SERVICES SECTOR AND NON-BALANCED GROWTH

Anuradha Saha

Thesis submitted to the Indian Statistical Institute in partial fulfillment of the requirements for the award of the degree of Doctor of Philosophy

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To my awesome Mother

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1 Introduction

But the growth is uneven, and there is a huge unfinished agenda.

Lars Thunell

Structural change is the offspring of economic development and the companion of sectoral non-balanced growth. In an expanding economy, there are several possible channels for structural change: the demand for different goods may grow differently or the sectoral total factor productivity (TFP) trends may vary or there could be differences in the types of production technologies. While the routes may be different, they all induce different sectors to grow at different rates.

Differential growth of sectors in an economy is a well-established phenomenon. However, growth, in almost all countries, being led by a tertiary sector - the services sector - is a more recent development. In the post 1970s era, the services sector has expanded to become the largest sector of most developed and developing economies, in terms of both output and employment. For the available data post 1970s, we present the sector-wise breakup of value-added and employment in Figures 1.1 and 1.2 respectively. Sectoral employment data is not available for India and South Africa, and there are gaps in the reported data for Brazil. Figures show that even in the manufacturing-hub of the world, China, services sector is expanding rapidly and now constitutes almost an equal share in value-added and employment as the manufacturing sector. In fact, in most of these countries, services sector is the fastest growing sector (see Table 1.1). Brazil seems to be the only exception, where agriculture grows at a slightly faster rate than services. In the words of Daniel Bell, a sociologist from Harvard University, this ongoing-period is the post-industrial era. We have crossed the stages of pre-industrial and industrial societies, and now are in a services-based economy. Today, the standard of living is measured by *quality* of goods (rather than quantity

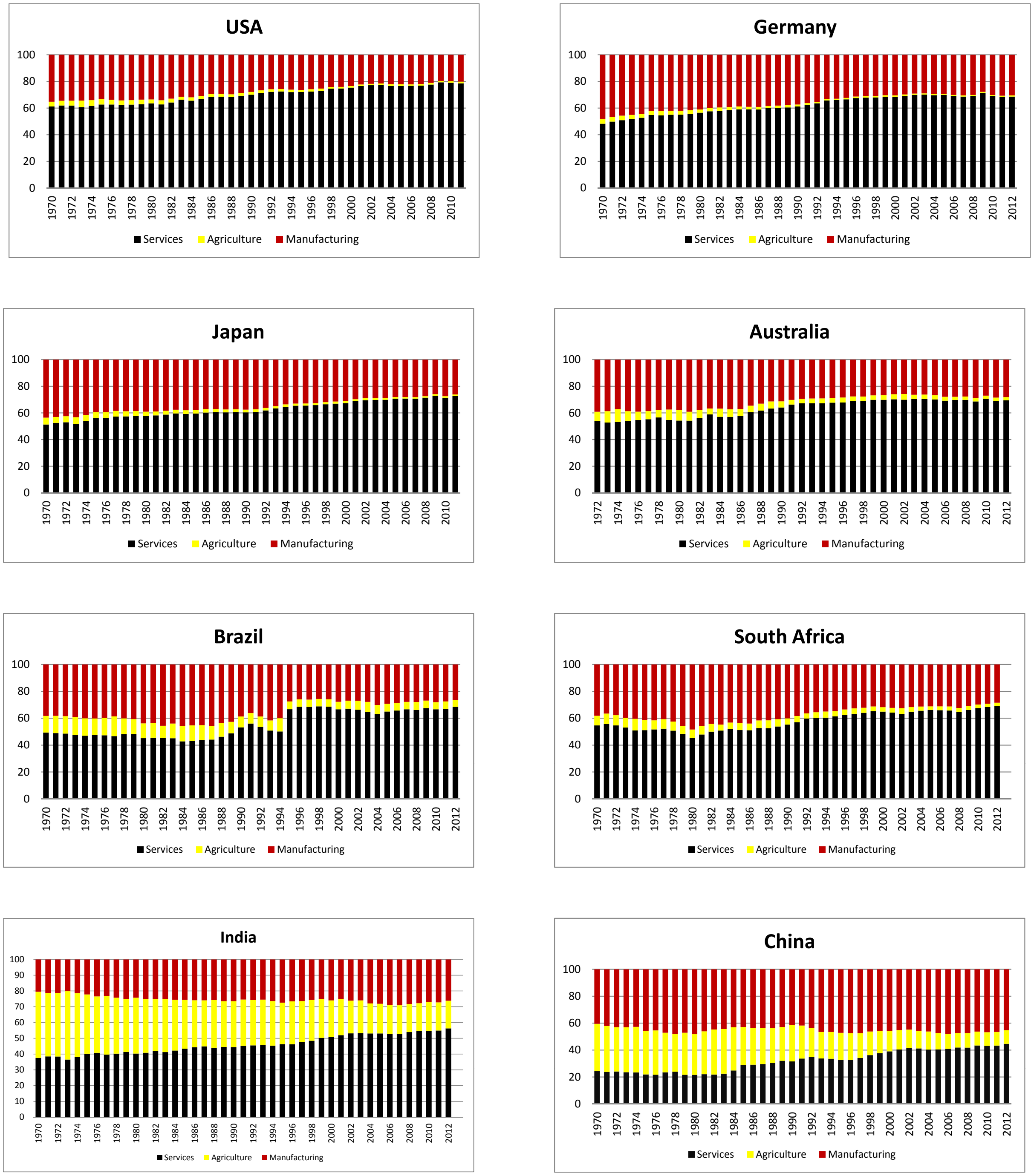


Figure 1.1: Sectoral Shares in Value Added. *Source: World Development Indicators, World Bank*

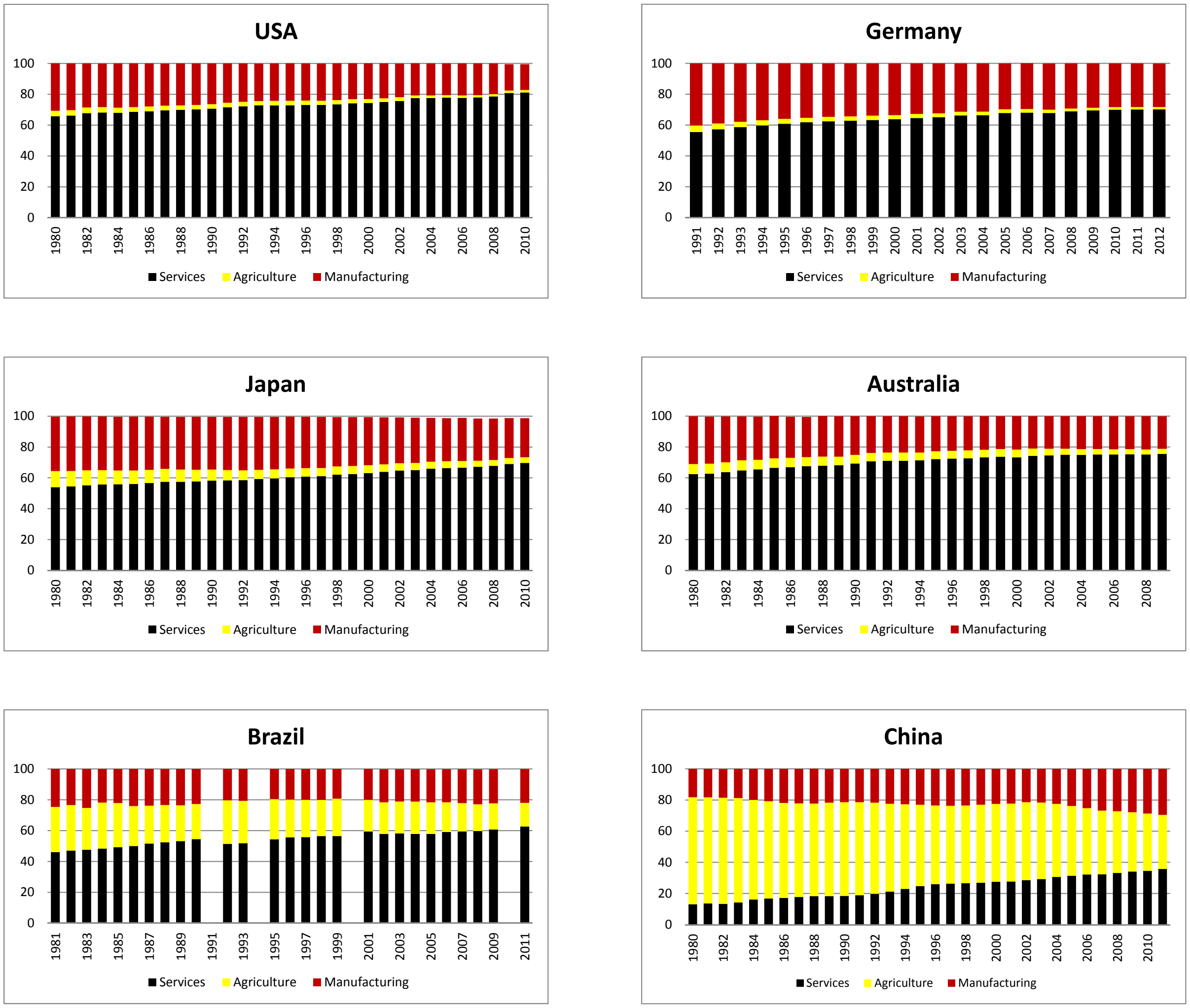


Figure 1.2: Sectoral Employment Shares. *Source: World Development Indicators, World Bank*

of goods), where information (rather than machines) are the key resource and services, rather than manufacturing or agriculture, is the key activity.

Unlike agriculture or manufacturing, services are not a commodity. The services sector produces “intangibles” like health, education, trade and telecommunications. While the agricultural goods provide us nourishment and the manufacturing goods help in leading a comfortable life, the services are typically seen as inessential or even luxurious goods. Services can not be provided without agriculture or manufacturing goods, for example there can be no restaurant services without food, no chauffeur services without cars and no doctor without medicines. In this sense, services is a derived sector. Further, production of most

Table 1.1: Compounded Annual Growth Rate for Sectoral Output (1970s-2012)

Country	Agriculture	Manufacturing	Services
USA	2.13	1.57	3.26
Germany	0.14	1.05	2.76
Japan	-0.32	1.91	3.14
Australia	2.63	2.69	3.55
Brazil	3.66	2.40	3.01
South Africa	2.07	1.54	2.08
India	2.74	5.81	6.78
China	4.06	10.79	11.26

Source: World Development Indicators, World Bank

services is very client-specific. There are several services (like teaching, medicine, financial services) which are customized to each buyer's specific requirements. In most of these, good quality services can not be 'produced' without inputs from the buyer. Given these characteristics of services, it is not apparent how this relatively inessential sector has become the leading sector of the economy.

In the context of services economy, this dissertation aims to understand and characterize non-balanced growth. There are two questions that I shall aim to answer in this thesis: why is the services sector the fastest growing sector in most economies and in the context of international trade, how do the effects of services trade differ from those of commodities trade?

There have been several demand-side and supply-side explanations on the growth of the services sector. The *demand-side explanations* are based on the income elasticity of demand for services being greater than unity, while that of the agriculture and manufacturing sectors are less than unity and unity respectively. This means that as the household's income expands, the demand for agriculture grows less than proportionately, the manufacturing demand grows in proportion with income however, the demand for services grows more than proportionately. Thus, the demand for services grows faster than demand for other goods and hence the services sector outpaces the commodities sectors (Kongsamut et al. (2001)). Buera and Kaboski (2012) explain that the growth of services is driven by the growing consumption demand of skill-intensive services. In their model, households have infinite desires, which can be ranked and are fulfilled by consumption of services. The high ranked desires require complex services which are market produced. So as desires expand over time, the demand for more complex services grows, which in turn, drives the demand for high-skilled workers. These high-skilled workers increasingly spend less time at home and more time in market, which further pushes the demand for skill-intensive services.

The *supply-side explanations* are based on developments in information and communication technology (ICT) which has reduced the cost of provision of services and led to higher growth of services globally (Ghani (2010)). A strand of literature explains that the recent growth of services is due to increase in outsourcing activities (Bhagwati (1984)). The idea is that some in-house service activities of the manufacturing firms (like accounting, customer services) are now produced by service firms which specialize in these activities. However, this is not able to fully explain the phenomenal increase in services output. Francois (1990) notes that as manufacturing processes become increasingly complex, services are required for co-ordination and specialized operations. He postulates that the need to improve the linkage, coordination and control of specialized operations in the manufacturing sector propels the growth of producer services. Thus, growth of services output does not merely reflect increase in outsourcing activities, but is also attributable to increase in demand for new and specialized services by the manufacturing sector. Other supply-side explanations like differential productivity growth in manufacturing and services (Ngai and Pissarides (2007)), differences in production function (Zuleta and Young (2013)) have been put forward, which we will discuss in greater detail in the next chapter. However, most of these explanations describe the higher growth of services employment as compared to manufacturing employment, but not the higher growth of services output viz-a-viz manufacturing output.

In this dissertation, I provide explanation for the higher growth of services *output and employment* as compared to manufacturing based on supply-side factors in the first two essays, and, in the last essay within a growth framework we study the effects of international trade in services.

1. In the first essay (Chapter 3), we postulate that the growth of business services drives the employment and output growth of the services sector. It also explains why the services sector may grow faster than manufacturing. We consider a closed-economy with manufacturing and services sectors. Business services is used in the production of manufactures. It is argued that higher returns to scale in services as compared to manufacturing as well as employment frictions in manufacturing explain the higher growth rate of the services sector as compared to manufacturing. The analysis also

includes consumer services and the model is able to explain that within the services sector the business services sub-sector may grow faster than household services.

2. In the second essay (Chapter 4), we include agriculture sector along with the manufacturing and services sectors. Differential land intensity in production is highlighted as a source of non-balanced growth. We stipulate that land use is highest in agriculture, followed by manufacturing and then services. We show that this is a contributing factor to differential sectoral growth, led by the services sector and then manufacturing and agriculture goods in that order. Further, we show that land intensity differentials explain a significant portion of short run sectoral output growth gaps, while in long run it is the capital intensity differences which have a larger explanatory power.

3. In the last essay (Chapter 5), we differentiate trade in commodities and trade in services in growing economies. Commodities include manufacturing (a production sector) and a numeraire good (an endowment sector). We show that static and dynamic effects depend on comparative advantage as well as features of trade among similar countries. Within the model's framework, the long run sectoral growth rate are unaffected by any change in trade regime. But change in trade regime affects the short-run growth dynamics and it affects the sectoral growth gaps. Further we quantify welfare gains and find that there are significantly higher gains from services trade as compared to commodities trade.

I will now discuss each of these essays in brief by outlining the motivation and results. In the chapters that follow, we analyze them in greater detail.

1.1 Growth of Business Services: A Supply-Side Hypothesis

In this essay based on Das and Saha (2013), we scrutinize the industries within services sector to determine the fastest growing services sub-sectors. We categorize services into three types: pure business services, pure consumer services and hybrid services. The pure business services are used only by firms (Renting and Other Business Activities); the pure consumer services are consumed only by households (Community, Social and Personal services); and the hybrid services can be consumed by both businesses and households (includes Utilities, Construction, Wholesale and Retail trade, Hotels and Restaurants, Transport and Storage and Communication).

We generate an additional stylized fact that business services grow faster than consumer services. In the period 1970-2006, for most developed countries the pure business services were the fastest growing segment in terms of both output and employment. In fact, we observe that, in terms of both output and employment, pure business services have grown faster than pure consumer services, which in turn have grown faster than manufacturing. We present a theoretical model which accords with this fact.

We develop a two-sector, closed-economy model, having a manufacturing sector and a business services sector. The production of business services requires only labor, while the manufacturing production uses both business services and labor in decreasing returns technology. Labor grows through endogenous human capital accumulation.

Our model is based on two supply-side assumptions or mechanisms. First, the returns to scale are less in manufacturing compared to the services; and second, adjustment of employment is more sluggish in manufacturing than in the services sector. It is easy to see, how differences in returns to scale contribute to differential sectoral growth. Suppose, all services are only business services, which requires only labor input. The manufacturing production is a decreasing returns technology with labor and business services as input. Suppose that in the steady state, employment in both sectors grow at the same rate, then the business services would grow at the same rate as employment but manufacturing growth rate would be smaller. Thus, a derived sector (business services) may grow faster than its parent sector. If, in addition to this, we find that employment adjustments are sluggish in manufacturing, then the growth rate of labor is slower in manufacturing than in services.

Both the assumptions are empirically motivated. In particular, Basu et al. (2006) estimate the returns to scale of both manufacturing and services and find the returns to scale for manufacturing to be about 0.94 and that in services about 1.16. Regarding employment frictions, there are evidences that the average size of manufacturing firm is bigger than the size of a service firm, unionization rates are larger in manufacturing and labor turnover rates are smaller in manufacturing. All these facts point to existence of labor frictions in the manufacturing sector.

In an extension of the model, we include a consumer services sub-sector. The service producers of business and consumer services are distinct, however the production of consumer services has the same linear technology. We find that in this extension, business services grows faster than consumer services, which in turn grows faster than manufacturing (in terms of both output and employment). To understand this, let us start by assuming no employment frictions in manufacturing sector. In this scenario, the steady state growth rate of labor in all the three sectors will be same. Hence both services sub-sector would grow at the same rate (equal to growth rate of labor), but manufacturing (owing to decreasing returns to scale) will grow at a slower pace. Now, if there are employment frictions in manufacturing then the demand for business services grows more than proportionately to demand for labor. This pushes up the growth rate of labor in business services at the expense of the growth rate of manufacturing employment. Thus the employment in the business services grows faster than consumer services and that in turn grows faster than manufacturing employment. The output growth rate follows the same ranking.

1.2 Three-Sector Non-Balanced Growth: The Role of Land

The second essay explores non-balanced growth in the context of *three* broad sectors of an economy, namely services, manufacturing and agriculture. The novelty compared to the existing literature lies in the fact that our supply-side explanation for the sectoral growth ranking is applicable to both developed and developing countries. The existing supply-side explanations for the three sectors growth ranking are primarily based on differences in sectoral TFP growth rates (for example, Ngai and Pissarides (2008)). However sectoral TFP growth rankings vary vastly across countries (Ghani (2010)), which means that the existing supply-side reasons for sectoral growth ranking can explain the phenomenon only for selected countries.

The central objective of this essay is to introduce the role of land as a non-reproducible input and differences in the land use intensity in sectoral goods production as the basis for non-balanced growth.

We consider a three-sector, closed-economy model where exogenous growth in sectoral TFP and labor serve as the basis for growth. We assume that agriculture is the most land-intensive sector, followed by manufacturing and then services. The production technologies of all three goods are Cobb-Douglas. Agriculture uses land and labor; manufacturing uses land, capital and labor; and services has capital and labor as inputs.

In this setting, we find that the steady state output growth is highest in the most land intensive sector. The logic being that in the long run the availability of land is limited. This implies that effectively, there are decreasing returns to scale in agriculture and manufacturing and constant returns to scale in services – this forms the basis for differences in sectoral growth.

We perform numerical simulations to decompose the sectoral growth differences on the basis of differences in sectoral TFP growth rates, differences in sectoral land intensity and differences in sectoral capital intensity. We find that in steady state capital intensity differences explain the largest portion of the sectoral output growth differences. However when the economy is away from the steady state (like economy is in transition or under the influence of exogenous TFP shocks), the land intensity differences explain most of the sectoral output growth differentials. This is due to the fact that more abundant input-factor, land in short run and capital in long run, has a larger scope for adjustment and hence contributes more to the sectoral output growth gaps.

1.3 International Trade in Commodities and Services: Static and Dynamic Effects

In the period 2005-12, trade in services had grown at almost the same pace as trade in merchandise (OECD database). The burgeoning importance of trade in services is analyzed in the third essay. We develop a two-country neoclassical growth model in which trade in commodities and trade in services are differentiated and we investigate the trade patterns of goods and services in different trade regimes. The novel feature of this essay is that it considers both household and business services in an open economy framework. Further, unlike in existing trade models, we capture the observed order of trade regime transitions, autarky to commodities trade only to commodities and services trade.

There are three sectors – manufacturing, services and a numeraire goods sector. The presence of this third good allows us to distinguish trade in commodities from trade in services. We assume a fixed endowment of the numeraire good. This assumption allows us focus on the manufacturing-services sector dynamics.

The services production employs labor and manufacturing goods in a Cobb-Douglas technology. Manufacturing goods is produced using labor and business services in a Cobb-Douglas production function. Both goods are consumed by the households. We differentiate services and manufacturing consumption by assuming income elasticity for demand for services to be greater than unity. Further, on the basis of the few existing studies on Armington elasticities of different goods, we postulate that in international market, the substitutability between services is lower than that in manufacturing. In our model, the manufacturing goods of two countries are perfect substitutes of each other, but not the services. We assume that the international varieties of services in the two countries are *imperfect substitutes* of one another, with Armington elasticity greater than unity. Human capital accumulation (as in the first essay) is the source of growth. We examine (one-period) static level effects, and dynamic (growth) effects of liberalization in commodities and services trade.

In terms of static effects, trade in commodities are founded on comparative advantage, while that in services contain elements of comparative advantage as well as those of trade among similar countries. The larger or the more developed country possesses comparative advantage in manufacturing and comparative disadvantage in services. In the absence of trade in services, technological superiority in producing manufacturing is a source of comparative advantage in manufacturing while, higher services productivity may serve as a basis of comparative advantage in manufacturing. In case of identical technologies across the two countries, trade in services features a service-output-equalization outcome: that is, despite differences in sizes or the level of development, both economies will produce the same amount of service output in equilibrium. It is because, individually, the world demand functions for service brands across countries are identical. Our model predicts leapfrogging by smaller or less developed economies in terms of producing services as service trade becomes freer in the world economy. Our numerical analysis points to strong and robust welfare gains from trade in services, compared to meager gains from commodities trade liberalization and the large gains from trade in services stem mainly from larger variety effects which directly benefits household utility and also enhances productivity across production sectors.

In all three trade regimes, output and employment growth rate in the services sector are higher than that in manufacturing. The sectoral growth ranking stems from the differences in income elasticity for demand. Over time, the growth rates of each sector decline monotonically and in the long run the sectoral growth rates asymptote to the growth rate of labor, and, in this sense there is convergence. Absent factors such as technological progress through R&D, learning by doing etc., long run growth in our model economy is unaffected by shifts in trade regime. Non-homotheticity of preferences implies transitional growth, which is influenced by trade-regime changes. Trade in commodities leads to movements along the growth functions, whereas trade in services implies both a shift and a movement along a functions. The shift occurs since trade in services leads to (one-time) productivity increase in both manufacturing and services sectors. In fact, in the case where the two countries differ only in their levels of development, commodities trade widens (respectively narrows) the sectoral growth gap for the manufacturing exporting (or importing) country. In the services trade, the effect on sectoral growth gap in the same two countries is ambiguous.

1.4 Plan of Thesis

The thesis is organized as follows. Chapter 2 provides a brief survey of the existing literature on services growth and services trade. The three essays are presented in Chapter 3, 4 and 5. Chapter 6 suggests some possible extensions for future research on the topics covered in the thesis.

2 Literature Survey

In this dissertation we aim to understand non-balanced growth and international trade in the context of service economy. In all three essays, services sector is the leading sector of the economy. The first and second essays of this dissertation (Chapters 3 and 4) are about differential sectoral growth with particular emphasis on the services sector. The third essay (Chapter 5) examines the differential effects of trade in commodities and trade in services.

Here, in this chapter, we provide a selected survey of the literature that relates closely to these topics. In Section 2.1, we present the different demand-side and supply-side explanations for non-balanced growth. Kongsamut et al. (2001), Buera and Kaboski (2012) and Eichengreen and Gupta (2012) postulate that the observed sectoral output and employment growth trends stem from the differential demand for the different goods. In contrast, Ngai and Pissarides (2007), Acemoglu and Guerrieri (2008), and Zuleta and Young (2013) emphasize on supply-side explanations for the phenomenon. We discuss all of this elaborately. Next, in Section 2.2, the existing studies linking trade and services sector are reviewed.

2.1 Non-balanced Growth

Economic structural change refers to a long-term shift in the fundamental structure of an economy, particularly movements in employment shares. Starting with Baumol (1967) and Kuznets (1973), the literature on non-balanced sectoral growth that accounts for the relative growth of manufacturing and services has grown. Krüger (2008) provides an excellent overview of the existing theoretical and empirical papers on structural change. He emphasizes that structural change implies that some sectors would grow faster than the others. Ray (2010) highlights the consequences of uneven growth, like the growing sectors attract the smartest people as they provide the most attractive remunerations while the stagnant sector often requires government support, which raises questions in political economy. In fact, persistent uneven growth could lead to a divided society and possibly conflict. These developmental aspects of non-balanced sectoral growth are serious issues, and remain unanswered. In this thesis, we do not address this, our focus is on the causes of non-balanced growth. Here, in this section, we delve into the different demand-side and supply-side factors leading to structural change.

2.1.1 Differences in Income Elasticity of Demand

It is a stylized fact that growth in income per capita is accompanied with a rise in services sector and a decline in agricultural sector, both in terms of employment share and share in GDP (Kongsamut et al. (2001), Eichengreen and Gupta (2012)).

Kongsamut et al. (2001)

This paper develops a closed economy growth model with three sectors: agriculture, manufacturing and services. These goods are represented through Stone-Geary preferences where the income elasticity of demand is less than unity for agriculture good, unity for manufacturing good and greater than unity for services. Labor and capital are the factors of production. The production functions of the three sectors are same, except for the Hicks-neutral total factor productivity parameter.

$$A_t = B_A F(\phi_t^A K_t, N_t^A X_t),$$
$$M_t + \dot{K}_t + \delta K_t = B_M F(\phi_t^M K_t, N_t^M X_t),$$
$$S_t = B_S F(\phi_t^S K_t, N_t^S X_t).$$

The agriculture and services output (A_t and S_t respectively) are consumed by the households. The manufacturing output can either be consumed (M_t) or invested in capital accumulation. The variables ϕ^i and N^i denote, respectively, the fraction of capital and labor employed in ith sector. So, $\phi_t^A + \phi_t^M + \phi_t^S = 1$ and $N_t^A + N_t^M + N_t^S = 1$. X_t is the level of technology which augments labor and grows at rate g.

Since, the production functions of different sectors are proportional to each other, the relative prices of agriculture and services in terms of manufacturing goods is given by

$$P_A = B_A/B_M, \qquad P_S = B_S/B_M.$$

The household's discounted life-time utility is

$$U_t = \int_0^\infty e^{-\rho t} \frac{\left[(A_t - \bar{A})^\beta M_t^\gamma (S_t + \bar{S})^{1-\beta-\gamma}\right]^{1-\sigma} - 1}{1-\sigma} dt,$$

which it maximizes subject to the economy-wide budget constraint

$$M_t + \dot{K}_t + \delta K_t + P_A A_t + P_S S_t = B_M F(K_t, X_t). \tag{2.1}$$

The optimization conditions yield

$$\frac{P_A(A_t - \bar{A})}{\beta} = \frac{M_t}{\gamma}, \tag{2.2}$$

$$\frac{P_S(S_t + \bar{S})}{1-\beta-\gamma} = \frac{M_t}{\gamma} \tag{2.3}$$

$$\frac{\dot{M}_t}{M_t} = \frac{B_M F_1(k_t, 1) - \delta - \rho}{\sigma} \tag{2.4}$$

where $k_t = K_t/X_t$. As the relative price of agriculture and services are constant, it is evident from (2.2) and (2.3) that agricultural output grows at a slower rate than M_t and services output grows faster than M_t. Thus, non-homothetic preferences is the basis for non-balanced growth.

