values in each time period, with the speed of adjustment depending upon adjustment costs and the costs of being out of equilibrium. The partial adjustment model is a special case of the Error Correction Mechanism (ECM) and can encompass other common time series models such as distributed lag models (Murphy *et al.* 1986:18). Nickell (1985:124) demonstrates that an ECM can represent a model in which adjustment towards the long-run equilibrium variables is costly, and in which the target variables follow common time series processes such as a random walk with drift or a second order autoregression with a root close to unity.

An ECM has the desirable feature of making explicit the long-run structural parameters while allowing for dynamic adjustment about the long run equilibrium values. For the problem considered here, however, it has the practical disadvantage of being nonlinear in the parameters. An alternative specification, the transformed regression model originally proposed by Bewley (1979) and recently re-examined by Wickens and Breusch (1988) also involves estimation of the long-run coefficients, but within a model which is linear in the parameters.

As Wickens and Breusch (1988:195) demonstrate, the system of transformed dynamic equations used in the analysis can be derived from a general reduced form equation system:

$$Y_t = \sum_{i=1}^m Y_{t-i} C_i + \sum_{i=0}^n X_{t-i} D_i + U_t$$

where: Y_t is a vector of endogenous variables; X_t is a vector of exogenous variables; and U_t is a vector of disturbances.

The matrix of long run multipliers for equation (2) is:

$$\Phi = (\sum B_i)(I - \sum C_i)^{-1}$$

To estimate the matrix of long run multipliers directly, we first add $D_i X_t$ to the X_t term on the right hand side of (2), maintaining the equality by adding $-D_i X_t$ to each of the X_{t-i} terms on the right hand

side. Subtracting $C_1 Y_t$ from both sides of (2) similarly leaves the equality undisturbed.

The matrix of long run coefficients can then be obtained directly by estimating the following system of equations:

$$Y_t = \sum_{i=1}^m \Delta_i Y_t F_i + X_t \Phi + \sum_{i=1}^n \Delta_i X_t G_i + V_t \quad (3)$$

where $F_i = C_i H$, $G_i = D_i H$, $V_t = U_t H$ and $H = (I - \sum_{i=1}^m C_i)^{-1}$

Because current endogenous variables appear on the right hand side of the equation system (3), a simultaneous equation estimator such as Three Stage Least Squares (3SLS) or Full Information Maximum Likelihood (FIML) is required. Direct estimation of the long run parameters in this way has two major advantages. Firstly, the fact that it provides direct estimates of both the long-run coefficients and their standard errors is substantially more convenient than solving for these values after estimation. Secondly, it becomes straightforward to impose and test the restrictions implied by economic theory (particularly homogeneity and symmetry) on the long run estimates.

The estimation method used is a relatively simple, linear-in-variables and linear-in-coefficients approach to estimation of the long run coefficients, together with the dynamics of interest. The simultaneous estimation of the long run coefficients and the dynamics should help to improve the quality of the long-run estimates, by overcoming omitted variable bias. Since the dynamic specification can be interpreted in terms of adjustment costs and lags, it has an economic interpretation, as well as playing an important statistical function by improving the specification of the model.

4. Data Sources

Two major data sources were used in this analysis. The World Bank's national accounts data (International Economic Data Bank 1988) were used to obtain estimates of the value and quantities of output from each sector, and the Summers and Heston (1988) data were used to obtain estimates of investment and population. The complete data set required was available for the period 1960 to 1985. In this exploratory analysis, only Thailand is considered, but a major advantage of these data sources is that they are available on an internationally comparable basis for a large number of countries, thus facilitating replication of the analysis for other countries at a later stage.

Obtaining the variables actually used in the econometric analysis required some transformation of the available data. For each sector identified in the data set, an implicit price deflator was calculated by dividing the current price estimate of the value of output (in value added terms to avoid double counting) by the constant price estimate of output. Where aggregation of sectors was required, a Tornquist price index was calculated using SHAZAM (White and Horsman 1986) and an implicit quantity index then calculated for the resulting composite sector.

The population estimates provided by Summers and Heston were used as a simple, crude measure of the size of the labour force. While some estimates of the labour force participation rate are available for the period from 1971, these are based on sample surveys with a significant margin of error and the incorporation of these errors may cause more problems than it overcomes. Some experimentation was undertaken using the available data from ILO and other sources, but the results were not encouraging.

The capital stock variable in the analysis was estimated using the Summers and Heston data series on investment at constant prices beginning in 1950. A capital stock series was first calculated using the recursive relationship:

$$K_t = (1-h).K_{t-1} + I_t \quad (4)$$

where: K_t is the capital stock at the end of each period, h is the depreciation rate and I_t is a constant-price measure of the quantity of investment in each period. A value of 0.05 was chosen for h based on estimates surveyed in Limskul (1988). Some sensitivity analysis of the responsiveness of the results to this estimate was undertaken over a range from 0.035 to 0.06, but the results were not found to be sensitive to this parameter over this range.

Estimating the capital stock series using equation (4) requires an estimate of the unknown opening capital stock in the initial period. To minimize the effect of this unknown variable on the analysis, it was estimated for 1949, giving the opening value for the first year of the Summers and Heston data set and ten years before the start of the National Accounts data set. The estimate was obtained by first regressing the log of investment against time for the period 1950-60 to obtain an average growth rate and a trend value for investment in

1949, designated I_0 . Assuming the capital stock was in steady state equilibrium at that time allowed the opening capital stock to be estimated as:

$$K_0 = I_0/(g + h) \quad (5)$$

where K_0 is the opening capital stock in 1950; g is the estimated growth rate of real investment (and also of capital in the steady state); and h is the rate of depreciation. Since the capital stock series was estimated recursively over the entire period from 1950, any errors resulting from mis-estimation of the initial period capital stock would be unlikely to be very important.

