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Dynamic Sectoral Linkages and Structural Change in a Developing Economy

by

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Abstract
The literature on the stylised facts of structural change in LDCs has been bedevilled by three problems: (i) drawing time-series inferences from cross-section results; (ii) endogeneity of the variables involved; and (iii) an inability to separate short-run from long-run effects. This paper uses time-series econometric techniques to address each of these problems - investigating linkages between agricultural, manufacturing and service GDPs (and productivity) for Malaysia. Our results suggest that expansion of manufacturing GDP, though associated with reduced agricultural output in the short-run, was associated with agricultural expansion over the long-run. Service GDP growth on the other hand seems to be inimical to growth of agricultural GDP in both the short- and long-runs. Interestingly, both manufacturing and service GDPs appear to be (weakly) exogenous in the sense that they 'Granger-cause' changes in agricultural GDP but **not** *vice versa*. Evidence on sectoral productivity indicates that increases in manufacturing and services both impact positively on agricultural productivity in the long-run. This is consistent with neoclassical arguments suggesting that higher productivity techniques in manufacturing tend to spill over to agriculture, so encouraging convergent tendencies in sectoral productivity levels.

Outline

I INTRODUCTION

Some of the best known stylised facts of economic development are those associated with the 'patterns of development' research of Hollis Chenery, with various associates (1968, 1975, 1979, 1986). Using predominantly cross-section data for developed and less developed countries (LDCs) these studies established, *inter alia*, that there are systematic differences across countries in the sectoral allocation of GDP and labour force, in association with differences in such variables as per capita income, trade orientation, and country size. In particular, higher income per capita tends to be associated with a lower share of GDP (and labour force) in agriculture, and a higher share in manufacturing and services. The various hypotheses put forward to explain this phenomenon are well known - Engel's Law, differing factor intensities and technical progress *etc*. - though their empirical validity continues to be debated.

Hwa (1989) has recognised that there are important linkages and dynamic interactions between different sectors of an economy so that, as he puts it 'the relationship between agriculture and industry is one of interdependence and complementarity' (p.107). However, a major constraint hampering research on structural change until recently has been a lack of sufficient time-series data for a large sample of LDCs (and appropriate techniques to deal with it) so that cross-section regression techniques have dominated investigations. Controversially, it is often assumed that these approximate (unobserved) long-run time-series behaviour. The few time-series investigations attempted, were generally conducted prior to the availability of modern econometric techniques. In addition, explicit modelling of the interactions between different sectors in the patterns of development literature has been very limited. An exception is Hwa (1989) who has attempted to explore some dynamic interactions by adapting standard Chenery-Syrquin type regressions to allow for an impact of agriculture sector growth on the growth of industrial activities, although even here, the methods used are essentially cross-section and the possibility of reverse impacts is not considered.

This paper investigates these dynamic interactions further by applying time-series techniques to structural changes involving agriculture, manufacturing and services in Malaysia - an LDC which has undergone a rapid transition in recent decades from a predominantly agrarian economy to one increasingly composed of sophisticated industrial and service activities. An important advantage of this approach is that it allows separate identification of both long-run *and* short-run interactions between sectors (a distinction which cross-section investigations can not hope to capture). The significance of this lies in the fact that the processes of factor allocation and accumulation and technical progress (which underlie sectoral GDP interactions) can clearly be expected to differ between the short- and long-term, yet little empirical evidence is available on this aspect.

We should stress at the outset that, as with the traditional cross-section 'patterns of development' studies, our objective is to establish the stylised facts of structural change. Our contention is that, since this process is essentially an inter-temporal one, a time-series analysis which takes account of dynamic interactions between sectors can shed new light on these 'facts'. Our objective is not to *explain* structural change in terms of 'underlying causes' - such as factor accumulation, technical progress, changes in relative prices *etc*.[1] - but to identify sectoral patterns of behaviour over time. Our findings should be interpreted as a statistical description of inter-sectoral linkages rather than an explanation for their existence or a model of the development process itself. Nevertheless, modern time-series techniques do however allow us to examine whether there is any consistent tendency for changes in one sector to 'cause' changes in others, where causality is interpreted as 'temporal precedence'.

This focus allows us to address such questions as: will an output recession in manufacturing (perhaps due to reduced world demand) tend to be associated with reduced or increased agricultural output in the short- and long-run, and does manufacturing 'lead' agriculture or *vice versa*? We are thus able to consider whether these 'transmission channels' between sectors are uni-directional (*e.g.* manufacturing-to-agriculture) or multi-directional. At least in an econometric sense, this helps to address the 'endogeneity' issues which have bedevilled the cross-section econometric literature in this area.

1 See Martin and Warr (1992, 1993) for an attempt at such an exercise for Indonesia and Thailand.

One reason why it is important to understand these inter-sectoral linkages is that government policies in LDCs are often aimed explicitly at boosting the output of particular sectors (in addition to those aimed at 'underlying causes' such as capital accumulation), or they implicitly favour certain sectors, for example by protecting different activities to varying degrees. Indeed, feeding the results of this type of modelling exercise into the policy formulation process may help to avoid or diminish unintended outcomes of such policy interventions.

Finally, the cross-section patterns of development research was almost exclusively concerned with sector *shares* (of output, employment etc.). However, since output shares are merely the outcome of different output levels and growth rates within each sector it is clearly more appropriate, in studying dynamic sectoral interactions, to work with the *level*, or *growth*, of sectoral GDP. It is these quantities that are employed here to shed light on any inter-sectoral interactions.