Kongsamut et al. (2001) prove that under the restriction $\bar{A}B_S = \bar{S}B_A$, a trajectory exists at which the real interest rate $(B_M F_1(k, 1) - \delta)$ is constant and the economy is on a balanced growth path. This implies that k is constant and hence M_t, the manufacturing output, and the aggregate output grow at a constant rate, g. Differential sectoral growth in an economy results from non-homothetic preferences: the services sector is the fastest growing sector, followed by manufacturing and then agriculture. Differences in growth rates, however, become narrower over time, and, asymptotically, the growth rates in all sectors are the same. Thus, the paper explains only the short-run differences in the growth rates of sectoral outputs and employment, the long-run growth rates are same across sectors.

Eichengreen and Gupta (2012)

Eichengreen and Gupta (2012) present an empirical study covering sixty countries from 1950 to 2005 that explains the growth of services due to rise in per capita income. They identify two waves of growth of the services sector. The first wave occurs at per capita incomes lower than USD 1,800 (in year 2000 purchasing power parity dollars). The second starts at per capita income of around USD 4,000. The first wave is made up primarily of traditional services, like retail and wholesale trade, transport and storage, public administration, and defense. The second wave is driven by the growth of modern services, like financial intermediation, computer services, business services, communication, and legal and technical services. The modern services have picked up growth in the latter years and are currently consumed by both households and businesses.

The relationship between per capita income and share of services in GDP appears like a cubic or quartic function from the Lowess plots. Hence the authors estimate regressions of the form

$$\frac{Ser_{it}}{GDP_{it}} = Constant + \sum_i \theta_i D_i + \alpha_1 Y_{it} + \alpha_2 Y_{it}^2 + \alpha_3 Y_{it}^3 + \alpha_4 Y_{it}^4 + \epsilon_{it}$$

where i refers to country and t to year. The country fixed effects are included in the regression. This relationship is estimated separately for the 1951-69, 1970-89, and 1990-2005 sub-periods. The results indicate that there are two waves of service sector growth: a first wave as a country moves from low to middle income and a second wave as it moves from middle to high income. There could be several possible explanations for this phenomenon. Factors like the size of the economy (GDP), openness to trade (as measured by the trade-to-GDP ratio), openness to trade in services (as measured by trade-in-services-to-GDP ratio); and a vector of demographic, geographical, and political variables (including democracy, latitude, share of land area in the tropics, the dependency ratio, both youth and old age, and proximity to the major economic and financial centres) could influence the growth of services due to rise in per capita income. The authors interact these correlates with the four terms in per capita income, and find which correlates reduce or eliminate the significance of all four per capita income terms. They find that openness to trade in services, democracy, and proximity to the major financial centres are drivers of the two-wave pattern. In last few decades, the IT 'revolution' has considerably reduced the transactions costs of providing cross-border services, which led to the significant growth in the volume of international trade in services.

2.1.2 Marketization of Services

High-income elasticity for demand of services refers to services which are similar to 'luxurious' goods. Another reason for growth of services is that some services are now produced by firms instead of households. Services, like hospitality, personal grooming, child care, that in past used to be produced at home, are lately being produced in the market. Economists believe that this shifting of services production from home to market has driven the growth of a segment of services, namely consumer services, and this has contributed to non-balanced growth.

Ngai and Pissarides (2008)

Related to the marketization of services, this paper presents a three-sector closed economy, where each good can be produced both at home and in market. Production of goods requires labor and capital in a constant returns to scale technology. The production functions are identical in all activities, as in Kongsamut et al. (2001), except for their technology parameter (A_{ij}).

$$F^{ij} = A_{ij} F(l_{ij} k_{ij}, l_{ij}); \qquad \dot{A_{ij}}/A_{ij} = \gamma_{ij} \qquad i = a, m, s, \quad j = H, M$$

where the i denotes sector and j denotes home or market production. The time allocated in each sector is l_{ij} and k_{ij} is the capital-labor ratio. Unlike Kongsamut et al. (2001), the growth in sectoral TFP, rather than labor augmenting TFP growth, is the source of growth in this economy. There are two claims regarding the TFP growth rates of different activities. First, TFP growth rate is highest in agriculture and lowest in services. Second, the market production activities have a higher TFP growth rate than home production of the same good. Thus,

$$\gamma_{aM} \geq \gamma_{mM} > \gamma_{sM}, \qquad \gamma_{iM} > \gamma_{iH} \quad \forall \quad i.$$

It is the TFP growth ranking which defines the three goods. The utility function of the infinitely-lived representative household is

$$U_t = \int_0^{\infty} e^{-\rho t} \left[\ln \left(\sum_{i=a,m,s} \omega_i c_i^{(\epsilon-1)/\epsilon} \right)^{\epsilon/(\epsilon-1)} + v(1-l) \right] dt \qquad \text{where}$$

$$c_i = \left[\psi_i c_{iM}^{(\sigma_i-1)/\sigma_i} + (1-\psi_i) c_{iH}^{(\sigma_i-1)/\sigma_i}\right]^{\sigma_i/(\sigma_i-1)} \qquad \text{and}$$

$$l, \psi_i \in (0,1), \quad \sum_i \omega_i = 1,$$

$v(\cdot)$ is the utility from leisure (l), c_i is the per capita consumption of composite goods, ϵ is the elasticity of substitution between composites, c_{iM} and c_{iH} are the per capita consumptions of market produced and home produced good i and σ_i is the elasticity of substitution between home produced and market produced goods i.

A key assumption is that the market produced agricultural, manufacturing and services goods are poor substitutes of each other. Further, the home produced products are close substitutes of their respective market produced counterparts. This implies $\sigma_i > 1 > \epsilon$.

The model predicts that when goods are poor substitutes of each other, the hours of work moves in the direction of the good with the lowest TFP growth rate. In this case, when across goods substitutability is low, it is essential to consume each of the goods and hence effort is shifted to the production of the least productive sector so as to increase its output. However, if the goods are close substitutes, the model predicts that hours of work move in the direction of the good with the higher TFP growth rate. Thus, there are two forces at work: a structural transformation force that moves market hours in the direction of services (the sector with lowest TFP growth rate), and a marketization force that moves hours from home to market production.

Given the sectoral productivity trends, the structural transformation and marketization forces both work against the home production of agricultural and manufacturing goods. In contrast, the home component of services gains hours because structural transformation favors growth of total services, but also loses hours to market production due to marketization forces. Thus, the home production of services may rise at first but fall later. It explains that over time, market production of services is the most prominent activity of the economy and labor growth is highest in the services sector (followed by manufacturing and agriculture). The long run sectoral output growth rate ranking is one-to-one related to the sectoral TFP growth ranking, which implies that the growth rate of services output is the least. Hence, the theory is able to explain the higher growth rate of services employment as compared to the other sectors, but does not explain the higher growth rate of services output.

Buera and Kaboski (2012)

Buera and Kaboski (2012) propose a similar idea that explains the growth of services due to increased consumption of high-skilled services. This is not a conventional two-sector economy. Services provide utility to households while manufacturing acts as an intermediate in the production of services. There is a representative household with unit mass of workers and a continuum of desires (z). The desires are satisfied only by consumption of services. The workers are ex-ante identical, ex-post they will be differentiated by their skill/education level, low or high ($e = l, h$). The skills can be acquired by investing a fraction θ time in learning specialized skills for production of a particular service. Services can either be produced at home or purchased from market. The utility function looks like

$$u(\mathcal{C}, \mathcal{H}) = \sum_{e=h,l} f^e \int_0^\infty \left[\mathcal{H}^e(z) + \nu(1 - \mathcal{H}^e(z))\right] \mathcal{C}^e(z) dz$$

where the function $\mathcal{C}^e(z) : \mathbb{R}^+ \to \{0, 1\}$ indicates whether a particular want in being satisfied by the household member with skill e and the function $\mathcal{H}^e(z) : \mathbb{R}^+ \to \{0, 1\}$ indicates if the want is satisfied by home production of services. It is assumed that $0 < \nu < 1$, which implies that home produced services provide greater utility than market produced services.

Goods which are used to produce type z services are produced in market by using low skilled and high skilled labor.

$$G(z) = A_l(z)L_G(z) + A_h(z)H_G(z)$$

where A_e is the productivity of worker with skill e and L_G, H_G are the number of low-skilled and high-skilled workers employed in the production of goods. The market production of services uses a Leontif technology as

$$S_M(z) = \min\{A_l(z)L_G(z) + A_h(z)H_G(z), G_M(z)/q\}$$

where the labor technology in market services is same as that in manufacturing goods production, but the production also requires q units of manufacturing good to produce one unit of market services. The home production of services ($s_N(z)$) has a similar technology as market produced services, with one exception that home produced services only use low skilled workers (n_z)

$$s_N(z) = \min\{A_l(z)n(z), g_N(z)/q\}.$$

The worker's productivity is given by

$$A_l(z) = Az^{-\lambda_l}, \qquad A_h(z) = A\phi \max\{z^{-\lambda_l}, z^{-\lambda_h}\} \qquad \phi > 1, \lambda_l > 0, \lambda_h \geq 0, \lambda_l \geq \lambda_h$$

where A grows at the rate g. The productivity patterns are such that the high skilled worker has absolute productivity advantage over the low skilled worker in all tasks (as $\phi > 1$) and has comparative advantage over the low-skilled worker in production of more complex services (i.e. $z > 1$).

As productivity A grows, the desires get sequentially satisfied. For wants $z < 1$, the low-skilled worker is more productive than high-skilled worker and hence all these wants are satisfied through home production of services. As A further increases, the range of market produced services increases faster than home produced services. The household's more complex desires now are fulfilled by consumption of more skill-intensive services, some of which are purchased from the market. With further expansion of A, the desires are so complex that more high-skilled rather than low-skilled workers are required for production. These high-skilled workers increasingly spend less time at home and more time in market, which further pushes the demand for skill-intensive services. In long run, everyone in the economy is high-skilled and share of market-services in consumption approaches unity. The model does not explicitly state the employment or output growth ranking between the two sectors. However, it is evident that as market production of services starts to expand, the growth of services output grows faster than manufacturing output.

Other Literature

There are other papers which explain the sectoral transformations in an economy, without explicitly ranking the sectoral output growth rates. Foellmi and Zweimller (2008) present hierarchic preferences (similar to that in Buera and Kaboski (2012)), where the most urgent wants could be interpreted as agricultural goods, the less urgent wants as manufacturing goods and the luxurious wants as services goods. The timing of the introduction of these goods in the market is such that they start of as luxurious goods (high income elasticity) but over time become essential goods (low income elasticity). The hierarchial utility specification dictates that the increase in demand for new goods is concurrent with a fall in the demand for old goods. The model predicts monotonically decreasing employment shares in agriculture simultaneous with growing employing shares in services. The employment share in manufacturing initially rises in the early stages of development and then falls in later stages. This is a theory of pure demand-driven structural change.

In another paper, Laitner (2000) explains the growth of agricultural and manufacturing goods in the post Industrial Revolution era. In the early periods, when income per capita was low, agricultural consumption was important, income from land was the source of wealth accumulation. Over time, with exogenous technological progress, incomes rose and so did the demand for manufacturing good (due to non-homothetic preferences). Capital income became more important than land income and over time manufacturing became the dominant sector of the economy. Thus, a mix of both demand-side and supply-side effects explains the rise of manufacturing sector. The paper does not relate to the growth of the services sector.

Echevarria (1997) also presents a similar story but with three sectors. In her closed-economy model, the three sectors differ in their income elasticities, production functions as well as sectoral TFP growth rates. All these factors contribute to non-balanced sectoral growth. Through simulations, the author finds that in long run, manufacturing sector (which has the highest TFP growth rate) is the dominant sector followed by services and agriculture. This is contrary to the stylized fact that in most countries services sector constitutes the largest share of GDP. Though the model explains the relationship between growth and GDP per capita, it does not explain the inter-sectoral output growth patterns.

2.1.3 Differences in Sectoral TFP Growth

We saw different demand-driven driven explanations for differential sectoral growth. Now, we move on to examine the supply-side sources of non-balanced growth. Supply side explanations include biased technological progress across sectors (e.g., Ngai and Pissarides (2008)) and differences in production technologies (e.g., Zuleta and Young (2013) and Acemoglu and Guerrieri (2008)).[1]

[1] Another strand of literature uses the framework of non-balanced growth to capture business cycles facts, e.g., (Moro (2012a)) and productivity trends (Moro (2012b) and Duarte and Restuccia (2010)). While these papers focus on effects of non-balanced growth, this thesis is concerned about the sources of non-balanced growth.

Baumol (1967)

Baumol (1967) was probably the first paper which underscored the role of differences in sectoral TFP growth in explaining structural change in an economy. He considered two sectors, both use labor as inputs, but one sector is more progressive than the other.

$$Y_{1t} = aL_{1t}, \qquad Y_{2t} = be^{rt}L_{2t},$$

where r is the rate of technological progress. Baumol observed that the productivity of manufacturing sector grew at a faster rate than services, so sector 1 can be thought of as services sector and sector 2 as manufacturing. If a constant output ratio (say K) is to be preserved (which indicates that no commodity 'vanishes' in long run),

$$\frac{Y_{1t}}{Y_{2t}} = \frac{a}{b}\frac{L_{1t}}{L_{2t}e^{rt}} = K$$

then the labor in the less progressive sector has to grow at the rate r. This is the basis for increase in employment share of services sector. This is a partial equilibrium model where labor reallocation ensures that in long run outputs in both sectors are proportional to each other and thus there are no differences in sectoral output growth.

Ngai and Pissarides (2007)

Like Baumol (1967), Ngai and Pissarides (2007) also present a purely technological explanation of structural change. They consider multi-sector growth model, where the production technology of these goods differ only in the growth rate of their sectoral TFP. Unlike Baumol (1967), the production of these goods uses both labor and capital. The economy has m-1 final consumption goods. The last good, say good m, could either be consumed or invested.

$$c_i = A_i F(n_i k_i, n_i), \forall \quad i \neq m; \qquad \dot{k} = A_m F(n_m k_m, n_m) - c_m - (\delta + \mu)k,$$

where δ is the depreciation rate, μ is the exogenous growth rate of labor, $n_i \geq 0$ is the employment share and $k_i \geq 0$ is the capital labor ratio of sector i. k is the aggregate capital labor ratio, A_i is ith sector's TFP which grows at the rate γ_i. Given the production structure, static efficiency implies

$$\frac{p_i}{p_m} = \frac{A_m}{A_i}.$$

So irrespective of the demand structure, the price of the less productive sector grows at a faster rate compared to the price of the more productive sector. The household's utility function is

$$U = \frac{\left(\sum_{i=1}^{m} \omega_i c_i^{(\epsilon-1)/\epsilon}\right)^{\epsilon(1-\theta)/(\epsilon-1)} - 1}{1-\theta}, \qquad \text{where} \qquad \sum_{i=1}^{m} \omega_i = 1.$$

The utility maximization yields

$$\frac{p_i c_i}{p_m c_m} = \left(\frac{\omega_i}{\omega_m}\right)^{\epsilon} \cdot \left(\frac{p_i}{p_m}\right)^{1-\epsilon}.$$

So if the consumption demand is too inelastic ($\epsilon < 1$), the expenditure on a good i is driven by its price change. Given that lower the TFP growth rate of a sector, faster is the growth of its prices and hence, in the case of low substitutability between final goods, higher is the growth rate of the household expenditure on this good. The GDP share of the sector with lowest TFP growth rate expands and hence employment shifts from the more productive sectors to the least productive sector. In steady state only 2 goods exist – the capital good and the least productive non-capital good. Ngai and Pissarides (2008) show that in USA (1930-2004), TFP growth was highest in agriculture followed by manufacturing and services. Using this theory, they explain the dominance of services sector. The manufacturing sector, being the capital goods producing sector, has the second largest share in employment and GDP. Agriculture is smallest sector of the economy. The model's predicted sectoral output growth ranking (led by agriculture, manufacturing and services in that order) does not match stylized fact of higher services sector growth.

2.1.4 Differences in Technology

Differences in production technologies is also a source of differential sectoral growth.

Acemoglu and Guerrieri (2008)

This paper develops a non-balanced, two-sector growth model without specific references to manufacturing or services. There are two sectors in the economy, both use capital (K) and labor (L) in Cobb-Douglas technology to produce their output. The labor intensity as well as the total factor productivity of the sectors are different.

$$Y_1(t) = M_1(t)L_1(t)^{\alpha_1}K_1(t)^{1-\alpha_1}, \qquad Y_2(t) = M_2(t)L_2(t)^{\alpha_2}K_2(t)^{1-\alpha_2}$$

where M denotes the sectoral TFP and it assumed that $\alpha_1 > \alpha_2$.

These two goods are then employed in a competitive market to produce the final good, which is consumed as well as invested to produce capital.

$$Y(t) = \left[\gamma Y_1(t)^{(\epsilon-1)/\epsilon} + (1-\gamma)Y_2(t)^{(\epsilon-1)/\epsilon}\right]^{\epsilon/(\epsilon-1)}$$

where $\gamma \in (0, 1)$ and $\epsilon \in [0, \infty)$.

Similar to Ngai and Pissarides (2008), there is TFP growth, but the ranking of the TFP growth across the two sectors is not critical to ranking of sectoral growth rates. As capital accumulates, the relative price of the more capital-intensive sectors good falls. This leads to capital and employment shifting to the less capital-intensive sector. This is termed 'capital deepening' and is the basis for non-balanced growth. Capital deepening increases the relative output of the more capital-intensive sector. Though the paper does not compare manufacturing and services sectors per se, but it alludes to services being the more capital intensive. If we assume this, then the model predicts faster output growth and lower employment growth in the services sector compared to manufacturing sector.

Zuleta and Young (2013)

Zuleta and Young (2013) present two sector model with manufacturing and services. Services is believed to be labor-centric so the services production uses labor and capital in Leontif production function. The manufacturing sector's production function is Cobb Douglas. Thus, one crucial difference between the two goods is that elasticity of substitution between capital and labor is higher in manufacturing than in services production. The technological progress in manufacturing is assumed to be labor saving. As a consequence, the share of the services sector in employment rises and over time, manufacturing becomes more capital-intensive. The share of services in value-added increases, however, the services output grows at a lesser rate compared to manufacturing. The model does not address the differences in sectoral output growths of the two sectors.

The supply-side explanations of non-balanced growth crucially depend on the sectoral TFP growth ranking. Given that this ranking varies across countries, the existing explanations do not fully explain the higher services growth witnessed in almost all countries. For example, in developing countries the TFP growth is highest in the services sector (Ghani (2010)) and the existing models would not be able to explain the higher employment growth in services in these countries. In this thesis, we explain growth-differentials on the basis of returns to scale, employment frictions and land intensity differences. These are relatively more fundamental reasons which are likely to be common in almost all countries. We believe that this is a significant contribution in the literature of non-balanced growth.

2.2 Trade in Services

Studies on services trade have focussed mainly on two broad questions - what affects services trade and what does services trade affect?

Many empirical papers have expounded on the different *factors that affect services trade*, like certain characteristics of services exporting/importing firm (Abramovsky and Griffith (2006) and Breinlich and Criscuolo (2011)), dependence of business services trade on the structure of manufacturing and business service industries (Guerrieri and Meliciani (2005), Nordås (2010)), effect of global financial crisis of services trade (Borchert and Mattoo (2010)), determinants of international services outsourcing (Ono (2003), Kedia and Lahiri (2007)), among others. Policy related papers on trade in business services include Hoekman and Mattoo (2008), Mattoo et al. (2008) and Francois and Hoekman (2010).

Hindley and Smith (1984) discussed the determinants of comparative advantage in services and Sampson and Snape (1985) classified the different modes of services trade which are incorporated in GATS.[2] One of the most significant factors behind rise of services trade are the development in ICT, which have reduced barriers in services trade enabled 'international outsourcing' of services (Bhagwati (1984)).[3] Jones and Kierzkowski (1990) and Jones et al. (2005) have explained, by using the standard two-sector competitive models of international trade theory, that in the presence of increasing returns to scale, fragmentation of production

[2]Beginning with Williamson (1975) and Grossman and Hart (1986) a body of literature has developed that explains a firm's choice of in-house versus outsourcing production (based on the magnitudes of transactions costs, asset specificity, and incomplete contracts), which can also be extended to understand services outsourcing.

[3]In a recent study of 151 countries in the period 1990-2006, Choi (2010) finds that doubling of internet usage increases services trade by 2 to 4%.

increases firm profits – which lays basis for international outsourcing. They observed that as world economy expanded in the period 1980s-2001, it led to greater outsourcing, particularly of services. Grossman and Helpman (2003, 2005) have explicitly modeled the choice problem facing a firm in contracting out tasks, in-house production versus outsourcing abroad or FDI, alluding in part to international outsourcing in services. They find that increments in factors such as number and productivity of firms engaged in outsourcing tasks, and contracting environment favor international outsourcing.

Factors like, geographical distance and economic freedom of trading countries have been found to have significant impact on services trade as compared to goods trade (Kimura and Lee (2006)). The authors study bilateral trade between OECD countries in 1999 and 2000 and find that geographical distance is correlated with transport costs, communication and cultural costs. As the need for communication is greater in services trade in comparison to goods trade, the services trade is significantly affected by geographical distance. The economically liberalized countries, which have more global outlook and a business-friendly environment, are more important for services trade as compared to goods trade.

Guerrieri and Meliciani (2005) find that services trade patterns are governed by complementarities between the manufacturing and services industries. For selected services like financial, communication and business services, they find that trade in these services is primarily driven by intermediate demand. The countries with a high share of knowledge-intensive manufacturing industries experience a higher demand for financial, communication and business service and, therefore, these countries are more likely to produce and export these services.

In empirical studies, the *effects of services trade* has been a topic of interest in a lot of recent studies. These studies indicate productivity and welfare gains from trade in services. Broda and Weinstein (2004) indicate that increase in varieties, of goods or services, has a positive impact on welfare. Görg et al. (2008) find that in Irish manufacturing plants, outsourcing of services significantly improves the productivity of only the exporting firms. Even in USA, Amiti and Wei (2009) observe that services offshoring between 1992 and 2000 increased productivity of the manufacturing firms.

The existing theoretical literature has also considered services as intermediate goods while analyzing the effects of services trade. Markusen (1989) analyzes the normative issues of gains from trade in final goods as compared to gains from trade in intermediate inputs (producer services). There are two final goods in the economy – one good (good Y) is produced using labor and capital and the other good (good X) uses producer services only, where services is the intermediate good,

$$Y = G(L_y, K);\ G_l > 0,\ G_{ll} < 0 \qquad \text{and} \qquad X = \left[\sum_{j=1}^{n} S_j^{\beta}\right]^{1/\beta} \quad 0 < \beta < 1.$$

where L_y is labor employed in production of good Y, K denotes capital, S_j is the jth variety of service used in production of good X. Services are produced in an increasing returns technology as

$$S_j = L_j - F$$

where L_j is labor employed in production of service variety j and F is the fixed cost. Three trade regimes are considered: autarky, trade in goods (X and Y) and trade in specialized inputs (good Y and producer services S). The two trading countries differ in only the sizes of their respective economies. Compared to autarky, free trade in goods does not guarantee to be Pareto-improving for both countries. The smaller country could lose in the free goods trade regime due to contraction of the sector X, which leads to distortions between prices and marginal costs. However as compared to autarky, the free input trade guarantees that both countries experience an expansion of production in the distorted sector (X) which is a sufficient condition for gains from trade. Further, free input trade is superior to free goods trade from the point of view of the world as a whole, although not necessarily from the point of view of both countries. This result follows from the complementarity of domestic and foreign specialized inputs in final goods production, or alternatively from the increased division of labor supported by trade.

Francois (1990) emphasizes that producer services facilitate specialization, which in turn, increases the welfare gains from trade. In this model economy, producer services, which are intermediate inputs, are used in managing the production process of the final goods. The final good is a differentiated product (n varieties), which is produced in steps, through various labor intensive activities as follows

$$x_j = v^{\delta} \Pi_{i=1}^{v} \left[D_{ij}^{(1/v)}\right], \qquad \delta > 1$$

where $v \in \mathbb{N}$ is an index of specialization, D_{ij} represents direct labor employed in production activity i for production of variety j to produce output x. Producer services are used to coordinate and control this complex production process,

$$S_j = \gamma_0 v + \gamma_1 x_j$$

where S_j is the total quantity of service inputs used by firm j. Services is produced from labor using a constant returns to scale technology. The household has symmetric Lancaster preferences, which implies that the elasticity of demand for each variety is a function of the total number of varieties available. In this setup, Francois (1990) considers free trade between two identical economies. He finds that as compared to autarky, the services market expands through trade. This allows increased specialization in production methods, which implies productivity gains in the production of final goods. In this model, producer services are important in realization of returns of scale and this suggests trade is producer services may help developing countries to take part in the process of specialization.

Van Marrewijk et al. (1997) also consider services as inputs in production process in an international trade framework. They consider two-country, three-sector general equilibrium model, where two final goods are produced in Cobb-Douglas technology with differing factor intensities and the intermediate good (services) is characterized by product differentiation and economies of scale. The two final goods are denoted by X and Y, which are produced using physical capital (K), labor (L) and human capital (H)

$$Z = K_z^{\alpha_z} L_z^{\beta_z} H_z^{\delta_z}, \qquad Z = \{X, Y\},$$

where $\alpha_z, \beta_z, \delta_z > 0$ and $\alpha_z + \beta_z + \delta_z = 1$. Human capital refers to trained labor which requires differentiated producer services S_j as inputs

$$H_z = \left[\sum_{j=1}^{n} S_{jz}^{\gamma} \right]^{\frac{1}{\gamma}}.$$

The production of services requires an increasing returns to scale technology with labor as the only input

$$S_j = \frac{1}{b} \left(L_j - F \right),$$

where only one firm produces the jth variety of services. Preferences are Cobb-Douglas. Comparative advantage in goods is determined by relative capital intensities of the goods as well as by number and technology of services. Three trade regimes are considered: autarky, trade in goods only, trade in goods and services. When two countries start to trade in goods, the country for which the services sector expands will unambiguously gain; the other country may gain or lose. This corroborates with the findings of Markusen (1989) and is a feature of scale economies. In trade in commodities and services, only the most efficient service firms survive. This trade regime is welfare improving as compared to autarky. The authors also show that FDI in services by means of a technology transfer does not replicate trade in goods and services. It highlights the importance of the different modes of services trade.

Compared to the existing models in trade in services, we consider both business and consumer services. Services and manufacturing goods, both, are used in final consumption as well as inputs in production of the other sector. In this sense, manufacturing and services do not have differences in their use. Further, we present a growth model where short term sectoral growth is affected by change in trade regime. To our knowledge, there is no theoretical study which links services trade and growth.

3 Growth of Business Services: A Supply-Side Hypothesis*

3.1 Introduction

It is a well known fact that, in terms of both output and employment, the services sector has overtaken manufacturing as the leading sector in many modern economies.[1] In the growth literature this phenomenon has been attributed to uneven growth in total factor productivity in market and home production of manufacturing and services goods (Ngai and Pissarides (2008)), non-homothetic preferences and rise in income (Eichengreen and Gupta (2012)), and, growing demand for skill intensive services with income (Buera and Kaboski (2012)). Less known are patterns of growth within the service sector. Various services can be categorized into three types: pure business services, pure consumer services and the 'hybrid' (consumed by both firms and households). Consumption or business services in total then consist of pure consumption or business services and some of the hybrid.