5. Estimation and Results

Econometric results obtained using time series data appear to be influenced by the time series behaviour of the data as well as the nature of the relationship between the variables of interest. Thus, it is highly desirable to examine the behaviour of the data prior to estimation. Even where a systems approach is taken to obtain greater efficiency in estimation, a valuable prior step is to examine the statistical and economic features of the individual equations which make up the system. Otherwise, as Beggs (1988) has argued, there is a real risk that the 'good' equations in the system will be adversely affected by joint estimation with 'inadequate' relationships. Thus, both the data and the individual equations were examined prior to analysis of the system.

5.1 Behaviour of the Data

The Thai economy grew relatively rapidly over the sample period, with an average growth rate of real GDP of 6.9 per cent, and hence the pressures for structural change would be expected to be relatively intense in this economy. As a middle income developing economy, it lies between the developed countries for which agricultural productivity growth is widely believed to be relatively rapid (see Lewis, Martin and Savage 1987 for evidence on Australia), and the poorer countries where agricultural productivity growth is widely believed to have been relatively sluggish.

The discussion in the literature on structural transformation has identified three major sectors whose behaviour needs to be considered: agriculture; manufacturing; and services. In all countries, these sectors are likely to be affected by differential trends in output prices. In addition, the factor proportions used in these sectors are likely to vary substantially. In developing countries, agriculture seems likely to be relatively labour intensive and manufacturing relatively capital intensive. The services sector seems usually to be assumed to be labour intensive, although it contains a range of social overhead sectors such as electricity, gas and water, which are relatively capital intensive.

The shares of agriculture, manufacturing, services and mining in the Thai economy are shown in Figure 1. Perhaps the dominant feature of this Figure is the decline in the share of the agricultural sector, from over 40 per cent in 1960 to around 17 per cent in 1985. On average, the share of the agricultural sector declined by almost one per cent per year.

By contrast, the share of the services sector grew from 47 per cent to around 62 per cent, an average increase of 0.5 per cent per year. The manufacturing share has risen, from a relatively small base, at 0.3 per cent per year. The share of the mining sector has remained relatively small throughout the period.

Changes in the volume of output, as measured by value added at constant prices, are depicted in Figure 2. These indexes of output are considerably less volatile than the corresponding value measures and their behaviour appears to be dominated by relatively steady trends. The average rate of growth of output was highest in the manufacturing sector, at 9.5 per cent per year, while services output grew at 7.5 per cent. Agricultural output grew at an average rate of 4.5 per cent per year.

To focus attention on relative prices, the implicit price deflators for each sector divided by a composite index formed using the Tornquist index option in SHAZAM (White and Horsman 1986) have been plotted in Figure 3. From the plot, it is clear that the price variables have been considerably more volatile than the corresponding quantity variables. Over the period as a whole, the prices of agricultural and manufactured goods trended down, by broadly similar amounts, while the price of services appears to have trended up. On average, the agricultural price index fell 0.4 per cent per year relative to the manufactures price index. By contrast, the price index for services rose by an average of 0.9 per cent per year relative to the price of manufactures.

In contrast with the price indexes, the indexes of the capital stock and of population shown in Figure 4 have increased relatively smoothly. The estimated real capital stock grew considerably faster than the rate of growth of population, with the capital stock growing at an average rate of 9 per cent per year while population grew at 2.6 per cent.

All of the series depicted in Figures 1 to 4 trended up or down for sustained periods. For some of the series, such as population and the capital stock, these trends were not subject to major changes while for others, the trend varied markedly. The price series, in particular, did not appear to trend smoothly, but rather appeared to 'drift', with persistent deviations from any underlying trend level of prices. This behaviour can have major implications for inferences based on econometric analysis (Stock and Watson 1987) and hence requires further consideration.

Most conventional econometric procedures and interpretations are intended for situations where the time series being analysed have a constant underlying mean and variance, that is are (mean-variance) stationary series. In recent years, it has been recognized that these procedures need to be carefully evaluated when the time series do not have a constant mean, but 'drift' in the sense that a shock in any one period changes the expected future value of the series in all subsequent periods. Such series are referred to as nonstationary or integrated series.

A number of techniques for the analysis of nonstationary (or integrated) series have now been developed. When two or more time series 'drift' in such a way that they do not move too far apart over time, they are said to be cointegrated (Engle and Granger 1987). In this situation, the nonstationarity of the variables causes the OLS estimates to converge relatively rapidly and hence may actually facilitate estimation of the long-run parameters, although the distribution of the estimates is non-normal and hence, the usual hypothesis tests may be invalidated (Stock 1987).

Given the major implications of nonstationarity (or integration) of the data for estimation, tests of nonstationarity are required. Most attention focusses on the series which are integrated of order 1, that is which are stationary after differencing once. It appears that most integrated time series are, in fact, stationary after differencing once (Nelson and Plosser 1982) so this relatively simple specification seems widely applicable.