II INTERSECTORAL LINKAGES AND THE DEVELOPMENT PROCESS

Since the seminal contributions of Lewis (1954) and Fei and Ranis (1964) an important strand of the development literature has sought to model the development process in terms of a structural transformation from agricultural to industrial activities. In more recent years neoclassical theories of growth and development have also incorporated this aspect (see Feder, 1986; Dowrick and Gemmell, 1991). Modelling the behaviour of service activities in this process has been less prominent, but a number of alternative models now exist (see Gemmell, 1982; Bhagwati, 1984; Dowrick, 1990). There are therefore a variety of diverse models in the literature (whose characteristics are generally well understood) which hypothesise numerous possible interactions between agriculture, manufacturing and services during the development process. We do not attempt to review each of these, nor produce some 'all encompassing' model, here. Rather our interest is in whether these models give any guidance on the circumstances under which interactions among the three sectors are likely to be mutually enhancing or inhibiting. This will help us identify relevant aspects for the specification and interpretation of an econometric model of these interactions in section IV.

In the Lewis tradition agricultural development is often seen as *assisting* the expansion of manufacturing activities. In particular, the positive contributions of agriculture are stressed - as a source of (surplus) labour and savings required for industrialisation; as a source of inputs for industrial processing (eg. food, textiles); and as a potential source of demand for manufactured products such as machinery, fertiliser and processed foods. In open economies, agricultural exports may provide scarce foreign exchange used to import key industrial intermediate or investment goods. Thus agriculture is seen as providing both demand- and supply-side links to industry. This is the aspect explored by Hwa (1989) who hypothesises that *ceteris paribus,* faster agricultural GDP growth 'causes' faster growth in industrial sector GDP.

While the literature has tended to stress agriculture-to-industry links, there is clearly also potential for reverse linkages. In foreign exchange constrained, or rapidly growing, economies for example, a domestic source of industrial input goods to the agricultural sector can release bottlenecks; rising industrial wages can foster growing agricultural demand. Linkages involving service activities are also well recognised (see Fuchs, 1968; Blades *et al*., 1974; Gemmell, 1982, Bhagwati, 1984). The contributions of intermediate services such as distribution, and retailing to both agriculture and manufacturing are obvious and frequently observed (from input-output tables) to increase over time in LDCs. In addition, 'final use' services can be close complements (or substitutes) in demand for agricultural and manufacturing products.

The above arguments suggest mutually *reinforcing* sectoral growth. However, they typically ignore the likelihood that for economies at or close to their production possibility frontiers, sectoral *competition* for resources will be important, resulting in, *ceteris paribus*, mutually *inhibiting* growth. 'Booming sector models' for example (see, Corden and Neary, 1982; Corden, 1984) illustrate how an exogenous expansion in one sector may be mutually reinforcing or inhibiting for other sectors depending, *inter alia*, on sector factor usage and the (non)tradability of different sectors' outputs. For present purposes, these models serve to remind us that expansion of agriculture, manufacturing or services could impact positively or negatively on the output of either of the other two sectors, particularly where sectors compete for inputs (physical and human capital, labour, etc.[2]). Such negative effects are especially likely in the *short-run*, when aggregate resources are relatively fixed, and any surplus resources may not be readily mobilised. In the *longer-run*, factor accumulation and the easier mobilisation of resources make simultaneous expansion in the output of several (or, indeed, all) sectors possible, even if some decline *relatively*.

Intersectoral Productivity Behaviour

If, as we argued above, the predicted effects of sectoral interactions on sectoral output levels are ambiguous (in sign) *a priori* for both the short- and long-run, are the implications for sectoral *productivity* similarly ambiguous? Until the work of Matsuyama (1992), the answer to this question has traditionally been that, in the long-run at least, some productivity predictions are *un*ambiguous. In both the Lewis and neoclassical traditions, it has been argued that industrialisation involves 'initial' industrial activities with high labour (and possibly total factor) productivity substituting at the margin for agricultural activities with low productivity. *Ceteris paribus*, over the long-run, marginal (and average) productivity are predicted to rise in agriculture relative to that in industry. This is reinforced if productivity-enhancing advances in industrial technologies tend to spill over to agriculture (see Feder, 1986; Williamson, 1987; and Dowrick and Gemmell, 1991)[3]. Given the interactions between sectors discussed earlier it would not be surprising if, in the long-run at least, productivity advances in one sector tended to spill over to others. In the case of small, open LDCs such as Malaysia where technological advances are generally imported this might be expected to take the form of productivity improvements in industry (via new industrial technologies) spilling over to agriculture, though reverse spill-overs are also

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2 For example, taking the simplest Corden and Neary (1982) case of two traded goods sectors and a nontraded service sector, with a single mobile factor input, it is readily shown that an exogenous expansion ('boom') in one of the traded sectors will cause the other traded sector to contract, with either expansion or contraction possible in the service sector.

3 Empirical evidence (see, for example, Sundrum, 1990) confirms that as per capita income rises productivity tends to rise across all major sectors but relatively faster in agriculture, bringing sectoral productivity levels towards equality. For services the issue is less clear-cut since 'traditional' services are often similar to agriculture in their productivity performance while 'modern' services behave more like industry. Since official data typically capture the latter more extensively, these tend to suggest service productivity being almost as high as (or in some cases higher than) that in industry, though increasing more slowly (see Sundrum, 1990, p.33).

conceivable. To the extent that the three sectors compete in factor markets this will reinforce tendencies towards equality in

Some of these productivity predictions have however been challenged recently by Matsuyama (1992) using a two-sector (agriculture-manufacturing) model of

essence Matsuyama highlights two factors which can cause increases in productivity *and* slower

version of the Lewis underemployment case where surplus labour both keeps agricultural productivity low and enables labour to be released to the high productivity

of *low* *open* economy where exogenously determined) relative prices do not adjust to stimulate agricultural development. A comparative advantage in manufactures is thus built on sustained low

economy model) also produces a negative link between agricultural productivity and industrialisation - higher (or increasing) agricultural productivity encourages resources

Standard neoclassical and endogenous growth models therefore yield quite different

productivity for small, open economies such as Malaysia, where prices are broadly determined in world markets. In particular, the
agriculture-industry productivity levels in a growing economy, while the learning-by-doing model predicts diverging
linkages across sectors for Malaysia may therefore shed some light on the merits of these competing hypotheses in this case. This is one of the
section IV. First, section III gives a brief introduction to the relevant aspects of the Malaysian economy.

