

BUSINESS AND FINANCIAL SERVICES: NEW ENGINE OF ECONOMIC GROWTH?

Dr Ya Ping Yin

UHBS2008:7

The University of Hertfordshire has been recognised as the exemplar of a business-facing university. The Business School employs approximately 200 academic staff in a state-of-the-art teaching and learning environment located in Hatfield Business Park. It offers 17 undergraduate degree programmes, 21 postgraduate programmes and there are about 80 research students, mostly working at doctoral level.

Business School staff are active in research in numerous areas, including complexity theory, institutional economics, the creative industries, employment studies, finance, accounting, statistics and management science.

<http://www.herts.ac.uk/courses/schools-of-study/business/home.cfm>

BUSINESS AND FINANCIAL SERVICES; NEW ENGINE OF ECONOMIC GROWTH?

Ya Ping Yin^a

Abstract

Does unbalanced sectoral productivity growth inevitably lead to continuous shift of resources to the less productive sectors and stagnation in aggregate productivity? This paper attempts to integrate the traditional stagnationist and the modern optimist arguments within a numerical simulation framework. The simulation framework consists of an applied general equilibrium multi-sectoral growth model for a small open regional economy that incorporates unbalanced sectoral growth and the growing role of business and financial services as intermediate service providers. The simulation results lend support to the stagnationist view in the long run but reveal some unconventional comparative-static properties in the short- to medium run.

Key words: unbalanced growth, intermediate linkages, resource shift, multi-sector growth model

JEL classification: O41, O14, C68

^a Department of Accounting, Finance and Economics, University of Hertfordshire Business School, Hatfield, Hertfordshire, United Kingdom. Email: y.p.yin@herts.ac.uk. Helpful comments on an earlier version of the paper by Geoff Hodgson are gratefully acknowledged. Any remaining errors are my own.

Business and Financial Services: New Engine of Economic Growth?

1. Introduction

The past two decades have witnessed a new pattern of structural change in the developed economies. In contrast to the massive reallocation of labour from agriculture into manufacturing and services as documented in earlier studies of economic growth (e.g., Clark, 1940; Kuznets, 1957; and Chenery, 1960), the recent structural shift has been manifested through substantial growth of the services sectors, particularly business and financial services (BFS), relative to both the primary and secondary sectors across the developed countries. Moreover, BFS have played an increasingly important role as intermediate service providers (ISPs) through their strong intermediate linkages to other industrial sectors (for empirical evidence, see Oulton, 2001 and Feinstein, 1999, for example.). The explanation of the structural shift and the stipulation of implications for future economic performance and policy conduct have long dominated the research agenda for growth economists. The apparently significant shift of resources from the primary and secondary sectors to the tertiary sector and the eminence of BFS as ISPs in the modern era have provided fresh challenges to economic theories of growth, which has been to date dominated by the Solow-Swan type aggregate models or multi-sectoral models with balanced growth mechanisms and the absence of intermediate sectoral linkages.

The central question for the present study is whether or not the uneven productivity growth across economic sectors and the growing role of BFS as ISPs imply inevitable stagnation in aggregate productivity growth and thus future living standard. The present study departs from the conventional growth literature in two main aspects. First, instead of the usual assumption of balanced productivity growth across sectors, unbalanced sectoral productivity growth rates are adopted. Second, given the significant historical as well as renewed interest in intermediate industrial linkages in economic growth, this study incorporates such linkages into a multi-sectoral growth model. As Hulten (1978) mentioned in an earlier study, by incorporating intermediate inputs into the production process in growth accounting, the importance of productivity improvement as a source of growth in real output is nearly doubled as compared with the findings in other studies. Moreover, the incorporation of

intermediate production also brings to the fore the distinction between productivity growth in gross output and productivity growth in value added. As Oulton (2001) pointed out, a faster rate in the former does not necessarily imply a faster rate in the latter. Since a rising living standard can only arise from growth in value added productivity, the distinction of different productivity growth rates is important for the study of economic growth.

Notwithstanding the theoretical and empirical significance of unbalanced productivity growth and intermediate linkages, a rigorous theoretical treatment of such issues remains a largely uncharted territory. The present study makes a modest attempt to shed light on some theoretical aspects of the unbalanced growth mechanism, but the main effort is to simulate the aggregate growth process using a tried-and-tested numerical regional computable general equilibrium (CGE) model augmented with the unbalanced growth mechanism and intermediate production. The simulation results lend support to the view that the shift of resources to services, including BFS, does lead to overall productivity slowdown in the long run. However, in the short- to medium run, uneven productivity growth at the sectoral level favours the BFS sector in resource allocation and aggregate productivity growth can be boosted for some lengthy time periods.

The rest of the paper is organised as follows. Section 2 provides UK empirical evidence on the changing industrial structure and reviews the debate on the implications for aggregate productivity growth. Section 3 sets up and evaluates a multi-sectoral production system with intermediate linkages and exogenous unbalanced technical progress. Section 4 presents the numerical simulation model for a small open regional economy and discusses the simulation results. The final section concludes.

2. UK evidence on structural change and the debate on aggregate productivity slowdown

Table 1 presents evidence of the changing industrial structure and the rise to eminence of the BFS sector in the UK over the period from 1978Q2 to 2004Q2¹.

¹ Due to the controversy in measuring output in the BFS and other services sectors, employment data are used to illustrate cross-sector growth comparisons.

Table 1 Changing UK industrial structure and the eminence of the BFS sector

| Sector | Average quarterly rate of growth in sectoral employment, 1978Q2-2004Q2 (%) | Sectoral share of total full-time employment in 1978Q2 (%) | Sectoral share of total full-time employment in 2004Q2 (%) |
|-------------------|--|--|--|
| Agriculture | -0.67 | 1.9 | 0.8 |
| Energy & water | -1.20 | 2.8 | 0.7 |
| Manufacturing | -0.69 | 28.6 | 12.9 |
| Construction | -0.07 | 5.7 | 4.8 |
| Distribution | 0.29 | 19.4 | 24.3 |
| Transportation | -0.02 | 6.6 | 5.9 |
| Banking & finance | 0.67 | 10.5 | 19.4 |
| Public services | 0.29 | 20.8 | 25.9 |
| Other services | 0.43 | 3.7 | 5.3 |
| Total services | 0.08 | 61.0 | 80.8 |

Source: ONS on-line data archive. Employment refers to employees in employment which excludes self and part-time employment.

As is clear from the table, over the past two decades, all the traditional sectors have been steadily losing employment whereas all the services sectors have been gaining employment. In relative terms, the biggest losers are energy and water, manufacturing and agriculture whilst the biggest gainers are BFS, other services and public services. By the second half of 2004, all the services sectors accounted for 81% of total full-time employment in the UK and three sectors (public services, distribution and BFS) alone shared around 70% of the total. It is also worth noting that the BFS sector has been enjoying the fastest quarterly growth rate of employment among all the sectors for over two decades.

In contrast to the pattern of employment growth in different sectors, the traditional sectors have consistently outperformed the services sectors in terms of productivity growth, as is clearly shown in Table 2.

Table 2 Sectoral productivity growth in the UK

| Sector | Rate of growth in sectoral labour productivity per annum, 1973 – 1996 (%) |
|-------------------------|---|
| Agriculture | 3.66 |
| Energy & water | 2.60 |
| Manufacturing | 4.96 |
| Construction | 3.14 |
| Distribution | 1.52 |
| Transportation | 3.88 |
| Banking & finance | 2.07 |
| Other personal services | 1.57 |

Source: N.Oulton (2001).

This contrasting picture of sectoral performance in employment (and output) growth on the one hand and productivity growth on the other is certainly not a new phenomenon and has led to the long-standing concern over the possibility of stagnation in the long-term aggregate productivity growth in a developed economy. The concern was originally presented in a seminal paper by Baumol (1967) which explained why productivity growth may be intrinsically slower in the services sectors than in the manufacturing sectors and the implications of unbalanced sectoral productivity growth for relative costs, the structure of employment and the overall productivity growth rate². The central theme of Baumol's analysis is that sectors with stagnant productivity growth (viz. services) will experience a rapid rise in their relative cost and share of total resources (employment) and ultimately the overall productivity growth will converge to that of the stagnant sector. Such a pessimistic view was expressed again, in the form of asymptotic stagnancy hypothesis, in a number of later studies by Baumol (1985) and Baumol et al. (1989).

However, this view was recently challenged by Oulton (2001). A central argument by Oulton is that Baumol's theoretical framework omits sectoral industrial (or intermediate) linkages

² Hodgson (1989) provides more insights to the reasons why manufacturing may enjoy a superior productivity performance than the other sectors.

with the rest of the economy, but such linkages are shown to have a significant impact on the overall productivity growth path. The mechanism by which intermediate linkages exert an impact on overall productivity growth is captured through the “Domar aggregation” procedure whereby aggregate productivity growth cannot be lower than the productivity growth in any individual sector. Under the assumption of perfect competition, a rise in the share of resources absorbed by an ISP raises the aggregate growth rate provided only that the ISP’s total factor productivity (TFP) growth is positive. Since BFS has strong industrial linkages with the other industries, any positive growth in this sector, no matter how much slower it is than that of the manufacturing sector, will contribute to a higher overall TFP growth rate in the aggregate economy.