Growth rates of these sub-sectors are hardly uniform. In U.S., U.K. and Japan for instance, the share of pure business services in the services sector as a whole has nearly or more than doubled in a span of over three decades 1970-2006. In 2006 pure business services formed 15% to 20% of the total services - a small but a significant proportion (according to EU KLEMS data).

Table 3.1 records the compounded annual growth rates (CAGR) of the sub-sectoral real

* Forthcoming in Canadian Journal of Economics. Satya P. Das and Anuradha Saha – Growth of Business Services: A Supply-Side Hypothesis. The paper is modified to suit the chapter-form of the thesis. The most significant change being that the related literature discussion has been reviewed in the Chapter 2.

[1] In China, considered today as the manufacturing hub of the world economy, the services sector is only a close second to manufacturing.

Table 3.1: CAGR (in %) of Sectoral Outputs and Employment (1970-2006)

	Output Growth			*Employment Growth*		
	US	UK	Japan	US	UK	Japan
Utilities	1.1	3.1	3.2	-0.4	-2.3	- 0.5
Construction	1.6	1.7	0.3	2.1	-0.3	0.7
Wholesale and Retail Trade	3.8	3.0	3.1	1.5	0.8	1.5
Hotels and Restaurants	3.0	2.0	2.3	2.7	1.8	2.7
Transport and Communication	3.6	3.9	3.0	0.8	-0.2	0.5
Pure Business Services	**5.9**	**6.0**	**5.1**	**4.9**	**3.1**	**5.1**
Pure Consumer Services	**2.8**	**2.1**	**3.1**	**1.9**	**1.4**	**2.3**
Manufacturing	**1.9**	**0.1**	**2.2**	**-1.0**	**-2.7**	**-0.4**

Source: EU KLEMS

(gross) output as well as employment within the service sector vis-a-vis manufacturing in these countries over the period 1970-2006.[2,3] Observe that *in terms of output and employment, pure business services have grown faster than pure consumer services, which in turn have grown faster than manufacturing.*

We treat this as a stylized fact, and, the objective of this chapter is to focus on business services and provide a rationale behind the above stylized fact.

A number of studies have attributed the rising share of services in GDP to preference changes accompanying economic development. In the long run, the argument goes, the rise in real income shifts demand from agricultural goods to manufacturing goods and then to services.[4] The manufacturing sector outgrowing the agricultural sector is understandable in terms of the preference-shift hypothesis. But the services sector – especially the business service sub-sector – outpacing manufacturing is not explained by this hypothesis, since the argument is applicable to consumer services. How a *derived* sector like business services may

[2]EU KLEMS reports, for each sub-sector of an economy, price indices, which are used in calculating real sectoral outputs.

[3]Pure business services data in Table 3.1 include outsourcing activities. Hence some critics point that the growth of business services might just be an ‘accounting’ phenomenon: the tasks which were performed in-house by the manufacturing firms are now bought from service firms. However, the growth of business services does not seem to be primarily driven by outsourcing. As Kox and Rubalcaba (2007) and Eichengreen and Gupta (2011) note, outsourcing can explain only a small part of the growth of business services. There may be several reasons. First, the IT revolution in the 1970s led to application of technology in novel ways which itself led to creation of *new* services (such as internet, market research and consultancy). Second, as Beyers and Lindahl (1996) have found, the need for specialized knowledge is by far the most important factor behind the demand for producer services. Finally, services rendered by the business services suppliers may be superior to the prior in-house service activities of the outsourcing firm (Kox (2001)). Raa and Wolff (2000) find that the use of business services led to higher total factor productivity growth in manufacturing - clearly indicating the additional benefit of business services over in-house services.

[4]See, for example, Fisher (1939) and Smith (2001).

grow faster than its *parent* sector, manufacturing, is not too obvious. It is also not apparent how the growth rate of business services may exceed that of consumer services. This chapter develops a theoretical model which accords with the above stylized fact via two supply-side assumptions or mechanisms.

A: *Returns to scale are less in manufacturing compared to the services sector.*

B: *Adjustment of employment is more sluggish in manufacturing than in the services sector.*

In view of A, it is easy to see how the latter may grow faster than the former. Suppose all services are business services, produced by one input, labor, and, output in the services sector is related one-to-one with labor employment in that sector (CRS technology). In contrast, let manufacturing output be a function of labor and (business) services under a decreasing-returns technology. Suppose that in the steady state employment grows at the same rate between the two sectors. It follows immediately that employment and output in the service sector grow at the same rate, while manufacturing output grows at a lesser rate. That is, the business services sector, whose existence is derived from demand by manufacturing, can grow faster than manufacturing. The same argument goes through even if both sectors may be subject to decreasing returns to scale as long as the scale elasticity is lesser in manufacturing.

Suppose, in addition, there are labor or worker frictions, and, they are more prevalent in manufacturing than in the services sector, implying that adjustment of employment is more sluggish in the manufacturing sector. In a growth scenario it would then imply that employment in the services sector would grow faster than that in manufacturing.

Our analysis indeed yields something more subtle, that is, assumptions A and B 'deliver' that business services would grow faster than consumer services, which, in turn, would grow faster than manufacturing. Intuitively, Assumption A (difference in returns to scale) implies, per se, that business and consumer-service outputs would grow at the same rate, which is higher than that of manufacturing. Assumption B tends to imply a higher growth rate of employment in the business-services sector than in manufacturing, which constitutes an additional source of higher output growth rate of business services – but not for consumer services – compared to manufacturing. As a result, the growth rate of consumer services in terms of employment and output falls short of that business services but exceeds that of manufacturing.[5]

[5]Furthermore, at the aggregate level, per capita output measured by per capita GDP grows at a constant

Table 3.2: Estimates of Returns to Scale of Selected Industries

Durable Manufacturing		*Nondurable Manufacturing*		*Nonmanufacturing*	
Lumber (24)	0.51	Food (20)	0.84	Construction (15-17)	1.00
Furniture (25)	0.92	Tobacco (21)	0.90	Transportation (40-47)	1.19
Stone, clay, & glass (32)	1.08	Textiles (22)	0.64	Communication (48)	1.32
Primary metal (33)	0.96	Apparel (23)	0.70	Electric utilities (491)	1.82
Fabricated metal (34)	1.16	Paper (26)	1.02	Gas utilities (492)	0.94
Nonelectrical machinery (35)	1.16	Printing & publishing (27)	0.87	Trade (50-59)	1.01
Electrical machinery (36)	1.11	Chemicals (28)	1.83	FIRE (60-66)	0.65
Motor vehicles (371)	1.07	Petroleum products (29)	0.91	Services (70-89)	1.32
Other transport (372-79)	1.01	Rubber & plastics (30)	0.91		
Instruments (38)	0.95	Leather (31)	0.11		
Miscellaneous manufacturing (39)	1.17				
Column Average	**1.01**		**0.87**		**1.16**
Median	**1.07**		**0.89**		**1.10**

Source: Basu et al. (2006); reproduced here with permission.
FIRE stands for finance, insurance, and real estate.

Assumptions A and B, both, are empirically motivated. There are numerous empirical studies on returns to scale in various industries, yielding different results owing to differences in data and methodology; for an overview, see (WDR, 2009, Chapter 4). In particular, Basu et al. (2006) is one of the few which estimate returns to scale for industries in both manufacturing and services. This U.S. economy based study finds that for manufacturing as a whole, there is evidence of decreasing returns in terms of gross output, less so for value-added. Within manufacturing, durable manufacturing exhibits increasing returns to scale while there are decreasing returns in non-durable manufacturing. Scale elasticities of services production exceed unity and are higher than those in durable manufacturing. For reference, Table 3.2 reproduces Table 1 in Basu et al. (2006), in which the last column (nonmanufacturing) contains various service industries.[6] Notice that service industries like transportation, communication and personal services have higher returns to scale than all manufacturing industries, except chemicals.

For Japan, Morikawa (2011) finds evidence of increasing returns to scale for ten ma-

rate: a Kaldor stylized fact. However, our model does not incorporate physical capital as a factor of production, and hence is silent about other Kaldor facts.

[6]The entry "Services (70-89)" refers to personal services.

jor personal services industries. He attributes this to knowledge spillover effects due to localization or agglomeration. It is also easy to 'see' strong scale economies in services like transportation, communication and utilities, having substantial overhead costs and relatively low marginal costs. There are several other services-sector-specific studies on measurement of returns to scale. Scale economies are also found for retail trade in Israel (Ofer (1973)), banking and finance in the U.S. (McAllister and McManus (1993)) and hospital industry in the U.S. (Berry (1967) and Wilson and Carey (2004)).

Apart from agglomeration or technology factors, a highly plausible underlying factor behind returns to scale in services being higher compared to manufacturing may be the scarcity of land and differences in the intensity of land use in production. In recent decades land has become a major issue in the expansion of manufacturing. Acquiring land has become increasingly costly and growing environmental regulations have led to stringent limitations for the use of acquired land towards industrial activities. In the context of growth of manufacturing in China and India, Srivastava (2007) and *Business Line* (2012) express that availability of land is one the reasons why manufacturing sector in China has grown much faster than in India. But, land is not so much of a constraint for service production units. For example, in a study of 15 major countries of the European Union, Hubacek and Giljum (2003) find that 2.1 million hectares of productive land is under manufacturing while only 1.1 million hectare is used for the services sector. Differential land constraints would imply differential returns to scale.

Turning to worker frictions, they seem to vary directly with firm size, via congestion, unionization and employment protection laws (EPLs). As the average firm size is larger in manufacturing than in services, worker frictions would tend to be more prevalent in manufacturing. According to Bureau of Labor Statistics (BLS) 2010, in U.S. about 34% of manufacturing enterprises had more than 20 employees, while the same was true for less than 10% of enterprises in the services sector.[7] OECD database shows that in almost all OECD countries, the average firm size in manufacturing is larger than in services.

In 2012, unionization rate (the percentage of employed workers in a sector that had a union or an employee association affiliation) in the U.S. private sector was about 11% in manufacturing and just over 6% in the services sector (BLS). According to ILOSTAT, an ILO database of 165 member countries, in 2010 manufacturing was one of the sectors with

[7]Typically, firms with less than 20 employees are taken to be small enterprises.

Table 3.3: Business Turnover in Selected Countries

		Enterprise Entry Rate (%)		Enterprise Exit Rate (%)	
Country	Year	Manufacturing	Services	Manufacturing	Services
Italy	2005	5.71	9.47	7.08	8.65
Norway	2005	4.39	7.27	2.96	5.15
Spain	2006	5.77	11.95	6.58	8.61
Canada	2007	4.78	7.9	6.92	8.86
Brazil	2005	9	13	6.73	8.35

Source: OECD database

Table 3.4: Labor Turnover Rates for U.S. in 2012

Sector	JOR	JSR
Manufacturing	2.0	1.9
Trade, Transportation and Utilities	2.7	3.3
Education and Health Services	3.2	2.3
Leisure and Hospitality	3.2	5.2
Professional and Business Services	3.1	4.5

JOR: % of workforce recruited on part time or full time basis in a given year;
JSR: % of workforce separated due to quits, layoffs and discharges

Source: Bureau of Labor Statistics.

the highest number of strikes, while they were the least in the business services sector.

EPLs, which are not sector-specific, stipulate more stringent norms for firms with more than 15 to 20 employees, firms having labor unions or when firms fire workers with long tenure (see Guner et al. (2008) among others). As these conditions prevail more in manufacturing than in services, employment friction is likely to be more in manufacturing.[8] Such cross-sector difference in employment flexibility is also noted by the European Commission in its policy brief European Research Area (2013).

Business turnover rate may be considered as an indirect proxy for labor turnover or employment variability which is inversely related to the degree of worker frictions. Table 3.3 presents supporting data for five countries – that is, business turnover is less in manufacturing.[9]

Last but not least, it is well-known that labor turnover rates, a direct proxy for employment flexibility, are lower in manufacturing than in the services sectors. To paraphrase Bertola (1992) who analyzed labor turnover costs, "employment is typically quite flexible

[8]BLS (2012) finds that in the U.S., workers in manufacturing have median job tenures of about 5-6 years, compared to about 3-5 years in services.

[9]These are the largest economies for which such data was available in the OECD database.

for small firms and firms in the service sector."[10] Table 3.4 presents the labor turnover rates in the U.S., in terms of job openings and separation rates (JOR and JSR respectively), for manufacturing and some service industries. JORs and JSRs are higher in service industries.

The existing literature cited in the previous chapter refers to consumption services, the most distinguishing feature of this chapter is to bring the growth of *business* services to the forefront and show how it may exceed the growth of consumption services and manufacturing. It purports to explain higher growth of both employment and output in the service sector – rather than one or the other. We emphasize two supply-side factors behind the pattern of differential growth rates among business services, consumption services and manufacturing, namely, differences in returns to scale and labor frictions. Furthermore, in our model differences in growth rates of sectoral outputs tend to persist in the long run, i.e., they do not vanish asymptotically.

The rest of the essay proceeds as follows. Our basic model of business services is developed in Section 3.2. The main result is that output and employment growth rates in the business-service sector exceed those in manufacturing. Consumption services are introduced in Section 3.3, the central section of the essay. The model therein ranks growth rates of business services, consumption services and manufacturing, and, 'predicts' the stylized fact. Some generalizations and alternative scenarios are explored in Section 3.4. They include demand shift towards consumption services as income rises via non-homothetic preferences. Section 5.6 concludes the essay.

3.2 The Basic Model

The source of growth *per se* is not our central concern. Throughout our analysis in this chapter, we abstract from TFP growth or physical capital accumulation and assume a simple story of human-capital-accumulation based growth. How growth rates may differ across sectors is our focus.

A closed economy has two sectors: manufacturing (the numeraire sector) and business services. Both sectors are perfectly competitive. Manufacturing output is produced by labor and business services via a decreasing and variable returns to scale technology so as to imply

[10] In their two-sector open economy model with a traded sector which is manufacturing and a non-traded sector which is services, Cosar et al. (2010) assume positive turnover costs in manufacturing, while the services sector is assumed to be frictionless.

sluggish adjustment in the employment of labor, while business services are produced by labor only under constant returns. Decreasing returns in manufacturing sector are founded on existence of fixed factors required in the manufacturing goods production. For example, land and natural resources are utilized more in manufacturing sector as compared to services sector. As long as the total availability of these factors to the manufacturing sector is inelastic, it would imply decreasing returns to scale in this sector. In fact, we do a detailed study on the role of land in inter-sectoral growth dynamics in Chapter 4.

Our results depend on higher returns to scale in the services sector – not necessarily constant returns in that sector and decreasing-returns in manufacturing. Difference in returns to scale implies difference in growth rates of sectoral outputs, but not in sectoral employment growth rates. Higher worker frictions in manufacturing (relative to services) would imply that the growth rate of employment in the services sector is higher than that in manufacturing.

3.2.1 The Static General Equilibrium

Let $q_{st} = L_{st}$ denote the business-service production function, where q_{st} is the total output and L_{st} is the amount of effective labor used in producing business services at time t. Free entry and exit imply the zero-profit condition: $p_{st} = w_t$, where p_{st} is the price of business services. Labor is measured in efficiency units and it grows over time. Its growth process will be specified later, but, at the moment, it is to be noted that w_t is the wage rate per such efficiency unit, *not* earnings per worker per unit of time; see, for instance, Jung and Mercenier (2010).

In the context of the manufacturing sector we keep in view frictional or congestion problems associated with labor size in a firm being large. They manifest in course of working with other factors of production (which give rise to the standard positive but diminishing marginal returns) as well as among workers (such as interpersonal conflicts of various kinds).[11] This leads to a direct loss of output, which is *not* attributable simply to the loss of aggregate labor time available for production. We do not develop a micro structure to incorporate

[11] GICE (2012), a blog, notes that that as manufacturing firms grow in size, their production processes become increasingly complex especially in terms of inter-departmental co-ordination among workers. The larger the firm size, greater is the scope for loss of potential output. Hence, these manufacturing firms typically invest in a variety of established human resource and operations management systems to reduce these worker problems between departments, say marketing and production; which is however not modelled here.

worker frictions in manufacturing and the resultant inflexibility in employment variation. Instead, we postulate that the technology itself features this attribute. Let the production function be:

$$q_{mt} = L_{mt}^{\alpha} q_{st}^{\beta} - \gamma L_{mt},\ \alpha,\ \beta,\ \gamma > 0,\ \alpha + \beta < 1, \tag{3.1}$$

where L_{mt} is the effective labor used in manufacturing at time t. The term, $L_{mt}^{\alpha} q_{st}^{\beta}$, may be interpreted as gross output, whereas γL_{mt} can be thought of as a penalty or loss of output because of worker frictions.

The production function (3.1) satisfies decreasing returns but is non-homothetic. The parameter γ being positive, cost minimization would imply that in response to a proportionate increase in labor and service input costs, the *proportional* reduction in labor employment is less than that of the services input, i.e., labor to services input ratio increases. Likewise, in the face of a proportional decrease in input prices, labor employment is increased less than proportionately compared to the services input, i.e., labor to services input ratio falls. In this sense, γ is the measure of worker frictions and resulting employment inflexibility in manufacturing.

Note that (3.1) permits negative marginal product – which can be interpreted as a *strong* congestion effect (whereas diminishing but positive returns for any level of employment may be seen as a situation of weak congestion effect). But, profit maximization would imply that in equilibrium the marginal returns to labor must be positive.[12] It is interesting that the *possibility* of negative returns has implications for equilibrium where the returns are positive.

The first-order conditions with respect to labor and services input are:

$$\alpha L_{mt}^{\alpha-1} q_{st}^{\beta} = w_t + \gamma^1 \tag{3.2}$$

$$\beta L_{mt}^{\alpha} q_{st}^{\beta-1} = p_{st}. \tag{3.3}$$

The l.h.s. and r.h.s of (3.2) can be respectively interpreted as the marginal product of labor in producing the *gross* output and the *effective* marginal cost of labor. Using (3.1), (3.2) can be stated indirectly as

$$\frac{\alpha q_{mt}}{L_{mt}} = w_t + (1-\alpha)\gamma. \tag{3.4}$$

[12]Interestingly, for a large public-sector steel conglomerate in India – SAIL (Steel Authority of India Limited), Das and Sengupta (2004) found evidence of negative marginal product of the managerial workforce.

Substituting the business services sector relations $q_{st} = L_{st}$ and $p_{st} = w_t$ into the ratio of the two first-order conditions in manufacturing, we get

$$\frac{L_{st}}{L_{mt}} = \frac{\beta}{\alpha} \cdot \frac{w_t + \gamma}{w_t}. \tag{3.5}$$

It reflects that the ratio of employment between the two sectors is proportional to the ratio of effective marginal costs of hiring labor in the two sectors.

We rewrite the manufacturing production function as eq. (3.6) below, wherein the production function of the business service sector is substituted . Eq. (3.7) is the full-employment condition, where $\bar{L}_t$ is the total labor (in effective units) available for production.

$$q_{mt} = L_{mt}^{\alpha} L_{st}^{\beta} - \gamma L_{mt} \tag{3.6}$$

$$L_{mt} + L_{st} = \bar{L}_t. \tag{3.7}$$

Static equilibrium is described by eqs. (3.4)-(3.7).

Lemma 3.1 *The static equilibrium exists and is unique for any $\bar{L}_t > 0$.*

Proof: Eqs. (3.4), (3.5) and (3.7) yield

$$L_{mt} = \frac{\alpha w_t}{\alpha w_t + \beta(w_t + \gamma)} \bar{L}_t; \quad L_{st} = \frac{\beta(w_t + \gamma)}{\alpha w_t + \beta(w_t + \gamma)} \bar{L}_t = q_{st}. \tag{3.8}$$

$$q_{mt} = \frac{w_t[w_t + (1-\alpha)\gamma]}{\alpha w_t + \beta(w_t + \gamma)} \bar{L}_t. \tag{3.9}$$

If we substitute (3.8) and (3.9) into (3.6),

$$\bar{L}_t = \left(\alpha + \beta + \frac{\beta\gamma}{w_t}\right) \left[\frac{\alpha^{\alpha}\beta^{\beta}}{w_t^{\beta}(w_t + \gamma)^{1-\beta}}\right]^{\frac{1}{1-\alpha-\beta}} \equiv \bar{L}(w_t). \tag{3.10}$$

The function $\bar{L}(w_t)$ is continuous and differentiable, satisfying $\bar{L}'(w_t) < 0$. Further, $\bar{L}(\cdot) \to 0$ or ∞ as $w_t \to \infty$ or 0. Hence, for any $\bar{L}_t > 0$, a positive solution for w_t exists and it is unique. Eqs. (3.8) and (3.9) imply that employment and output solutions are unique. ■

Eq. (3.10) essentially states that total labor demand is negatively related to the wage rate, which results from decreasing returns to scale in manufacturing. Also recall that w_t in our model is the wage rate per *efficiency unit*. Wage earnings per worker equal $w_t\bar{L}_t$, an increasing function of $\bar{L}_t$.

Consider comparative statics of an increase in $\bar{L}_t$, the stock of effective labor.

Proposition 3.1 *If $\bar{L}_t$ increases, wage rate (per unit of effective labor) falls, employment and output in both sectors expand, and output and employment ratios, q_{st}/q_{mt} and L_{st}/L_{mt}, both increase.*

Proof: Since $\bar{L}'(w_t) < 0$, w_t falls. Suppose L_{st} falls too. In view of (3.5), L_{mt} decreases. But both L_{st} and L_{mt} falling as $\bar{L}_t$ increases is incompatible with the full employment equation. Hence L_{st} increases, and thus q_{st} rises too. Eqs. (3.4) and (3.6) imply (3.2), in the light of which a decrease in w_t and an increase in q_{st} imply that L_{mt} increases. As both L_{mt} and q_{st} increase, q_{mt} also increases.

In view of eq. (3.5), the ratio L_{st}/L_{mt} rises. Using $q_{st} = L_{st}$ and dividing (3.5) by (3.4),

$$\frac{q_{st}}{q_{mt}} = \frac{\beta(w+\gamma)}{w_t[w_t + (1-\alpha)\gamma]}.$$

The r.h.s. is a decreasing function of w_t. As w_t falls, the ratio q_{st}/q_{mt} must increase. ■

3.2.2 Households

The economy consists of infinitely lived representative households, who can be treated as one unit. At a given point of time, the representative household possesses L_t units of effective labor and one unit of time. It could spend its time in either augmenting its human capital or working in production sectors. Let $H_t \in (0,1)$ denote time in human capital investment and let

$$L_{t+1} = a_L H_t L_t, \quad a_L > 1. \tag{3.11}$$

Thus the growth rate of human capital is proportional to the time invested in human capital. Since there are no education sectors, eq. (3.11) can be seen as a self-learning function. The trade-off is that the higher the investment in human capital, the greater will be the effective labor and hence the higher will be the total wage earnings in the future, but the less will be the total wage earnings in the current period.

There are two sources of income: wage income in both sectors and profit income in manufacturing (π_m). In making consumption choices, these incomes are treated as exogenous by a household.

Denoting the discount factor by ρ, the amount consumed of manufacturing by c_{mt} and assuming the felicity function $\ln c_{mt}$, we can write down the household's problem as:

$$\text{Maximize} \sum_{t=0}^{\infty} \rho^t \ln c_{mt}, \text{ subject to (3.11), and the budget } c_{mt} \leq w_t \bar{L}_t + \pi_{mt},$$

where $\bar{L}_t \equiv (1 - H_t)L_t$ is the total effective labor working in the production sectors. Given L_0, the household chooses $\{c_{mt}\}_0^\infty$, $\{H_t\}_0^\infty$ and $\{L_t\}_1^\infty$. The lagrangian is

$$\mathcal{L} = \sum_{t=0}^{\infty} \rho^t \ln c_{mt} + \sum_{t=0}^{\infty} \mu_{1t} [w_t(1 - H_t)L_t + \pi_{mt} - c_{mt}] + \sum_{t=0}^{\infty} \mu_{2t} [a_L H_t L_t - L_{t+1}].$$

The first order conditions are

$$\begin{aligned}
\{c_{mt}\}: &\quad \frac{\rho}{c_{mt}} = \mu_{1t}, \\
\{H_t\}: &\quad \mu_{1t} w_t = \mu_{2t} a_L, \\
\{L_{t+1}\}: &\quad \mu_{2t} = \mu_{1t+1} w_{t+1}(1 - H_{t+1}) + \mu_{2t+1} a_L H_{t+1}, \\
&\lim_{T\to\infty} \mu_{2T} L_{T+1} = 0
\end{aligned}$$

These conditions yield the Euler equation and the transversality conditions as follows:

$$\frac{c_{mt+1}/w_{t+1}}{c_{mt}/w_t} = \rho a_L \tag{3.12}$$

$$\lim_{t\to\infty} \frac{\rho^t w_t L_{t+1}}{a_L c_{mt}} = 0. \tag{3.13}$$

We assume $\rho a_L > 1$, such that the c_{mt}/w_t ratio grows at a positive rate. A marginal increase in investment entails a marginal loss in terms of current utility equal to w_t/c_{mt} and entitles a marginal gain in terms of future utility equal to $a_L w_{t+1}/c_{mt+1}$. At the optimum, the former is equal to the discounted value of the latter.[13]

[13] Substituting the human capital investment function into the household budget constraint, the household's problem can be equivalently cast as: Maximize $\sum_0^\infty \rho^t \ln[w_t(L_t - L_{t+1}/a_L) + \pi_{mt}]$, subject to $L_t \geq 0$ for $t \geq 1$. For given w_t and π_{mt}, the function $\ln[w_t(L_t - L_{t+1}/a_L) + \pi_{mt}]$ is concave in L_t and L_{t+1}. Hence the overall objective function is concave in $\{L_t\}_1^\infty$. The Euler equation is thus a sufficiency condition.

3.2.3 Dynamics

A perfect-foresight, dynamic, competitive equilibrium is a set of sequences of $\{w_t\}_0^\infty$, $\{p_{st}\}_0^\infty$, $\{\pi_{mt}\}_0^\infty$, $\{q_{mt}\}_0^\infty$, $\{q_{st}\}_0^\infty$, $\{L_{mt}\}_0^\infty$, $\{L_{st}\}_0^\infty$, $\{c_{mt}\}_0^\infty$, $\{H_t\}_0^\infty$ and $\{L_t\}_1^\infty$, such that
(i) $\{c_{mt}\}_0^\infty$, $\{H_t\}_0^\infty$ and $\{L_t\}_1^\infty$ solve the household problem, given $\{w_t\}_0^\infty$, $\{\pi_{mt}\}_0^\infty$ and the initial condition L_0,
(ii) $c_{mt} = q_{mt}$ (market clearing),
where, from the static equilibrium, w_t, p_{st}, π_{mt}, q_{st}, L_{mt} and L_{st} are implicit functions of $\bar{L}_t \equiv (1 - H_t)L_t$.