For a time series variable to 'drift' in its level form, but to have a constant mean when differenced once implies that an autoregression

Figure 1

Sectoral shares of GDP

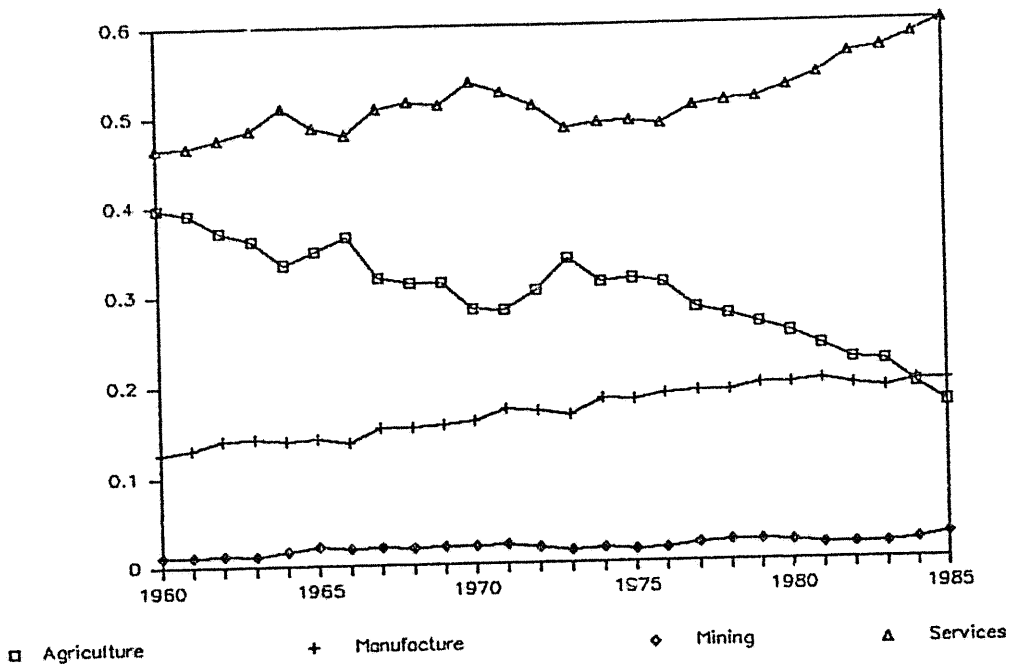


Figure 2

Sectoral output trends

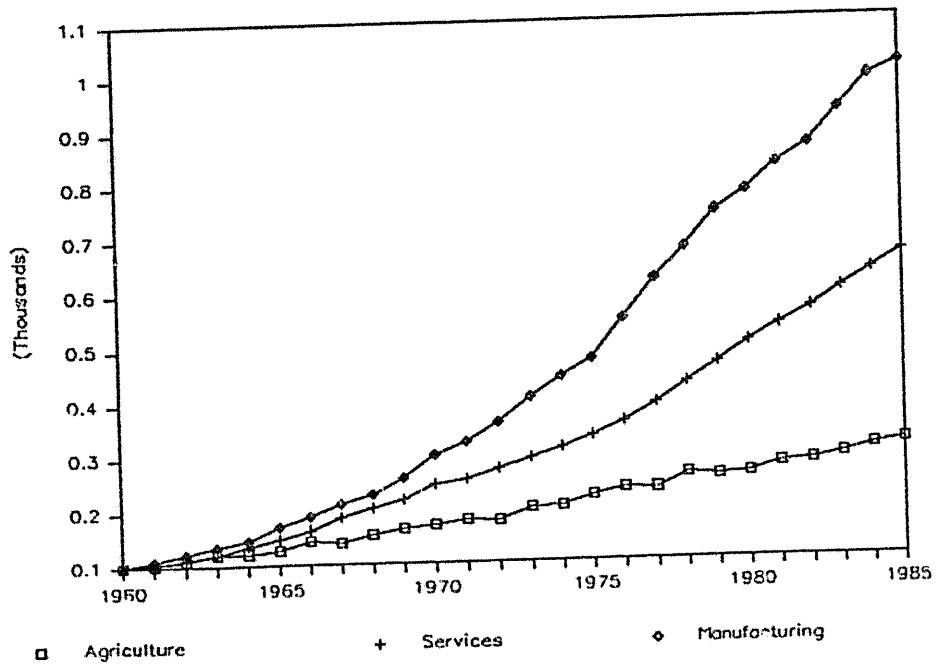


Figure 3 Trends in deflated relative prices

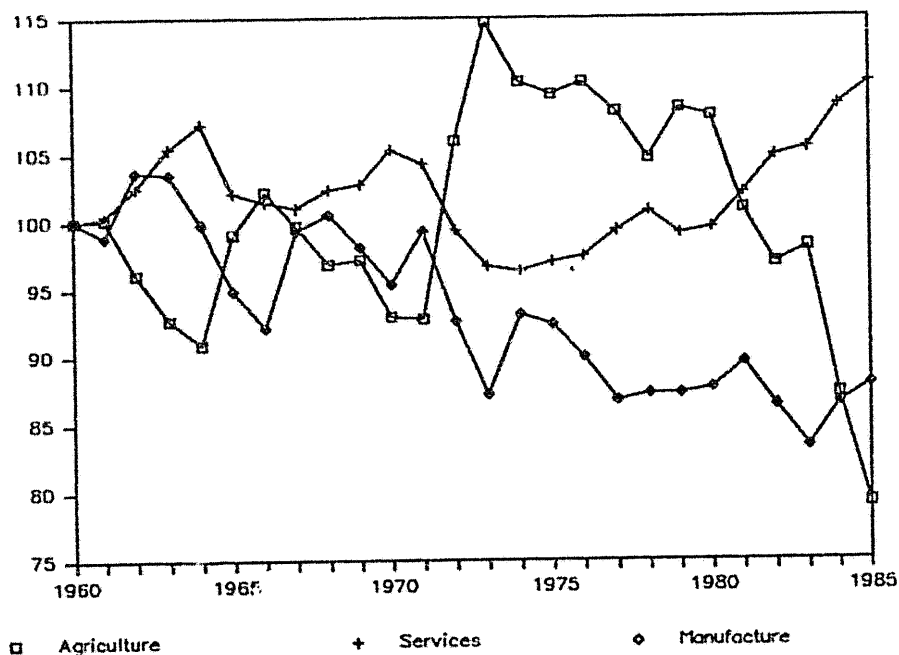
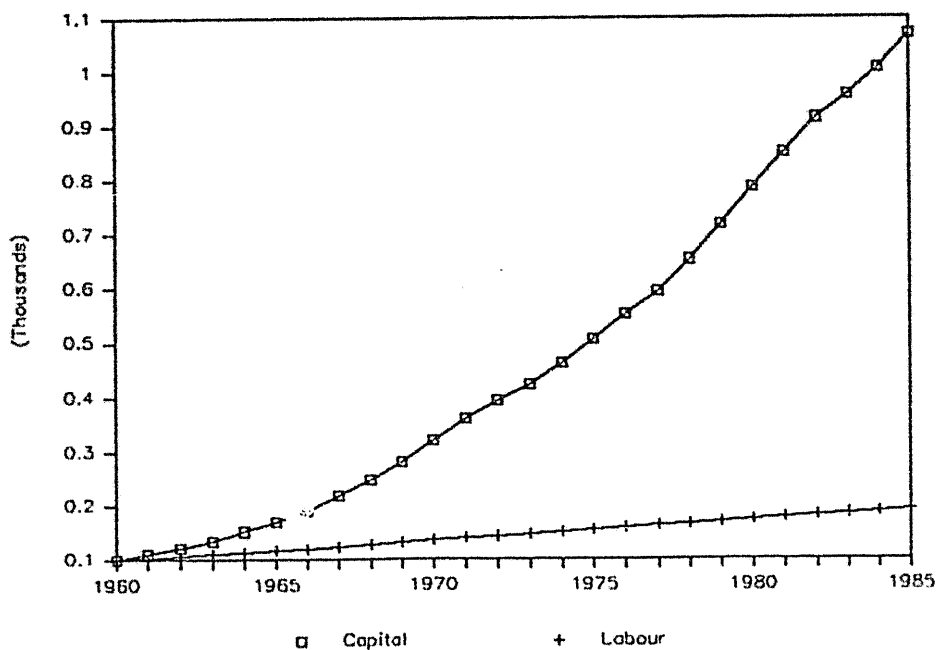


Figure 4 Trends in capital and labour



of the current value of the series on its lagged value has a unit coefficient. The simplest model for which this applies is the random walk model:

$$z_t = 1.z_{t-1} + e_t \quad (6)$$

where: z is a time series variable, and e_t is a random error term.

The Dickey-Fuller test for which critical values are provided in Fuller (1976:373) provides a relatively simple and straightforward test for integration based on a regression in the form of equation (6). For convenience, z_{t-1} may also be subtracted from both sides of (6) making the test statistic the usual t value of the coefficient b on z_{t-1} in the regression:

$$(z_t - z_{t-1}) = b.z_{t-1} + e_t \quad (7)$$

For higher order time series processes, this estimating equation may be augmented with additional lagged differences of z_t to obtain uncorrelated residuals.

Assessing whether two or more nonstationary time series variables are cointegrated involves analysing whether the residuals from the cointegrating regressions are stationary. The Durbin-Watson statistic for the cointegrating regression provides one possible indication of nonstationarity. Very low values of the Durbin-Watson statistic, as in the case of 'spurious' regressions, are an indication that the data series are not cointegrated. Engle and Granger (1987:260) suggest applying the Augmented Dickey-Fuller test to the residuals of the cointegrating equation.