The Baumol-Oulton unbalanced growth framework departs from the conventional Solow-Swan type aggregate model of economic growth or the balanced growth literature, but still shares the conventional growth accounting – partial equilibrium characteristics³. It is not clear *a priori* whether either result holds in a more general and realistic representation of the economy. A more general theoretical framework for examining multi-sectoral growth mechanisms is the Uzawa two-sector growth model and its extensions that attracted much interest in the 1960s and 1970s (see, for example, Uzawa, 1961, 1963; Meade, 1961; Kurz (1963); Burmeister and Dobell, 1970; Stiglitz and Uzawa, 1970). There seems to be a current revival of interest in the multi-sectoral unbalanced growth models (e.g., Baumol, 1989; Rauch, 1997; Oulton, 2001; Kongsamut, et. al. 2001; Jensen and Larsen, 2004). Since the Oulton model is the only one that incorporates both unbalanced growth and intermediate linkage, for the purpose of clarifying later discussion, a very brief technical representation of the Oulton results is presented here.

Let y_i , x_i , m_i , w_i , p_i and p_i^m denote gross output, a single input (either labour or a composite input), intermediate input, factor price, product price and the price of the intermediate input in a sector i , and let the total output production function be $y_i = f_i(x_i, m_i, t)$ where t is time. Assuming constant returns to scale and perfect competition, then TFP growth in sectoral

³ Baumol’s model, in particular, has made some highly simplifying abstractions of the real economy, such as the absence of intermediate production and labour as the only factor input.

output in the i th industry can be obtained as the Solow residue (note that a hat ^ above a variable denotes the instantaneous rate of growth in that variable):

$$\hat{q}_i = \hat{y}_i - \left(\frac{w_i x_i}{p_i y_i}\right) \hat{x}_i - \left(\frac{p_i^m m_i}{p_i y_i}\right) \hat{m}_i \quad (1)$$

Through some algebraic manipulation, it is possible to obtain an important relationship between the TFP growth rate in value added and the TFP growth rate in gross output in that sector:

$$\hat{q}_i^v = \left(\frac{p_i y_i}{w_i x_i}\right) \hat{q}_i \quad (2)$$

Since the nominal value of a sector's gross output is greater than its nominal value of intermediate inputs, TFP growth in value added is larger than TFP growth in gross output. On the basis of equation (2) and other conditions, it is possible to derive a fundamental relationship between the TFP growth rate in aggregate value added (which is taken to measure the overall productivity growth rate) and the sectoral TFP growth rates in outputs in individual sectors:

$$\hat{q} = \sum_{i=1}^n \left(\frac{p_i y_i}{p^v v}\right) \hat{q}_i \quad (3)$$

where v is aggregate value added (or GDP) and p^v is its price. This relationship is a variant of the commonly adopted "Domar aggregation" procedure, which shows that the aggregate TFP growth in value added is a weighted sum of the sectoral TFP growth rates in outputs *with the weights summing to more than unity*. Moreover, given some simplifying assumptions, the aggregate TFP growth rate is asymptotically the sum of individual sectoral TFP growth rates. Therefore, any TFP growth in any sector contributes (asymptotically) one-for-one to the aggregate TFP growth – no stagnation is possible!

However, it should be borne in mind that the Domar aggregation procedure is derived in a partial equilibrium framework that consists of the production system of individual industries and the aggregate economy but without the demand side. Therefore, Domar aggregation captures how productivity improvements by individual sectors affect (both shift and tilt) the aggregate supply curve, but completely ignores the movements of the aggregate demand curve and thus cannot measure aggregate factor productivity improvement when the economy has reached general equilibrium. This problem is particularly acute in the short to medium

run when there are significant changes in relative prices and the demand structure. The assumption of a small open (regional) economy, as is adopted here, puts further strain on the validity of the partial equilibrium analysis, as the resource constraint for the regional economy is not bounding due to potential migration of factor inputs. With the exception of the very long-run when the non-substitution theorem holds, the Domar aggregation procedure will give rise to inaccurate measures of aggregate TFP growth in the short to medium run. Even if this general equilibrium issue is ignored, a close inspection of equation (3) suggests that Domar aggregation does not necessarily produce an aggregate TFP growth rate that is significantly above the slowest sectoral TFP growth rate, as the share of (nominal) output (i.e. $p_i y_i / \sum p_i y_i$) by the fast-growing sectors may be significantly lower than that by the slow-growing sectors so that the weight attached to the sectoral TFP growth rate (i.e. $p_i y_i / p^v v$) in the fast-growing sector may be insignificant. Therefore, whether or not Domar aggregation will produce superior aggregate TFP growth rate depends crucially on the evolution of the sectoral shares of output and the wedge between the volume and price of gross outputs on the one hand and the volume and price of value added on the other. However, the formula by itself cannot provide an unambiguous answer and the issue can only be settled empirically or through numerical simulation.

In a general equilibrium model, the evolution of prices and quantities depends on the specification of the demand and supply conditions in the factor and goods markets as well as the production technology. Since the literature has typically assumed homothetic consumer preferences so that consumers with different incomes but facing the same prices will demand goods in the same proportions, ultimately the allocation of resources and sectoral production are determined by relative sectoral prices, which in turn are determined by supply conditions. Therefore, the focus of the growth literature has been on the supply conditions including production technology⁴. A limitation of the general literature is that the implications of

⁴ It is worth pointing out that in the real world the structure of aggregate demand also matters for long-run economic growth. As Rowthorn (1992) points out, in decomposing the increase in the share of services in total employment in the US from 1973-1988, less than two-fifths of the increase was due to the productivity lag in services, while more than three-fifths was due to the faster growth in the output of services as compared with goods. This implies that demand factors rather than unbalanced productivity growth were the major force behind the apparent shift to a service economy in the US over that time period. However, a rigorous incorporation of more realistic consumer preferences into a long-run model of economic growth remains an intellectual challenge.

technical progress for the resource constraint faced by the economy have been ignored. Continuous technical progress – in the Harrod labour-augmenting or Hicks-neutral sense – implies that the effective supply of labour in efficiency units is infinite in the long-run. Unbalanced sectoral technical progress implies that not only the total amount but also the sectoral composition of effective labour supply is constantly changing. Such changes will invalidate the usual assumption that the real wage rate is the same across all sectors and changes at the same rate as the uniform technical progress rate. Therefore, the evolution of relative factor prices, and hence that of relative goods prices, will depart from the trajectory in a balanced growth model. The evolution of relative factor prices in an unbalanced growth context is a key aspect of the theoretical concern in the current paper.

Following the literature, the current study focuses on the supply side but additionally incorporates unbalanced technical progress as well as intermediate linkages. The role of intermediate linkage has received central attention in the (largely informal) literature on industrial linkages and economic growth/development, which is technically captured in Hirschman's concepts of the Backward Multipliers (BM) and Forward Multipliers (FM). Moreover, it is commonly assumed, although never formally proven, that growth in sectors with strong industrial linkages will act as an impetus (or the engine) to the overall growth rate. This sentiment seems to be shared by the modern optimist view of BFS as the "soft engine of economic growth". The next section introduces an extended two-sector-two-factor production system, but not a fully-fledged general equilibrium model, to shed light on the complex nature regarding the dynamic properties of multi-sector growth (MSG) mechanisms. Due to the technical complexity regarding general economic equilibrium in the context of unbalanced growth, no attempt is made to present a formal proof for the existence of a globally stable overall growth path for the aggregate economy. It is worth pointing out that even in the much simpler setting of balanced growth, although the literature has identified a number of (mostly) sufficient conditions for stability, the conditions are judged to be either peculiar or highly restrictive (see, e.g. Hahn, 1965).

3. Unbalanced growth in a two-sector-two-factor production system with intermediate production and unbalanced technical progress

The modelled economy consists of two sectors producing two goods with two homogeneous inputs: labour and capital. A nested and separable CES production structure is adopted for each of the two sectors: sectoral gross output is a composite of value added and a composite intermediate input; value added in turn is produced by labour and capital; and the composite intermediate input consists of own good and the other good.

$$y_i = [\alpha_i v_i^{-\rho} + (1 - \alpha_i) m_i^{-\rho}]^{-1/\rho} \quad \text{Sectoral gross output} \quad (4)$$

$$v_i = [\beta_i (\theta_i L_i)^{-\rho} + (1 - \beta_i) (\theta_i K_i)^{-\rho}]^{-1/\rho} \quad \text{Sectoral value added} \quad (5)$$

$$m_i = [\gamma_i x_{ii}^{-\rho} + (1 - \gamma_i) x_{ji}^{-\rho}]^{-1/\rho}, \quad j \neq i \quad \text{Composite intermediate input} \quad (6)$$

$$x_{ij} = a_{ij} y_j \quad \text{Sectoral intermediate input} \quad (7)$$

where $i, j (=1, 2)$: index for sectors; v : value added; m : composite intermediate input which consists of own good and the other good; θ is a labour- and capital-augmenting factor; a_{ij} is the fixed intermediate input-output coefficients; ρ is related to the elasticity of substitution between two inputs ($\sigma = \frac{1}{1 + \rho}$). For simplicity reasons, the elasticity of substitution is

assumed to be the same across sectors and the levels of the production hierarchy. θ evolves from an initial level of technology in the following way: $\theta_i = \theta_{i,0} \exp(r_i t)$. In other words, a costless Hicks-neutral technical progress (or manna from heaven) at the rate of r_i in sector i is imposed with $r_1 < r_2$ (thus sector one can be assumed to be the service sector).