We have

Proposition 3.2 *Output and employment in both sectors grow, and, the growth rates of output and employment in the business services sector are higher than those in the manufacturing sector.*

Proof: Substituting $c_{mt} = q_{mt}$ into the Euler equation, we see that the q_{mt}/w_t ratio grows at the (gross) rate ρa_L. If we substitute (3.4)–(3.5) into the full-employment equation (3.7), we have

$$\frac{q_{mt}}{w_t} = \frac{\bar{L}_t[1 + \Phi(\bar{L}_t)]}{\alpha + \beta}, \text{ where } \Phi(L) \equiv \frac{\gamma\alpha(1 - \alpha - \beta)}{(\alpha + \beta)w(\bar{L}_t) + \beta\gamma} > 0. \tag{3.14}$$

We have $\Phi'(\cdot) > 0$, since $w'(\bar{L}_t) < 0$. Thus q_{mt}/w_t bears an increasing, one-to-one, relation with $\bar{L}_t$. Hence $\bar{L}_t$ grows over time. In view of Proposition 3.1, output and employment in both sectors grow; the proportions q_{st}/q_{mt} and L_{st}/L_{mt} rise, implying that growth rates of output and employment in the business-services sector exceed those in manufacturing.[14] ■

Importantly, note that if the friction parameter γ were zero, the output of the business service sector would still grow faster than that of manufacturing, but the employment growth in the two sectors will be the same. Hence, unbalanced growth of sectoral outputs follows from difference in returns to scale and that of employment stems from differences in worker frictions across the two sectors. Proposition 3.2 is consistent with our stylized fact insofar as it compares the business-services sector to manufacturing.

Ours is a one-factor model without physical capital, so compliance with many Kaldor facts is outside its purview. However,

[14] Output growth ranking also holds when manufacturing output is measured in terms of value-added.

Proposition 3.3 *As $t \to \infty$, per capita real income tends to grow at a constant rate.*

Proof: Eq. (3.14) and that q_{mt}/w_t grows at a constant rate for all t imply that $\lim_{t\to\infty} \bar{L}_t = \infty$. Hence, from (3.10), $\lim_{t\to\infty} w_t = 0$. In view of (3.14), $\lim_{t\to\infty} q_{mt}/w_t \propto \bar{L}_t$; thus the growth rate of $\bar{L}_t$ approaches ρa_L. Consider (3.8). We have $L_{st} \simeq \bar{L}_t$, since $w_t \to 0$. Hence L_{st}, and thus q_{st} approach the growth rate, ρa_L. From (3.2), it follows that the growth rate of L_{mt} tends to $(\rho a_L)^{\beta/(1-\alpha)}$. In view of (3.4), $\lim_{t\to\infty} q_{mt} \propto L_{mt}$. Hence, the growth rate of q_{mt} approaches $(\rho a_L)^{\beta/(1-\alpha)}$.

Since population is fixed, per capita income, proportional to aggregate income, q_{mt}, tends to grow at $(\rho a_L)^{\beta/(1-\alpha)}$. ■

Dynamics of Learning and the Transversality Condition

The solution of the dynamic model is not complete without characterizing the dynamics of investment in human capital, H_t. It will be shown in Appendix 3.A that $H_t < \rho$ for all t and approaches ρ. Moreover, along the solution path, the transversality condition (3.13) is met.

3.3 Services for Households

The basic model is now extended to include household or consumer services. It is the main section of this chapter. Unlike Buera and Kaboski (2012), all such services are provided by the market. The services sector has two competitive sub-sectors: business services and consumer services. The resulting model implies the stylized fact that in terms of both output and employment, the growth rates of the business services sub-sector exceed those of the consumer services sub-sector, which, in turn, are higher than those of the manufacturing sector.

We assume here that business and household services are distinct: one set of services are demanded mostly by businesses (manufacturing) and the other by households. It will be shown in Section 3.4 that similar conclusions hold for services shared by businesses and households.

The behavior of the business-service providers is the same as before. Let the household-service providers face similar constant-returns technology. For algebraic simplicity, we use the same production function: $q^h_{st} = L^h_{st}$. (A single firm may provide both.)

Households derive utility from consuming the manufacturing good as well as consumer services. Let the felicity function be $U_t = \lambda \ln c_{mt} + (1-\lambda)\ln c^h_{st}, \lambda \in (0,1)$, where c^h_{st} is the quantity of consumer services demanded. The assumed utility function implies that the income elasticity of demand for either good is unity; this will be relaxed in Section 3.4.

The household's problem is to maximize $\sum_{t=0}^{\infty} \rho^t U_t$, subject to the learning function (3.11) and the budget $c_{mt} + p^h_{st} c_{st} \leq w_t \bar{L}_t + \pi_{mt}$, where p^h_{st} is the price of consumer services. The dichotomy between the static and the dynamic components of the household's optimization problem is obvious. The former yields

$$\frac{\lambda}{1-\lambda}\frac{c^h_{st}}{c_{mt}} = \frac{1}{p^h_{st}}. \tag{3.15}$$

In the supply side, zero-profit conditions of service firms are:

$$p_{st} = p^h_{st} = w_t. \tag{3.16}$$

The situation of the manufacturing sector is same as in the basic model. Eqs. (3.4)–(3.6) continue to hold. In equilibrium, $c_{mt} = q_{mt}$ and $c^h_{st} = q^h_{st} = L^h_{st}$. Substituting these and the zero-profit conditions (3.16) into the first-order condition (3.15) gives the analog of (3.5) for the household:

$$\frac{\lambda}{1-\lambda} \cdot \frac{L^h_{st}}{q_{mt}} = \frac{1}{w_t}. \tag{3.17}$$

Finally, we have the full-employment condition:

$$L_{mt} + L_{st} + L^h_{st} = \bar{L}_t. \tag{3.18}$$

Eqs. (3.4)–(3.6) together with (3.17)–(3.18) constitute the static production system of the economy. They determine five variables: the wage rate in the economy, employment and output in manufacturing and those in the two service sub-sectors. Various substitutions lead to an analog of (3.10):

$$\bar{L}_t = \left\{\alpha + \beta + \frac{\beta\gamma}{w_t} + \frac{1-\lambda}{\lambda}\left[1 + \frac{(1-\alpha)\gamma}{w_t}\right]\right\}\left[\frac{\alpha^\alpha \beta^\beta}{w_t^\beta (w_t+\gamma)^{1-\beta}}\right]^{\frac{1}{1-\alpha-\beta}} \equiv \tilde{L}(w_t). \tag{3.19}$$

A solution to this equation exists and it is unique and it implies the same for other variables. Lemma 3.1 thus holds. We have $\tilde{L}'(w_t) < 0$ and as $\bar{L}_t \to 0$ or ∞, w_t approaches

∞ or 0. As an extension of Proposition 3.1,

Proposition 3.4 *An increase in $\bar{L}_t$ leads to a decrease in the wage rate (per unit of effective labor); expansions in output and employment in manufacturing and the two service sub-sectors, and increases in*

$$\frac{L_{st}^h}{L_{mt}}; \quad \frac{q_{st}^h}{q_{mt}}; \quad \frac{L_{st}}{L_{st}^h}; \quad \frac{q_{st}}{q_{st}^h}.$$

Proof: In view of (3.19), w_t falls. It is straightforward to derive that L_{mt}, L_{st} and L_{st}^h all increase. Hence, employment and output expand in each sector or sub-sector. Multiplying (3.4) by (3.17) yields

$$\frac{L_{st}^h}{L_{mt}} = \frac{1-\lambda}{\alpha\lambda} \cdot \frac{w_t + (1-\alpha)\gamma}{w_t}, \tag{3.20}$$

the r.h.s. of which is a decreasing functions of w_t. Hence, the L_{st}^h/L_{mt} ratio rises as w_t falls. In view of (3.17), q_{st}^h/q_{mt} rises, since $q_{st}^h = L_{st}^h$. Next, divide (3.5) by (3.20). It gives

$$\frac{L_{st}}{L_{st}^h} = \frac{\beta\lambda}{1-\lambda} \cdot \frac{w_t + \gamma}{w_t + (1-\alpha)\gamma}. \tag{3.21}$$

The r.h.s. increases as w_t falls; hence this ratio rises. Given $q_{st} = L_{st}$ and $q_{st}^h = L_{st}^h$, the q_{st}/q_{st}^h ratio also increases. ■

The dynamic part of the household optimization remains essentially same. The ratio of total household expenditure to the wage rate grows at the rate ρa_L. Since the expenditure on manufacturing constitutes a constant fraction (λ) of total household expenditure, the Euler equation (5.7) continues to hold.[15] The ratio q_{mt}/w_t grows at the constant rate ρa_L. Similar to the basic model, the static system implies

$$\frac{q_{mt}}{w_t} = \frac{\lambda\bar{L}_t[1+\bar{\Phi}(\bar{L}_t)]}{1-\lambda(1-\alpha-\beta)}, \text{ where} \tag{3.22}$$
$$\bar{\Phi}(\bar{L}_t) \equiv \frac{\lambda\alpha\gamma}{[1-\lambda(1-\alpha-\beta)]w(\bar{L}_t) + [(1-\lambda)(1-\alpha)+\lambda\beta]\gamma}$$

and it has the same limit properties. As $\bar{\Phi}(\cdot)$ is increasing in $\bar{L}_t$, $\bar{L}_t$ grows over time without

[15]The indirect felicity function is $\lambda \ln\lambda + (1-\lambda)\ln(1-\lambda) - (1-\lambda)\ln p_{st}^h + \ln E_t$, where E_t is the household expenditure. Using the budget constraint, it is equal to: $\lambda\ln\lambda + (1-\lambda)\ln(1-\lambda) - (1-\lambda)\ln p_{st}^h + \ln\left[w_t\left(L_t - \frac{L_{t+1}}{a_L}\right) + \pi_{mt}\right]$, which is concave in L_t and L_{t+1}. Hence, the sufficiency condition is met. The same transversality condition holds.

bound.[16]

Our central position below – which ranks growth rates within the services sector vis-a-vis manufacturing – follows immediately in the light of Proposition 3.4.

Proposition 3.5 *The output and employment in the business services sub-sector grow faster than output and employment (respectively) in the consumer services sub-sector, which, in turn, grow faster than output and employment (respectively) in manufacturing.*

The upshot is that the employment and output growth rankings among the two service sub-sectors and manufacturing accord with the stylized fact we wish to explain. To understand this intuitively, it will be useful to first think what the ranking would have been if worker frictions in manufacturing were absent. It is clear that employment would grow at the same rate in all the three 'sectors.' Because the technology is similar between the two service sub-sectors, their outputs would have grown at the same rate. This common rate would have exceeded the growth rate of manufacturing, because returns to scale are lower in manufacturing.

Now bring into consideration the presence of worker frictions in manufacturing. They would imply a relatively higher demand for business services and less for labor as manufacturing output expands. Hence, compared to the case of no worker frictions in manufacturing, the growth rate of employment in the business-service sub-sector would exceed that in manufacturing, while the growth rate of employment in the consumer-services sub-sector would lie in-between. The same ranking extends to output growth rates.

Furthermore, as in the basic model, the growth rate of per capita real income is bounded away from zero and approaches a constant rate, i.e., Proposition 3.3 holds. This is proved in Appendix 3.B.

3.4 Generalizations and Alternative Environments

Main results obtained in the preceding sections are robust to some generalizations and alternative market environments.

[16] In the light of (3.22), $g_{\bar{L}_t} = \rho a_L \dfrac{1+\bar{\Phi}(\bar{L}_t)}{1+\bar{\Phi}(\bar{L}_{t+1})} < \rho a_L$. Hence the dynamics of H_t is qualitatively same as in the base model. The transversality condition holds along the saddle path.

3.4.1 Service-Oriented Relative Demand Shift

The relative rise of the service sector in the post-WWII era has been largely attributed to the hypothesis that as real income rises the consumer demand for services rises more than proportionately, i.e., the income elasticity of demand for household services exceeds one.

It is shown below that such a preference structure, which leads to a relative demand shift towards consumer services, tend to imply higher growth rates of output and employment in the household services sub-sector. Hence the growth ranking between the two service sub-sectors becomes ambiguous, while that between the services sector as a whole and manufacturing remains in tact.

Let a household's felicity function be $U_t = \lambda \ln c_{mt} + (1-\lambda)\ln(c^h_{st}+\delta), \lambda \in (0,1),\ \delta > 0$. The presence of the parameter δ, an index of 'non-essentiality' of services in consumption, implies income elasticity of demand for consumer services to be greater than unity. Static optimization has the first-order condition

$$\frac{\lambda}{1-\lambda}\frac{c^h_{st}+\delta}{c_{mt}} = \frac{1}{p^h_{st}}. \tag{3.23}$$

All other equations remain the same as in Section 3.3 except (3.17), which is replaced by

$$\frac{\lambda}{1-\lambda}\cdot\frac{L^h_{st}+\delta}{q_{mt}} = \frac{1}{w_t}. \tag{3.24}$$

This follows from (3.23) by substituting $c^h_{st} = q^h_{st} = L^h_{st}$ and $p^h_{st} = w_t$.

Appendix 3.C works out the solution of the static system. Qualitatively, the effects of an increase in $\bar{L}_t$ on the wage rate and sectoral employment and outputs are same as earlier.

The nature of dynamic trade-off for the household is also the same. By substituting (3.24) into the budget constraint and eliminating c^h_{st}, it can be derived that the c_{mt}/w_t ratio grows at the rate ρa_L. Hence q_{mt}/w_t – and thus $\bar{L}_t$ – grow over time.

Output and employment growth rate rankings are given by

Proposition 3.6 *In the presence of income-induced relative demand shift towards consumer services, output as well as employment growth rates in business and consumer services sub-sectors cannot be ranked, but both growth rates exceed those in manufacturing.*

Proof: From (3.4) and (3.5) and that w_t decreases over time, it follows that the business services output (respectively employment) grows more rapidly than manufacturing output (respectively employment). Likewise, in view of (3.4), (3.24) and w_t falling over time, the consumer-services output (respectively employment) also rises faster than manufacturing output (respectively employment).

Eliminating q_{mt} and L_{mt} from (3.4), (3.5) and (3.24) yields

$$\frac{\beta\lambda}{1-\lambda} \cdot \frac{L_{st}^h + \delta}{L_{st}} = \frac{w_t + (1-\alpha)\gamma}{w_t + \gamma}.$$

Since w_t decreases over time, the r.h.s. falls and thus $(L_{st}^h + \delta)/L_{st}$ declines with time. But δ being positive, the ratio L_{st}^h/L_{st}, equal to q_{st}^h/q_{st}, may increase or decrease over time. ■

The relation between the manufacturing sector and the business service firms is the same as in the previous model; hence the growth-rate rankings between them is the same. The demand shift towards consumer services constitutes an added factor for its growth. Hence its growth rate remains higher than that in manufacturing.

However, growth rates between the two sub-sectors within the services sector cannot be unambiguously ranked, because, on one hand, business services tend to grow faster than consumption services due to labor frictions in manufacturing, while, on the other hand, because of the relative demand shift towards consumption services, consumption-service production would tend to grow faster than business services. It depends on the magnitudes of labor friction in manufacturing (γ) and the degree of non-essentiality of consumption services (δ), relative to each other.

In what follows, we revert back to the assumption of homothetic preferences, as in the base model.

3.4.2 Services Shared by Businesses and Households

We have considered business and consumer services as distinct products. There are however many types of services demanded by both businesses and households. Examples include retail trade, transport and communication and financial intermediation. Consider the scenario where the same service is sold to firms in the manufacturing sector as well as to households. It will be shown that the same rankings between growth rates of manufacturing and volumes of (same) services sold to the 'two sectors' hold, as was true for pure business and consumer services.

Let the common price for the service good be denoted as p_{st}^c and the production function be

$$q_{st} + q_{st}^h = L_{st}^c. \tag{3.25}$$

As earlier, competitive pressures imply $p_{st}^c = w_t$.

Relations pertaining to the manufacturing sector and households are unchanged. The model structure follows that in Section 3.3, except that there is no notion of L_{st} or L_{st}^h; they are substituted respectively by q_{st} and q_{st}^h. Similar to Section 3.3, an increase in $\bar{L}_t$ implies a decline in w_t and increases in q_{st}, q_{st}^h, L_{mt} and q_{mt}; increases in q_{st} and q_{st}^h imply that L_{st}^c increases, i.e., employment expands in the services sector too.

The Euler equation remains same; thus q_{mt}/w_t grows at the gross rate of ρa_L. This implies that $\bar{L}_t$ grows over time. Thus w_t falls, and output and employment in both sectors expand. Furthermore, the ratios L_{st}^c/L_{mt}, q_{st}^h/q_{mt} and q_{st}/q_{st}^h rise over time. Hence,

Proposition 3.7 *Employment growth is higher in the services sector. In terms of output/sales, the business-oriented component of the services grows faster than the component serving the households services and the latter grows faster than the manufacturing sector.*[17]

3.4.3 Differentiated Services

Services have been thought of and modeled by many authors as differentiated brands produced in a monopolistically competitive market, e.g., Eswaran and Kotwal (2002) and Matsuyama (2013) among many others. Let q_{st} and c_{st}^h denote respectively composites of business and household services, defined respectively by:

$$q_{st} = \left(\int_0^{N_t} q_{it}^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1$$

$$c_{st}^h = \left(\int_0^{N_t^h} c_{it}^{h\,\frac{\sigma^h-1}{\sigma^h}} di \right)^{\frac{\sigma^h}{\sigma^h-1}}, \quad \sigma^h > 1,$$

where N_t and N_t^h are the number of respective varieties available at time t, and, σ and σ^h are respectively the elasticity of substitution between any two brands of business and consumer services.

Let both types of services be produced by linear, increasing-returns technologies: $q_{it} =$

[17] It amounts to hypothesizing that if more disaggregated data on hybrid services were available, it would exhibit higher growth rate of the business-services segment, vis-a-vis consumption services.

$L_{it} - 1$ for business services and $q_{it}^h = L_{it}^h - 1$ for household services. As long as manufactures are produced by the same decreasing-returns to scale technology (3.1), the same qualitative differences between the sectors continue to hold.

It can be shown that all results hold under one further assumption, namely,

$$\alpha + \frac{\beta\sigma}{\sigma - 1} < 1. \tag{3.26}$$

Increasing returns to scale along with constant marginal product of labor in the production of services present an element of instability in the labor market. The inequality (3.26) is indeed a stability condition for the labor market.[18]

3.4.4 Manufacturing as an Input in the Production of Services

Production of services typically uses products, tools and equipment from manufacturing, both as durables and intermediates. For instance, transportation services use capital goods like vehicles. Financial services extensively require computers and modern tools of information technology. Almost all services use a variety of "consumables" produced in the manufacturing sector. However, physical capital accumulation is beyond the scope our analysis. It is shown that the growth ranking between the two sectors remains the same even if services production required manufactures as intermediates.

For simplicity of illustration, we consider business services only. Let the production function of the business-services sector be:

$$q_{st} = L_{st}^{\eta} {q'}_{mt}^{1-\eta}, \quad 0 < \eta < 1, \tag{3.27}$$

where q'_{mt} is the manufacturing input. The first-order conditions can be stated as

$$\eta p_{st} q_{st} = w_t L_{st}, \tag{3.28}$$

$$\frac{L_{st}}{q'_{mt}} = \frac{\eta}{1-\eta} \frac{1}{w_t}. \tag{3.29}$$

The price of services is no longer proportional to the wage rate. From (3.27)-(3.29), it can be derived that $p_{st} \propto w_t^{\eta}$. The manufacturing firm's problem is same as in the base

[18] The inequality (3.26) is not restrictive as long as the elasticity of substitution among business services is sufficiently large – which is eminently plausible.

model. Eq. (3.28) and the cost-minimization condition in manufacturing imply

$$\frac{\alpha}{\beta\eta}\frac{L_{st}}{L_{mt}} = \frac{w_t + \gamma}{w_t}. \tag{3.30}$$

The static general equilibrium is spelt by (3.1)-(3.2), the full employment condition (3.7) and (3.27)– (3.30). The same comparative statics hold: an increase in $\bar{L}_t$ leads to a decrease in w_t and increases in sectoral output and employment levels. In view of (3.30), as the wage rate falls, the ratio of employment in business services to that in manufacturing increases. Using $p_{st} \propto w_t^\eta$ and eqs. (3.1)-(3.2), eqs. (3.28) and (3.30) yield

$$\frac{q_{st}}{q_{mt}} \propto \frac{1}{w_t^\eta}\left[1 + \frac{\alpha\gamma}{w_t + (1-\alpha)\gamma}\right].$$

Hence, the services output to manufacturing output ratio rises.

The household's problem is the same as in the base model. The Euler equation states that c_{mt}/w_t ratio grows at the constant rate ρa_L. Substituting (3.1)-(3.2), (3.7) and (3.29)–(3.30) into the manufacturing market clearing condition $c_{mt} = q_{mt} - q'_{mt}$,

$$\frac{c_{mt}}{w_t} = \frac{(1-\beta+\beta\eta)\bar{L}_t}{\alpha+\beta\eta}\left[1 + \frac{\alpha\gamma(1-\alpha-\beta)}{(1-\beta+\beta\eta)[\beta\eta\gamma + (\alpha+\beta\eta)w(\bar{L}_t)]}\right], \tag{3.31}$$

Given that $w'(\bar{L}_t) < 0$ and c_{mt}/w_t grows without bound, $\lim_{t\to\infty} \bar{L}_t = \infty$ and $\lim_{t\to\infty} w_t = 0$. The growth rate of $\bar{L}_t$ asymptotes to ρa_L.

The next proposition states the sectoral output and employment rankings as well as how growth rates and the differences in growth rates are sensitive to the share of manufacturing in services.

Proposition 3.8 *(a) Output and employment growth rates in the business services sector are higher than those in manufacturing. (b) In the long run, the higher the share of manufacturing in the business-services sector, the slower are the output growth rates of both sectors, the larger the gap in the employment growth rates and the smaller is the gap in the output growth rates.*

Proof: Part (a) is obvious. Following the same logic and algebraic manipulations as in the base model, the asymptotic growth rates of sectoral employment and output can be calculated as:

$$\text{(i) } \frac{L_{st+1}}{L_{st}} \rightarrow \rho a_L; \text{ (ii) } \frac{L_{mt+1}}{L_{mt}} \rightarrow (\rho a_L)^{\frac{\eta\beta}{\eta\beta+1-\alpha-\beta}};$$
$$\text{(iii) } \frac{q_{st+1}}{q_{st}} \rightarrow (\rho a_L)^{\frac{\eta(1-\alpha)}{\eta\beta+1-\alpha-\beta}}; \text{ (iv) } \frac{q_{mt+1}}{q_{mt}} \rightarrow (\rho a_L)^{\frac{\eta\beta}{\eta\beta+1-\alpha-\beta}}.$$

The expression (i) is independent of η, whereas (ii)-(iv) are increasing functions of η. A decrease in η reflects a higher share of manufacturing input in services production. It follows that $L_{st+1}/L_{st} - L_{mt+1}/L_{mt}$ increases and $q_{st+1}/q_{st} - q_{mt+1}/q_{mt}$ decreases as η falls – which proves Part (b). ■

It is interesting that as the share of manufacturing in services production increases, the growth gap between the two sectors in terms of employment increases, but that in terms of output falls.

Intuitively, the growth of the total supply of effective labor depends on the rate of time discount (ρ) and the productivity in the enhancement of human capital (a_L), not on η. Since employment growth in the services sector is higher, in the long run it tows that of aggregate supply of effective labor, hence independent of η. At the same time, the dependence of technology of producing business-services on manufacturing goods as inputs has a 'locomotive' effect: a slower growing sector's output being used as input in the faster growing sector, the growth rate of the latter is pulled down, which, in turn, drags down the growth rate in the former sector. Hence, the employment growth rate of manufacturing as well as output growth rates in both sectors decline as η falls. It then follows that, as η declines, the difference between the output growth rates falls, while the difference between the employment growth rates rises (because the growth rate of employment in the services sector is independent of η).[19]

3.5 Concluding Remarks

In the post WWII world economy the services sector has grown consistently faster than manufacturing. In many countries the share of this sector in GDP now stands well above 50%. This phenomenon has been mainly attributed to a relative demand shift towards

[19]It is worth noting that the preceding analysis does not consider the dynamic effects of the use of manufactures in services production such as an embodied technological progress; otherwise, it would have tended to enhance the growth rate of the services sector.

consumer services as real income rises. While this may very well be true, we have taken the position that it is not designed to explain the growth of *business* services in particular. We have posited a stylized fact that business services have grown faster than consumer services, which, in turn, have outpaced manufacturing.

Our analysis began with business services, and consumption services were introduced later. We believe it has enabled us to uncover some supply-side factors behind the rise of the services sector relative to manufacturing. One is higher returns to scale in the services sector compared to manufacturing, although in our model we have assumed a specific structure. Prevalence of worker frictions in manufacturing (relative to services) is another. In tandem, these two factors explain the stylized fact.

By abstracting from TFP growth, the general goal of our analysis is to understand *inter*-sectoral – rather than *intra*-sectoral or intra-sub-sectoral – differences in the growth rates of employment and output. However, major productivity improvements have been recorded not just for manufacturing but also in the services sector. Triplett and Bosworth (2003) noted that the TFP growth in the services sector is no less than that in manufacturing.[20] Heshmati (2003) presents a survey of productivity growth in many manufacturing and services industries. He notes that over time services productivity has grown over time, and, owing to services outsourcing, has contributed to higher productivity growth in manufacturing.

We have incorporated a very simple source of growth namely that of human capital. The static implications of an increase in overall resources available to an economy map directly to growth rates. In the next chapter, we incorporate TFP growth, capital accumulation as well as returns to scale differences. The resulting analysis generates output ranking of services, manufacturing *and* agriculture in decreasing order. The model also complies with Kaldor facts. In contrast to the existing literature, this explanation for non-balanced growth can be applied to both developing and developed countries.

[20]That is, the so-called Baumol's disease (see Baumol (1967)) has either been "cured" or not struck.

Appendix 3.A

It refers to Section 3.2.

Growth Rate of $\mathbf{\bar{L}_t}$

Lemma A1: $g_{\bar{L}_t} \equiv \dfrac{\bar{L}_{t+1}}{\bar{L}_t} < \rho a_L$.

Proof: Since q_{mt}/w_t grows at the rate of ρa_L, eq. (3.14) implies

$$g_{\bar{L}_t} = \rho a_L \cdot \frac{1 + \Phi(\bar{L}_t)}{1 + \Phi(\bar{L}_{t+1})}. \tag{3.A.1}$$

Further, $\bar{L}_{t+1} > \bar{L}_t$ (as $\bar{L}_t$ increases over time) and $\Phi'(\cdot) > 0$ imply $\Phi(\bar{L}_t) < \Phi(\bar{L}_{t+1})$. Hence, $g_{\bar{L}_t} < \rho a_L$. ■

Lemma A2: $g_{\bar{L}_t} \to \rho a_L$ as $\bar{L}_t \to 0$ or ∞.

Proof: As $\bar{L}_t \to 0$ or ∞, $w_t \to \infty$ or 0 and hence the term in the square brackets of (3.14) approaches 1 or $1 + (\alpha/\beta)(1 - \alpha - \beta)$. In either case, $q_{mt}/w_t \propto \bar{L}_t$. Hence $g_{\bar{L}_t} \to \rho a_L$.[21] ■

Dynamics of $\mathbf{H_t}$

By using $\bar{L}_t \equiv (1 - H_t)L_t$ and the learning function (3.11),

$$\Delta H_t \equiv H_{t+1} - H_t = (1 - H_t)\left(1 - \frac{g_{\bar{L}_t}}{a_L H_t}\right). \tag{3.A.2}$$

Hence $\Delta H_t = 0$ spells the relation

$$H_t = \frac{g_{\bar{L}_t}}{a_L} \equiv \Psi(\bar{L}_t), \tag{3.A.3}$$

where $\Psi(\cdot)$ is an implicit function based on (3.A.1).