III ECONOMIC DEVELOPMENT IN MALAYSIA

The structure of the Malaysian economy has changed radically in the last twenty-five years to the extent that it is no longer dependent on a few primary commodities. The production base has broadened with the manufacturing sector's share of GDP rising from around 10% in 1965 to more than 25% by 1990. Over the same period, though service sector GDP as a whole fluctuated in the 42-48% range, there was considerable growth in 'modern' services, while agriculture's contribution to GDP declined from about one third to less than 20%. Nevertheless, agriculture is widely considered to have played an important part in sustaining a real rate of economic growth of around 7-9% per year with successful modernisation of the plantation sub-sectors (rubber, oil palm, and cocoa).

Like other Asian countries, rapid industrialisation has become a major objective of Malaysian development policy since the 1960s. Motivated by the desire to diversify away from a perceived over-reliance on primary production and, more generally to modernise the economy, exports of manufactures have been strongly encouraged. In recent years the share of manufacturing exports has doubled and now accounts for around 70% all Malaysian exports. Growth has been especially strong in the non-resource based industries of electronics, electrical machinery and textiles.

Table 1: Percentage Contributions to Malaysian GDP (1980 prices)

Sector	1965	1975	1985	1990*	1995†
Agriculture	31.5	27.7	20.8	18.7	13.0
Manufacturing	10.4	16.4	19.7	27.0	33.0
Services	44.6	47.5	44.2	42.2	44.0

Source: Yap and Nakamura (1990); *Government of Malaysia (1991);
†World Bank (1997), current price share.

Since a consistent set of data on the main sectoral GDP aggregates for Malaysia are available for 1965-91 this forms the sample period for our investigation of sectoral

GDP linkages. Comparable data on employment are available from 1970 so that our productivity comparisons cover this shorter period. Sectoral GDP (at 1980 prices) and productivity profiles are given in Figures 1 and 2 respectively and indicate generally increasing GDP and productivity. After a long period of rapid growth, the mid-1980s represent something of an interruption in these trends however, with a slight decline in manufacturing and service GDP in 1985, and a large fall in service GDP (and productivity) in 1986. The reasons for this recession (unprecedented in Malaysia's recent development), and its particular severity for services are discussed in Ariff (1991). The major impact on services arose from a unique retrenchment in government services and major depreciation of the currency in 1986 which dramatically raised the relative price of non-tradables (mainly services). For present purposes, its significance lies in the need to model the temporary shock to GDP and productivity trends in services (see Section V).

IV MODELLING STRATEGY

Section II has outlined some of the competing hypotheses and *a priori* arguments offered to account for the patterns of sectoral interdependence in developing countries. The pattern of sectoral GDPs, which represents the *outcomes* of the various structural relationships discussed in that section, ideally requires a statistical/empirical model with sufficient generality to accommodate a variety of (reduced form) relationships. Furthermore, imposing assumptions of exogeneity on the variables should be avoided since these is not known *a priori*. In this context a vector autoregressive (VAR) framework is particularly appealing since it allows the data to determine the precise model specification and treats all variables as potentially endogenous. So, consider a general polynomial distributed lag framework, or VAR(k) model:

$$\mathbf{x}_t = \boldsymbol{\Pi}_1\mathbf{x}_{t-1} + \boldsymbol{\Pi}_2\mathbf{x}_{t-2} + \boldsymbol{\Pi}_k\mathbf{x}_{t-k} + \boldsymbol{\mu} + \boldsymbol{\varepsilon}_t \qquad (1)$$

with an equilibrium-correcting form such that,

$$\Delta\mathbf{x}_t = \boldsymbol{\Gamma}_1\Delta\mathbf{x}_{t-1} + \ . \ . \ . \ + \boldsymbol{\Gamma}_{k-1}\Delta\mathbf{x}_{t-k+1} + \boldsymbol{\Pi}\mathbf{x}_{t-k} + \boldsymbol{\mu} + \boldsymbol{\varepsilon}_t \qquad (2)$$

where t = 1,. . . , T; $\mathbf{x}_t$ is a $(n \times 1)$ vector of endogenous variables that are linear functions of past values of $\mathbf{x}_t$ and $\boldsymbol{\mu}$ is an $(n \times 1)$ vector of constants such that $\boldsymbol{\varepsilon}_t$, an

$(n \times 1)$ vector of independently distributed disturbances of zero mean and diagonal variance-covariance matrix $\mathbf{\Omega}$, *i.e.* $\boldsymbol{\varepsilon}_t$ ~ n.i.d.$(0, \mathbf{\Omega})$ In this model,

$$\mathbf{\Gamma}_i = \sum_{i=1}^{k-1} \mathbf{\Pi}_i - \mathbf{I}$$

captures the dynamic effects of the system and

$$\mathbf{\Pi} = \sum_{i=1}^{k} \mathbf{\Pi}_i - \mathbf{I}$$

expresses the relationships pertinent to the 'long run'. In the current context, we may consider such 'equilibrium relationships' as representing enduring inter-sectoral linkages that bind sectors together in the process of economic development as the growth of one sector reflects, *inter alia*, the size and state of others with which it interacts. To the extent that resource competition or technological spillovers between sectors induce long-lasting (linear) effects, those long-run relationships should be evident through the coefficients of $\mathbf{\Pi}$.