On the basis of equations (4) to (7), the corresponding growth rates are derived as:

$$\hat{y}_i = s_i^v \hat{v}_i + (1 - s_i^v) \hat{m}_i \quad (8)$$

$$\hat{v}_i = r_i + s_i^L \hat{L}_i + (1 - s_i^L) \hat{K}_i \quad (9)$$

$$\hat{m}_i = \hat{y}_i \quad (10)$$

where the s 's are the share parameters (e.g., $s_i^v = \frac{\alpha_i v_i^{-\rho}}{\alpha_i v_i^{-\rho} + (1 - \alpha_i) m_i^{-\rho}}$ is the share of value added in gross output, s_i^L is the share of labour income in value added). It is straightforward to obtain the sectoral TFP growth rate in value added as:

$$\hat{q}_i^v = r_i \quad (11)$$

Thus, regardless of a sector's intermediate linkage, its TFP growth rate in value added depends only on the rate of technical progress. To derive the sectoral TFP growth rate in output, equation (5) is substituted into (4) and the growth rate in output is re-expressed in terms of the growth rates of three inputs:

$$\hat{y}_i = s_i^L (r_i + \hat{L}_i) + s_i^K (r_i + \hat{K}_i) + (1 - s_i^L - s_i^K) \hat{m}_i \quad (12)$$

where $s_i^L = \frac{\alpha_i \beta_i (\theta_i L_i)^{-\rho}}{\alpha_i \beta_i (\theta_i L_i)^{-\rho} + \alpha_i (1 - \beta_i) (\theta_i K_i)^{-\rho} + (1 - \alpha_i) m_i^{-\rho}}$ is the share of labour in gross output and $s_i^K = \frac{\alpha_i (1 - \beta_i) (\theta_i K_i)^{-\rho}}{\alpha_i \beta_i (\theta_i L_i)^{-\rho} + \alpha_i (1 - \beta_i) (\theta_i K_i)^{-\rho} + (1 - \alpha_i) m_i^{-\rho}}$ is the share of capital. Thus,

the sectoral TFP growth rate in output is obtained as:

$$\hat{q}_i = (s_i^L + s_i^K) r_i = (s_i^L + s_i^K) \hat{q}_i^v \quad (13)$$

Since $s_i^L + s_i^K < 1$, the sectoral TFP growth rate in output is unambiguously lower than the sectoral TFP growth rate in value added. Moreover, the higher the share of intermediate input in a sector, the larger the gap between the two growth rates. Therefore, sectors with strong (backward) intermediate linkages will have faster TFP growth rates in value added than TFP growth rates in output, whilst sectors with weak (backward) intermediate linkage will have similar TFP growth rates in output and value added. Moreover, if the (backward) intermediate linkage is stronger, a given technical progress will translate into a slower sectoral growth rate in output⁵.

In the above exposition the *overall* TFP growth rate (in value added) for the aggregate economy has not been related to the *sectoral* TFP growth rates. In the literature, the aggregate TFP growth rate (in value added or output) is simply obtained through the Domar aggregation method. As is argued above, this method is at best a rough approximation and likely to produce inaccurate results for the short to medium term in the general equilibrium context. This reservation is indeed confirmed by the simulation results later. A satisfactory approach must take into account the general equilibrium patterns of prices as well as quantities. Such an approach necessitates the incorporation of the factor market and the goods market (i.e. the

⁵ It is worth pointing out that in this setting it is not possible to show how a sector's forward linkage affects the relationship between technical progress and the TFP growth rate in output. Nevertheless, this effect is fully captured in the numerical model.

demand side) into a general equilibrium framework. A comprehensive and rigorous analytical treatment is beyond the remit of this paper. Instead, the study relies on numerical simulations to generate the aggregate TFP growth path and then examines its properties. Nevertheless, before the numerical simulations are carried out some relevant theoretical aspects are explored in the next few sections.

What lies at the heart of the stagnationist argument is the “cost disease hypothesis” – the relative unit cost in services to manufacturing will asymptotically approach infinity. Such a strong result is derived from some very restrictive assumptions⁶. Here a more general approach to the examination of the evolution of the relative unit cost is taken. Adopting the standard assumption of zero profit at every level of the production hierarchy gives rise to:

$$p_i^y y_i = p_i^v v_i + p_i^m m_i \quad (14)$$

$$p_i^v v_i = W_i L_i + R_i K_i \quad (15)$$

$$p_i^m m_i = p_i^y x_{ii} + p_j^y x_{ji} \quad (16)$$

where W is the nominal wage and R is the capital rental rate. Aggregate output and value added are simply the sums of the sectoral counterparts:

$$p^y y = \sum p_i^y y_i \quad (17)$$

$$p^v v = \sum p_i^v v_i \quad (18)$$

To examine the evolution of relative unit cost and the potential shift of labour resources between sectors, the optimal sectoral demand for labour inputs is derived as follows:

$$L_i = \left(\frac{p_i^v \beta_i}{W_i} \right)^\sigma v_i \theta_i^{\sigma-1} \quad (19)$$

Let $S = L_1/L_2$ denote the ratio of labour inputs in the two sectors, the rate of change in S is:

$$\hat{S} = \sigma(\hat{w}_2 - \hat{w}_1) + \hat{v}_1 - \hat{v}_2 + (\sigma - 1)(r_1 - r_2) \quad (20)$$

where $w_i = W_i / p_i^v$ is the real wage rate. Equation (20) illustrates that the cross-sector shift of labour resources is determined by four categories of factors: i) the technical parameter of the elasticity of substitution between labour and capital; ii) the differential between the growth rates in sectoral real wage; iii) the differential between the growth rate in sectoral value added; iv) the differential between the sectoral rates of technical progress. It is rather

straightforward to derive a number of partial equilibrium (i.e. under the *ceteris paribus* condition) comparative-static properties of the resource shift process:

- 1) Provided that wage growth in sector two exceeds the growth in sector one by more than the differential between technical progress rate in sector two and that in sector one (i.e., $\hat{w}_2 - \hat{w}_1 > r_2 - r_1$), the easier it is for labour to substitute capital, the higher is the shift of labour from sector two to sector one.
- 2) The higher the growth rate in a sector's value added, the larger the shift of labour to that sector.
- 3) If a sector's wage growth exceeds that in the other sector, labour will shift from the former to the latter.
- 4) Provided that $\sigma < 1$, an increase in a sector's technical progress will cause outward shift of labour from that sector.

Therefore, how resources shift from sectors to sectors depends on the intricate interplay of a plethora of factors in the economy. Since in the growth literature the focus has been narrowly placed on labour costs as the determinant factor, the evolution of sectoral wage rates is examined in detail here. It is usually assumed that $\hat{w}_2 = \hat{w}_1$. However, given unbalanced sectoral technical progress, no such presumption is made here. In a perfectly competitive labour market, the real factor prices equal their marginal products. Thus,

$$w_i = \frac{\partial v_i}{\partial L_i} \quad (21)$$

$$r_i^K = \frac{\partial v_i}{\partial K_i} \quad (22)$$

By partially differentiating the value added production function and obtaining the marginal products, it is possible to derive the rate of change in the sectoral real wage rate as:

$$\hat{w}_i = r_i + (1 + \rho)(1 - s_i^L)(\hat{K}_i - \hat{L}_i) \quad (23)$$

⁶ Some typical assumptions include that even though productivity growth in services is zero, the real wage in services still grows without limit at the same rate as the growth rate of the manufacturing wage, plus, there is no substitution between labour and capital and demand for services is income elastic but price inelastic.

where s_i^L is the sectoral share of labour in value added. Clearly the sectoral real wage will grow at different rates. Even if the steady-state is achieved with a constant capital/labour ratio, the sectoral real wage will evolve at the different sectoral technical progress rates.

Let the sectoral unit labour cost be defined as $UCL_i \equiv \frac{W_i L_i}{p_i^i v_i}$ (i.e., the labour cost in producing one unit net output⁷). Then it is possible to derive the rate of change in the relative unit labour cost in the two sectors as:

$$\hat{r}_{UCL} = \frac{\sigma - 1}{\sigma} [s_1^K (\hat{L}_1 - \hat{K}_1) - s_2^K (\hat{L}_2 - \hat{K}_2)] \quad (24)$$

It is clear that one sufficient condition for the relative unit cost to remain constant is that the elasticity of substitution between labour and capital is unity. Another sufficient condition for the relative unit cost to remain constant is that $s_1^K (\hat{L}_1 - \hat{K}_1) = s_2^K (\hat{L}_2 - \hat{K}_2)$. In other words, if any differential in the labour and capital growth rates, adjusted by the share of capital, is the same across the two sectors, then the relative unit cost will remain constant. Therefore, the relative unit cost in services (sector one) does not necessarily rise without limit. Baumol's cost disease result is just a special case. A sufficient condition for the Baumol scenario to occur is: $\sigma > 1$ and $s_1^K (\hat{L}_1 - \hat{K}_1) > s_2^K (\hat{L}_2 - \hat{K}_2)$, i.e., the elasticity of substitution between labour and capital is greater than unity *and* labour intensity in sector one (services) rises faster than that in sector two (manufacturing). However, this condition is not necessary for relative unit labour cost to rise. Indeed, the relative unit cost could go the opposite way under the sufficient conditions that the elasticity of substitution is less than unity and that labour intensity in services rises faster than that in manufacturing.