In view of Lemmas A1 and A2 and the continuity and differentiability of the function $\Psi(\cdot)$, $\Psi(\cdot) < \rho$ for any $\bar{L}_t > 0$ and $\Psi' \lesseqgtr 0$ as $\bar{L}_t \to 0$ or ∞. However, the curvature of $\Psi(\cdot)$ is ambiguous in general. Figure 3.1 depicts a particular shape of the function $\Psi(\cdot)$, same as $\Delta H_t = 0$, consistent with the aforementioned properties. As we shall see, the existence of saddle path is independent of the curvature of the $\Psi(\cdot)$ function, as long as $\Psi(\cdot) < \rho$ and $\Psi' \lesseqgtr 0$ according as $\bar{L}_t \to 0$ or ∞.

[21] In terms of (3.A.1), both $\Phi(\bar{L}_t)$ and $\Phi(\bar{L}_{t+1})$ approach 0 or $(\alpha/\beta)(1 - \alpha - \beta)$ as $\bar{L}_t \to 0$ or ∞.

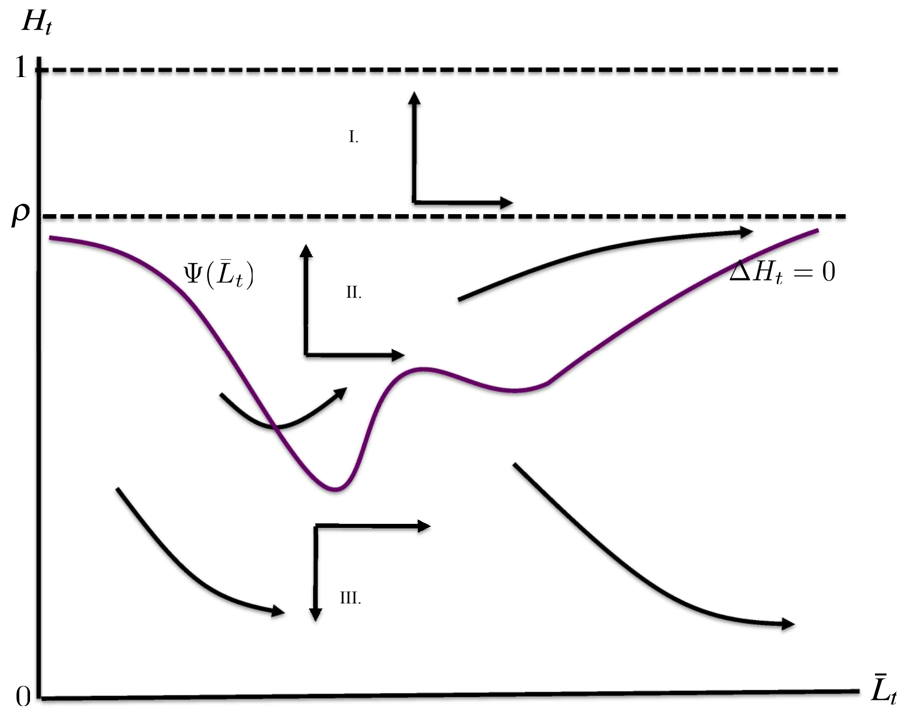


Figure 3.1: Dynamics of H_t

Consider Figure 3.1, which depicts the $\Delta H_t = 0$ curve, and, the dynamics of H_t and $\bar{L}_t$.[22] We have $\Delta H_t \gtrless 0$ according as $(\bar{L}_t,\, H_t)$ lies above or below this curve. This implies the directions of vertical arrows. Because $\bar{L}_t$ increases over time monotonically, the horizontal arrows always point to the right.

There is no steady state in that there is no stationary solution of H_t in (3.A.3); for any initial value of L_t, H_t varies over time. Any trajectory with an initial value of $H_t \geq \rho$ approaches $H_t = 1$. This would imply $\bar{L}_t \to 0$, which is implausible and inconsistent with $\bar{L}_t$ growing over time. In the domain of $H_t < \rho$, as shown, one set of trajectories approach $H_t = 0$. This would imply the stock of effective labor approaching zero, which is also implausible as well as inconsistent with that $\bar{L}_t$ grows over time. However, there is one, a saddle path, along which H_t asymptotes towards ρ. It will be shown below that this trajectory meets the transversality condition. Hence, it is the solution path, and along this path, $H_t < \rho \; \forall t$ and $\lim\limits_{t\to\infty} H_t = \rho$.

[22] The $\Psi(\cdot)$ curve may have more complex curvature, but, the important feature is that it lies below $H_t = \rho$ line.

Transversality Condition

By using (3.9), (3.11), the market clearing condition $c_{mt} = q_{mt}$ and $\bar{L}_t = (1 - H_t)L_t$,

$$\begin{aligned}\frac{w_t L_{t+1}}{a_L c_{mt}} &= \frac{w_t H_t L_t}{q_{mt}} \\ &= \frac{H_t}{1 - H_t} \cdot \frac{w_t \bar{L}_t}{q_{mt}} \\ &= \frac{H_t}{1 - H_t} \cdot \frac{\alpha w_t + \beta(w_t + \gamma)}{w_t + (1 - \alpha)\gamma}.\end{aligned}$$

Along the saddle path, $\lim_{t\to\infty} H_t/(1-H_t) = \rho/(1-\rho)$. As shown earlier, $\lim_{t\to\infty} w_t = 0$. Therefore,

$$\lim_{t\to\infty} \frac{\rho^t w_t L_{t+1}}{a_L c_{mt}} = \frac{\rho\beta}{(1-\rho)(1-\alpha)} \cdot \lim_{t\to\infty} \rho^t = 0,$$

i.e. the transversality condition is met along the saddle path.

Appendix 3.B

It refers to Section 3.3. It will be shown that growth of per capita real income asymptotes a constant rate. Normalizing population size to unity, real per capita income has the expression $I_t^R = (q_{mt} + p_{st}^h q_{st}^h)/(p_{st}^h)^{1-\lambda} \propto q_{mt}^{\lambda} {L_{st}^h}^{1-\lambda}$ in view of (3.15)–(3.17).

The following holds as $t \to \infty$. We have $w_t \to 0$. This implies that the growth rate of $\bar{L}_t$ approaches ρa_L, and $L_{st} \propto \bar{L}_t$, $L_{st}^h \propto L_{st}$ and $q_{mt} \propto L_{mt}$. Thus,

$$\begin{aligned} &\frac{L_{st+1}^h}{L_{st}^h} \to \rho a_L; \quad \frac{q_{mt+1}}{q_{mt}} \to (\rho a_L)^{\frac{\beta}{1-\alpha}} \\ \Rightarrow \frac{I_{t+1}^R}{I_t^R} &= \left(\frac{q_{mt+1}}{q_{mt}}\right)^{\lambda} \cdot \left(\frac{L_{st+1}}{L_{st}}\right)^{1-\lambda} \\ &\to (\rho a_L)^{\frac{\lambda\beta}{1-\alpha}} (\rho a_L)^{1-\lambda} \\ &= (\rho a_L)^{\frac{\beta\lambda}{1-\alpha} + 1 - \lambda}. \end{aligned}$$

■

Appendix 3.C

It refers to Section 3.4.1, which introduces relative demand shift towards consumer services. The static system is characterized by (3.4)–(3.6), the full-employment condition (3.18), and (3.24). Eliminating the variables q_{mt}, L_{mt}, L_{st} and L^h_{st}, the following equation summarizes the static equilibrium in terms of solving w_t.

$$(\alpha^\alpha \beta^\beta)^{\frac{1}{1-\alpha-\beta}} \left[\frac{1-\lambda}{\lambda} \Omega(w_t) + \Gamma(w_t) \right] - \delta = \bar{L}_t \tag{3.A.4}$$

where

$$\Omega(w_t) \equiv \frac{w_t + (1-\alpha)\gamma}{w^{\frac{1-\alpha}{1-\alpha-\beta}} (w_t + \gamma)^{\frac{1-\beta}{1-\alpha-\beta}}}; \quad \Gamma(w_t) \equiv \frac{(\alpha+\beta) w_t + \beta\gamma}{w^{\frac{1-\alpha}{1-\alpha-\beta}} (w_t + \gamma)^{\frac{1-\beta}{1-\alpha-\beta}}}.$$

Both $\Omega'(w_t)$ and $\Gamma'(w_t)$ being negative, an increase in $\bar{L}_t$ implies a fall in w_t. It is straightforward to derive that L_{mt}, L_{st}, L^h_{st} and q_{mt} all increase with $\bar{L}_t$.

4 Three-Sector Non-Balanced Growth: The Role of Land

4.1 Introduction

In recent decades and in almost all countries, of the three production sectors, namely services, manufacturing and agriculture, the services sector has posted highest growth, followed by manufacturing, while agriculture is the least growing sector – in terms of both output and employment. Such differentials have mostly been explained by demand-side reasons, e.g. Echevarria (1997), Kongsamut et al. (2001), Eichengreen and Gupta (2012), among others. Ngai and Pissarides (2007) present a supply-side driven theory of non-balanced growth which explains this phenomenon on the basis of differences in sectoral TFP growth rates. But their explanation for sectoral output growth ranking is valid only for developed countries, where the sectoral TFP growth rankings are highest in agriculture, followed by manufacturing and services.

In this chapter, we build a supply-side model of non-balanced growth which demonstrates the witnessed growth phenomenon and is applicable to both developed and developing countries. Our explanation is based on sectoral land intensity differences. In this vein, recently Acemoglu and Guerrieri (2008)) have analyzed how differences in intensity of capital use across sectors explains differences in sectoral growth. In a two-sector model of capital accumulation with two factors of production, labor and capital, they show that the capital accumulation will be accompanied by capital deepening so that the relatively capital intensive sector would grow faster. While they fall short of asserting that their model is meant to explain the higher growth rate of the service sector relative to manufacturing, they present data on capital intensities across sectors in the U.S., which indicate that the services

Table 4.1: Sectoral Non-Labor Shares of Selected Countries (2005-10)

Country	Services	Manufacturing	Agriculture
France	0.42	0.34	0.76
Spain	0.48	0.40	0.79
Japan	0.47	0.50	0.85
Germany	0.49	0.31	0.55
Australia	0.44	0.42	0.77
UK	0.38	0.29	0.53
USA	0.43	0.42	0.71
EU	0.41	0.33	0.65
China	0.63	0.69	0.09
Brazil	0.52	0.51	0.57

Source: OECD Database

sector as a whole is the mildly more capital intensive than manufacturing.[1] Hence, one can interpret their model as one which provides a capital deepening argument as to why the service sector would grow faster than manufacturing.

How far does the capital deepening argument apply to the differences in growth rates between manufacturing and agriculture? If the agriculture sector in an economy is relatively primitive or less advanced (as would be in relatively poor countries), then it surely applies. But countries which are relatively rich and land-scarce are likely to employ more capital-intensive techniques in agriculture.

Table 4.1 presents data on non-labor shares across services, manufacturing and agriculture for OCED and some other countries. Insofar as non-labor inputs is representative of capital, Table 4.1 shows that for many countries, services are mildly more capital intensive than manufacturing, while agriculture is more capital intensive than manufacturing. Therefore, while the capital deepening argument serves to explain (in part) why the service sector would grow faster than manufacturing, its applicability toward explaining differential growth between manufacturing and agriculture is relatively weak.

The central objective of this essay is to examine the role of land, as a non-reproducible input, and differences in the land use intensity in production in explaining the stylized differences in growth across services, manufacturing and agriculture. True, land does not

[1] They tabulate the capital shares for selected industries within the services and manufacturing sectors. Over 1987-2005, the average capital share in manufacturing was about 0.37 and that in the selected services industries was about 0.373. According to EUKLEMS database, in the period 1970-2007, USA, UK have a slightly higher capital intensity in services as compared to manufacturing. This stems for higher use of IT capital in services sector. Also see Kutscher and Mark (1983).

figure prominently in the literature on growth.[2] But, as much incontrovertible is that, it is required for production, transportation, consumption, waste disposal, etc. In the last decade, the demand for land has grown phenomenally, which, in turn, has led to substantial increase in land prices. Even if we set aside land demand for housing, the production sectors have been investing in land, both in the developed and developing countries. According to Land Matrix (an online database on land deals), over 48 million hectares of land has been bought and sold since 2000. While the largest land deals took place in South East Asia (primarily India, China and Malaysia), the "land rush" in the last five years or so is seen in Africa (e.g. South Africa, Tanzania and Mali).

Land contributes to different sectors of production in different ways. In agriculture, it is almost synonymous with output – food. In manufacturing, it provides an area for production – base and space, and, in services, it is just a location. In most countries that have favorable climate and relief conditions, a large proportion of land is used in agriculture.[3] Setting up manufacturing plants requires large expanses of land. Most countries have allocated vast regions to develop manufacturing plants and townships for workers together with transportation and other infrastructures facilities. Of late, land issues have been springing up in developing countries, like India and China. In China, the demand for industrial land is about 67,000 acres per year, but the supply is less than 40% of that (Anderson (2011)). In India too, the demand for land has played a crucial role in the growth of industry. Difficulty in acquiring land is one of the primary reasons for low investment in power sector (Singh (2012)).[4] Service-sector firms or providers, typically small in size, often require a modest 'floor space' – in a multi-storey building, at a home or along the corridors of shops and other establishments.

It is almost natural to hypothesize that among the three broad sectors, agriculture is most

[2]There are a few studies only. Nichols (1970) is one of the early papers, where land is introduced as third input in production, besides labor and capital in a Solow economy. There is land and labor augmenting technical progress at an exogenous rate. Wealth has two components: capital and the value of land, a function of price of land. In steady state, land price and output grow at the same rate. Roe et al. (2009) have several chapters on multi-sector growth, with land as an input only in agriculture sector (not in manufacturing or services) and with the added role of land as an asset. Unlike Nichols (1970), Roe et al. (2009) use an infinite-horizon Ramsey framework, but in both papers in steady state the asset value of land grows at the same rate as the GDP of the economy.

[3]According to World Bank database, the share of arable land of total available land is 0.6 in India, 0.3 in Brazil, 0.4 in USA and 0.7 in UK.

[4]Decentralized manufacturing production is a relatively new trend. A firm manufactures its good in parts in plants across the globe. Various parts of a product are then assembled near the points of sale. Although this method has greatly reduced the manufacturing sector's dependence on vast plots of land, land continues to be an important factor for industrial growth.

land-intensive, manufacturing is the next and the services sector is the least land-intensive. The implication of this hypothesis on non-balanced growth is immediate: the supply of land being inelastic, *ceteris paribus*, the services sector would tend to grow faster than manufacturing and the latter would tend to grow faster than agriculture.

However, data on inter-sectoral land use intensity is rather meager. To our knowledge, CORINE data is the only database which classifies land use by industry type, and it covers European countries only. Using this database, Hubacek and Giljum (2003) calculate total sectoral land area (in hectares) per unit of sectoral output (in tons) and call this measure the land appropriation coefficient (LAC). This measure quantifies the intensity of land use in different sectors. They find that in 1999, the LAC for agriculture in EU-15 was 89.67, for manufacturing was 0.79 and for electricity, water, transport and services was 0.19 - which is supportive of our hypothesis on land intensity.

It is important to note that most measures of capital include land. If so, given our hypothesis on land intensity differences, the difference of non-labor share between services and manufacturing would underestimate that of capital share differences between the two sectors. In other words, the presumption of the hypothesis of services being more capital intensive than manufacturing, and by the same logic manufacturing being more capital intensive than agriculture, is higher than what is suggested in Table 4.1.[5]

More specifically, the model of the chapter provides a *non-balanced growth decomposition* into sectoral TFP growth rates and the parts attributable to intensity differences in terms of land use and capital use and how TFP shocks may affect non-balanced growth.

Section 4.2 presents an elementary model of growth without capital accumulation, which features land as an input in production. Agriculture and manufacturing use land and labor, while services are produced by labor alone. Growth in the economy is driven by TFP growth across sectors and growth of labor, both exogenous. By construction, non-balanced growth decomposition does not include differences in capital intensity. It serves as a prelude to our main model in Section 4.3, which incorporates capital accumulation. Growth decomposition includes capital intensity differences and we characterize that for the long run and during transition. Section 4.4 concludes.

[5]It must however be borne in mind that neither the land-intensity ranking nor the capital intensity ranking should be viewed as substitutes of each other, and neither is meant to claim itself as the most important explanation for non-balanced growth.

4.2 An Elementary Growth Model with Land as an Input

There are three sectors: agriculture (a), manufacturing (m) and services (s). Each is produced in a perfectly competitive market with constant-returns technology and consumed by households. There are two primary inputs - labor and land. Land supply is fixed. Sectors a and m use both inputs, while sector s uses labor only. Thus, sector s is (trivially) the least land-intensive. We assume sector a is more land-intensive, relative to labor, than sector m. The three goods are differentiated on the basis of land intensity differences, not through differences in household's income elasticity of their demand. Land has an additional role of being an asset. Households 'accumulate' land, although in the aggregate, land accumulation is zero.

Technologies in sectors a and m are Cobb-Douglas. Let γ and α be the share land in total cost in these sectors respectively. That sector a is more land intensive than sector m is captured by

Assumption 1 $\gamma > \alpha$.

We shall express production functions in terms of unit cost functions. These are $c_a(r_{Dt}, w_t)/A_t \equiv r_{Dt}^{\gamma} w_t^{1-\gamma}/A_t$ for agriculture and $c_m(r_{Dt}, w_t)/M_t \equiv r_{Dt}^{\alpha} w_t^{1-\alpha}/M_t$ for manufacturing. We assume constant-returns technology for services too: $c_s(w_t)/S_t \equiv w_t/S_t$. Variables r_{Dt} and w_t are the land rental rate and wage rate respectively and A_t, M_t and S_t are overall productivity (TFP) parameters in sectors a, m and s respectively.

We can now write down the production side of this economy in general form in terms of the familiar zero-profit and full-employment conditions, *a la* Jones (1965).

$$\frac{c_a(r_{Dt}, w_t)}{A_t} = p_{at}; \quad \frac{c_m(r_{Dt}, w_t)}{M_t} = 1; \quad \frac{c_s(w_t)}{S_t} = p_{st} \tag{4.1}$$

$$\frac{1}{A_t}\frac{\partial c_a(r_{Dt}, w_t)}{\partial r_{Dt}} Q_{at} + \frac{1}{M_t}\frac{\partial c_m(r_{Dt}, w_t)}{\partial r_{Dt}} Q_{mt} = \bar{D} \tag{4.2}$$

$$\frac{1}{A_t}\frac{\partial c_a(r_{Dt}, w_t)}{\partial w_t} Q_{at} + \frac{1}{M_t}\frac{\partial c_m(r_{Dt}, w_t)}{\partial w_t} Q_{mt} + \frac{1}{S_t}\frac{dc_s(w_t)}{dw_t} Q_{st} = L_t \tag{4.3}$$

where manufacturing goods is the numeraire, p_{at} and p_{st} are prices of food and services (in terms of manufactures), $\bar{D}$ is the total, fixed endowment of land in the economy and L_t is the total labor supply. These are five equations in five variables: the two factor prices and three outputs.

In the demand side, a household's total utility at t equals L_tU_t, where

$$U_t = \phi_a \ln C_{at} + \phi_m \ln C_{mt} + \phi_s \ln C_{st},\ \phi_a,\ \phi_m,\ \phi_s > 0;\ \phi_a + \phi_m + \phi_s = 1,$$

and C_{jt} denotes per capita consumption of good j. This is maximized subject to the budget:

$$L_t(p_{at}C_{at} + C_{mt} + p_{st}C_{st}) = E_t, \tag{4.4}$$

where E_t is the total expenditure. The demand functions are:

$$L_tC_{at} = \frac{\phi_a E_t}{p_{at}}; \quad L_tC_{mt} = \phi_m E_t; \quad L_tC_{st} = \frac{\phi_s E_t}{p_{st}}. \tag{4.5}$$

The static equilibrium is described by the supply-side equations, and, the following market clearing conditions:

$$L_tC_{at} = Q_{at}; \quad L_tC_{mt} = Q_{mt}; \quad L_tC_{st} = Q_{st}. \tag{4.6}$$

Any two of the above along with supply-side equations solve the system.

Proposition 4.1

$$\begin{gathered}
D_{at} \propto \bar{D}; \quad D_{mt} \propto \bar{D}; \quad L_{at} \propto L_t; \quad L_{mt} \propto L_t; \quad L_{st} \propto L_t \\
Q_{at} \propto A_t\bar{D}^{\gamma}L_t^{1-\gamma}; \quad Q_{mt} \propto M_t\bar{D}^{\alpha}L_t^{1-\alpha}; \qquad Q_{st} \propto S_tL_t \\
r_{Dt} \propto M_t\bar{D}^{-(1-\alpha)}L_t^{1-\alpha}; \quad w_t \propto M_t\bar{D}^{\alpha}L_t^{-\alpha} \\
p_{at} \propto A_t^{-1}M_t\bar{D}^{-(\gamma-\alpha)}L_t^{\gamma-\alpha}; \quad p_{st} \propto S_t^{-1}M_t\bar{D}^{\alpha}L_t^{-\alpha} \\
E_t \propto M_t\bar{D}^{\alpha}L_t^{1-\alpha}.
\end{gathered}$$

Proof: See Appendix 4.A. ■

Proposition 4.1 means that sectoral factor employment levels are independent of productivity parameters. They vary directly with respective total factor supplies only. There is no cross dependence – total labor supply does not affect sectoral land allocations nor does total land supply affect sectoral labor allocations. Cobb-Douglas specifications imply that the ratio of sectoral land allocation, D_{at}/D_{mt}, is proportional to the ratio of value of outputs, $p_{at}Q_{at}/Q_{mt}$. In equilibrium, this is equal to the ratio of respective consumption expenditures, which, in turn, is constant under log-linear preferences. Thus, sectoral land allocation is proportional to total land supply and independent of total supply of labor. Same reasoning holds for labor allocations.

We assume that population (labor supply) and TFP parameters grow at constant rates:

$$\frac{L_{t+1}}{L_t} = g_L; \quad \frac{A_{t+1}}{A_t} = g_A; \quad \frac{M_{t+1}}{M_t} = g_M; \quad \frac{S_{t+1}}{S_t} = g_S, \tag{4.7}$$

where g_L, g_A, g_M and g_S are greater than unity.

The household's consumption/land-investment decisions are inter-temporal. Let $\tilde{\rho}$ (< 1) and $\rho \equiv \tilde{\rho} g_L$ (< 1) be the individual and population (household) size adjusted time discount factor. The household's dynamic problem is to choose $\{E_t\}_0^\infty$, $\{D_t\}_1^\infty$ that maximize its discounted lifetime utility

$$\sum_{t=0}^{\infty} \rho^t \left(\ln E_t - \phi_a \ln p_{at} - \phi_s \ln p_{st}\right)$$

subject to $p_{Dt}(D_{t+1} - D_t) + E_t \leq w_t L_t + r_{Dt} D_t$. Here D_t is the household's land holding and p_{Dt} is the price of land (in terms of manufactures). The Euler equation and the transversality conditions are:

$$\frac{E_{t+1}}{E_t} = \rho \left(\frac{r_{Dt+1} + p_{Dt+1}}{p_{Dt}} \right). \tag{4.8}$$

$$\lim_{t \to \infty} \frac{\rho^t}{E_t} p_{Dt} D_{t+1} = 0. \tag{4.9}$$

The output and employment dynamics can be summarized as

Proposition 4.2 *Employment in each sector grows at the (gross) rate of g_L, and, output growth rates have the expressions:*

$$g_{Qa} = g_A g_L^{1-\gamma}; \; g_{Qm} = g_M g_L^{1-\alpha}; \; g_{Qs} = g_S g_L. \tag{4.10}$$

Proof: It follows immediately from Proposition 4.1. ■

Thus, non-balanced growth results from differential TFP growth and differential land intensity (as long as total labor supply has a positive growth rate). Let $\tilde{g}_x$ denote the net growth rate of variable x, equal to $g_x - 1$. Expressions in (4.10) imply $\tilde{g}_{Qa} \simeq \tilde{g}_A + (1-\gamma)\tilde{g}_L$,

$\tilde{g}_{Qm} \simeq \tilde{g}_M + (1-\alpha)\tilde{g}_L$ and $\tilde{g}_{Qs} \simeq \tilde{g}_S + \tilde{g}_L$. Hence

$$\begin{aligned} \tilde{g}_{Qm} - \tilde{g}_{Qa} \equiv \delta_{m-a} &= (\tilde{g}_M - \tilde{g}_A) + (\gamma - \alpha)\tilde{g}_L; \\ \tilde{g}_{Qs} - \tilde{g}_{Qm} \equiv \delta_{s-m} &= (\tilde{g}_S - \tilde{g}_M) + \alpha\tilde{g}_L, \end{aligned} \tag{4.11}$$

where δ's denote difference in (net) growth rates of two sectors. Expressions in (4.11) are decompositions of sectoral growth rate differentials into TFP differentials (first term in the brackets in the r.h.s.) and those due to land intensity differentials (second term in the r.h.s.). Furthermore, because land intensities differ across sectors relative to labor,

Proposition 4.3 *Sectoral growth differentials ascribed to land intensity differential are proportional to the growth rate of labor.*

Notice that land allocation between agriculture and manufacturing is invariant over time, implying that technologies in these sectors exhibit decreasing-returns in terms of the variable input, labor, as opposed to constant-returns in services. Thus, differences in land-intensity amounts to difference in scale with respect to variable inputs, which can explain non-balanced growth across sectors. The role of land use in non-balanced growth is brought out by

Corollary 4.1 *Under Assumption 1 and if TFP differences are not sufficiently large, the services sector output grows the fastest, followed by the manufacturing sector and then the agriculture sector.*

There are two general conclusions. First, besides differences in TFP growth, differences in land intensity in production explain the stylized facts on relative growth rates of services, manufacturing and agriculture. Second, the growth ranking in Corollary 4.1 may hold even when $g_A > g_M > g_S$. That is,

Corollary 4.2 *Output growth ranking may be exactly the opposite of TFP growth ranking.*

Remarks

1. For developing countries, data on TFP growth is rather scarce. The few studies on TFP growth in developing countries like India, China, Pakistan, do not show any pronounced rankings (Bosworth and Collins (2008), Bosworth and Maertens (2010)). This accords with Corollary 4.1.

2. However, Wachter (2001), a European Central Bank study, shows that in the U.S. and France the TFP growth of manufacturing far exceeds that of services sector. But the services sector in these countries grow faster than manufacturing. Our model conveys that land constraints may very well be an underlying reason, although an empirical investigation of the same is beyond our scope.

It also immediately follows from (4.10) that

Corollary 4.3 *An increase in the TFP growth rate in a sector leads to one-to-one increase in the growth rate of output in that sector, without any spillover effects to other sectors.*

Real GDP and Land Price Dynamics

Apart from sectoral growth rates, the model predicts the growth rate of real GDP, and, that of land price in particular. The GDP of the economy in terms of manufactures is equal to $Y_t \equiv p_{at}Q_{at} + Q_{mt} + p_{st}Q_{st}$. In equilibrium, both $p_{at}Q_{at}$ and $p_{st}Q_{st}$ are proportional to Q_{mt}. Hence GDP in terms of manufactures grow at the same rate as does Q_{mt} - which, in view of Proposition 4.1, equals $g_M g_L^{1-\alpha} \equiv \bar{g}$.