The methodology used in the analysis reported in this paper involved first testing the integration properties of the individual series used in the analysis. If all or most of the series were found to be integrated, then attention would be focussed on the cointegration properties of the estimating regressions. If the dependent variables, but not the regressors, were found to be integrated, as Bewley and Elliott (1988) suggest is frequently the case in demand systems, then attention would need to be given to transforming the regressands to achieve nonstationarity. If all variables were found to be nonstationary, then standard regression theory would be applicable. The transformed regression model used is appropriate both for regressions on stationary data and for cointegrating regressions on

nonstationary data, and so only the interpretation of the results is affected in these cases.

The results of the Dickey-Fuller and Augmented Dickey-Fuller tests for the variables appearing in the analysis are presented in Table 1.

Table 1. Dickey-Fuller and Augmented Dickey-Fuller tests for variables used in the analysis

	DF	ADF	Interpretation
LPA	-0.22 (-1.55)	0.03 (0.2)	Integrated
LPS	-0.10 (-0.93)	0.07 (0.79)	Integrated
LCAP	-0.02 (-4.4)	-0.2 (-4.6)	Not integrated
LLAB	-0.02 (-14.3)	-0.02 (-14.9)	Not integrated
SA	-0.008 (-0.12)	0.04 (0.79)	Integrated
SS	0.01 (0.13)	0.11 (1.4)	Integrated

Note: LPA = Log of the price of agricultural output deflated by the price of manufactures; LPS = Log of the price of services deflated by the price of manufactures; LCAP = Log of the beginning of period capital stock; LLAB = Log of the population; SA = Value share of agriculture in non-mining GDP; SS = Share of services in non-mining GDP. Critical values: DF Test: -3.0 at 5 per cent, -2.63 at 10 per cent; ADF Test approximately -2.8.