A further complication to the discussion of resource shift on the basis of relative unit cost of labour is that it is relative *goods* prices, not RUCL, which regulates sectoral production and resource allocation. As is well-known, efficient production in a competitive economy requires the marginal rate of transformation between two products to be equated with their

⁷ UCL can also be defined with reference to gross output. However, the derivation of the change in RUCL will be more complicated but adds little to the qualitative result that RUCL in services could increase as well as fall. Nevertheless, different definitions will lead to different patterns of RUCL – even if RUCL in net output rises, RUCL in gross output could fall if the sector uses a significant proportion of intermediate inputs in production.

relative prices. However, movements in sectoral RUCL do not necessarily follow movements in sectoral relative product prices, due to substitution between labour and capital and between primary inputs and intermediate inputs. Moreover, the changing structure of demand in the economy (in the short to medium run) will create further wedge between RUCL and relative prices. Although a rigorous theoretical depiction is not attempted here, the general equilibrium patterns of RUCL and relative prices (or sectoral terms of trade) will be ascertained in the simulation exercises below.

As is mentioned above, the analyses here only concern the supply side adjustments to uneven sectoral productivity growth and completely ignore the demand side (e.g. consumption and investment⁸) adjustment. The central contribution of the Uzawa model is to capture both the supply-side and demand-side conditions to enable the derivation of the sufficient conditions for achieving the factor market equilibrium and the steady-state growth path. Such a task is far more complicated in the present context. As is well known in the original Uzawa models, different assumptions about the savings behaviour in the economy generate different sufficient conditions for the attainment of unique market equilibrium and dynamic steady state. The extensions here will necessarily complicate the dynamic properties of the original Uzawa models even further. Therefore, this study does not attempt to provide the formal sufficient or necessary conditions for achieving equilibrium or steady-state (a recent theoretical attempt is made in Jensen and Larsen, 2004). As the original Uzawa two-sector model illustrates, such an endeavour is already highly complex and controversial⁹. Moreover, the Uzawa model does not depict the aggregate growth path or explore how it is related to the technical progress, which is the primary concern of this study. In the next section, a fully-fledged numerical applied multi-sectoral growth model is adopted to simulate the growth paths of the economy in the context of unbalanced sectoral technical progress.

4. A general equilibrium MSG model for a small open economy and simulation results

4.1 Structure of the simulation model

⁸ The omission of investment demand also leaves out the specification of the capital accumulation process.

⁹ According to Frank Hahn (1965), the assumptions adopted for deriving the necessary or sufficient conditions achieving uniqueness and dynamic stability are all “terrible” assumptions.

The simulation model that is adopted here is a general equilibrium MSG model for a UK region – Scotland. The model has been used extensively for policy analysis (for example, see Harrigan, et. al. 1991; McGregor, et. al. 1996, 2000; Ferguson, et. al., 2005). The following section presents a brief summary of the main features of the model used for the current study.

- Economic transactors: Households, firms, government, residents in the rest of the UK (RUK) and the rest of the world (ROW).
- Production structure and factor market: There are three sectors, manufacturing, non-manufacturing traded (NMT) and sheltered. The NMT sector is dominated by BFS. The sheltered sector is distinguished from the other sectors through the adoption of much lower import and export propensities than the other sectors. The hierarchical structure of production is very similar to the one introduced in the above section. Cost minimisation in production with multi-level CES production functions is imposed at almost every level of the hierarchy¹⁰. Intermediate imports are generally determined via an Armington link (Armington, 1969). Exogenous Hick-neutral technical progress is introduced into the sectoral value added production functions. All markets are assumed to be competitive. Moreover, given the small open nature of the regional economy, all factors are assumed to be imperfectly mobile in the short-run through the imposition of sluggish adjustment factors in the regional migration function and the investment function, but perfectly mobile in the long run.
- Final demand: there are four major components of final demand: consumption, investment, government expenditure and exports. Of these, real government expenditure is exogenous. Consumption is a linear homogeneous function of real disposable income. Exports (and imports of final goods) are also generally determined via the Armington link. Investment is determined in such a way that the actual capital stock is ultimately adjusted to the desired capital stock, which is compatible with a simple theory of optimal investment behaviour given the assumption of quadratic adjustment costs.

Therefore, apart from the empirical richness and the introduction of unbalanced sectoral technical progress, the simulation model is very similar to the theoretical counterpart of the

¹⁰ The only exception is the production of local intermediate inputs, which is assumed to adopt the Leontief technology.

conventional two-sector two-factor growth model. The simulation exercises aim to shed light on the following central questions:

- Does unbalanced sectoral productivity growth lead eventually to the overall growth rate converging to the growth rate of the slowest sector?
- Which sector provides the strongest spur to the overall growth rate?
- Are the above results dependent on the sector's industrial linkage?

4.2 Sectoral industrial linkages

Since a key issue to be investigated is the relationship between a sector's industrial linkage and the impact of its TFP growth on the overall TFP growth path, the next section presents empirical evidence for the sectoral industrial linkages in the UK and the modelled regional economy (Scotland) in Table 3 and 4.

Table 3 UK industrial linkage, 2003

| | Share of intermediate inputs in gross output (%) | Share of gross output for intermediate use (%) | Backward multipliers | Forward multipliers |
|-----------------------------------|--|--|----------------------|---------------------|
| Agriculture | 53.93 | 49.68 | 2.21 | 1.27 |
| Mining and quarrying | 29.46 | 63.49 | 1.59 | 1.65 |
| Manufacturing | 63.67 | 38.41 | 2.45 | 5.00 |
| Electricity, gas and water supply | 64.99 | 64.55 | 2.34 | 1.70 |
| Construction | 61.70 | 43.00 | 2.39 | 1.86 |
| Wholesale and retail trade | 48.28 | 17.42 | 2.01 | 1.23 |
| Transport and communication | 53.35 | 67.85 | 2.11 | 2.20 |
| Financial intermediation | 39.81 | 62.00 | 1.77 | 4.03 |
| Public administration | 52.78 | 5.21 | 2.13 | 1.05 |
| Education, health and social work | 40.34 | 18.81 | 1.83 | 1.30 |
| Other services | 47.51 | 35.67 | 1.93 | 1.45 |

Source: derived from the UK input-output table for 2003 by the ONS.

Table 4 Scottish industrial linkage, 1989

| | Share of intermediate inputs in gross output (%) | Share of gross output for intermediate use (%) | Backward multipliers | Forward multipliers |
|--------------------------|--|--|----------------------|---------------------|
| Manufacturing | 70 | 21 | 1.44 | 1.28 |
| Non-manufacturing traded | 43 | 35 | 1.32 | 1.47 |
| Sheltered | 22 | 17 | 1.19 | 1.19 |

Source: derived from the Scottish input-output table for 1989 by the Scottish Office.

It is clear from both Table 3 and 4 that for the UK and Scottish economies the BFS sector has both strong backward and forward linkages with the other sectors, but the forward linkages dominate. A significant proportion of the BFS output goes into intermediate use (the proportion has increased over the past decade). In Scotland, the product of the non-manufacturing sector, of which BFS are a dominant part, has the highest share of intermediate use. Accordingly, the BFS sector also has the highest forward linkage in the Scottish economy and the second highest forward linkage in the UK. Similarly, manufacturing has very important backward and forward linkages with the rest of the economy. In both the UK and Scotland, the sheltered sector has the weakest forward or backward linkages. Therefore, it is expected that the gap between TFP growth in value added and TFP growth in output will be larger in the manufacturing and BFS sectors than the sheltered sector.

Having established the sectoral industrial linkages in the modelled economy, this study proceeds to simulate the impact on the overall productivity growth path by introducing unbalanced Hicks-neutral technical progress to each of the three sectors. If the stagnationist view holds, the overall TFP growth rate should converge to the slowest sectoral TFP growth rate. On the contrary, if the optimist view holds, the overall TFP growth rate is expected to be significantly higher than the slowest TFP growth rate (and possibly higher than the fastest sectoral TFP growth rate). Moreover, if intermediate linkages are important in determining a sector's impact on the overall TFP growth, improvement in productivity growth in BFS should exert a strong impact, whereas productivity improvement in the sheltered sector has a weak impact, on the overall productivity growth.