Following Johansen (1988), the rank of the steady state coefficient matrix $\mathbf{\Pi}$, denoted by *r*, corresponds to the number of linearly independent combinations of $\mathbf{x}_t$ that are integrated of order zero {I(0)}. So $r < n$ implies that there exists *r* I(0) linear combinations of the *n* I(1) variables in the system. This special case, where the variables of $\mathbf{x}_t$ *cointegrate,* allows $\mathbf{\Pi}$ to be expressed as a decomposition comprising a matrix of cointegrating vectors, $\boldsymbol{\beta}$, and a matrix of 'equilibrium correction' coefficients, $\boldsymbol{\alpha}$. Thus (2) becomes

$$\Delta \mathbf{x}_t = \boldsymbol{\alpha}\boldsymbol{\beta}' \mathbf{x}_{t-k} + \sum_{i=1}^{k-1} \mathbf{\Gamma}_i \Delta \mathbf{x}_{t-i} + \boldsymbol{\mu} + \boldsymbol{\varepsilon}_t \qquad (3)$$

Empirically, the rank of $\mathbf{\Pi}$, and thus the number of long-run relationships, is determined using the *trace* and *maximal eigenvalue* test statistics. Locating a single cointegrating vector (so that *r* = 1) implies that the series are integrated of order one, and the elements of $\boldsymbol{\beta}$ quantify (the unique) long-run relationship between the variables in the system and the elements of $\boldsymbol{\alpha}$ capture deviations from the equilibrium (*i.e.*

$\beta' x_{t-k}$) describing short run behaviour The Γ_i coefficients in (3) estimate the short-run (or impact) effect of shocks to $\Delta \mathbf{x}_t$, and thereby allow the short and long run responses to differ.

A VAR also facilitates investigation of the related concepts of exogeneity and temporal precedence, or more commonly, Granger-causality (Granger 1969). Whereas single equation methods force exogeneity of the explanatory variables by assumption, a system-based approach allows these assumptions to be tested empirically, via parameter restrictions. Johansen's (1992) test for 'weak exogeneity' (based on the notion that variables that do not respond to disequilibrium in the system of which they are a part, may be considered (weakly) exogenous to that system), tests the significance of specific elements in α of (3). If weak exogeneity of ($n-1$) is upheld then this reduces the complexity of the modelling exercise and legitimises the use of single equation methods. Furthermore, for a VAR(1) model in which components cointegrate (the case below) weak exogeneity implies Granger non-causality.[4] In the current context, these results signal whether the adjustment mechanisms - or transmission channels - between sectors are uni-directional or multi-directional.

In sum, vector autoregressive methods offer a natural framework for the study of structural change - an inherently inter-temporal phenomenon - allowing previously untested aspects of the process to be addressed systematically. Caveats are nevertheless warranted, not least since VAR methods have been the subject of critical assessment on methodological grounds. Of particular relevance here is that the asymptotic theory upon which inference is based rests uneasily with the small samples at our disposal and the inherent over-parameterisation of system-based approaches. We report finite sample corrections of the test statistics below, but the exact finite sample distributions are unknown and thus adjustments for sample size are necessarily approximations to the true critical values (Cheung and Lai, 1993). Our results should be interpreted in this spirit.

4 In general, additional restrictions on the coefficients in Γ_i are also required to demonstrate Granger non-causality (see Johansen, 1992; Mosconi and Giannini, 1992) but are clearly redundant in the VAR(1) case. For obvious reasons Hall and Milne (1994) have called this form of Granger-causality 'weak causality'.

V ESTIMATION AND TESTING

We now proceed to analyse the data on Malaysian sectoral GDP and labour productivity using the following abbreviations: a_t, m_t and s_t denote the logarithms of sectoral GDP (1980 prices) in agriculture, manufacturing and services respectively; and similarly ap_t, mp_t and sp_t denote sectoral labour productivity (1980 prices) in the three sectors. D_t denotes an intercept dummy (D_t = 1 when t = 1986, zero otherwise) to accommodate policy change in 1986.[5]