The results presented in Table 1 are generally consistent with the impression created by inspection of the data that most of the data series 'drift', with shocks to the series affecting all of their future values.

The share variables which form the dependent variables in the translog estimating equations each appear to have a root close to unity. While deflating the prices of agricultural and service sector output by the price of manufactured output removes the common nominal trends, it is not sufficient to make the resulting series stationary. Thus, in contrast with the problem considered by Bewley and Elliott (1988), the price series, as well as the dependent variables, appear to be nonstationary in this case.

The formal hypothesis of a unit root is decisively rejected for both the capital and labour variables. This could present problems given the apparent nonstationarity of the dependent variables since a stable long-run relationship cannot exist between a stationary and a non-stationary variable (Engle and Granger 1987). In this case, however, the problem may lie more with the nature of the formal test than with the behaviour of the time series. By the nature of these series, a shock in one period persists for a very long time. This is consistent with the very small estimated coefficients obtained in the tests. In practice, it seems likely that these variables will behave like integrated series.

The relationship between the variables was therefore investigated using the procedures discussed in Section 2. With the economy divided into three sectors, there are only two independent share equations to be estimated. The two equations estimated in this study were the agriculture and the services equations.

Two sets of single equation estimates of the relevant equations are presented in Table 2. The first pair of equations was estimated by ordinary least squares (OLS), while the second group of three was estimated using a two-stage least squares estimator. The OLS equations allow an initial exploration of the properties of the relationship between the variables, and enable diagnostic tests on the regression residuals to be performed to ensure that the major underlying assumptions of the regression approach are not violated.

The OLS estimates are of particular interest given the apparently nonstationary nature of the variables being analysed. They allow simple tests for the existence of a stable long-run relationship between the variables (ie whether they are cointegrated) to be performed. Further if such a stable long-run relationship is found to exist, the estimators are known to converge relatively rapidly and hence the OLS estimates may provide a reasonably good indication of the long-run relationship despite the omission of relevant dynamic variables.

The OLS regression for the share of agriculture in total output (SA) presented in Table 2 yields coefficient estimates whose signs are consistent with expectations. As expected, the price of agricultural output has a positive impact on the value share of agriculture in non-mining output. Similarly, the price of services has a negative impact on agriculture's share. Consistent with the Rybcznski effect, an increase in the stock of capital has a large negative effect on agriculture's share. Also as expected, an increase in the supply of labour would be expected to raise the share of agriculture in the economy. The coefficient on the time trend variable used as a proxy for the effects of technical change is negative, consistent with relatively slow technical

change in agriculture, although this coefficient is not statistically significant.

The coefficients in the SS equation are also of interest. The positive coefficient on LPS and the negative coefficient on LPA are as expected. However, the positive coefficient on the capital variable, and the negative coefficient on the labour variable, are somewhat surprising. In terms of the Rybcznski effect, these results would be consistent with the service sector being relatively capital intensive. This result may, however, not be unreasonable given the inclusion of some relatively capital intensive industries in this aggregate. With subsectors such as electricity and transport infrastructure included in this sector, and the relatively heavy capital investment required for industries such as tourism, these results may well be reasonable. Technological change in services appears to occur at a similar rate to the weighted average of agriculture and manufacturing.

A range of diagnostic tests was performed on the residuals of the OLS regressions, and the results of some of the major tests performed are reported in Table 2. None of these test results provide statistical grounds to question the adequacy of the model. Even though indications of autocorrelation due to omitted dynamics would be acceptable, and even expected, given the simple, static nature of the specification, the test results provide virtually no indication of residual autocorrelation. The RESET tests for functional form and the Breusch-Pagan test for heteroscedasticity are particularly important since these problems would not be alleviated by the inclusion of additional dynamics. Neither of these tests provides cause for concern.

Table 2 Single equation estimates of the translog share equations^a

	OLS		2SLS ^b		
	SA	SS	SA	SS	SA ^c
Constant	-3.9 (-1.11)	5.54 (1.57)	-5.10 (-1.08)	5.24 (1.07)	-2.15 (-1.00)
LPA	0.20 (11.6)	-0.20 (-11.6)	0.21 (9.56)	-0.22 (-9.6)	0.22 (11.1)
LPS	-0.17 (-3.2)	0.29 (5.4)	-0.17 (-3.09)	0.29 (5.06)	-0.18 (-3.47)
LCAP	-0.20 (-2.6)	0.21 (2.65)	-0.23 (-2.47)	0.22 (2.24)	-0.19 (-2.66)
LLAB	0.62 (1.49)	-0.69 (-1.69)	0.76 (1.40)	-0.68 (-1.21)	0.43 (1.57)
T	-0.003 (-0.78)	0.001 (0.22)	-0.004 (-0.70)	-0.0004 (-0.07)	
R ²	0.98	0.96	0.98	0.96	0.98
DW	2.21	1.69			
Diagnostics ^d					
Bera-Jarque	1.14	5.58			
RESET(2)	4.21	0.39			
B.P Hetero	0.69	0.43			
LM					
-1	-0.67	0.75			
-2	0.59	0.41			
D.F.	-1.13 (-5.46)	-0.85 (-4.13)			
ADF	-1.03 (-3.12)	-0.80 (-2.83)			

^aFigures in parentheses are t-statistics.