4.3 Simulation results

The first simulation exercise imposes a 3% Hicks-neutral technical progress in the manufacturing sector and 1% technical progress in the remaining two sectors. This set-up reflects the common observation that technical progress in manufacturing is much faster than those in the services sectors. The model is run for 100 years and the sectoral and aggregate TFP growth paths are obtained. The sectoral TFP growth rates in value added are calculated as the Solow residue by deducting from the sectoral growth rates in value added the weighted average of sectoral labour and capital growth rates. As the analytical analysis suggests, the TFP growth rates in value added should converge to the sectoral rates of technical progress. The simulation results (not shown here) do conform to the analytical results, suggesting that the numerical model does track the theoretical growth path well.

In calculating the sectoral TFP growth rates in output, equation (2) is inverted – a procedure that is commonly used in applied studies on growth accounting. An advantage of this study is that the weights are constantly updated using the most recent prices and quantities from the model solutions. The resultant sectoral TFP growth paths in outputs are shown in Figure 1.

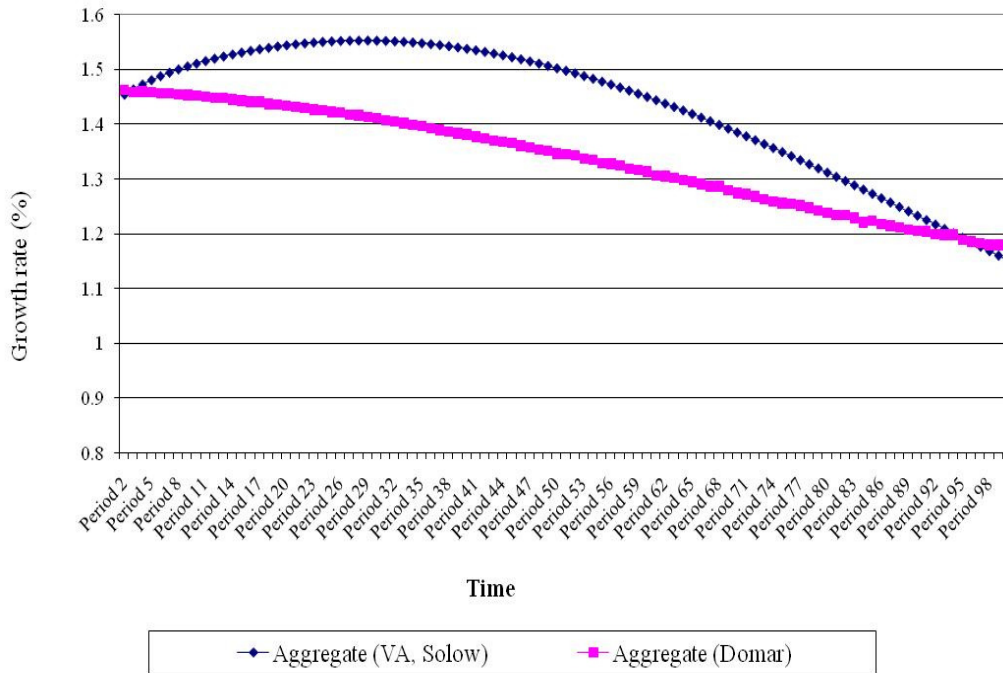
Fig. 1 Sectoral TFP growth paths (gross output)



Figure 1 is clearly in keeping with the analytical result in equation (2) or (13) that the TFP growth rates in output are lower than the TFP growth rates in value added. Moreover, whilst the TFP growth rate in output remains relatively stable over the entire simulation time span in the sheltered sector, output TFP growth rate declines slightly in NMT but sharply in manufacturing. This distinctive pattern in manufacturing is explained by further detailed simulation results that show a continuous rise in the share of intermediate inputs in gross output in the manufacturing sector. Again, this conforms to the earlier theoretical result that the higher the share of intermediate input, the lower the TFP growth rate in output. Indeed, the rise in the share of intermediate inputs, or the fall in the share of value added, happens across the board, albeit to a lesser extent in the NMT and sheltered sectors. Clearly the assumed Hicks-neutral technical progress enables producers, particularly manufacturers, to substitute the direct use of primary inputs such as labour and capital with intermediate inputs from other sectors in their production processes. This increasing across-the-board reliance on the intermediate inputs, part of which is imported, will inevitably lead to the shrinking share of aggregate value added in the nation's gross output, and hence decline in the aggregate TFP growth in value added. The next section turns to the examination of the key issue of whether the aggregate TFP growth path converges to that of the slowest-growing sector.

It should be noted that the aggregate TFP growth path can be obtained by two alternative methods: one being the Domar aggregation method using sectoral data (as in equation 3) and the other being the Solow residue method using aggregate data (on aggregate value added, labour and capital inputs) directly. It is worth noting that in the present adoption of the Domar aggregation procedure, the weights have been constantly updated using the model solutions for each period. The two aggregate TFP growth paths are shown in Figure 2.

Fig. 2 Aggregate TFP growth paths - comparison between Solow residue and Domar aggregation methods

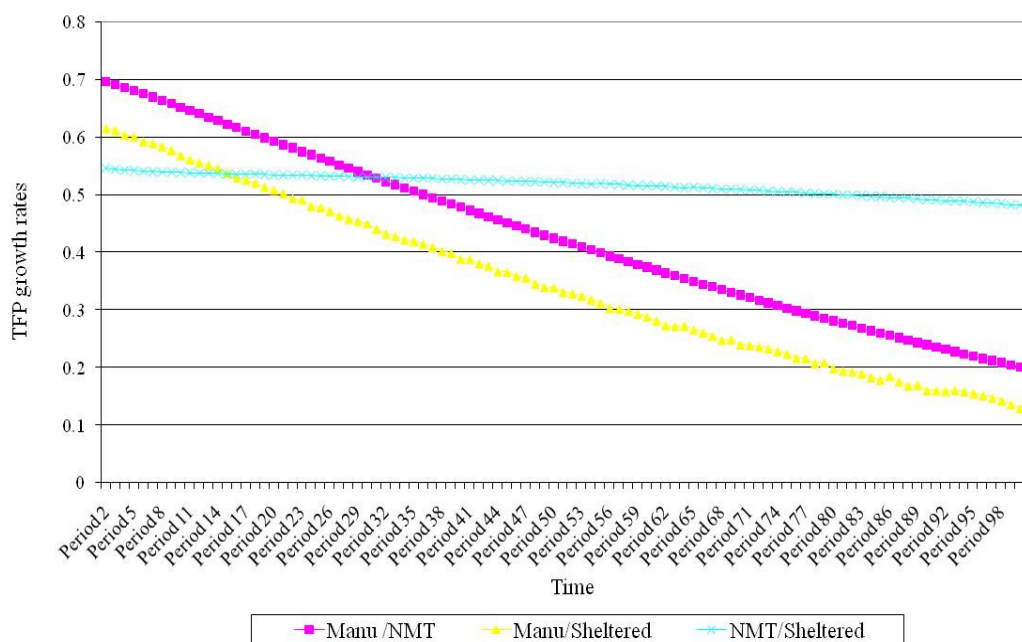


A careful inspection of Figure 2 reveals a number of interesting findings. First, the two alternative methods of driving the aggregate TFP growth rate give very different results. The Domar method significantly underestimates the aggregate TFP growth rate in the short- to medium-run but overestimates it in the long-run. As is discussed above, the Domar method is expected to give inaccurate results due to the ignorance of the general equilibrium adjustments in quantities and prices. The Domar method also fails to capture the rich dynamics of aggregate TFP growth over the short- to medium-run. Since in the numerical model the differences between the short-run and the long-run are mainly due to the extent of factor mobility and the speed of adjustment in the actual capital stocks to the desired levels, it can be argued that the Domar method is particularly a poor approximation in situations where “market imperfections” are significant. In applied studies on growth accounting, the derivation of aggregate TFP growth rates on the basis of sectoral data could be rather misleading, particularly if the study is over the short- to medium-term.

A second and more important finding is that, regardless of the method being used, aggregate TFP growth stagnates in the long run. Therefore, the optimist view is clearly rejected and the stagnationist view vindicated by the simulation results here. Nevertheless, unlike the

conventional stagnationist view, the stagnation process here is very slow and non-monotonic. Unbalanced growth with manufacturing leading the league table of technical progress will lead to the aggregate TFP accelerating for over three decades before it turns to settle on a long and slow declining path. Further understanding of the adjustment process in the economy can be gained from the inspection of the changing patterns of the sectoral relative unit cost of labour, terms of trade and resource shifts.