Assumed preferences imply a general price index, $P_t \equiv p_{at}^{\phi_a} p_{st}^{\phi_s}$, where the price of goods are weighed by their respective weights in the household's preferences. The real GDP equals Y_t/P_t. As the value of three outputs are proportional to each other, each is proportional to real GDP. Hence

$$\frac{Y_t}{P_t} \propto \frac{(p_{at}Q_{at})^{\phi_a} Q_{mt}^{\phi_m} (p_{st}Q_{st})^{\phi_s}}{p_{at}^{\phi_a} p_{st}^{\phi_s}} \propto Q_{at}^{\phi_a} Q_{mt}^{\phi_m} Q_{st}^{\phi_s}.$$

It follows from Proposition 4.2 that the growth rates of real GDP and per capita real GDP are, respectively: $g_A^{\phi_a} g_M^{\phi_m} g_S^{\phi_s} g_L^{1-(\phi_a\gamma+\phi_m\alpha)}$ and $g_A^{\phi_a} g_M^{\phi_m} g_S^{\phi_s} g_L^{-(\phi_a\gamma+\phi_m\alpha)}$.

Corollary 4.4 *If there is no TFP growth in the three sectors, then real GDP per capita falls over time.*

This is an outcome of limited supply of land. If there is no TFP growth, then agriculture and manufacturing sector grow slower than the total labor supply while the growth rate of services sector is same as that of the total labor supply. In equilibrium per capita real GDP falls over time.

In the light of Proposition 4.1, E_t and r_{Dt} both grow at the rate $\bar{g}$. Using this, the land price dynamics is solved from the Euler equation (4.8) as a first-order difference equation:

$$p_{Dt} = \left(p_{D0} - \frac{\rho r_{D0}}{1-\rho}\right)\left(\frac{\bar{g}}{\rho}\right)^t + \frac{\rho r_{D0}}{1-\rho}\bar{g}^t. \tag{4.12}$$

where the initial land rental rate, r_{D0}, is derived from the static system. As $0 < \rho < 1$, $\bar{g}/\rho > g$. Hence, initially, if $p_{D0} \neq \rho r_{D0}/(1-\rho)$, it is evident from above that in the long run, the first term in the r.h.s. of (4.12) would dominate and thus p_{Dt} would tend to grow or decline at the rate $\bar{g}/\rho$. The transversality condition rules out this possibility however.[6] Rational agents bring to pass the initial land price being equal to $p_{D0} = \dfrac{\rho r_{D0}}{1-\rho}$, so that the first-term is zero and

$$p_{Dt} = \frac{\rho r_{D0}}{1-\rho}\bar{g}^t. \tag{4.13}$$

It follows that

Proposition 4.4 *Real land price grows at the same rate the real GDP of the economy.*

4.3 Capital Accumulation

We now introduce capital and its accumulation. Capital is assumed to be made up from the manufacturing good in one-to-one proportion. We retain the land intensity ranking of Section 4.2. As already discussed in the Introduction, capital intensity ranking, particularly between manufacturing and agriculture, is not clear-cut across countries, and, insofar as our focus is on the role of land use ranking, any definite ranking of capital intensity is not necessary. However, for sharpness of results to accord with the stylized facts on non-balanced growth across the three sectors, we assume that capital intensity is highest in services and least in agriculture. Further, for the sake of analytical simplicity we make this assumption in its extreme form: that is capital is not used in agriculture at all.[7] The end result is that the land use intensity ranking and the opposite ranking of capital intensity both contribute

[6] If $p_{D0} \neq \rho r_{D0}/(1-\rho)$,

$$\lim_{t\to\infty} \frac{\rho^t}{E_t} p_{Dt} D_{t+1} = \frac{\rho^t[p_{D0} - \rho r_{D0}/(1-\rho)](g/\rho)^t}{E_0 g^t} = \frac{p_{D0} - \rho r_{D0}/(1-\rho)}{E_0} \neq 0.$$

Hence the transversality condition (4.9) is not met.

[7] Roe et al. (2009) develop a three-sector growth model in the context of a small open economy. Agriculture and manufacturing are traded sectors, while services are not. Land is used only in agriculture sector. Capital and labor are used in all three sectors. In some chapters, the additional role of land as an asset has been considered. While the framework is similar to ours, the focus of their work is not on unbalanced growth. Using such a framework, they attempt to explain the dynamics of the Turkish macro economy over the last four decades.

towards the stylized fact of services sector grows faster than manufacturing and the latter grows faster than agriculture. Non-balanced growth decomposition has three elements: differences in TFP, differences in capital-intensity and differences in land-intensity relative to labor.

4.3.1 Static Equilibrium

The production side of agriculture is same as in the elementary model. Manufacturing production requires three primary inputs: land, labor and capital. The unit cost function is given by $c_m(r_{Dt}, r_t, w_t)/M_t \equiv r_{Dt}^{\alpha} r_t^{\beta} w_t^{1-\alpha-\beta}/M_t$, α, $\beta < 1$, where r_t is rental earned by capital. The services sector uses labor and capital. Let $c_s(r_t, w_t)/S_t \equiv r_t^{\eta} w_t^{1-\eta}/S_t$, where $0 < \eta < 1$.

We impose

Assumption 2 $\gamma > \dfrac{\alpha}{1-\beta}$

Assumption 3 $\eta > \beta$.

Assumption 2 signifies that, between agriculture and manufacturing the former is more land intensive relative to labor (in the total share of land and labor in the respective sector).[8] It replaces our earlier Assumption 1. Assumption 3 reflects that capital is used more intensively in the services than in manufacturing; this is a weaker assumption than the service sector being more capital-intensive than manufacturing in the total share of capital and labor in the respective sector.

The supply side is expressed in terms of the following the zero profit and full employment conditions

$$\frac{c_a(r_{Dt}, w_t)}{A_t} = p_{at} \tag{4.14}$$

$$\frac{c_m(r_{Dt}, r_t, w_t)}{M_t} = 1 \tag{4.15}$$

$$\frac{c_s(r_t, w_t)}{S_t} = p_{st} \tag{4.16}$$

$$\frac{1}{A_t}\frac{\partial c_a(r_{Dt}, w_t)}{\partial r_{Dt}} Q_{at} + \frac{1}{M_t}\frac{\partial c_m(r_{Dt}, r_t, w_t)}{\partial r_{Dt}} Q_{mt} = \bar{D} \tag{4.17}$$

[8] If land were present in the service sector production, the corresponding assumption would have been that manufacturing is more land intensive than service production in the total share of land and labor in the respective sector.

$$\frac{1}{A_t}\frac{\partial c_a(r_{Dt},w_t)}{\partial w_t}Q_{at}+\frac{1}{M_t}\frac{\partial c_m(r_{Dt},r_t,w_t)}{\partial w_t}Q_{mt}+\frac{1}{S_t}\frac{\partial c_s(r_t,w_t)}{\partial w_t}Q_{st}=L_t \tag{4.18}$$

$$\frac{1}{M_t}\frac{\partial c_m(r_{Dt},r_t,w_t)}{\partial r_t}Q_{mt}+\frac{1}{S_t}\frac{\partial c_s(r_t,w_t)}{\partial r_t}Q_{st}=K_t, \tag{4.19}$$

where K_t is the aggregate stock of capital at time t.

The demand functions are given by (4.5), except that E_t, total household expenditure on goods, equals total income minus savings.

Static equilibrium yields sectoral levels of factor employment and output being dependent on productivity levels, factor supplies as well as total expenditure (spending). Given Cobb-Douglas technologies and log-linear preferences, such dependencies assume following forms:

Proposition 4.5

$$D_{at}=\bar{D}\cdot f_{Da}(\mathcal{K}_t,\mathcal{E}_t);\quad D_{mt}=\bar{D}\cdot f_{Dm}(\mathcal{K}_t,\mathcal{E}_t);$$

$$L_{at}=L_t\cdot f_{La}(\mathcal{K}_t,\mathcal{E}_t);\quad L_{mt}=L_t\cdot f_{Lm}(\mathcal{K}_t,\mathcal{E}_t);\quad L_{st}=L_t\cdot f_{Ls}(\mathcal{K}_t,\mathcal{E}_t);$$

$$K_{mt}=M_t^{\frac{1}{1-\beta}}\bar{D}^{\frac{\alpha}{1-\beta}}L_t^{\frac{1-\alpha-\beta}{1-\beta}}\cdot f_{Km}(\mathcal{K}_t,\mathcal{E}_t);K_{st}=M_t^{\frac{1}{1-\beta}}\bar{D}^{\frac{\alpha}{1-\beta}}L_t^{\frac{1-\alpha-\beta}{1-\beta}}\cdot f_{Ks}(\mathcal{K}_t,\mathcal{E}_t);$$

$$Q_{at}=A_t\bar{D}^{\gamma}L_t^{1-\gamma}\cdot f_{Qa}(\mathcal{K}_t,\mathcal{E}_t);\quad Q_{mt}=M_t^{\frac{1}{1-\beta}}\bar{D}^{\frac{\alpha}{1-\beta}}L_t^{\frac{1-\alpha-\beta}{1-\beta}}\cdot f_{Qm}(\mathcal{K}_t,\mathcal{E}_t);$$

$$Q_{st}=S_tM_t^{\frac{\eta}{1-\beta}}\bar{D}^{\frac{\alpha\eta}{1-\beta}}L_t^{\frac{1-\alpha\eta-\beta}{1-\beta}}\cdot f_{Qs}(\mathcal{K}_t,\mathcal{E}_t);$$

$$r_{Dt}=M_t^{\frac{1}{1-\beta}}\bar{D}^{-\frac{1-\alpha-\beta}{1-\beta}}L_t^{\frac{1-\alpha-\beta}{1-\beta}}\cdot f_{rD}(\mathcal{K}_t,\mathcal{E}_t);\quad w_t=M_t^{\frac{1}{1-\beta}}\bar{D}^{-\frac{\alpha}{1-\beta}}L_t^{\frac{-\alpha}{1-\beta}}\cdot f_w(\mathcal{K}_t,\mathcal{E}_t);$$

$$r_t=f_r(\mathcal{K}_t,\mathcal{E}_t);$$

$$p_{at}=A_t^{-1}M_t^{\frac{1}{1-\beta}}\bar{D}^{-\frac{(1-\beta)\gamma-\alpha}{1-\beta}}L_t^{\frac{(1-\beta)\gamma-\alpha}{1-\beta}}\cdot f_{pa}(\mathcal{K}_t,\mathcal{E}_t);$$

$$p_{st}=S_t^{-1}M_t^{\frac{1-\eta}{1-\beta}}\bar{D}^{\frac{\alpha(1-\eta)}{1-\beta}}L_t^{-\frac{\alpha(1-\eta)}{1-\beta}}\cdot f_{ps}(\mathcal{K}_t,\mathcal{E}_t).$$

where

$$\mathcal{K}_t\equiv\frac{K_t}{M_t^{\frac{1}{1-\beta}}\bar{D}^{\frac{\alpha}{1-\beta}}L_t^{\frac{1-\alpha-\beta}{1-\beta}}};\quad \mathcal{E}_t\equiv\frac{E_t}{M_t^{\frac{1}{1-\beta}}\bar{D}^{\frac{\alpha}{1-\beta}}L_t^{\frac{1-\alpha-\beta}{1-\beta}}}. \tag{4.20}$$

Proof: See Appendix 4.B. ∎

Remarks

1. The variables $\mathcal{K}_t$ and $\mathcal{E}_t$ can be termed as 'normalized' capital stock and total household expenditure respectively.[9] Later, the dynamic system will be expressed in ($\mathcal{K}_t$, $\mathcal{E}_t$)

[9] These are counterparts of capital and consumption per effective labor in the one-sector, Solow-Ramsey-Koopman model.

space and in the steady state both these variables are constant.

2. Expressions in Proposition 4.5 anticipate that the growth process of factor employment and outputs will be governed by *transitional effects* via endogenous evolution of $\mathcal{K}_t$ and $\mathcal{E}_t$ and *long-run effects* through exogenous growth of productivities and increase in labor supply.

3. Unlike in the previous model, the factor-employment ratios between two sectors are time-varying. Because a part of manufacturing output constitutes savings, the ratio of the

   for example, while D_{at}/D_{mt} is proportional to $p_{at}Q_{at}/Q_{mt}$, the latter ratio is not constant. Consequentially, land used in each sector depends on total land supply as well as total supplies of labor and capital and total household expenditure. The same holds for employment of labor and capital.

4. Note that productivity in manufacturing affects output of services because a part of manufacturing is converted to capital and capital is an input to the services sector. (It would have affected agricultural output if capital were used in that sector.)

4.3.2 Dynamics

Households own two assets - land and capital. They maximize the discounted sum of its welfare: $L_0 \sum_{t=0}^{\infty} \rho^t U_t$. A household has two sources of income used to finance purchase of goods and asset accumulation: namely, wage earnings and rental income from assets (land and capital). Its dynamic problem is

$$\text{Maximize} \sum_{t=0}^{\infty} \rho^t [\ln E_t - \phi_a \ln p_{at} - \phi_s \ln p_{st}],$$

$$\text{subject to } E_t + K_{t+1} - K_t + p_{Dt}(D_{t+1} - D_t) \leq w_t L_t + r_t K_t + r_{Dt} D_t,$$

where U_t is substituted by its indirect form. For simplicity, the rate of capital depreciation is assumed to be zero. Given L_0, D_0 and K_0, the household chooses $\{E_t\}_0^\infty$, $\{D_t\}_1^\infty$ and $\{K_t\}_1^\infty$. We obtain the standard Euler equation

$$\frac{E_{t+1}}{E_t} = \rho(1 + r_{t+1}). \tag{4.21}$$

There are two transversality conditions: (4.9) and

$$\lim_{t\to\infty} \frac{\rho^t}{E_t} K_{t+1} = 0. \tag{4.22}$$

The no-arbitrage condition between the assets is

$$1 + r_{t+1} = \frac{p_{Dt+1} + r_{Dt+1}}{p_{Dt}}. \tag{4.23}$$

Note, the services demand function (4.5) and the full employment condition for capital (4.19) together imply $\beta Q_{mt} = r_t K_t - \phi_s \eta E_t$. Thus, the law of motion of capital, $K_{t+1} = Q_{mt} - \phi_m E_t + K_t$, can written as

$$K_{t+1} = \frac{r_t K_t}{\beta} - \frac{\phi_m \beta + \phi_s \eta}{\beta} E_t + K_t. \tag{4.24}$$

This equation, the Euler equation, the no-arbitrage condition as well as the transversality condition form the basis of the dynamic system.

Using the expressions in Proposition 4.5 and defining $g^\circ \equiv g_M^{\frac{1}{1-\beta}} g_L^{\frac{1-\alpha-\beta}{1-\beta}}$, eqs. (5.7) and (4.24) can be expressed as

$$\begin{aligned} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} &= \frac{\rho\left[1 + f_r(\mathcal{K}_{t+1}, \mathcal{E}_{t+1})\right]}{g^\circ} \\ \mathcal{K}_{t+1} &= \frac{1}{g^\circ} \cdot \left[\frac{f_r(\mathcal{K}_t, \mathcal{E}_t)\mathcal{K}_t}{\beta} - \frac{\phi_m \beta + \phi_s \eta}{\beta} \mathcal{E}_t + \mathcal{K}_t\right]. \end{aligned} \tag{4.25}$$

These two equations form the core dynamic system of the economy. Once the dynamics of the $\mathcal{K}_t$ and $\mathcal{E}_t$ are determined, the dynamics of the other macroeconomic variables can be derived.

In particular, for land price dynamics we rewrite the non-arbitrage equation (4.23) in terms of the normalized variables

$$\mathcal{P}_{Dt+1} = \frac{1 + f_r(\mathcal{K}_{t+1}, \mathcal{E}_{t+1})}{g^\circ} \mathcal{P}_{Dt} - f_{rD}(\mathcal{K}_{t+1}, \mathcal{E}_{t+1}) \tag{4.26}$$

where $\mathcal{P}_{Dt} \equiv p_{Dt} M_t^{-\frac{1}{1-\beta}} \bar{D}^{-\frac{\alpha}{1-\beta}} L_t^{-\frac{1-\alpha-\beta}{1-\beta}}$.

4.3.3 Steady State

This is defined by $\mathcal{K}_t = \mathcal{K}^*$ and $\mathcal{E}_t = \mathcal{E}^*$. Eqs. (4.25) yield

$$\begin{aligned} r^* = f_r(\mathcal{K}^*, \mathcal{E}^*) &= \frac{g^\circ}{\rho} - 1 \\ \frac{\mathcal{E}^*}{\mathcal{K}^*} &= \frac{(g^\circ - 1)(1 - \beta\rho) + 1 - \rho}{\rho(\phi_m \beta + \phi_s \eta)}. \end{aligned} \tag{4.27}$$

The former is the modified golden rule. The latter defines the trajectory where savings grow at a constant rate. Eqs. (4.27) solve $(\mathcal{K}^*, \mathcal{E}^*)$. In Appendix 4.B we show that the steady state exists and it is unique.

Proposition 4.6 *Along the steady state, land allocation is fixed between the two sectors, labor and capital in each sector grow respectively at the rates* g_L *and* $g_K \equiv g_M^{\frac{1}{1-\beta}} g_L^{\frac{1-\alpha-\beta}{1-\beta}}$ *and output growth rates are:*

$$g_{Qa} = g_A g_L^{1-\gamma};\ g_{Qm} = g_M^{\frac{1}{1-\beta}} g_L^{\frac{1-\alpha-\beta}{1-\beta}};\ g_{Qs} = g_S g_M^{\frac{\eta}{1-\beta}} g_L^{\frac{1-\alpha\eta-\beta}{1-\beta}}. \tag{4.28}$$

Proof: It follows directly from Proposition 4.5. ■

Since capital is not used in the agriculture sector, the growth rate of this sector is affected by the TFP growth in that sector and the exogenous growth rate of labor; it is not affected by capital accumulation.

Manufacturing output, and, capital which is made out of manufacturing, grow at the same rate. Since a manufacturing good is used as an input in the production of manufacturing, there is a multiplier effect (captured by the term $1/(1-\beta)$). The manufacturing output and capital growth rate exceeds the manufacturing TFP growth rate. Services sector growth is affected by TFP growth in that sector as well as by that in manufacturing since capital is used in the services sector. Because the growth of capital exceeds that TFP in manufacturing, TFP growth in manufacturing may exert more than one-to-one impact on the growth rate of services output. Also notice that an increase in the exogenous growth rate of labor affects the growth rates of manufacturing and services output directly as well as indirectly via enhancing the growth rate of capital.

In this economy, there are three sources of long-run sectoral output growth gaps: differences in TFP growth rates, land intensity differences *and* capital intensity differences. The r.h.s. expressions of eqs. (4.29) below provide the decompositions.

$$\begin{aligned}\delta_{m-a} &= (\tilde{g}_M - \tilde{g}_A) + \left(\gamma - \frac{\alpha}{1-\beta}\right)\tilde{g}_L + \frac{\beta}{1-\beta}\tilde{g}_M;\\ \delta_{s-m} &= (\tilde{g}_S - \tilde{g}_M) + \frac{\alpha(1-\eta)}{1-\beta}\tilde{g}_L + \frac{\eta-\beta}{1-\beta}\tilde{g}_M.\end{aligned} \tag{4.29}$$

The three right-hand side terms respectively express the contribution of TFP differential, land intensity differential (relative to labor) and capital intensity differential.

Proposition 4.7 *While sectoral growth differentials attributable to differences in land intensity vary directly with the growth rate of labor, those due to differences in capital intensity vary directly with the TFP growth rate of manufacturing.*

This is a generalization of Proposition 4.3. Note that

1. An increase in the growth rate of labor widens the difference in sectoral rates between manufacturing and the agricultural sector and between services and manufacturing. This is due to differences in the land use intensities across sectors.

2. The sectoral capital-intensity differences affect the sectoral output growth difference in conjunction with the manufacturing TFP growth rate. This is because in steady state the growth rate of capital, being a manufacturing good, is determined by TFP growth rate of manufacturing.

3. An increase in TFP growth in manufacturing leads to more than one to one widening of difference in output growth rates between manufacturing and the agriculture sector and less than one to one narrowing of differences in output growth rates between services and manufacturing.

Corollaries 4.1 and 4.2 carry over under Assumptions 2 and 3. However, Corollary 4.3 does not hold, i.e., there are cross sectoral effects of TFP growth.

Corollary 4.5 *TFP growth in agriculture or services sector affects output growth in their respective sectors only, whereas that in manufacturing affects output growth in manufacturing as well as services.*

It is because capital, a manufacturing good, is used in the production of services. If capital was an input in the agriculture sector or if sectoral goods were inputs in the production of other sectors, then there would have been other cross-dependencies of sectoral TFP and output growth.

In steady state, it follows from (4.26) that land price (in terms of manufacturing good) grows at the rate g°. In fact,

Proposition 4.8 *Real land price grows at the same constant rate as the real GDP of the economy.*

Proof: In steady state, normalized capital and expenditure are constant. It follows from (4.26) that $\mathcal{P}_{Dt} = \mathcal{P}_D^*$ and land price grows at the rate g°. We already know from Proposition 4.5 that the GDP (in terms of the numeraire good) of the economy grows at the rate g°. As land price and GDP grow at the same rate, g°, so it follows that real land price and real GDP also grow at the same rate. ■

We already know that in steady state, the value of output of the three sectors is proportional to each other, so we get real GDP as

$$\frac{GDP_t}{P_t} \propto \frac{(p_{at}Q_{at})^{\phi_a} Q_{mt}^{\phi_m} (p_{st}Q_{st})^{\phi_s}}{p_{at}^{\phi_a} p_{st}^{\phi_s}} \propto Q_{at}^{\phi_a} Q_{mt}^{\phi_m} Q_{st}^{\phi_s}.$$

From Proposition 4.5 and the expression for g°, we get that the growth rate of real land price and real GDP is

$$g_A^{\phi_a} g_M^{\frac{\phi_m+\phi_s\eta}{1-\beta}} g_S^{\phi_s} g_L^{\frac{\phi_a(1-\beta)(1-\gamma)+\phi_m(1-\alpha-\beta)+\phi_s(1-\alpha\eta-\beta)}{1-\beta}} > 1.$$

wherein the weights on g_A and g_S are the respective preference weights on the agricultural and services goods consumption. However, the weights on g_M and g_L depend on both preference and production parameters. This stems from the fact that manufacturing good (as capital) is an input in manufacturing and services sector; and labor is an input in all three sectors. The weights on g_A, g_S and g_L are less than one, but the weight on g_M may be more than unity. If $\phi_m + \phi_s\eta > 1 - \beta$, then 1 percentage point increase in g_M raises the growth rate of real GDP by more than 1 percentage point.

Despite non-balanced growth across sectors, the model is consistent with Kaldor's facts on aggregate economy-wide growth:

Proposition 4.9 *Over the steady state, the capital-output ratio, return on capital, factor shares in national income and the growth rate of output per worker are all constant.*

Proof: Output is measured by GDP of an economy. At steady state, $\mathcal{K}_t = \mathcal{K}^*$ and $\mathcal{E}_t = \mathcal{E}^*$. So it follows from Proposition 4.5, growth rate of GDP_t/L_t is constant; the variables K_t/GDP_t, r_t, w_tL_t/GDP_t and r_tK_t/GDP_t are constant at steady state. ■

4.3.4 Non-balanced Growth Off the Steady State

Imagine that an economy, which is initially along the steady state, is perturbed by a shock that may be temporary or permanent, or an economy yet to achieve steady state. For simplicity, let us limit ourselves to displacement in the local neighborhood of the steady state.

The first issue is stability. Linearizing the dynamic system (4.25) around the steady state, as shown in Appendix 4.B, we get that the steady state is saddle-path stable. As in standard literature, we analyze the economy when the initial normalized capital stock is low, i.e. $\mathcal{K}_0 < \mathcal{K}^*$. We find that in this case the normalized capital as well as normalized expenditure both monotonically grow over time to reach the steady state. Note that in the other case of initial high capital stock (i.e. $\mathcal{K}_0 > \mathcal{K}^*$), the growth trajectories of the variables are reversed.

As one would expect, complete *analytical* characterization of (local) dynamics of sectoral output and employment levels is not possible. We note the following two (analytical) propositions on co-movement of sectoral inputs, and, then resort to numerical simulations to understand the evolution of sectoral output and employment growth rates.

Through numerical simulations, we find that if the initial capital stock is low, the growth rate of agriculture and services output monotonically declines to its steady state level while that on manufacturing output monotonically rises to its steady state rate. The short run output growth ranking varies over time, but in long run the most (or least) land dependent sector is the slowest (or fastest) growing sector. We decompose sectoral growth differentials to analyze the strengths of the different sources of growth. We find that the more available input-factor contributes more to sectoral growth differences. In short run land intensity differences play the largest role in explaining non-balanced growth, while in long run the capital intensity differences have the largest explanatory power.

Co-Movement of Sectoral Input Uses

Proposition 4.10 *Sectoral factor allocations over time exhibit proportional relationships*

$$\frac{D_{at}}{D_{mt}} \propto \frac{L_{at}}{L_{mt}} \propto \frac{L_{st}}{L_{mt}} \propto \frac{K_{st}}{K_{mt}}.$$

Proof: As factors of production are mobile across sectors, the rental rates of their use would be equal across sectors. The first proportionality arises from equating the wage rate to land rental rate ratio in the agriculture and manufacturing sectors. Similarly, the third proportionality stems from equating the ratio of wage rate to capital rental rate in the manufacturing and services sectors. The second proportionality follows from the fact that household expenditure on agriculture and services goods are proportional to each other. ■

This proposition implies that irrespective of the initial conditions, the factor movements in this economy are inter-linked. For example, if an input-factor in agriculture sector grows faster (or slower) than its manufacturing counterpart then all production factors in agriculture and services sector would grow faster (respectively slower) than their respective manufacturing counterparts. So at any instant only one of these two cases are possible: either Case (a) $g_{Da} \geq g_{Dm}$, $g_{La} \geq g_{Lm}$, $g_{Ls} \geq g_{Lm}$, $g_{Ks} \geq g_{Km}$; or Case (b) $g_{Da} \leq g_{Dm}$, $g_{La} \leq g_{Lm}$, $g_{Ls} \leq g_{Lm}$, $g_{Ks} \leq g_{Km}$.

Further at any time period t, the full employment conditions for land, labor and capital imply that in Case (a) $g_{Da} \geq g_{\bar{D}} = 1 \geq g_{Dm}$, $g_{La} = g_{Ls} \geq g_L \geq g_{Lm}$ and $g_{Ks} \geq g_{Kt} \geq g_{Km}$; while in Case (b) $g_{Da} \leq g_{\bar{D}} = 1 \leq g_{Dm}$, $g_{La} = g_{Ls} \leq g_L \leq g_{Lm}$ and $g_{Ks} \leq g_{Kt} \leq g_{Km}$. Note, for the initial condition $\mathcal{K}_0 < \mathcal{K}^*$, we know from the trajectory of capital stock (derived in Appendix 4.B) that $g_{Kt} > g_K^*$. So the rank of sectoral capital growth rate relative to the steady state growth rate of capital is ambiguous.

Using the production function of the three goods, we can link the input-factor growth rates to output growth rates. In Case (a) as $g_{Da} \geq g_{\bar{D}}$, $g_{La} = g_{Ls} \geq g_L$ and $g_{Ks} \geq g_K^*$, its is evident that $g_{Qa} \geq g_{Qa}^*$ and $g_{Qs} \geq g_{Qs}^*$, and by similar logic $g_{Qm} \gtreqless g_{Qm}^*$. In Case (b) the opposite ranking holds.