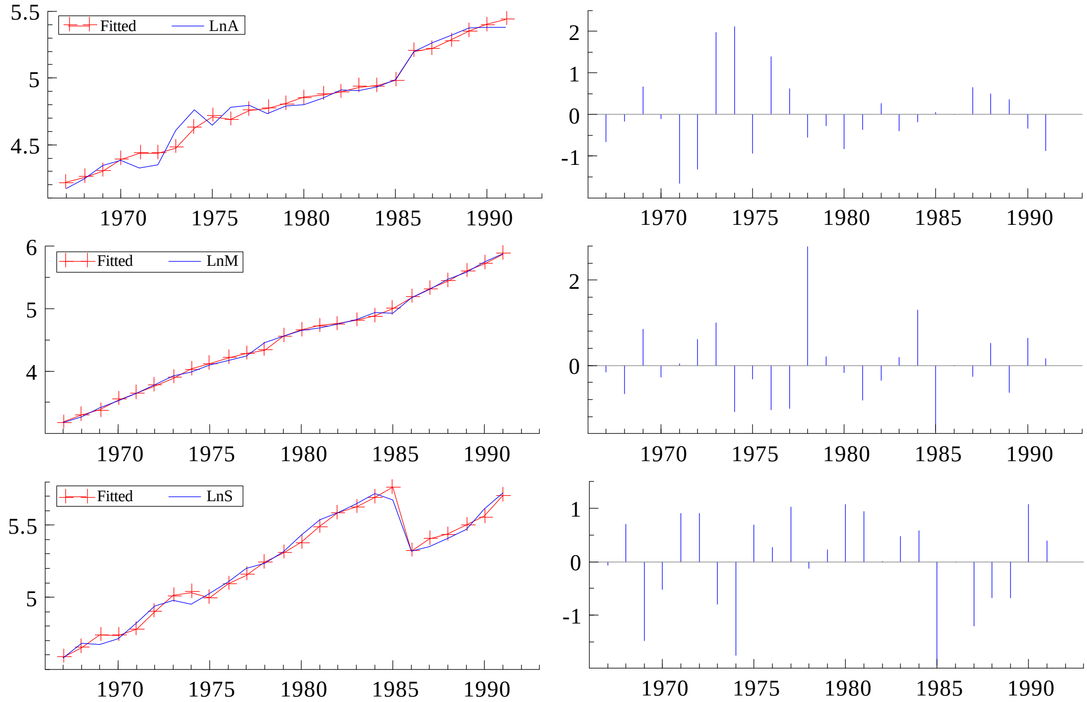
(i) Sectoral GDP data

To test for the order of integration of the series and cointegration a VAR is estimated. Mindful of the small sample we have at our disposal a VAR(2) model of equation (1) is specified comprising the variables a_t, m_t, s_t and D_t. Following estimation, system-based tests for residual autocorrelation, normality and heteroscedasticity do not uncover departures from the stated assumptions at conventional significance levels, although the system does appear to be over parameterised: testing that $\hat{\Pi}_2$ is a null matrix is easily accepted ($F(9,36) = 1.08$ $[p - value$ $0.40]$). This reduction delivers the VAR(1) system with white noise residuals and R^2 of 0.99 that is depicted in Figure 1 and is the model to which the tests for cointegration are applied (reported in Appendix Table A1). Using Cheung and Lai (1993) finite sample correction, the test statistics indicate rejection of the null of no cointegrating vectors in favour of one or more, but one cointegrating vector cannot be rejected in favour of two or more marginally below the 10 per cent critical value.[6] Combined with the strong evidence of cointegration in (5) we infer the existence of a single cointegrating vector between sectoral GDPs in Malaysia. With three variables in this system and one cointegrating vector there are (n - r =) 2 unit roots, implying that all the variables are I(1) processes, as is confirmed by conventional univariate tests of non-stationarity.

5 The statistical analysis is conducted within *PCFiml 9.0.* In the interest of brevity only key results are reported. All data and computer print-out has been given to the referees and copies may be obtained from the authors upon request.

6 As expected asymptotic (unadjusted) critical values suggest rejection of the null at the 10 per cent significance level with both tests.

Figure 1 Actual and Fitted values from the VAR(1) Model of Sectoral GDPs (logs) and Standardised Residuals



Normalising on a_t suggests a long-run relationship between sectoral GDPs of the form

$$a = 0.67m - 0.47s \qquad (4)$$

implying, *ceteris paribus*, a 1% increase in manufacturing (services) GDP leads to a 0.67% rise (0.47% fall) in agricultural GDP. While this normalisation is arbitrary, as written it implies the exogeneity of manufacturing and services GDPs to agricultural GDP, and is supported by small loading coefficients in α corresponding to the manufacturing and services equations (-0.1 and -0.17 respectively). Testing the joint significance of these coefficients using Johansens's (1992) test yields a $\chi^2(2)$ likelihood ratio test statistic of 2.06, [p-value 0.36] indicating the weak exogeneity of manufacturing and services in the equilibrium relation. This result implies that in the long run it is only agriculture that adjusts to sectoral disequilibrium within the economy and (by virtue of the VAR(1) specification) indicates that agriculture is not a Granger-cause of growth in the manufacturing or service sectors. Interestingly, manufacturing and services *are* Granger-causes of growth in agricultural GDP. In the Malaysian case, agriculture would appear to assume a passive role in the development process, reacting to changes elsewhere in the economy rather than forcing resource reallocation itself.

The foregoing analysis implies that single equation methods are efficient and allows Δm_t and Δs_t to enter as explanatory variables in the final equilibrium correction representation given below (*t*-ratios beneath parameter estimates):

$$\underset{}{\Delta a_t} = \underset{(4.34)}{2.78} - \underset{(-1.86)}{0.39\Delta m_t} \underset{(-5.69)}{-0.72\Delta s_t} \underset{(-4.40)}{-0.61}(a - 0.67m + 0.47s)_{t-1} \qquad (5)$$

$\bar{R}^2 = 0.64$ $\qquad F(3,21) = 12.79$ [0.0000] $\qquad$ DW = 1.84

Diagnostic Testing [*p* - value]

Autocorrelation :	$F(1,21) = 1.3$	[0.72]	Reset test :	$F(1,21) = 0.03$	[0.86]
Normality :	$\chi^2(2)=3.33$	[0.19]	Heteroscedasticity :	$F(6,15) = 1.26$	[0.33]

Diagnostic testing confirms the model's statistical adequacy (also see Figure 2) and its behaviour is interpreted as follows. The underlying rate of growth in agriculture is estimated at some 2.8% per year, a little over half the actual average growth rate, indicating a substantial degree of intersectoral interdependence. At times when the steady-state relationship between sectoral GDP does not hold, disequilibrium feeds back into agricultural growth via the equilibrium correction coefficient, at an estimated annual rate of 61%, presumably through resource flows between sectors. In other words, sectoral disequilibrium does not persist for long, since the agricultural sector reacts rapidly, making half of any necessary adjustments within ten months. Given the rapid rate of economic growth of the Malaysian economy and labour market flexibility, this estimated rate of adjustment is highly plausible.

The coefficients on Δm_t and Δs_t in (5) represent the short-run (or impact) semi-elasticities and imply, *ceteris paribus,* that a 1 percentage point increase in the growth rate (from say 2% to 3%) in either the manufacturing or service sector retards growth in agriculture by around 0.4 and 0.7 percentage points respectively. Whilst *ex post* explanations of dynamic responses are inevitably conjectural, these estimates are suggestive of short-run sectoral competition for resources. The magnitude of the point estimates imply that agricultural GDP is more sensitive to short-run expansion of services than to manufacturing, possibly reflecting the respective degrees of resource substitutability between sectors. Certainly, it is a reasonable expectation that short-run substitution of mobile factor inputs (primarily labour) is more likely between services and agriculture than between manufacturing and agriculture.