Fig. 3 Relative unit cost of labour (manufacturing leading)



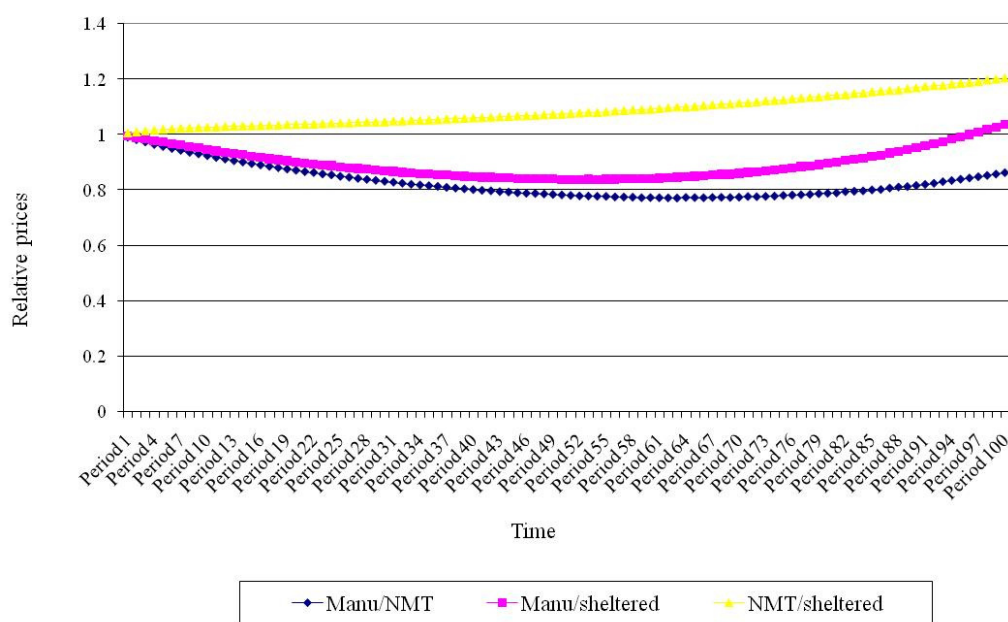
As Figure 3 shows, the relative unit cost of labour is rising monotonically in the NMT and sheltered sectors. According to equation (24), the rate of change in the relative unit cost of labour in NMT over manufacturing can be defined as:

$$\hat{r}_{UCL} = \frac{\sigma - 1}{\sigma} [s_{NMT}^K (\hat{L}_{NMT} - \hat{K}_{NMT}) - s_M^K (\hat{L}_M - \hat{K}_M)]$$

Since the numerical model has assumed a value of 0.3 for the elasticity of substitution between labour and capital, for NMT's relative unit labour cost to rise (i.e. $\hat{r}_{UCL} > 0$), it requires that the term in the square brackets becomes negative, or the differential between the growth in labour and the growth in capital must be greater in manufacturing than in NMT. This is indeed reflected in the simulation results. Combined with the earlier result, it is clear that as a consequence of the superior Hick-neutral technical progress in manufacturing, this sector is not only using more intermediate inputs instead of labour and capital, but also

substituting more capital with labour over time as compared with the other two sectors. There is certainly empirical evidence to suggest that the share of intermediate inputs in manufacturing output is rising as revealed by the UK input-output tables for recent years. Therefore, even though the relative unit labour costs in NMT and the sheltered sectors are rising, their relative prices (to manufacturing) do not necessarily rise unambiguously, as Figure 4 on the sectoral terms of trade shows.

Fig. 4 Sectoral terms of trade



As a result of the faster technical progress in manufacturing, manufacturing product prices initially become cheaper compared with the other products due to the rising unit labour costs in the other sectors, so manufacturing terms of trade vis-à-vis the other two sectors both deteriorate initially. This deterioration continues for a lengthy period, but manufacturing soon starts to substitute both labour and capital with intermediate inputs. As higher intermediate input prices also cause manufacturing product prices to increase, the deterioration in manufacturing terms of trade eventually reverses. By the end of the simulation period, the manufacturing/sheltered terms of trade actually exceeds the starting level, although that between manufacturing and NMT never recovers to the starting level. Interestingly, the NMT sector is gaining terms of trade over the sheltered sector continuously. The evolution of sectoral unit labour costs and terms of trade in the present context confirms the long-held view that relative unit labour costs only play a partial role in explaining sectoral price

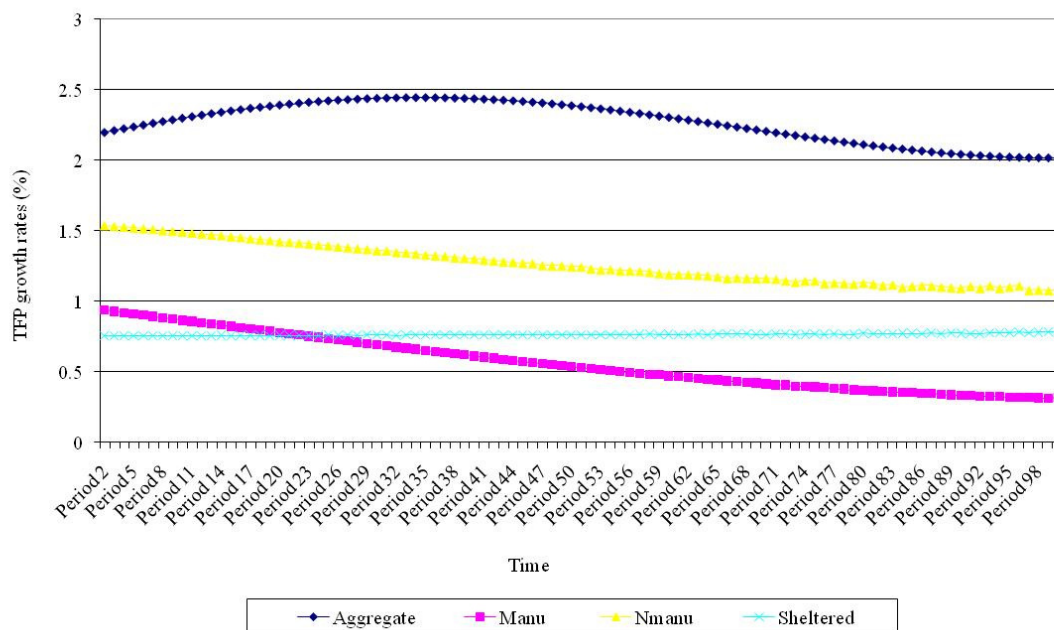
movements and thus resource shifts (for an earlier discussion, see McGeehan, 1968). By restricting input factor to labour only, Baumol's model omits some important price adjustment mechanisms in the real economy.

The changes in the terms of trade encourage resources to shift away from manufacturing to the other sectors, albeit to a limited extent. In fact, the NMT sector is the only gainer of employment share, as the sheltered sector also loses its share slightly (this sector is losing terms of trade not only against NMT, but also Manufacturing). This pattern of employment change seems to resemble remarkably what has been observed in the real world! Contrary to the optimist view, the continuous shift of resources to the NMT (and thus BFS) sectors can only sustain a limited period of acceleration in TFP growth before stagnation eventually sets in. The bell-shaped aggregate TFP growth path is also consistent with the changing patterns of factor substitution and sectoral terms of trade. As manufacturing terms of trade deteriorate initially, resources are shifting to the other sectors and outputs also grow at a faster rate in the other two sectors. Since the other two sectors have a higher share of value added, the structural shift in resources and production leads to a faster growth rate in aggregate value added and aggregate TFP growth (in value added). However, as manufacturing continuously substitutes primary factors with intermediate inputs and the higher intermediate input prices also improve manufacturing terms of trade, the disadvantage in the growth rate of manufacturing output relative to the other two sectors is reduced. Furthermore, the substitution of primary factors with intermediate inputs also takes place in the other two sectors so that the share of value added in gross output falls universally. The final outcome is an inevitable fall in the aggregate TFP growth rate in value added!

It is worth pointing out that the elasticity of substitution between labour and capital seems to play a crucial role in the evolution of the relative unit labour costs and hence possibly the evolution of sectoral terms of trade and production. Thus, a sensitivity analysis is conducted with an alternative value of 2. Nevertheless, apart from some slight changes in the simulation results (e.g. both NMT and the sheltered sectors gain employment share at the expense of manufacturing), the main qualitative results as presented above (e.g., the bell-shaped aggregate TFP growth path) still stand.

Some optimists argue that the contribution by BFS to aggregate TFP growth has not received due credit since the productivity growth rate in BFS is typically underestimated as a result of the problem in measuring service outputs. Therefore, in the second simulation, a 3% technical progress rate is assumed for both manufacturing and NMT but still 1% is given to the sheltered sector. The resulting productivity growth paths are depicted in Figure 5.