^bInstrument list for 2SLS; LPS; LCAP; LLAB; LPA_{t-1}; T; LKA_{t-1}; LKS_{t-1}; LCAP_{t-1}; LLAB_{t-1} where LKA_{t-1} is the quantity of output in period t-1 and LKS is the corresponding quantity variable for services. All other variables are as defined in Table 1.

^cExcluding the time trend variable.

^dDW is the Durbin-Watson statistic. The Bera-Jarque test for normality of residuals is distributed as a Chi-Squared with 2 df (Critical value at 5 per cent = 5.99). The RESET(2) test is distributed as F(1, 19), with a critical value of 8.18 at the 5 per cent significance level. The Breusch-Pagan test for heteroscedasticity is distributed as a Chi-Squared with 1 d.f. and a critical value of 3.84 at a 5 per cent significance level. The LM t-statistics test for residual autocorrelation at each order of lag. The critical value for the D.F test for co-integration is -3.0 at 5 per cent. (See Beggs 1988 for a detailed discussion of Diagnostic statistics. A tabulated critical value for the A.D.F. test at this sample size was not available, but would be approximately -2.8 (see Fuller 1976, p.373; Engle and Granger 1987).

The final two tests reported in Table 2 are the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests for cointegration (see Engle and Granger 1987). When applied to the residuals of a potentially cointegrating regression, these tests provide an indication of whether a stable long-run relationship exists between variables which are themselves nonstationary. In this case, both the DF test and the ADF test lead to the conclusion that there is cointegration between the shares of agriculture and services, and the explanatory variables hypothesised to determine them.

One concern with the use of OLS to estimate the relationships of interest is the use of the current price of agricultural output as an explanatory variable. Given the production lags in agriculture, many major management decisions such as land preparation and planting, must be made based on expectations about future agricultural prices, rather than knowledge of actual prices. As is the case when decisions are based on expected rather than actual output (Martin 1984), this leads to an errors-in-variables problem. The variable observed, actual output price, can be viewed as a proxy variable for the relevant variable, the expectation about price held at time $t-1$. Such an errors-in-variables problem can be expected to lead to a downward bias in the estimated coefficient.

A relatively straightforward approach to dealing with an errors-in-variables problem is to replace the variable observed with an error with an instrument correlated with the relevant unmeasured variable, but uncorrelated with the measurement error. In this case, since the relevant expectation is formed at time $t-1$, it seems appropriate to replace the actual agricultural price variable with an instrumental variable formed using information available in time $t-1$.

In the estimation of the 2SLS estimates reported in Table 2, the actual value of LPA was replaced by an instrument formed using the relevant lagged price and quantity variables, and the relatively predictable capital and labour variables. A Wu-Hausman exogeneity test for statistically significant differences between the OLS and 2SLS estimators was performed by augmenting the OLS equation with the residuals from the first stage regression of the 2SLS procedure (see Beggs 1988 for a discussion). This variable was significant at the 10 per cent level in the SA equation and at the 5 per cent level in the SS equation.

As can be seen from Table 2, the coefficients in the 2SLS equations are, in most cases, very similar to those in the OLS equations. However, the coefficient on LPA is noticeably larger in the 2SLS equations. The coefficients on both the labour and capital

variables also increase in absolute value in the agricultural share equation.

Further examination of the results in Table 2, however, reveals a major concern with their economic interpretation. Some of the key elasticities of output with respect to price do not satisfy the requirements of economic theory at all points in the sample. To illustrate this problem, the estimated elasticities of agricultural output with respect to price obtained from the 2SLS equations are presented in Table 3 for selected points in the sample.

Table 3 Elasticities of agricultural output with respect to price

	Agriculture	Services	Manufacturing
A. From equation including technical change bias			
1961	-0.06	0.03	0.03
1965	-0.05	0.02	0.03
1970	0.03	-0.04	0.01
1975	0.0	-0.05	0.05
1980	0.07	-0.1	0.03
1985	0.4	-0.38	-0.02
Sample mean	0.01	-0.04	0.03
B. From equation excluding bias of technical change			
1961	-0.04	0.01	0.03
1965	-0.03	-0.01	0.04
1970	0.06	-0.09	0.03
1975	0.03	-0.09	0.06
1980	0.09	-0.15	0.06
1985	0.48	-0.46	0.02
Sample mean	0.04	-0.09	0.05

A necessary condition for a translog profit or revenue function to be consistent with economic theory is that it be convex with respect to output prices. A necessary (but not sufficient) condition for convexity relevant in a single equation context is that the elasticities of output with respect to own-price be positive. As can be seen from Table 3, this condition is not satisfied at all points in the sample and is only marginally satisfied at the sample means.

It was thought likely that the low estimated elasticity of agricultural output with respect to its own price may have been due the use of the less efficient single-equation approach to estimation.

Accordingly, the two independent share equations in the system were next estimated as an interdependent static system. Finally, the system was estimated when augmented with first order dynamics to account for the major adjustment costs and delays in structural transformation. The results obtained from the estimation of these two equation systems are presented in Table 4.