The results are also informative regarding the relative importance of changes in manufacturing and services on the size of the agricultural sector over the longer term. A decomposition of the predicted growth in agriculture (using estimates from (4) and average rates of sectoral growth) indicates that manufacturing growth is by far the most influential source of growth in agriculture. Indeed, the estimates suggest that over the sample period the positive effects of growth in the manufacturing sector have been more than three times as great as the retardation of agriculture resulting from the expansion of the service sector.[7] While expansion of both sectors may have similar demand-related impacts on agriculture, the transfer of manufacturing technology represents a plausible explanation for this dominance. By their very nature, spill-over effects take time to percolate through the economy and thus play a more significant role in the longer run. In so far as production and managerial technology originates in the manufacturing sector (e.g. via the operation of MNCs and indigenous capital intensive industries) one may expect *a priori* the agricultural sector to be more responsive to output growth in manufacturing than services. Note also that we do not find a significant reverse effect - exogenous expansion of agriculture does not appear to affect the other two sectors' GDPs. This Granger non-causality is consistent with labour market evidence in Malaysia that, while modern sectors can attract labour out of plantation agriculture, significant reverse flows are rare. When demand for agricultural commodities increases, labour expansion generally takes the form of low-skill *foreign migrant* workers.

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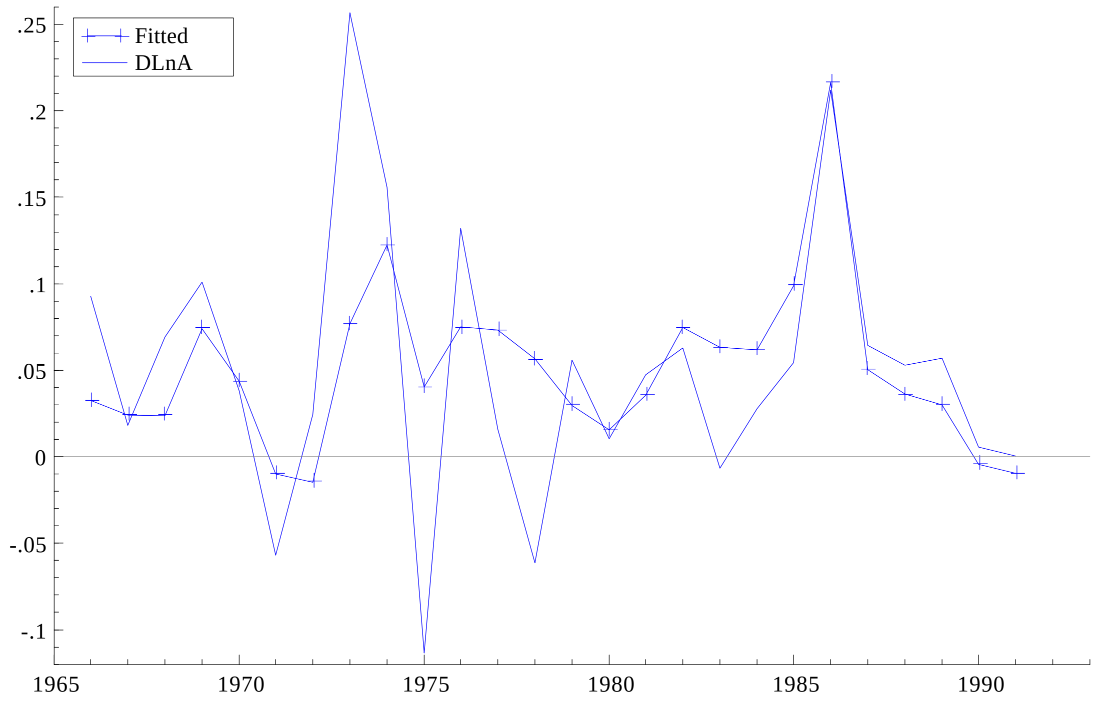
7 Over the sample, average annual rates of growth in manufacturing and services are 12.1% and 5.4% respectively, hence the predicted annual growth rate of agriculture is 0.056 = 0.67(.121)-0.47(.054).

Figure 2 Actual and Fitted Values of GDP Growth in Agriculture



Whatever the underlying explanations, these results would seem to suggest that, in terms of long-run GDPs, expansion of services has been inimical to agricultural development while manufacturing expansion has had a more complimentary role. Furthermore, the positive effects of manufacturing growth outstrip the negative effects of services in the long run. However, in the *short-run*, expansion of either services or manufacturing GDP is at the expense of agriculture, as would be expected when different sectors have to compete for relatively fixed factor supplies.

(ii) Sectoral Productivity

In an analogous manner to that above, we test for the existence of relationships between sectoral labour productivity using a VAR(2) model that comprises the I(1) series ap_t, mp_t, sp_t and D_t. As before, system reduction is confidently upheld {F(9,