Given the initial condition $\mathcal{K}_0 < \mathcal{K}^*$, it is unclear which one of the two possible cases manifests. It does not seem possible to analytically characterize output and employment growth patterns over time because it depends on the relative importance of different goods. To understand the transitional dynamics in more detail, we resort to numerical simulations through which we track the growth paths of sectoral output and employment over time. We also decompose the sectoral output growth gaps into the various sources of non-balanced growth: differences in TFP growth, differences in capital intensity and differences in land intensity across sectors.

4.3.5 Numerical Simulation

The behaviour of this economy can be analyzed only after we assign values to its technology and preference parameters. The values are chosen from the US economy of the period 1998-2012 to get 13 parameter values (γ, α, β, η, g_A, g_M, g_S, g_L, ϕ_a, ϕ_m, ϕ_s, ρ, $\bar{D}$) and 5 initial conditions (A_0, M_0, S_0, L_0, K_0). On the basis of these values, we characterize the local behaviour of the nonlinear dynamic system.

National Income of Public Accounts (NIPA) reports employment and composition of GDP by industry. The agriculture sector is broadly interpreted as the 'Agriculture, forestry, fishing, and hunting' industry in the NIPA dataset. Similarly the manufacturing sector is the 'Manufacturing industry' and the services sector is the 'Private services-producing industries'. For labor intensity in production, we take the average of the sectoral employment shares for the period 1998-2012. It gives $\gamma = 0.71$, $\alpha + \beta = 0.41$ and $\eta = 0.49$ which are the respective labor shares in the agriculture, manufacturing and services sectors. We do not have any information to determine the land and capital intensities of manufacturing production. So we take them to be almost equal $\alpha = 0.20$ and $\beta = 0.21$. Note, the values of factor intensities satisfy Assumptions (2) and (3).

Total labor force is captured by the 'full-time and part-time employees' data. We calculate the compounded annual growth rate of total employment for 1998-2012 and choose it as the population growth rate, leading to $g_L = 1.004$. The sectoral TFP growth rates are calculated such that they match the sectoral output growth rates witnessed in 1998-2012. Following the methodology in Acemoglu and Guerrieri (2008), the total factor productivity growth rates calculated are $g_A = 1.0178$, $g_M = 1.0142$ and $g_S = 1.0096$.

The preference parameters, ϕs, for different goods are taken from the average sectoral shares in value-added. We get $\phi_a = 0.01$, $\phi_m = 0.17$ and $\phi_s = 0.82$.

The standard parameter value for annual discount rate is adopted, which gives the discount factor $\rho = 0.98$ (Acemoglu and Guerrieri (2008)). Total US land area is 10 million square km, so $\bar{D} = 10$.

As we characterize the transitional dynamics *near* the steady state, the initial period considered in simulation is 2012. In 2012 employment in the three sectors was 108768 thousand employees, which is scaled to get $L_0 = 100$. Capital stock, measured by the real intermediate inputs, gives $K_0 = 78.64$. The TFP parameters are calculated so that they match the output levels, $A_0 = 94.5$, $M_0 = 125.5$ and $S_0 = 112.5$.

Overall Trends

Given $\mathcal{K}_0 < \mathcal{K}^*$, in this economy both normalized capital stock and normalized expenditure grow monotonically over time to approach their steady state values (Figure 4.1). This matches the trajectories for $\mathcal{K}_t$ and $\mathcal{E}_t$ which were analytically derived in Appendix 4.B.

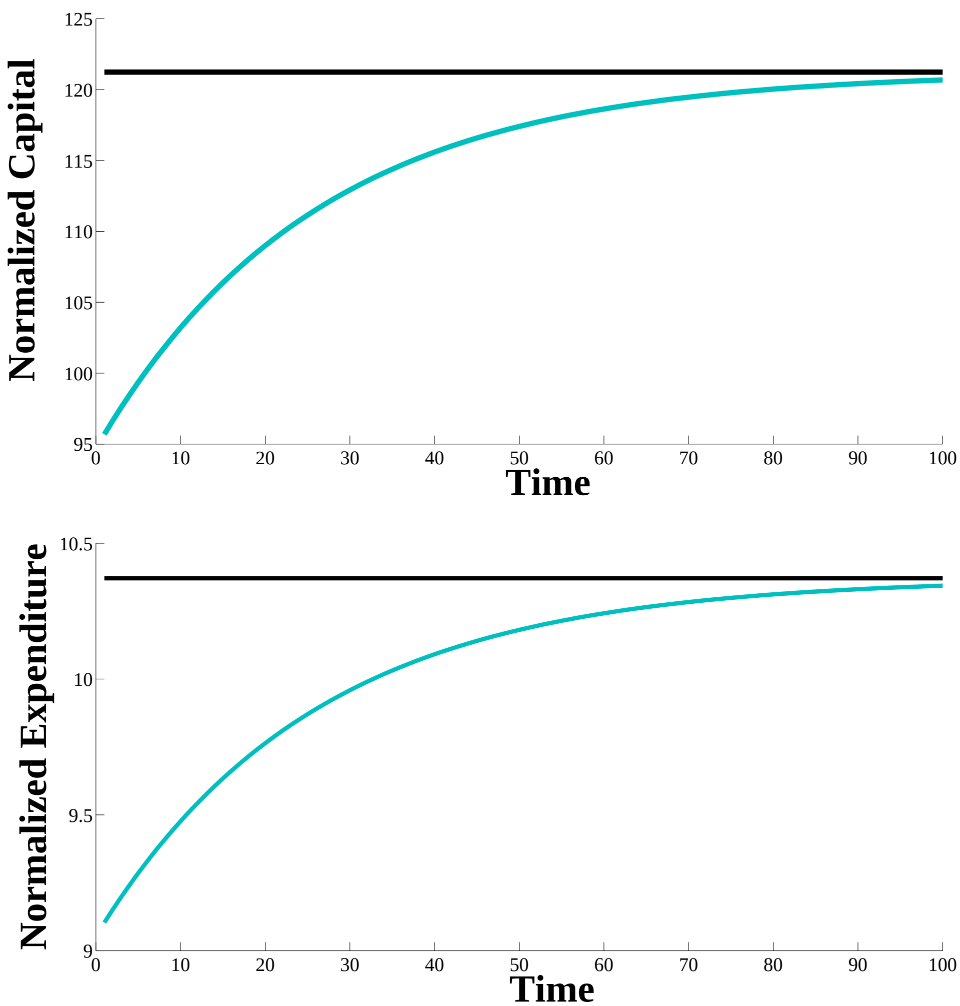


Figure 4.1: Transition Dynamics of Normalized Capital and Normalized Expenditure.

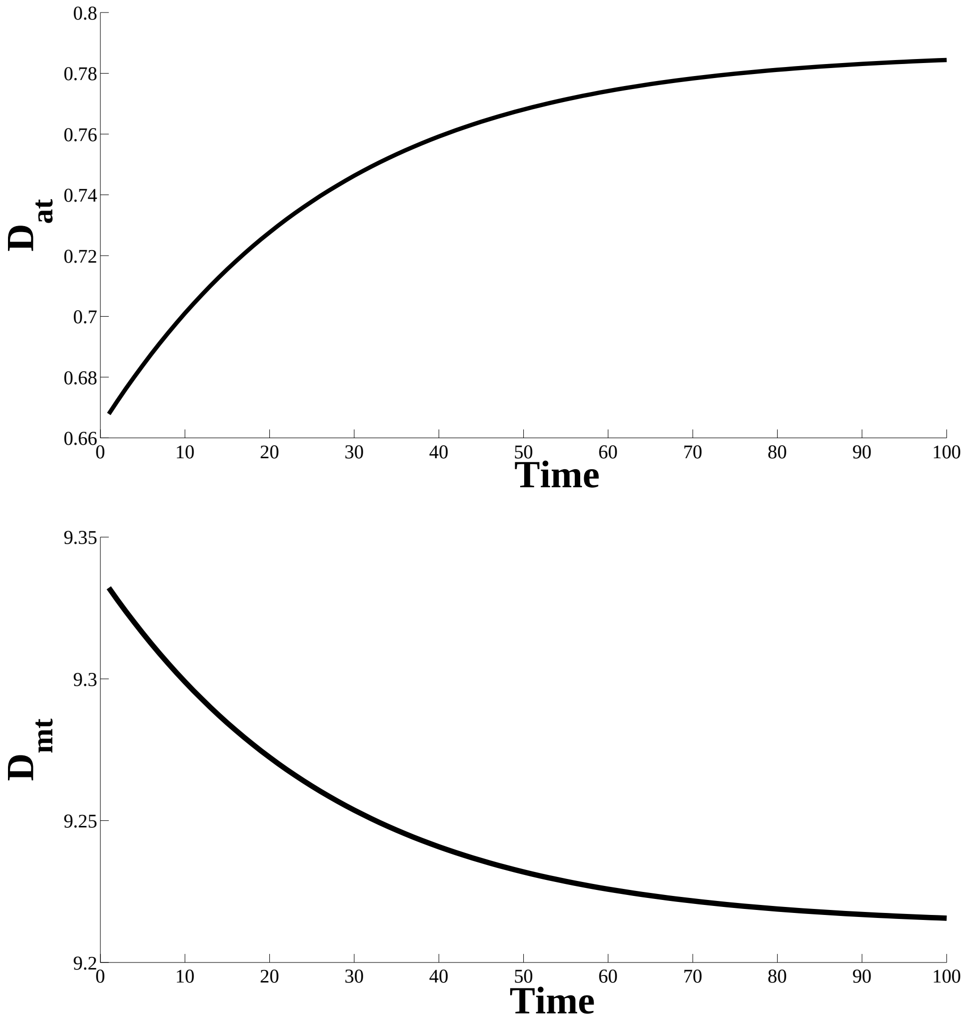


Figure 4.2: Transition Dynamics of Land Allocations.

Regarding the sectoral factor-input growth rates, simulations show that the factor proportions are skewed in favor of the manufacturing sector

$$\frac{D_{a1}}{D_{m1}} < \left(\frac{D_{at}}{D_{mt}}\right)^*, \quad \frac{L_{a1}}{L_{m1}} < \left(\frac{L_{at}}{L_{mt}}\right)^*, \quad \frac{L_{s1}}{L_{m1}} < \left(\frac{L_{st}}{L_{mt}}\right)^*, \quad \frac{K_{s1}}{K_{m1}} < \left(\frac{K_{st}}{K_{mt}}\right)^*.$$

In the initial period ($t = 1$), the manufacturing sector has more share of land, capital and labor than in steady state. This may be attributed to the fact that as the initial capital stock is low ($\mathcal{K}_0 < \mathcal{K}^*$), the manufacturing sector appropriates input resources to produce more output and hence more capital. Over time, as capital grows the manufacturing sector releases land, capital and labor to the other production sectors. Hence, the input-factors grow at a faster rate in the agriculture and services sectors than in the manufacturing sector,

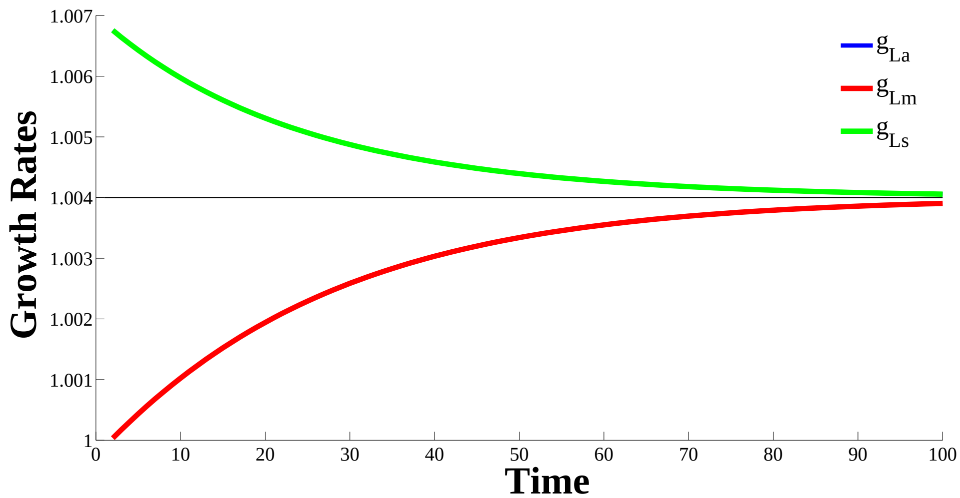


Figure 4.3: Transition Dynamics of Employment Growth Rates.

which in turn implies that the factor ratios rise to their steady state values.

Particularly, the land ratio D_{at}/D_{mt} rises over time and land moves from the manufacturing sector to the agricultural sector (Figure 4.2). Further, the labor ratios L_{at}/L_{mt} and L_{st}/L_{mt} grow and hence employment grows faster in services and agriculture as compared to manufacturing (Figure 4.3). By similar logic, capital in services sector grows faster than that in manufacturing sector. These trends indicate that the economy is in case (a), whereby factor inputs in the agriculture and services sectors grow faster than their respective manufacturing counterparts, as discussed in Section 4.3.4. This also implies that growth rates of agriculture and services outputs are initially high and over time fall to their respective steady state growth rates. We see this in Figure 4.4. Further, simulations show that the manufacturing output growth rate, whose trajectory was ambiguous analytically, is increasing over time (Figure 4.4).

In short run, the sectoral output growth ranking varies with time however in steady state, services sector (the least land intensive sector) has the highest growth rate followed by manufacturing and agriculture (the most land intensive sector). Note, the steady state sectoral output growth ranking is exactly reverse of the sectoral TFP growth rankings. This highlights the importance of factor intensity differences in explaining non-balanced sectoral growth.

The output growth gaps can be decomposed into their long run and short run sources. The long run sources of sectoral output growth differentials affect the output growth ranking

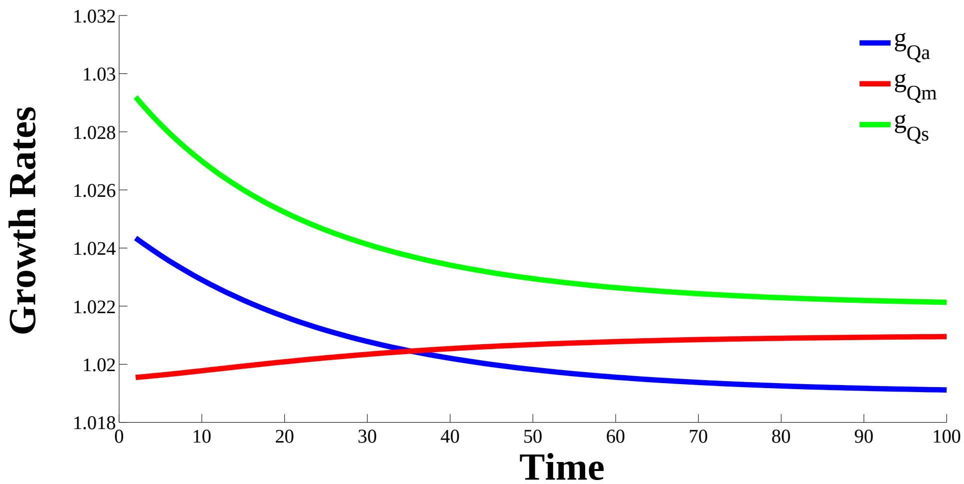


Figure 4.4: Sectoral Output Growth Rates.

in both transitional periods and steady state, where the magnitude of their effect may vary over time but never be zero. In contrast to this, the short run sources of growth differentials affect only the transition periods and in steady state their effect vanishes. Primarily there are two agents which cause differences in growth rates of sectoral output (say, sector i and j):

1. If TFP of sector i and j grow at different rates, then it would induce differences in their output growth rates. This is a long run source of output growth differentials as the effect of TFP growth differences persist in both transitional periods and steady state.

2. Differences in factor intensities of sectors i and j have both long run and short run effects on sectoral output growth gaps. Factor intensities affect output growth only in conjunction with factor growth. Note, a sector's input-factor may grow because of two reasons: either the input share of that sector is expanding over time or the total supply of that input is growing over time. The effect of differences in factor intensities on output growth gaps which manifest due to differences in growth rate of sectoral input shares, is termed the short run effects of factor intensity differences. Similarly, when factor intensity differences manifest together with growth of total supply of factor-input, it constitutes the long run sources of output growth differentials.

We now discuss the different sources of non-balanced growth in greater detail.

Analyzing Non-balanced Growth

To quantify the different sources of non-balanced growth, we rewrite the sectoral production functions as

$$Q_{at} = A_t \bar{D}^{\gamma} L_t^{1-\gamma} d_{at}^{\gamma} l_{at}^{1-\gamma}, \qquad Q_{mt} = M_t \bar{D}^{\alpha} L_t^{\beta} K_t^{1-\alpha-\beta} d_{mt}^{\alpha} k_{mt}^{\beta} l_{mt}^{1-\alpha-\beta},$$
$$Q_{st} = S_t K_t^{\eta} L_t^{1-\eta} k_{st}^{\eta} l_{st}^{1-\eta},$$

where $d_{it} \equiv D_{it}/\bar{D}$, $l_{it} \equiv L_{it}/L_t$ and $k_{it} \equiv K_{it}/K_t$ are the respective land, labor and capital shares for sector i. By writing the production function in this form, we have derived it in terms of the factor shares, which influence the short run growth dynamics. Following the methodology described in (4.11) and using $g_{Kt} = g_{\mathcal{K}_t} \left(g_M g_L^{1-\alpha-\beta} \right)^{1/(1-\beta)}$, we decompose the sectoral growth rates into its long run and short run sources. The decomposed output growth gaps are

$$\tilde{g}_{Qm} - \tilde{g}_{Qa} = [\tilde{g}_M - \tilde{g}_A] + \left(\gamma - \frac{\alpha}{1-\beta} \right) \tilde{g}_L + \left[\frac{\beta}{1-\beta} \tilde{g}_M + \beta \tilde{g}_{\mathcal{K}_t} \right]$$
$$+ [(\alpha \tilde{g}_{dm} - \gamma \tilde{g}_{da}) + ((1-\alpha-\beta)\tilde{g}_{lm} - (1-\gamma)\tilde{g}_{la})] + [\beta \tilde{g}_{km}] \qquad (4.30)$$

$$\tilde{g}_{Qs} - \tilde{g}_{Qm} = [\tilde{g}_S - \tilde{g}_M] + \frac{\alpha(1-\eta)}{1-\beta} \tilde{g}_L + \left[\frac{\eta-\beta}{1-\beta} \tilde{g}_M + (\eta-\beta) \tilde{g}_{\mathcal{K}_t} \right]$$
$$+ [-\alpha \tilde{g}_{dm} + ((1-\eta)\tilde{g}_{ls} - (1-\alpha-\beta)\tilde{g}_{lm})] + [\eta \tilde{g}_{ks} - \beta \tilde{g}_{km}] . \qquad (4.31)$$

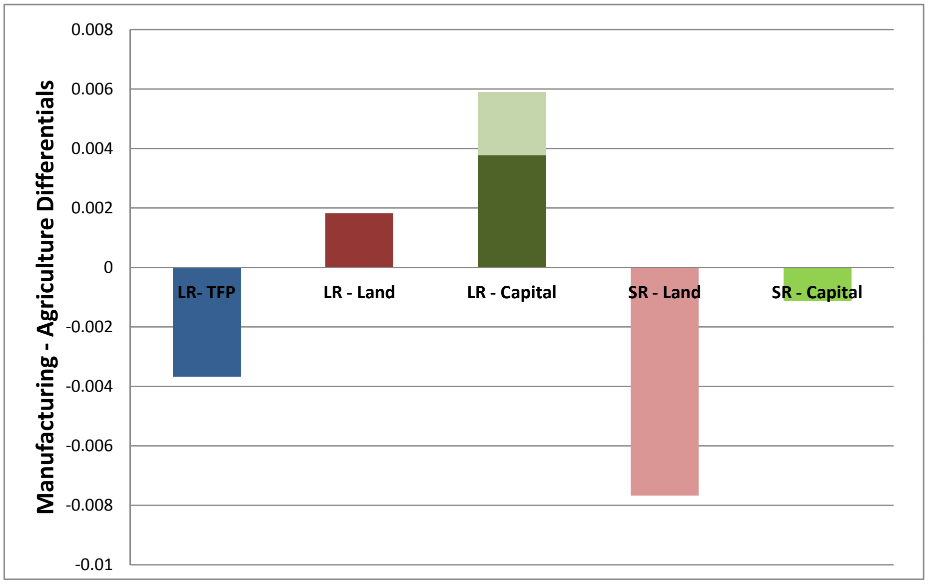
Note, the first three terms on the right hand side of the above expressions are the long run sources of differential sectoral output growth. The three terms respectively capture the contribution of sectoral TFP growth differences (LR TFP), long run contribution of differences in land intensity (LR Land) and long run contribution of differences in capital intensity (LR Capital) on the differential sectoral output growth rates. Note, as the growth rate of capital stock changes with time, there is a transitory component, $\tilde{g}_{\mathcal{K}_t}$, within the long run contribution of capital intensity differences (LR Capital). In steady state, when this transitory component vanishes, i.e. $\tilde{g}_{\mathcal{K}_t} = 0$, the long run sources of output growth differences fully explain the steady state differences in output growth rates and the expressions match eq. (4.29).

The last two square-bracketed terms on the right hand side of the above two equations account for the short run sources of output growth gaps. To be more precise, in (4.30) and (4.31), the fourth $[\cdot]$ term encapsulates the short run effect of land intensity differences (SR Land) and the last $[\cdot]$ term accounts for the short run effect of capital intensity differences (SR Capital) on output growth gap. Over time as input-factor shares tend to a constant at steady state, these short run effects of factor intensity differentials diminish and ultimately vanish at steady state. For time period $t = 2$, we present the magnitudes of these five sources of sectoral output growth gaps in Figure 4.5.

The five bars in both plots of Figure 4.5 constitute the different sources of sectoral output growth gaps. From left to right, the bars in the top (and bottom) plot represent the five terms of eqs. (4.30) (and (4.31) respectively). Note, the transitory component of long run contribution of capital intensity differences on sectoral growth differentials is highlighted by the light green area within LR Capital. Over time, this transitory component along with SR Land and SR Capital disappears.

The top plot of Figure 4.5 depicts the decomposition of the manufacturing-agriculture output growth gap as calculated in (4.30). One way to look at this plot is that the bars on the positive (or negative) y-axis favour higher growth of manufacturing (or agriculture) output as compared to agriculture (or manufacturing) output. The plot suggests that the short run sources of growth favor agriculture sector while the long run sources of growth cumulatively favor manufacturing sector. To understand this, remember that initially with low capital stock, the manufacturing sector had appropriated inputs relatively more than what was required in steady state. Over time, production factors shift away from the manufacturing sector and into the agriculture sector. Hence short run growth favors agricultural sector viz-a-viz the manufacturing sector. Within the long run sources of differential growth, even though TFP growth differences favor the agricultural sector, but land and capital intensity differences favor the manufacturing sector (as discussed in Proposition 4.7).

Of the two short run sources of growth gap, land intensity differentials have a greater effect on the output growth gap, while among the three long run sources of growth differences, capital intensity differences has the largest contribution towards the manufacturing-agriculture output growth gap. Thus, the more available input-factor has a larger explanatory power for sectoral output growth differentials. In the initial periods, capital stock is low while land is abundant, which explains the larger effect of land intensity differences in short run. However,



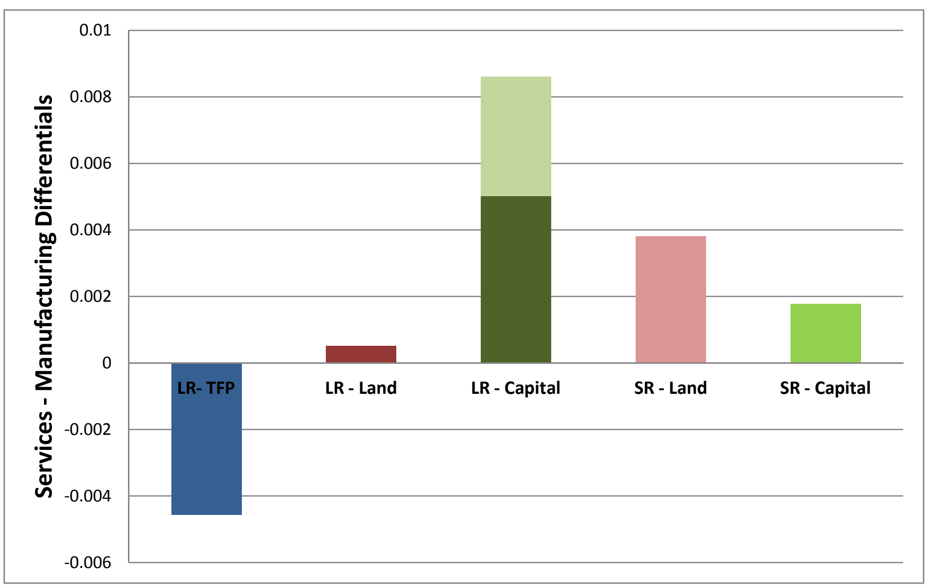


Figure 4.5: Different Sources of Growth Differentials at $t = 2$.

in long run sectoral land allocations are fixed while capital is abundant and growing. Thus in steady state, the capital intensity differences have a greater explanatory power. The scarce input-factor contributes less to growth as compared to the more abundant input-factor.

The lower plot of Figure 4.5 maps out the factors contributing to services-manufacturing growth gaps. The bars on the positive (or negative) y-axis favours higher output growth in the services (or manufacturing) sector. Unlike in the previous case, here both short run and long run sources of growth favor the growth in the services sector. The intuition for the effects of short run of sources of growth is the same as in the previous case. The manufacturing sector releases the initially appropriated input resources to the services sector which implies faster growth in the services sectors viz-a-viz manufacturing sector in the transitional periods. Further, the land intensity and capital intensity differences favor the services sector, as postulated in Proposition 4.7.

Regarding the explanatory power of the various sources of growth, as in the previous case, the capital intensity differentials explain a significant portion of the long run services-manufacturing output growth differentials. In the short run, land intensity differentials have a larger explanatory power. This follows from hypothesis that the abundant factor has greater contribution to growth differences.[10]

Note, we do not claim that land intensity differences are more or less important than capital intensity differences in explaining differential sectoral growth. We merely highlight that in transition periods or when an exogenous productivity shock deviates the economy from its balanced growth path, the land intensity differentials explain more of sectoral growth differences than capital intensity differences or sectoral productivity growth differentials. In steady state, the capital intensity differences appear to explain more of the output growth differences. Further note that if we account for growth in human capital, then the short run as well as the long run effects of land intensity effect shall get magnified. Unlike population

[10] Regarding the robustness of the results, observe that excluding the land and capital shares in manufacturing production (α and β), all parameter values have been derived from data. So we run sensitivity checks only with respect to these two parameters. As constant returns to scale exist in manufacturing sector, an increase in α is accompanied by a decrease in β to keep $\alpha + \beta$ unchanged (whose value is derived from data). An increase in manufacturing capital share β, increases the convergence rate and also affects the steady state variables but does not affect our results qualitatively. We find that a increase in β affects the short run sources of growth gaps much more than the long run sources of growth gaps. This is because factor growth rates are higher in short run, so a higher β has a larger effect on sectoral output growth gaps. Both short run and long run sources of output growth gaps are sensitive to changes in β, which indicates towards the importance of factor intensities in explaining output growth gaps. A decrease in α has similar effects as an increase in β.

growth, human capital accumulation does not have a natural limit and hence may grow at a much higher rate. This would strengthen the contribution of land intensity differences in explaining sectoral non-balanced growth.