Table 4 **Estimates of the static and dynamic systems subject to the symmetry constraint**

	SA	SS	SA	SS
Constant	-4.03 (-1.15)	5.65 (1.62)	-8.18 (-2.04)	14.06 (3.05)
LPA	0.20 (11.8)	-0.20 (-12.02)	0.185 (10.4)	-0.18 (-9.02)
LPS	-0.20 (-12.0)	0.31 (9.56)	-0.18 (-9.0)	0.27 (5.14)
LCAP	-0.21 (-2.8)	0.21 (2.82)	-0.25 (-3.82)	0.29 (3.68)
LLAB	0.64 (1.55)	-0.72 (-1.76)	1.09 (2.4)	-1.63 (-3.17)
T	-0.003 (-0.7)	0.0006 (0.13)	-0.01 (-1.59)	0.02 (2.19)
DLPA ^a			-0.07 (-2.2)	0.06 (1.56)
DLPS			0.17 (1.51)	-0.08 (-0.57)
DLCAP			-0.04 (-0.27)	0.06 (0.32)
DLLAB			-1.31 (-0.84)	4.73 (2.62)
DSA			-0.22 (-0.36)	-0.26 (-0.36)
DSS			-0.63 (-0.78)	-0.18 (-0.19)

^aThe prefix D designates the first difference of the relevant variable.

The systems of interdependent equations reported in Table 4 were first estimated without imposing the restriction that the matrix of coefficients on the output prices be symmetric so as to allow testing of this hypothesis. The unrestricted estimates of the cross price effects were similar in magnitude and the Wald Chi-squared statistic (with 1 degree of freedom) for this restriction was only 0.6 in the static model

and 0.1 in the dynamic model. Thus, the restriction was imposed in estimating the systems reported in Table 4.

Unfortunately, the systems approach to estimation did not appear to overcome the problems identified in the original single-equation estimates. In general the results from estimation of the static Seemingly-Unrelated-Regression were similar to those obtained using the single equation approaches. One unexpected consequence of the systems estimation, however, was a decline in the estimated own-price coefficient in the share equation for agriculture.

The results of the general first order dynamic model presented in Table 5 were of particular interest given the failure of the static system to satisfy the convexity condition. As was discussed in Section 3, estimation of the dynamic system leads to coefficients on the current explanatory variables which can be interpreted as long-run coefficients. Given this, it was expected that the coefficients obtained in this model would be larger in absolute value than those obtained using the static model. Unfortunately, as is evident from the coefficients in Table 4, this was not the case for the price coefficients.

The failure of the systems estimates to satisfy the convexity condition in prices is unfortunate since it leaves us unable to satisfactorily achieve one of our major objectives in this paper: to measure the extent to which adjustment costs reflected in the dynamic model reduce the level of GDP, and hence create the impression that efficiency gains would be attainable by transferring resources out of agriculture. Any such gains would, of course, be illusory since adjustment costs are as real as any other costs and should be taken into account in the efficient allocation of resources over time.

Given the desirability of obtaining estimates of the complete GDP function, considerable effort was devoted to understanding the reason for its failure and to identifying alternative specifications which might better represent behaviour. One potential concern with the use of the dynamic translog model is the somewhat *ad hoc* nature of the economic basis for the adjustment process. Quadratic adjustment costs of the type underlying ECM models Nickell (1985), or the dynamic transformed model used in this study, have a clear interpretation for adjustment of quantities but their meaning is less clear for adjustment of shares.

To examine whether this somewhat *ad hoc* dynamic specification caused the observed problems, a direct log-linear specification based on the solution of the first order conditions for profit maximisation subject to equation (1) was investigated. Following Fisher (1979), the theoretical restrictions of homogeneity and symmetry were tested and

imposed and, in addition, convexity of the matrix of output price elasticities was imposed at the sample means using the Choleski decomposition suggested by Lau (1978). Unfortunately, these specifications also failed to provide satisfactory statistical estimates.

The failure of the estimated models to satisfy the restrictions imposed by economic theory might be due to a number of factors. As Peterson (1979) has observed, estimation of price elasticities from time series data rarely leads to estimates of the own-price elasticity for agricultural output above 0.15, while he obtained estimates ranging from 1.25 to 1.66 using cross-sectional data. In this context, the difficulties experienced in the use of aggregate systems approaches in this study are symptomatic of the generally problematic process of obtaining aggregate long-run price elasticities from time series data.

Given the failure of the systems estimators to satisfy the convexity condition, further attention was given to the single equation 2SLS estimates which at least satisfy the necessary condition of a positive own-price elasticity at the sample mean and at most points in the sample. These equations allow a simple decomposition of changes in the share of agriculture in the economy in response to the major determinants identified in the literature: changes in relative prices, changes in relative factor endowments, and biases in technical change. The results of two such decompositions are presented in Table 5.

Table 5 Sources of change in the share of agriculture in GDP

	Contribution incl. technical bias ^a	Contribution excl. technical bias ^b
Contributions of		
DLPA	10	10
DLPS	17	18
Total price effect	27	28
DLCAP	245	194
DLLAB	-221	-122
Total factor effect	24	72
Technology	49	-
Total	100	100

^aFrom equation including T in column 3 of Table 2.

^bFrom equation excluding T in column 5 of Table 2.

The first column of Table 5 is based on the results of the complete static 2SLS equation including the relative price variables

(LPA and LPS), the relative factor endowments (LCAP and LLAB) and a time trend as a proxy for technological advance. Because the time trend is not statistically significant, a second set of estimates is presented based on the 2SLS equation with this variable set to zero.

From the results in the first column of Table 5, all three of the hypothesised factors have an important influence on the share of agriculture in GDP. The average decline in the share of agriculture in the economy was just under 0.9 per cent per year over the sample period. Based on the estimates from the full equation, approximately 10 per cent of this decline was due to the measured fall in the price of agricultural output relative to the price of manufactured output. Another 17 per cent was due to the increase in the relative price of services.