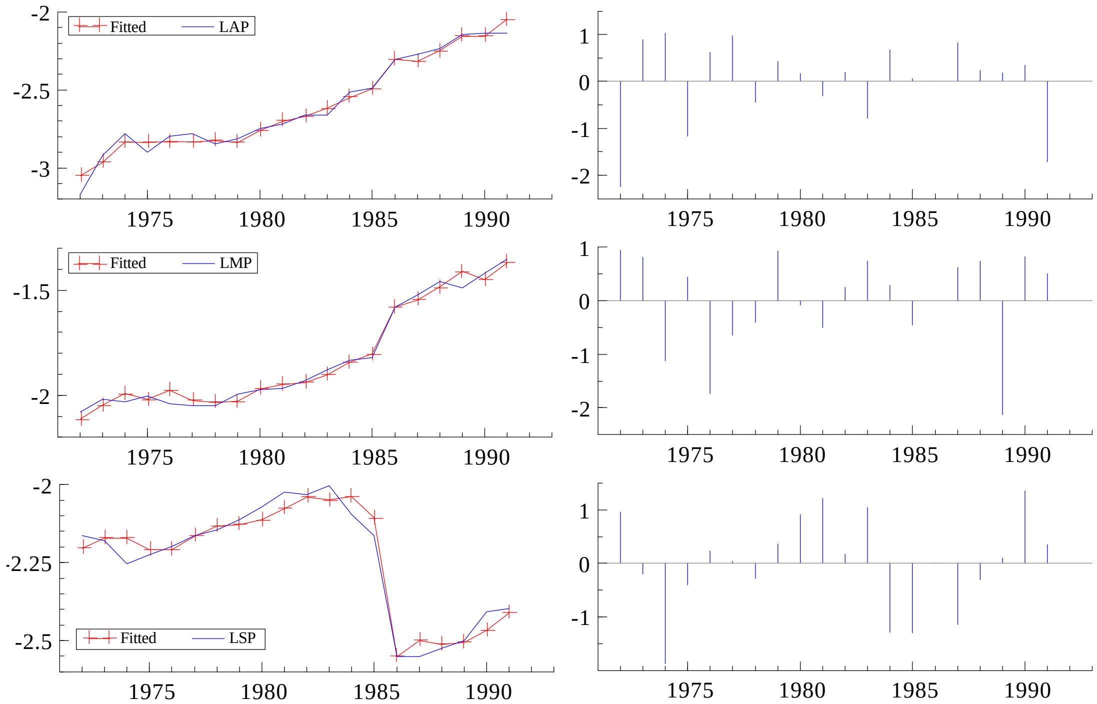
24) = 0.91 [p-value 0.52] } and tests on system residuals indicate model adequacy. Cointegration tests are reported in Appendix Table A2 and the data model and residuals are shown in Figure 3.

The results tend to indicate the presence of a unique cointegrating vector which (having normalised on the coefficient of ap_t) is estimated as

$$ap = 1.51 mp + 0.45 sp \tag{6}$$

Testing for the weak exogeneity of mp_t and sp_t in this relation yields a $\chi^2(2)$ test statistic of 2.26 [*p* value = 0.32] supporting the conditioning inherent in (6). Moreover, this result suggests that labour productivity in agriculture is not a Granger-cause of labour productivities elsewhere in the economy but that labour productivities in manufacturing and services *do* Granger-cause productivity growth in the agricultural sector.

Figure 3 : Actual and Fitted values from the VAR(1) Model of Sectoral Labour Productivity (logs) and Standardised Residuals



The final error correction model of productivity growth in agriculture is illustrated in Figure 4 and is estimated as

$$\Delta ap_t = 0.84 - 0.24\Delta mp_t \; - 0.58\Delta sp_t \; - 0.66(ap \; -1.50mp \; - 0.45sp)_{t-1} \qquad (7)$$

$$(5.87)(-0.97) \qquad (-4.08) \qquad (-5.50)$$

$\overline{R}^2 = 0.75$ $\qquad$ $F(3,17) = 17.75 \; [0.0000]$ $\qquad$ DW $= 2.15$

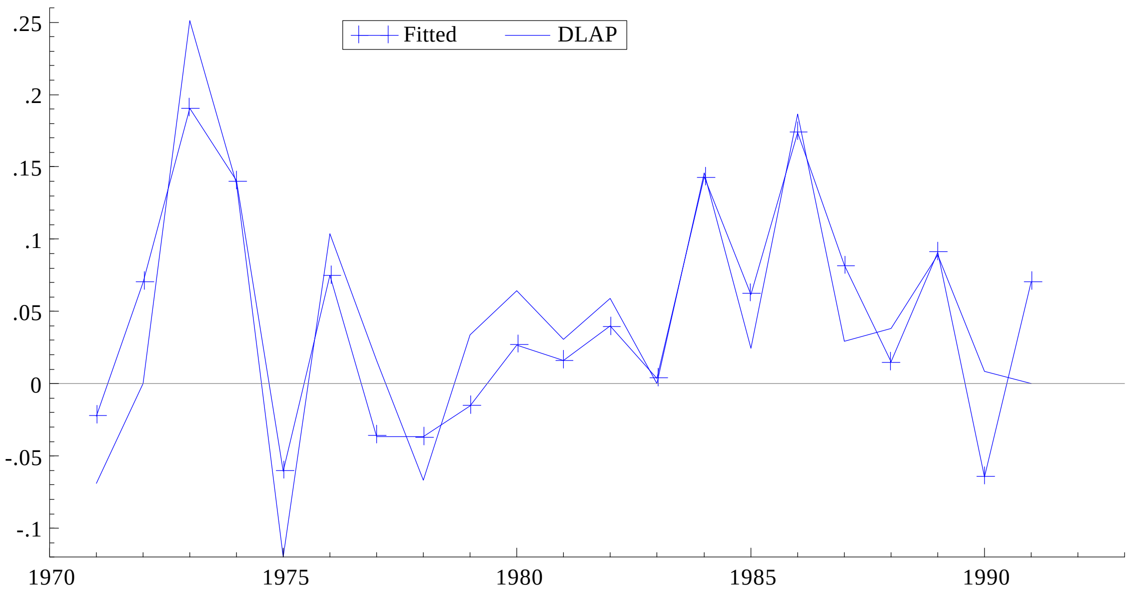
Diagnostic Testing [p value]

Autocorrelation :	$F(1,16) = 1.1$ [0.32]	Reset test :	$F(1,16) = 1.51$ [0.24]
Normality :	$\chi^2(2) = 1.25$ [0.53]	Heteroscedasticity :	$F(6,10) = 1.07$ [0.44]

It is apparent from (7) that the underlying rate of agricultural productivity growth is less than 1% per year during the sample period, considerably below the average rate over the sample of 4.6%, and underlines the important linkages in labour productivity growth. In the short term, increases in labour productivity elsewhere in the economy have a negative impact on agricultural productivity, although this is statistically insignificant for manufacturing.[8] These negative short-run relationship(s) are again unsurprising: expanding activities might be expected to have the resources (and incentives) to attract the better quality or more productive inputs so that a short-run productivity decline in the sectors from which they are attracted (in this case, agriculture) could also be expected. The dominant short-run effect is thus one of sectoral competition, and in a manner analogous to the GDP results, and it is the service sector that most keenly appears to compete with agriculture. These results may therefore lend support to the commonly held view, that for much of the agricultural labour force, it is the service sector that represents the most likely alternative to agricultural employment.