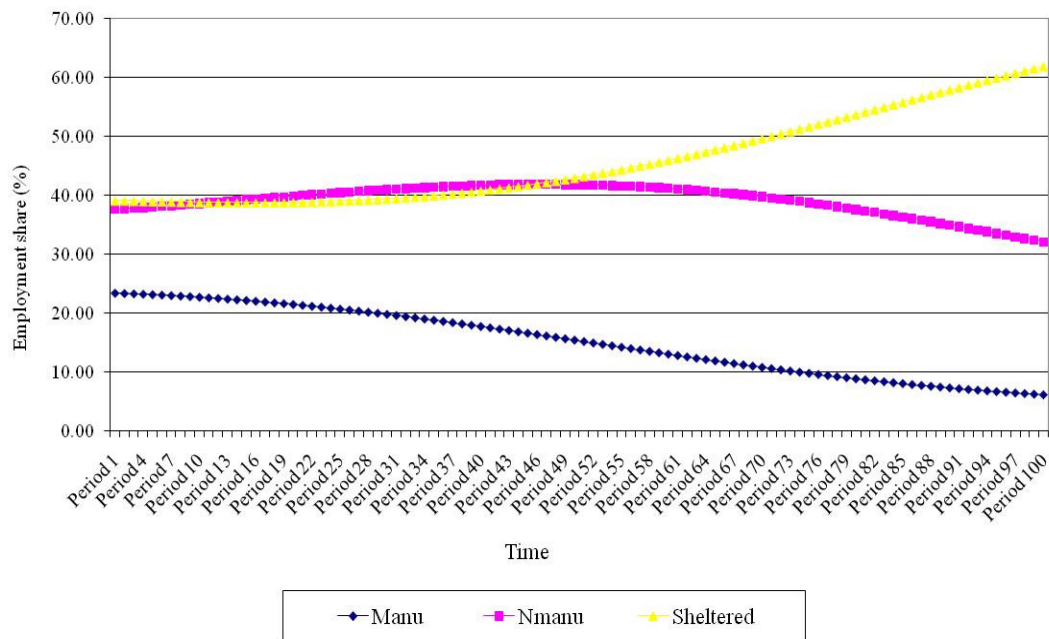
Fig.5 TFP growth paths (manufacturing and NMT leading)



The simulation results show that despite the substantial technical progress in both the manufacturing and NMT sectors, the aggregate TFP growth rate will reach a maximum of around 2.44% and then eventually drops to around 2%, less than 1% above the long-run aggregate TFP growth rate in the first scenario. Therefore, a tentative conclusion is drawn that even if the productivity growth in BFS were substantial, it would not make a significant difference to the long-run aggregate TFP growth rate in the economy if the sheltered sector still has a very slow productivity growth rate. On the face of it, this result looks puzzling. However, it is worth noting that a sector's linkage with the rest of the economy is not restricted to intermediate linkage only, but also linkages through final sales and contribution to national income (wages and profits). Sales to final demands accounted for 83% of the sheltered sector's output (see Table 4) and this sector also had the largest share of employment (39%) at the start of the simulation period. Therefore, slow productivity growth in that sector acts as a heavy drag on the aggregate TFP growth even though the other sectors

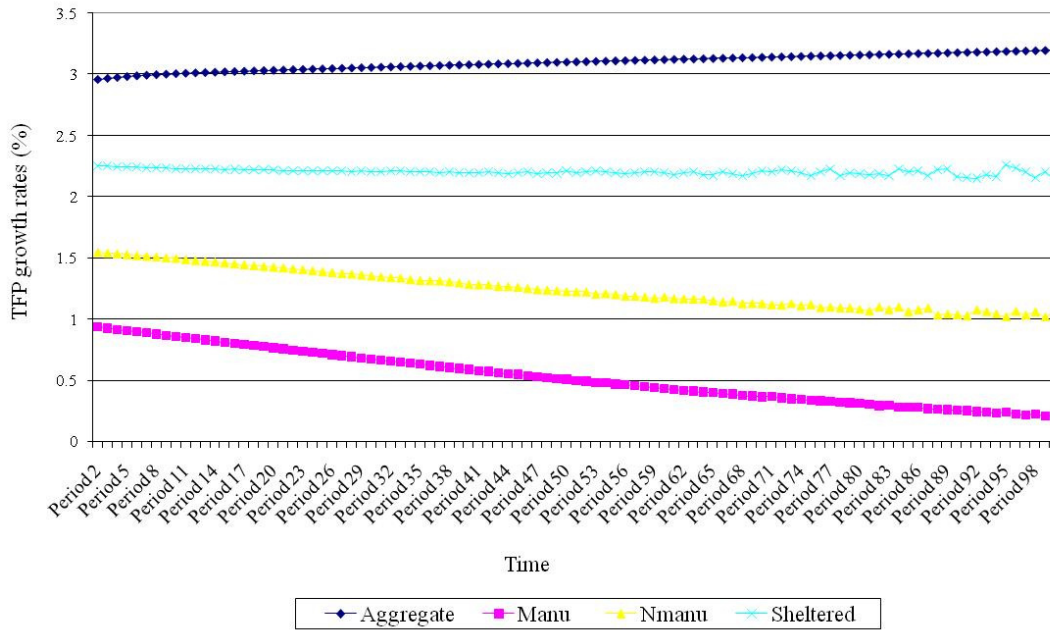
experience far superior productivity performance. As Figure 6 shows, faster technical progress in the other two sectors will cause resources to shift from those sectors to the sheltered sector. The trend in resource shift does not appear to subside even by the end of the simulation period.

Fig. 6 Sectoral employment share (manufacturing and NMT leading)



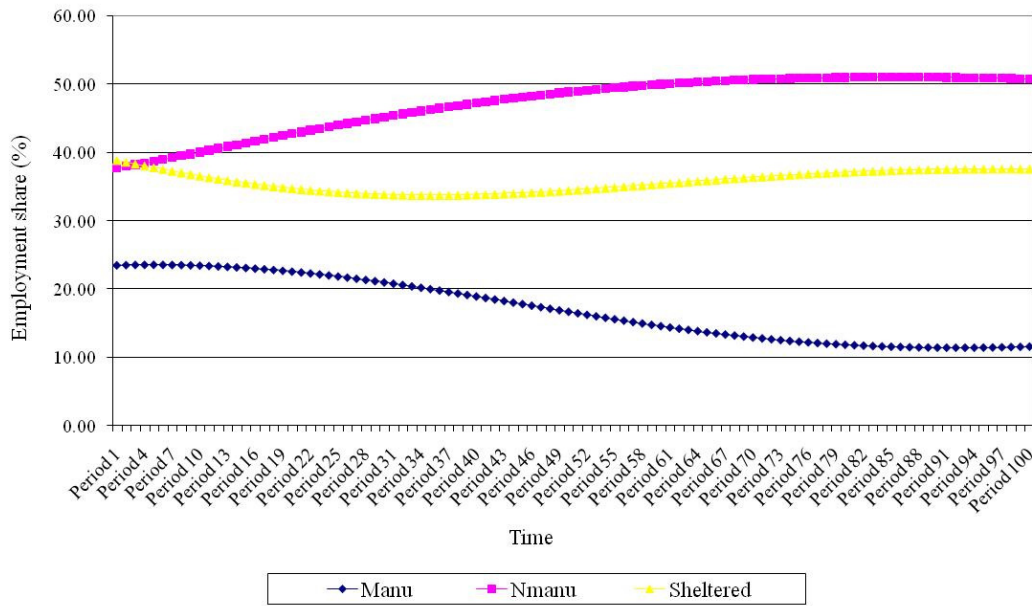
The next simulation concerns a balanced growth scenario of 3% technical progress in all three sectors. Although this is an unlikely scenario in the real world given the generally poor productivity performance in public and other private services, the intention is to see what a difference it would make if productivity in this sector were to improve. The simulated growth paths are given in Figure 7.

Fig.7 TFP growth paths (balanced growth)



Clearly, balanced productivity growth in all sectors generates a very strong aggregate TFP growth path, which reaches 3.2% at the end of the simulation period. It is worth noting that even though technical progress is balanced across sectors, but the resultant TFP growth in output is very different in different sectors. Whilst the TFP growth rate in the sheltered sector remains stable at around 2.2% throughout the simulation periods, the other two sectors all suffer from a monotonic decline in the TFP growth rate in output. Nevertheless, the trend in resource shift eventually stops with employment shares in all sectors stabilising toward the end of the simulation period (see Figure 8). What is more, in the long-run the employment share by the sheltered sector reverts back to the initial level, but manufacturing still loses a significant share to the NMT sector.

Fig. 8 Sectoral employment share (balanced growth)



Finally, another three simulations were conducted to generate the marginal impact on the aggregate TFP growth rate as a result of a 1% technical progress in one sector but no technical change in the remaining two sectors. The simulation results are summarised in Table 5.

Table 5 Marginal impact on the aggregate TFP growth rate as a result of 1% technical progress in an individual sector

| Sector where technical progress takes place | Starting period aggregate TFP growth rate (%) | Ending period aggregate TFP growth rate (%) | Average aggregate TFP growth rate (%) |
|---|---|---|---------------------------------------|
| Manufacturing | 0.23 | 0.30 | 0.28 |
| NMT | 0.37 | 0.58 | 0.47 |
| Sheltered | 0.39 | 0.53 | 0.44 |

The second column reports the aggregate TFP growth rates in the first simulation period following the introduction of the technical change. The third column reports the end-of-simulation period aggregate TFP growth rates, and the average TFP growth rates for the entire simulation time span are given in the final column. Clearly technical progress in the sheltered sector has the highest starting-period, the second highest ending-period, and the second highest average marginal impact on aggregate TFP growth rate. NMT has the second

highest starting-period, the highest ending-period, and the highest average marginal impact. In contrast, technical progress in manufacturing has the lowest marginal impact on aggregate TFP growth in any measure. These results run against the common perception that sectors with strong industrial linkages with the rest of the economy have also strong influence on the overall productivity performance. The results also cast further doubts on the perception of manufacturing as the “engine of economic growth”. Perhaps the optimists can take some comfort in seeing the results concerning the NMT (and thus the BFS) sector. Nevertheless, as is already shown above, without the sheltered sector also catching up on the technical progress front, aggregate productivity stagnation is inevitable.