Given the very low output price elasticities implied by this equation, these relative price effects are largely due to valuation effects rather than to output effects. If the output price elasticities were higher, the effects of price on the value shares would obviously be higher, although this effect would not be greatly affected by an own price elasticity in the 0.15 range which Peterson (1979) argues is typical for time series regression.

From both sets of results presented in Table 5, the observed changes in the capital and labour endowments would each, alone, have had an enormous effect on the share of agriculture. In the model including the technological change proxy, the net effect of the relatively rapid increase in the stock of capital relative to labour was estimated to have caused 24 per cent of the observed reduction in the share of agriculture. This effect is consistent with the predictions of the Rybcznski theorem which predicts that, other things being equal, both the share of, and the absolute size of, the labour intensive sector will decline when the stock of capital is increased. To our knowledge, the estimate provided in this study is the first empirical estimate of the importance of this phenomenon for the size of the agricultural sector.

Using the equation excluding the statistically insignificant time trend, the contribution of the price effects changes very little. While the own price elasticity rises slightly, this effect is insufficient to greatly change the measured contribution of relative price changes to the share of output. In the absence of a separate variable for bias in technical change, the variables representing the Rybcznski effect assume much greater importance. Using this equation, the rapid accumulation of capital relative to labour accounts for 72 per cent of the estimated decline in agriculture's share.

Given the apparent importance of changes in factor proportions for the structure of the economy, and the marked variations in the rate of capital accumulation by level of economic development noted by Dowrick and Gemmell (1989), the effect of this phenomenon on the structure of the economy would appear to warrant greater attention in future studies of economic transformation.

The coefficient on the time trend variable used to proxy the possible bias of technical change in agriculture relative to the rest of the economy presents particular difficulties. While this variable is statistically insignificant, there is widely believed to be such a bias in technical change, at least in the poorer countries (Dowrick and Gemmell 1989). Further, the lack of significance of this variable may be more indicative of multicollinearity between this and other trending variables than of a lack of bias. If this is the case, then exclusion of this relevant explanatory variable may result in bias in other coefficient estimates.

When the measure for the potential bias of technical change is included, this effect is an important contributing factor to the overall decline in the share of agriculture in the economy. This factor alone contributes an estimated 49 per cent of the reduction in agriculture's share. Despite its apparent statistical insignificance, this variable is potentially of very great economic importance.

6. Conclusions

Based on a survey of the literature on the role of agriculture in economic development, we identified four fundamental determinants of the ubiquitous decline in the economic role of agriculture as economies develop:

- (1) demand side influences which lower the price of food relative to prices of all other goods;
- (2) demand/supply forces which raise the price of nontraded goods relative to all traded goods;
- (3) changes in factor endowments which can be expected to cause relatively labour intensive sectors to contract; and
- (4) a possible bias in technical change against agriculture.

The two demand-side influences identified operate solely through relative commodity prices. We have not attempted to explain these relative price movements in this paper. Our attention is focussed on the proximate determinants of agriculture's share: relative output prices; relative factor endowments; and bias in technical change.

A system of equations based on a translog profit function representation involving these determinants of output was formulated. In the empirical section of the paper, these equations were estimated for Thailand, a middle income developing country where structural transformation has been proceeding rapidly.

Some difficulty was experienced in obtaining estimates which satisfy one of the necessary conditions for the translog profit function to characterise a technology - that of convexity in output prices. In fact, all of the full system estimates obtained failed to satisfy this condition at the sample means. Somewhat surprisingly, the incorporation of dynamic adjustment terms based on an adjustment cost model resulted in smaller rather than larger estimates of the long run price response elasticities.

The preferred single equation estimators yielded small positive own-price supply elasticities at the sample mean and at most points in the sample, and quite sizeable estimates at the end of the sample. Small absolute values of the own price elasticities are not particularly surprising, since own price elasticities at the aggregate level would be expected to be substantially smaller than estimates at the individual commodity level. Nevertheless, the very small average own-price elasticities obtained may also reflect problems of aggregation, and the well known tendency for time series estimates of supply response parameters to be small in absolute value.

A decomposition of the total decline in the share of agriculture in GDP was undertaken using the preferred single-equation parameter estimates. Based on these estimates, the relative price effects which have received the most attention in the literature were found to be relatively minor influences. With both of the models used, the decline in the price of agricultural output relative to the price of manufactured output contributed around ten per cent of the measured decline in agriculture's share of GDP. The rise in the relative price of services contributed an additional 17 or 18 per cent. Moreover, the mechanism through which these relative price changes affected agriculture's measured share of GDP was almost entirely their effects on the value shares used in measuring GDP, rather than through agriculture's quantity response.

Changes in the economy's stocks of capital and labour, and a possible bias against agriculture in technical change were found to contribute over three quarters of the total decline in the share of agriculture in the Thai economy. In one of the models used for the decomposition, a trend term for bias in technical change was retained despite an apparent lack of statistical significance because of the

possibility that the standard error on this variable was overestimated. In this model, the bias in technical change was found to be an extremely important influence, accounting for almost half of the measured decline. When this variable was omitted because of its apparent lack of statistical significance, the importance of the capital and labour variables increased considerably, accounting for almost three quarters of the observed decline in the share of agriculture.

Overall, the tentative conclusion to emerge from this exploratory study was that, for Thailand at least, supply side influences such as capital accumulation and technical change may be the most important determinants of the decline in agriculture's share of GDP. Demand side factors, operating through relative commodity prices, seem to be much less important. If supported by further research, this conclusion has major implications for policies for economic development and structural change, and suggests a need for a reorientation of the literature on agriculture's role in economic development towards supply side influences of factor accumulation and technical change.

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