8 Estimates and standard errors of remaining parameters are qualitatively unchanged when Δm_t is omitted.

Figure 4 Actual and Fitted Values of Labour Productivity Growth in Agriculture



Turning to the long run relationship implied by (6) it is apparent that improvements in labour productivities in manufacturing and services lead, in the long run, to higher productivity in the agricultural sector, a result indicative of technological spill-overs.[9] Whilst the long-run response to changes in service productivity is relatively inelastic (0.45), the manufacturing elasticity (1.51) implies that in the long term the agricultural sector is responsive to productivity growth in that sector. Indeed, given that productivity in the service sector has remained largely unchanged over the sample period it is the developments in manufacturing that are largely associated for the rapid growth of labour productivity in agriculture, that has averaged almost 7.5% per year.

A further implication of this elastic response is that, *ceteris paribus*, we may expect to see a *convergence* of sectoral productivity levels over time. Though similar forces do not appear to operate for services, the evidence of convergence in agriculture-manufacturing productivity levels provides some backing for a 'traditional' neoclassical interpretation of the industrialisation process in Malaysia rather than an endogenous

9 Competition between sectors need not, of course, have a *net* negative impact on agriculture if the sector can respond to the loss of better quality inputs by improving the productivity of resources that remain.

growth interpretation. Furthermore, (7) suggests that short-run disequilibrium in labour productivities across sectors is corrected relatively rapidly by appropriate resource (labour) flows, in that about two-thirds of disequilibrium is corrected for per year. In sum, the productivity results are similar to those obtained for sectoral GDP in that the inimical short-run effects of non-agricultural growth on the agricultural sector are overturned by the complimentary long-run relationships.

V CONCLUSION

The empirical literature on structural change from agricultural to non-agricultural sectors in LDCs is extensive, but attempts to obtain reliable estimates have been bedevilled by three problems. (i) Though essentially a time-series phenomenon, previous estimates have generally relied on international cross-section data; (ii) neither theory nor econometric practice has satisfactorily dealt with problems of endogeneity of the variables involved; and (iii) it has not been possible to separate short-run from long-run structural change effects. This paper has argued that modern time-series econometric techniques provide the appropriate methodology to deal with each of these problems and have allowed us to explore the linkages between sectoral GDP and productivity for agriculture, manufacturing and services in a more satisfactory manner.

Our results suggest that, in Malaysia at least, the rapid expansion of manufacturing GDP since the 1960s, though associated with reduced agricultural GDP in the short-run, is associated with expanding agricultural GDP over the long-run. Service (GDP) growth on the other hand seems to be inimical to growth in agricultural GDP in both the short- and long-runs. The data also suggest that it is appropriate to regard manufacturing and service GDPs as ‘weakly exogenous’ in the sense that changes in these appear to affect changes in agricultural GDP but not vice versa. We have not attempted to identify the 'underlying causes' of these interactions here, but have argued that the signs and magnitudes which we identify are plausible given known characteristics of the Malaysian economy. On sectoral productivity, results suggest that increases in manufacturing and services both impact positively on productivity in agriculture in the long-run. This is consistent with neoclassical arguments suggesting, *inter alia*, that higher productivity techniques in manufacturing will tend to spill over to agriculture, so encouraging convergent tendencies in sectoral productivity levels.

Appendix

Definitions and sources of the data are as follows:

GDP (at factor cost) by sector, at constant 1980 prices: World Bank, *World Tables*; UN *National Account Statistics Yearbooks* (various issues); Asian Development Bank, *Key Indicators of Developing Asian and Pacific Countries*.

Labour productivity is defined as GDP divided by employment in the relevant sectors. Employment data are from: Ministry of Finance, Malaysia, *Economic Report* (various issues).

Sector definitions are the familiar ISIC classifications: Agriculture includes Forestry and Fishing. Services includes Commerce; Transport, Storage and Communications; Public Utilities; Government Services; and Other Services (Community, Social and Personal Services).

Table A1: Cointegration Tests in the GDP Model

(Asymptotic (∞) and Finite Sample (T) 10 % Critical Values)

26 observations (1966 - 1991) Eigenvalues: 0.53 0.28 0.03

H_0	H_1	*Trace*	∞	T	*ME*	∞	T
$r = 0$	$r \geq 1$	29.1	26.8	29.9	19.7	18.6	20.8
$r \leq 1$	$r \geq 2$	9.4	13.3	14.8	8.7	12.1	13.5
$r \leq 2$	$r = 3$	0.8	2.7	3.0	0.8	2.7	3.0

Critical values are those calculated by Osterwald-Lenum (1992) and Cheung and Lai (1993)

Table A2: Cointegration Tests in the Productivity Model

(Asymptotic (∞) and Finite Sample (T) 10 % Critical Values)

21 observations (1971 - 1991) Eigenvalues: 0.68 0.22 0.03

H_0	H_1	*Trace*	∞	T	*ME*	∞	T
$r = 0$	$r \geq 1$	28.9	26.8	30.8	22.8	18.6	21.4
$r \leq 1$	$r \geq 2$	6.0	13.3	15.3	4.7	12.1	13.9
$r \leq 2$	$r = 3$	1.3	2.7	3.1	1.3	2.7	3.1

Critical values are those calculated by Osterwald-Lenum (1992) and Cheung and Lai (1993)

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