6. Discussion and tentative conclusions

The present study has extended the Uzawa two-sector-two-factor growth model to incorporate intermediate linkage and unbalanced sectoral technical progress in a numerical simulation model. As in the original Uzawa model, there is no guarantee that unbalanced sectoral technical growth will lead to a unique and stable overall growth path for the economy. Nevertheless, the theoretical discussion has shed light on several relevant issues such as the difference between sectoral TFP growth rates in output and value added as well as the evolution of relative unit labour costs. However, the study relies on an applied general equilibrium MSG model for a small open regional economy to simulate the aggregate TFP growth paths in order to evaluate the debate between the conventional stagnationist view and the modern optimist view. The simulation results present a clear and robust *prima facie* case against the optimist view whilst endorse the traditional stagnationist view, but only in the very long-run. In the short- to medium-run, there may well be accelerated growth in the aggregate economy before stagnation eventually sets in.

Although a rigorous analytical derivation of the results is not attempted here, the simulation exercises have generated a number of interesting insights on the growth dynamics. First of all, in contrast to the Kaldor’s idea of “cumulative causation” and “engine of economic growth”, faster productivity growth in an individual sector (e.g. manufacturing) does not necessarily lead to faster growth in *net output* productivity for the economy as a whole! Although Baumol’s original contribution reached the same conclusion, the original result is

expressed in terms of *gross* output, not *net* output. As is already mentioned, it is the growth of productivity in net output that ultimately delivers a higher living standard. Moreover, the result here is obtained from a far more comprehensive and realistic setting of the modelled economy. The argument against the “cumulative causation” mechanism runs as follows. A superior technical progress in manufacturing eventually leads to the substitution of primary inputs with intermediate inputs in the manufacturing production process. Since the intermediate inputs from the other two sectors embody inferior technical progress, the total factor (including intermediate inputs) productivity growth rate in manufacturing is inevitably dragged down. As the other two sectors also start to use more intermediate inputs, the production of net output in the whole economy switches to a less efficient mode and inevitably aggregate TFP growth in net output suffers. Therefore, efforts to identify the “engine of economic growth” on the basis of a sector’s superior factor productivity may be misguided.

Second, the strength of a sector’s intermediate linkages may not be an adequate indicator of whether or not it is the “engine of economic growth” either. The simulation results suggest that there is little correlation between a sector’s industrial linkage or its role as an intermediate service provider and the effect of its productivity performance on the overall TFP growth rate. As the theoretical discussion reveals, a sector with strong intermediate linkages may act as a drag, rather than a spurt, to aggregate growth in net output. This finding is confirmed by the simulation results that even if both manufacturing and non-manufacturing traded sectors – two sectors with very strong intermediate linkages – enjoy superior technical progress, aggregate productivity still stagnates in the long run if productivity growth in the sheltered sector is inferior. Moreover, any improvement in technical progress in the sheltered sector – which has the weakest intermediate linkages – exerts a strong marginal impact on the overall TFP growth rate.

Finally, the simulation results suggest that technically progressive sectors do lose the share of resources to the technically stagnant sectors and overall TFP growth rate does stagnate eventually. The crucial mechanism underlying the bell-shaped aggregate TFP growth path and the ultimate productivity stagnation in the context of unbalanced technical progress seems to be the universal adoption of substituting primary inputs with intermediate inputs in

the production processes, particularly by manufacturers. This simulated structural adjustment process has certainly been borne out by empirical evidence which shows a rising (falling) share of intermediate inputs (value added) in industrial outputs over the past two decades. A more speculative conclusion is that any effort to identify “the engine” of economic growth may be ultimately futile, as an important part of TFP improvement originates from a more efficient combination of all factors of production, which in turn constantly adjusts to the changing factor scale and intensity arising from the good fortune of “manna from heaven”. In other words, following exogenously imposed and uneven disturbances to sectoral technical progress, the market economy contains a self-righting mechanism to overcome the initial imbalance in factor productivity. Nevertheless, the simulation results do not rule out possible policy gains in the short to medium term through targeted measures in improving technical progress or production efficiency in certain specific sectors. In particular, proponents of the “soft engine of economic growth” argument may take some comfort from the simulation results in recommending measures to improve technical efficiency in the BFS sector. As a final concluding remark, it must be borne in mind that the qualitative results of this study have been obtained from a framework that has completely ignored the endogenous growth mechanisms. Incorporation of such mechanisms explicitly into the general equilibrium MSG model remains a challenge.

References

- Armington, P. (1969) “A Theory of Demand for Products Distinguished by Place of Production”, IMF Staff Papers, vol. 16, 157-178.
- Baumol, W J (1967) “Macroeconomics of unbalanced growth: the anatomy of urban crisis”, *American Economic Review*, 57, 415-426.
- Baumol, W J (1985) “Productivity and the service sector”, in R.P.Inman (ed.) *Managing the Service Economy: Prospects and Problems*. Cambridge University Press, New York: Cambridge University Press.
- Baumol, W J, S A B Blackman and E N Wolff (1989) *Productivity and American Leadership: the Long View*, the MIT Press, Cambridge, MA.
- Burmeister, E and A.R. Dobell (1970) *Mathematical Theories of Economic Growth*. New York: Macmillan.

- Carlaw, K I and R G Lipsey (2003) "Productivity, technology and economic growth: what is the relationship?" *Journal of Economic Surveys*, vol. 17, no. 3, pp.457-495.
- Chenery, H. B. (1960) "Patterns of Industrial Growth", *American Economic Review*, 50, 624-654.
- Clark, C. (1940) *The Conditions of Economic Progress*, London: Macmillan.
- Echevarria, C. (1997) "Changing Sectoral Composition Associated with Economic Growth", *International Economic Review*, 38, 431-452.
- Feinstein, C., (1999) "Structural Change in the Developed Countries during the Twentieth Century," *Oxford Review of Economic Policy*, vol. 15(4), 35-55.
- Ferguson, L; P G McGregor, J K Swales, K R Turner and Y P Yin (2005) "Incorporating sustainability indicators into a computable general equilibrium model of the Scottish economy", *Economic Systems Research*, vol. 17, no. 2, pp.103 - 140.
- Hahn, F H (1965) "On Two-Sector Growth Models", *Review of Economic Studies*, Vol. 32, p.339-46.
- Harrigan, F; P G McGregor; N Dourmachkin; R Perman; J K Swales and Y P Yin (1991) "AMOS: A macro-micro model of Scotland", *Economic Modelling*, pp.424-479.
- Hodgson, G. (1989) "Institutional rigidities and economic growth", *Cambridge Journal of Economics*, 13, 79-101.
- Hulten, C.R. (1978) "Growth accounting with intermediate inputs", *Review of Economic Studies*, 45, 511-518.
- Jensen, B S and M E Larsen (2004) 'General Equilibrium Dynamics of Multi-Sector Growth Models', *Journal of Economics*, Supplement, 10, pp.17-56.
- Kongsamut, P., S.Rebelo and D.Y.Xie (2001) "Beyond Balanced Growth", *Review of Economic Studies*, vol. 68, no. 4, pp. 869-882.
- Kurz, M (1963) "A Two-Sector Extension of Swan's Model of Economic Growth: The case of no technical change", *International Economic Review*, Vol. 4, p.68-79.
- Kuznets, S. (1957) "Quantitative Aspects of the Economic Growth of Nations: 11", *Economic Development and Cultural Change*, Supplement to Vol. 5, 3-1 11.
- McGeehan, J.M. (1968) "Competitiveness: A Survey of Recent Literature", *Economic Journal*, Vol. 78, No. 310, (Jun., 1968), pp. 243-262.
- McGregor, P.G.; J K Swales and Y P Yin (1996) "A Long-Run Interpretation of Regional Input-Output Analyses", *Journal of Regional Science*, vol. 36, pp. 479-501.
- McGregor, P.G, E P McVittie, J K SWALES and Y P Yin (2000) "The Neo-classical Economic-Base Multiplier", in *Journal of Regional Science*, vol. 40, no. 1, pp. 1 – 31.

- Meade, J. E. (1961) *A Neo-Classical Theory of Economic Growth*, London: Allen and Unwin.
- Oulton, N (2001) "Must the growth rate decline? Baumol's unbalanced growth revisited", *Oxford Economic Papers*, 53, 605-627.
- Rauch, J E (1997) "Balanced and unbalanced growth", *Journal of Development Economics*, Vol. 53 (1997) 41-66.
- Rowthorn, R E (1992) "A Review of W. J. Baumol, S. A. B. Blackman and E. N. Wolff, *Productivity and American Leadership: The Long View*, MIT Press, Cambridge, MA, 1989", *Review of Income and Wealth*, Series 38, Number 4, 475-496.
- Stiglitz, J E and H. Uzawa (1970) *Readings in the Theory of Economic Growth*. New York: Cambridge.
- Uzawa, H (1961) "On a Two-Sector Model of Economic Growth, I", *Review of Economic Studies*, Vol. 29, p.40-7.
- Uzawa, H (1963) "On a Two-Sector Model of Economic Growth, II", *Review of Economic Studies*, Vol. 30, p.105-18.