4.4 Concluding Remarks

In recent decades, the services sector has recorded highest output and employment growth in almost all countries. Sectoral growth is lead by services sector and followed by manufacturing and agriculture, in that order. This phenomenon is mainly attributed to demand-side factors like non-homothetic preferences. There are a few supply-side explanations for the three sector growth ranking, but they are based on sectoral TFP growth rankings. As the ranking of sectoral TFP growth rates is not uniform across developing and developed countries, these explanations are applicable to mostly developed countries. In this chapter, we propose a supply-side phenomenon which explains the sectoral output growth ranking and is not country-specific. We regard that differences in factor intensities in goods production explain non-balanced growth. In particular, we postulate that given limited supply of land, the differences in land intensity across sectors manifest into differences in sectoral growth – highest growth of services (the least land intensive) sector followed by manufacturing and agriculture (the most land intensive sector).

Our analysis began with a three-sector model with only land and labor as inputs. Labor and sectoral TFP grow over time at exogenous rates. We showed that differences in growth rates of sectoral outputs are due to differences in sectoral TFP growth rate as well as due to differences in sectoral land intensity. If TFP growth differences are not large, then land intensity differences determine the inter-sectoral growth ranking. Further, it is possible that output growth ranking may be exactly opposite of TFP growth ranking.

We also extended this basic model by including capital in the production of manufacturing and services goods and incorporating endogenous accumulation of capital. Labor growth and sectoral TFP growth continue to be the sources of long run growth. Now, capital intensity differences in addition to differences in sectoral TFP growth rates and land intensity differences, all three contribute to the sectoral output growth differences. In transitional periods, the input-factor movements are entwined and it is not possible toe characterize the exact trajectories of the economy. We simulate the model to analyze short run trends. We find that as the initial capital stock is low, initially manufacturing sector appropriates all input resources more than what is required in the steady state. Over time, it releases land to agriculture and slows down its pace of capital and land use relative to other sectors. We also decompose sectoral growth differentials to analyze the strengths of the different sources of growth. We find that the more available input-factor contributes more to sectoral growth differences. Hence, in short run land intensity differences play a larger role in explaining non-balanced growth and in long run the capital intensity differences have a larger explanatory power.

In this chapter, we have presented a supply-side explanation for higher growth of the services sector as compared to manufacturing and agriculture which can be applied to both developing and developed countries. While this analysis is confined to a closed economy, introducing international trade – in goods *and* services – which would permit analyzing growth of the services sector in the context of the global economy. In the next chapter, we incorporate three-sectors in an open economy. The production sectors are different from what we have presented in this chapter. In a more simplified framework, we characterize the differential impact of commodities trade and services trade on trading patterns and the sectoral growth rates.

Appendix 4.A

In this Appendix we prove Proposition 4.1.

We use Jones's "hat" calculus, where equations are log-differentiated and proportionate change variables are indicated by a '$\hat{.}$' Zero-profit conditions imply

$$\begin{aligned} \gamma \hat{r}_{Dt} + (1-\gamma)\hat{w}_t &= \hat{p}_{at} + \hat{A}_t \\ \alpha \hat{r}_{Dt} + (1-\alpha)\hat{w}_t &= \hat{M}_t \\ \hat{w}_t &= \hat{p}_{st} + \hat{S}_t. \end{aligned} \tag{4.A.1}$$

Log-differentiating full-employment conditions,

$$\begin{aligned} \lambda_{Da}\left[\hat{Q}_{at} - (1-\gamma)(\hat{r}_{Dt} - \hat{w}_t)\right] + \lambda_{Dm}\left[\hat{Q}_{mt} - (1-\alpha)(\hat{r}_{Dt} - \hat{w}_t)\right] \\ = \hat{\bar{D}} + \lambda_{Da}\hat{A}_t + \lambda_{Dm}\hat{M}_t \\ \lambda_{La}\left[\hat{Q}_{at} + \gamma(\hat{r}_{Dt} - \hat{w}_t)\right] + \lambda_{Lm}\left[\hat{Q}_{mt} + \alpha(\hat{r}_{Dt} - \hat{w}_t)\right] + \lambda_{Ls}\hat{Q}_{st} \\ = \bar{L}_t + \lambda_{La}\hat{A}_t + \lambda_{Lm}\hat{M}_t + \lambda_{Ls}\hat{S}_t, \end{aligned} \tag{4.A.2}$$

where λ_{Nj} is share of factor N employed in sector j.

Market-clearing conditions imply

$$\begin{aligned} \hat{Q}_{mt} - \hat{Q}_{at} &= \hat{p}_{at} \\ \hat{Q}_{mt} - \hat{Q}_{st} &= \hat{p}_{st}. \end{aligned} \tag{4.A.3}$$

Eqs. (4.A.1) and (4.A.3) imply

$$\begin{aligned} (\gamma - \alpha)(\hat{r}_{Dt} - \hat{w}_t) &= \hat{Q}_{mt} - \hat{Q}_{at} + \hat{A}_t - \hat{M}_t \\ \alpha(\hat{r}_{Dt} - \hat{w}_t) &= \hat{Q}_{st} - \hat{Q}_{mt} + \hat{M}_t - \hat{S}_t. \end{aligned} \tag{4.A.4}$$

Substituting the above into (4.A.2), we solve $\hat{Q}_{at}$, $\hat{Q}_{mt}$ and $\hat{Q}_{st}$:

$$\begin{aligned} \hat{Q}_{at} &= \hat{A}_t + \gamma\hat{\bar{D}} + (1-\gamma)\hat{L}_t \\ \hat{Q}_{mt} &= \hat{M}_t + \alpha\hat{\bar{D}} + (1-\alpha)\hat{L}_t \\ \hat{Q}_{st} &= \hat{S}_t + \hat{L}_t. \end{aligned} \tag{4.A.5}$$

Eqs. (4.A.5) imply the proportionality relations for outputs claimed in Proposition 4.1. Substituting (4.A.5) into (4.A.3) yields proportionality relations for relative prices. Proportionality relations for factor prices follow from (4.A.1) once we know those of relative prices. Those for output and prices implies the proportionality relation for E_t. We have

$$\begin{aligned}
\hat{D}_{at} &= \hat{Q}_{at} - (1-\gamma)(\hat{r}_{Dt} - \hat{w}_t) - \hat{A}_t = \hat{\bar{D}} \\
\hat{D}_{mt} &= \hat{Q}_{mt} - (1-\alpha)(\hat{r}_{Dt} - \hat{w}_t) - \hat{M}_t = \hat{\bar{D}} \\
\hat{L}_{at} &= \hat{Q}_{at} + \gamma(\hat{r}_{Dt} - \hat{w}_t) - \hat{A}_t = \hat{L}_t \\
\hat{L}_{mt} &= \hat{Q}_{mt} + \alpha(\hat{r}_{Dt} - \hat{w}_t) - \hat{M}_t = \hat{L}_t \\
\hat{L}_{st} &= \hat{Q}_{st} - \hat{S}_t = \hat{L}_t,
\end{aligned}$$

where we have made use of (4.A.4) and (4.A.5).

The above expressions imply the proportionality relations for sectoral factor employment in Proposition 4.1. The proportionality relations of relative prices follow from (4.A.3). In turn, those of input prices follow from (4.A.1). Finally, since, in equilibrium, $E_t \propto Q_{mt}$; hence their proportionality relations are the same.

Appendix 4.B

Proof of Proposition 4.5

The full employment conditions (4.17)-(4.19) yield the following expressions of value of sectoral outputs in terms of aggregate earnings of three factors: land, labor and capital.

$$\begin{aligned}
\theta_1 p_{at} Q_{at} &= [(1-\alpha)\eta - \beta] r_{Dt} \bar{D} - \alpha\eta w_t L_t + \alpha(1-\eta) r_t K_t \\
\theta_1 p_{st} Q_{st} &= \beta(1-\gamma) r_{Dt} \bar{D} - \beta\gamma w_t L_t + [(1-\beta)\gamma - \alpha] r_t K_t \\
\theta_1 Q_{mt} &= -(1-\gamma)\eta r_{Dt} \bar{D} + \gamma\eta w_t L_t - \gamma(1-\eta) r_t K_t.
\end{aligned} \tag{4.A.6}$$

where $\theta_1 \equiv \gamma(\eta - \beta) - \alpha\eta$.

Next, the demand functions (5.6) along with agriculture and services goods market clearing conditions $L_t C_{at} = Q_{at}; L_t C_{st} = Q_{st}$ imply $p_{at} Q_{at} = \phi_a E_t;\ p_{st} Q_{st} = \phi_s E_t$. Substituting the above into the first two expressions of (4.A.6) and dividing the resulting equations by

$(M_t\bar{D}^{\alpha}L_t^{1-\alpha-\beta})^{1/(1-\beta)}$ and rearranging give rise to

$$\begin{aligned}\beta\mathcal{R}_{dt} &= \alpha r_t\mathcal{K}_t + \theta_2\mathcal{E}_t \\ \frac{\beta}{\mathcal{R}_{dt}^{\frac{\alpha}{1-\alpha-\beta}}} &= \theta_3\mathcal{E}_t r_t^{\frac{\beta}{1-\alpha-\beta}} + (1-\alpha-\beta)r_t^{\frac{1-\alpha}{1-\alpha-\beta}}\mathcal{K}_t.\end{aligned} \tag{4.A.7}$$

where $\theta_2 \equiv \phi_a\beta\gamma - \phi_s\alpha\eta \gtreqless 0$, $\theta_3 \equiv \phi_a\beta(1-\gamma) - \phi_s[(1-\alpha)\eta - \beta] \gtreqless 0$, $\mathcal{K}_t$ and $\mathcal{E}_t$ are as defined in (4.20) and

$$\mathcal{R}_{dt} = \frac{r_{Dt}}{M_t^{\frac{1}{1-\beta}}\bar{D}^{-\frac{1-\alpha-\beta}{1-\beta}}L_t^{\frac{1-\alpha-\beta}{1-\beta}}}. \tag{4.A.8}$$

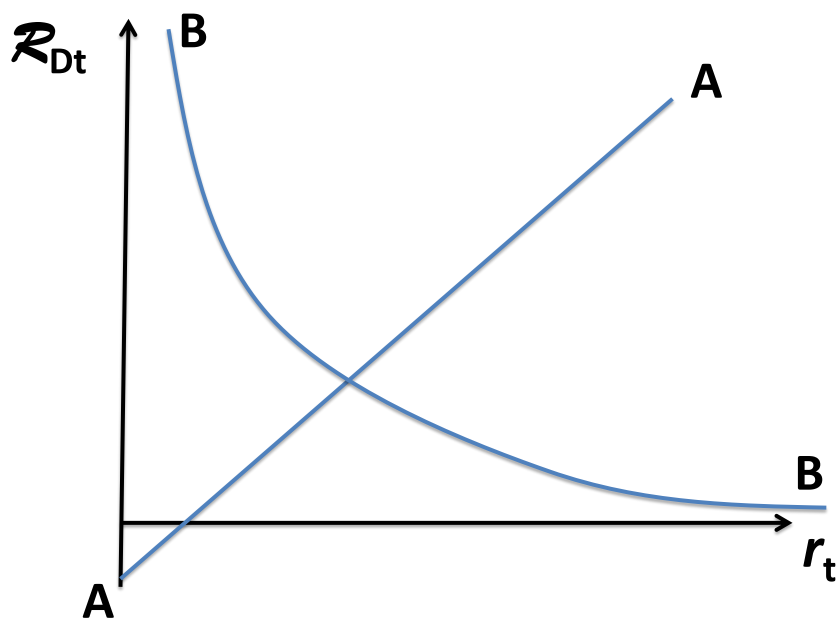


Figure 4.6: The Reduced Form Static System

We can call $\mathcal{R}_{dt}$ the normalized land rental, just as $\mathcal{K}_t$ and $\mathcal{E}_t$ are the normalized capital stock and normalized total expenditure. (As discussed in the text, all normalized variables become constant or time-invariant along the steady state.) Eqs. (4.A.7) implicitly solve $\mathcal{R}_{Dt}$ and r_t as functions of $\mathcal{K}_t$ and $\mathcal{E}_t$. As shown in Figure 4.6, the first equation in (4.A.7) defines a upward sloping straightline (AA) relating $\mathcal{R}_{Dt}$ and r_t, whose intercept on the vertical axis may be positive or negative as $\theta_2 \gtreqless 0$. The second equation in (4.A.7) defines a negative locus between $\mathcal{R}_{Dt}$ and r_t (BB), which is asymptotic to the horizontal axis and asymptotic to the vertical line at $r_t = \xi$, where $\xi \geq 0$ depending on the sign and magnitude of θ_3. Hence a unique intersection between AA and BB in the first is assured. That is, solutions to $\mathcal{R}_{Dt}$ and r_t exist and they are unique. Accordingly, let

$$\mathcal{R}_{dt} = f_{rD}(\mathcal{K}_t, \mathcal{E}_t); \quad r_t = f_r(\mathcal{K}_t, \mathcal{E}_t).$$

Following the definition of $\mathcal{R}_{dt}$,

$$r_{Dt} = M_t^{\frac{1}{1-\beta}} \bar{D}^{-\frac{1-\alpha-\beta}{1-\beta}} L_t^{\frac{1-\alpha-\beta}{1-\beta}} \cdot f_{rD}(\mathcal{K}_t, \mathcal{E}_t).$$

The zero-profit condition for the manufacturing sector yields the expression of w_t in Proposition 4.5, where $f_w(\mathcal{K}_t, \mathcal{E}_t)$ is a function of $f_{rD}(\mathcal{K}_t, \mathcal{E}_t)$ and $f_r(\mathcal{K}_t, \mathcal{E}_t)$. In turn, the zero-profit conditions for the agriculture and service sectors imply the expressions of relative prices, where $f_{pa}(\cdot)$ and $f_{ps}(\cdot)$ are functions of $f_{rD}(\cdot)$, $f_r(\cdot)$ and $f_w(\cdot)$. Substituting factor price and product price expressions into (4.A.6) gives the output expressions in Proposition 4.5. Sectoral employment of a factor is a product of the respective factor coefficient - a function of factor prices - and output. Hence expressions of factor prices and outputs lead to the expressions of factor employments in Proposition 4.5. ■

Existence and Uniqueness of the Steady State

Instead of using the implicit function $f_r(\mathcal{K}_t, \mathcal{E}_t)$, we use the reduced form static system (4.A.7) for our purpose. Substituting to these equations the steady state relations (4.27), we obtain two equations in $\mathcal{R}_D^*$ and $\mathcal{K}^*$:

$$\frac{\mathcal{R}_D^*}{\mathcal{K}^*} = \frac{\phi_a\beta\gamma[(g^\circ - 1)(1-\beta\rho) + (1-\rho)] + \phi_s\alpha\beta\eta\rho(g^\circ - 1)}{\beta\rho(\phi_m\beta + \phi_s\eta)} \tag{4.A.9}$$

$$\beta\left(\frac{g^\circ - \rho}{\rho}\right)^{-\frac{\beta}{1-\alpha-\beta}} \frac{(\mathcal{R}_D^*)^{-\frac{\alpha}{1-\alpha-\beta}}}{\mathcal{K}^*} = \frac{[\phi_a\beta(1-\gamma) + \phi_s\beta][(g^\circ - 1)(1-\beta\rho) + (1-\rho)]}{\rho(\phi_m\beta + \phi_s\eta)} + \frac{\phi_s\beta(g^\circ - 1)\rho[(1-\alpha)\eta - \beta]}{\rho(\phi_m\beta + \phi_s\eta)} + \frac{\phi_s\beta(g^\circ - \rho)(1-\eta)}{\rho(\phi_m\beta + \phi_s\eta)}. \tag{4.A.10}$$

Eq. (4.A.9) is a linear, positively sloped relationship between $\mathcal{R}_D^*$ and $\mathcal{K}^*$, which goes through the origin. Eq. (4.A.10) defines a decreasing, relationship between $\mathcal{R}_D^*$ and $\mathcal{K}^*$, asymptotic to both axes. Hence an intersection point (steady state) exists and it is unique.

Transition Dynamics

The static system (4.A.7) yields an implicit function of rental rate in terms of the normalized variables, $r(\mathcal{K}_t, \mathcal{E}_t)$. The static system is rewritten as

$$\left(\frac{\alpha r_t \mathcal{K}_t + \theta_2 \mathcal{E}_t}{\beta}\right)^{-\frac{\alpha}{1-\alpha-\beta}} \beta r_t^{-\frac{\beta}{1-\alpha-\beta}} = (1-\alpha-\beta) r_t \mathcal{K}_t + \theta_3 \mathcal{E}_t.$$

Taking a logarithmic transformation, we get

$$\begin{aligned}\psi(r_t, \mathcal{K}_t, \mathcal{E}_t) \equiv \Upsilon &- \frac{\alpha}{1-\alpha-\beta} \ln(\alpha r_t \mathcal{K}_t + \theta_2 \mathcal{E}_t) \\ &- \frac{\beta}{1-\alpha-\beta} \ln(r_t) - \ln((1-\alpha-\beta) r_t \mathcal{K}_t + \theta_3 \mathcal{E}_t).\end{aligned}$$

where Υ is a constant. Differentiating the above with respect to r_t, $\mathcal{K}_t$ and $\mathcal{E}_t$, we get

$$\begin{aligned}\frac{\partial \psi}{\partial r_t} &= -\frac{\alpha^2 \mathcal{K}_t}{(1-\alpha-\beta)(\alpha r_t \mathcal{K}_t + \theta_2 \mathcal{E}_t)} - \frac{\beta}{(1-\alpha-\beta) r_t} - \frac{(1-\alpha-\beta)\mathcal{K}_t}{(1-\alpha-\beta) r_t \mathcal{K}_t + \theta_3 \mathcal{E}_t} < 0 \\ \frac{\partial \psi}{\partial \mathcal{K}_t} &= -\frac{\alpha^2 r_t}{(1-\alpha-\beta)(\alpha r_t \mathcal{K}_t + \theta_2 \mathcal{E}_t)} - \frac{(1-\alpha-\beta) r_t}{(1-\alpha-\beta) r_t \mathcal{K}_t + \theta_3 \mathcal{E}_t} < 0 \\ \frac{\partial \psi}{\partial \mathcal{E}_t} &= -\frac{\alpha \theta_2}{(1-\alpha-\beta)(\alpha r_t \mathcal{K}_t + \theta_2 \mathcal{E}_t)} - \frac{\theta_3}{(1-\alpha-\beta) r_t \mathcal{K}_t + \theta_3 \mathcal{E}_t} \lesseqgtr 0.\end{aligned} \tag{4.A.11}$$

Thus, the partial derivatives of f_r with respect to $\mathcal{K}_t$ and $\mathcal{E}_t$ are

$$\begin{aligned}f_{r1} &\equiv \frac{\partial f_r}{\partial \mathcal{K}_t} = -\frac{\partial \psi / \partial \mathcal{K}_t}{\partial \psi / \partial r_t} \equiv -\frac{\psi_{\mathcal{K}}}{\psi_r} < 0 \\ f_{r2} &\equiv \frac{\partial f_r}{\partial \mathcal{E}_t} = -\frac{\partial \psi / \partial \mathcal{E}_t}{\partial \psi / \partial r_t} \equiv -\frac{\psi_{\mathcal{E}}}{\psi_r} \lesseqgtr 0\end{aligned}$$

where ψ_r, $\psi_{\mathcal{K}}$ and $\psi_{\mathcal{E}}$ are the three expressions in (4.A.11). The dynamic system (4.25) is linearized at the steady state to give

$$\begin{bmatrix} \Delta \mathcal{K}_{t+1} \\ \Delta \mathcal{E}_{t+1} \end{bmatrix} = \begin{bmatrix} \frac{\partial \mathcal{K}_{t+1}}{\partial \mathcal{K}_t} & \frac{\partial \mathcal{K}_{t+1}}{\partial \mathcal{E}_t} \\ \frac{\partial \mathcal{E}_{t+1}}{\partial \mathcal{K}_t} & \frac{\partial \mathcal{E}_{t+1}}{\partial \mathcal{E}_t} \end{bmatrix} \begin{bmatrix} \Delta \mathcal{K}_t \\ \Delta \mathcal{E}_t \end{bmatrix}.$$

where $\Delta x_t = x_t - x^*$. The transition matrix, lets call it Λ, has elements

$$\frac{\partial \mathcal{K}_{t+1}}{\partial \mathcal{K}_t} = \frac{1}{g^\circ} \left[\frac{\mathcal{K} f_{r1} + f_r}{\beta} + 1\right] \equiv \Lambda_{\mathcal{K}\mathcal{K}} > 0$$

$$\frac{\partial \mathcal{K}_{t+1}}{\partial \mathcal{E}_t} = \frac{\mathcal{K} f_{r2} - (\phi_m \beta + \phi_s \eta)}{\beta g^\circ} \equiv \Lambda_{\mathcal{K}\mathcal{E}} < 0$$
$$\frac{\partial \mathcal{E}_{t+1}}{\partial \mathcal{K}_t} = \frac{\rho \mathcal{E} f_{r1} \Lambda_{\mathcal{K}\mathcal{K}}}{g^\circ - \rho \mathcal{E} f_{r2}} \equiv \Lambda_{\mathcal{E}\mathcal{K}} < 0$$
$$\frac{\partial \mathcal{E}_{t+1}}{\partial \mathcal{E}_t} = \frac{g^\circ + \rho \mathcal{E} f_{r1} \Lambda_{\mathcal{K}\mathcal{E}}}{g^\circ - \rho \mathcal{E} f_{r2}} \equiv \Lambda_{\mathcal{E}\mathcal{E}} > 0,$$

where each element is evaluated at $(\mathcal{K}^*, \mathcal{E}^*)$. If λ_1 and λ_2 are the two eigenvalues, then

$$\lambda_1 + \lambda_2 = Tr(\Lambda), \qquad \lambda_1 * \lambda_2 = Det(\Lambda).$$

Using the properties of eigenvalues, we get

$$\lambda_1 = \frac{\Lambda_{\mathcal{K}\mathcal{K}} + \Lambda_{\mathcal{E}\mathcal{E}} - \sqrt{(\Lambda_{\mathcal{K}\mathcal{K}} + \Lambda_{\mathcal{E}\mathcal{E}})^2 - 4\Lambda_{\mathcal{K}\mathcal{E}}\Lambda_{\mathcal{E}\mathcal{K}}}}{2}$$

$$\lambda_2 = \frac{\Lambda_{\mathcal{K}\mathcal{K}} + \Lambda_{\mathcal{E}\mathcal{E}} + \sqrt{(\Lambda_{\mathcal{K}\mathcal{K}} + \Lambda_{\mathcal{E}\mathcal{E}})^2 - 4\Lambda_{\mathcal{K}\mathcal{E}}\Lambda_{\mathcal{E}\mathcal{K}}}}{2}$$

where λ_1 is the smaller eigenvalue. We find from the dynamic system that $Det(\Lambda) > 0$ and

$$(1-\lambda_1)(1-\lambda_2) = \frac{1}{1 - \frac{\rho \mathcal{E}}{g^\circ} f_{r2}} \cdot \frac{\rho \mathcal{E}(\phi_m \beta + \phi_s \eta)}{\beta (g^\circ)^2 \mathcal{K}} \cdot (\mathcal{K} f_{r1} + \mathcal{E} f_{r2}) < 0,$$

where we have used $r^* = g^\circ/\rho - 1$ and (4.A.11) to derive the sign of the expression. This implies that one of the eigenvalues is greater than one while the other is less than one. The system has a saddle path. Let $0 < \lambda_1 < 1$ be associated with the eigenvector $(\mu_{\mathcal{K}}, \mu_{\mathcal{E}})$. The trajectory for normalized capital is

$$\mathcal{K}_t - \mathcal{K}^* = \mu_{\mathcal{K}} \lambda_1^t.$$

At $t = 0$, $\mathcal{K}_t = \mathcal{K}_0$, which implies $\mu_{\mathcal{K}} = \mathcal{K}_0 - \mathcal{K}^*$. Thus,

$$\mathcal{K}_t = \mathcal{K}^* + (\mathcal{K}_0 - \mathcal{K}^*)\lambda_1^t$$

which implies that if the economy starts at a point when the initial normalized capital is smaller than the steady state normalized capital, the normalized capital monotonically grows to its steady state value. As $\mu_{\mathcal{E}} = -\Lambda_{\mathcal{E}\mathcal{K}} \mu_{\mathcal{K}} / (\Lambda_{\mathcal{E}\mathcal{E}} - \lambda_1)$, the trajectory for normalized expenditure is

$$\mathcal{E}_t = \mathcal{E}^* - \frac{\Lambda_{\mathcal{E}\mathcal{K}}(\mathcal{K}_0 - \mathcal{K}^*)}{\Lambda_{\mathcal{E}\mathcal{E}} - \lambda_1}\lambda_1^t.$$

Using the value of λ_1, it can be easily shown that $\Lambda_{\mathcal{E}\mathcal{E}} > \lambda_1$. Thus, if the initial normalized capital stock is low ($\mathcal{K}_0 < \mathcal{K}^*$) then we find that initial normalized expenditure is low ($\mathcal{E}_0 < \mathcal{E}^*$) and normalized expenditure monotonically grows over time to its steady state. At $t = 0$, the expenditure is

$$\mathcal{E}_0 = \mathcal{E}^* - \frac{\Lambda_{\mathcal{E}\mathcal{K}}(\mathcal{K}_0 - \mathcal{K}^*)}{\Lambda_{\mathcal{E}\mathcal{E}} - \lambda_1}.$$

5 International Trade in Commodities and Services: Static and Dynamic Effects

5.1 Introduction

The world economy has experienced phenomenal growth of the services sector in the post-war era, and a part of this rise is attributed to increased international trade in services. The volume of service imports tripled between 1994 and 2004 (Hoekman and Mattoo (2008)). According to WTO, the global value of cross-border export of services became 20% of world trade in commodities and services by the year 2007 (Francois and Hoekman (2010)).[1] Since the 1990s the average annual growth of trade in services is about 10%, and, a major share of it is constituted by trade in business services, inclusive of pure business services (those consumed mostly by businesses, like computer and information services, royalties and licensing fees, etc.) and services shared by both businesses and households such as transport, finance and communication.[2] According to WTO data, the share of services that are common to households and businesses in total service trade is about 50%.

Keeping in view the rising importance of services in national economies and in total basket of trade, this essay builds a framework which differentiates between trade in commodities (manufacturing) and trade in services and analyzes trade liberalization in commodities and services. Services are distinguished from commodities (manufacturing) in two respects: (a) income elasticity of demand for services by households exceeds that for manufacturing

[1] The share of service trade is about the same in 2012.

[2] See Breinlich and Criscuolo (2011).

and (b) services produced in different countries are differentiated, whereas manufacturing is homogeneous. In particular, the assumption (b) captures that services are typically less standardized across domestic and foreign service providers, whereas manufacturing products from competing trading countries are more standardized - in terms of horizontal differentiation.

The sequence of events assumed in our model is the following. Starting from autarky, trade liberalization (free trade) by countries occurs for commodities first, followed by that for services. Perfect competition prevails in all sectors, hence international trade leads to welfare gains. We focus on positive aspects while magnitudes of welfare gains are quantified using simulations.

Another distinguishing feature of the essay is that it analyzes both the static as well as dynamic (growth) effects trade liberalization in commodities and services are analyzed.

There are a few papers that analyze growth of manufacturing and the services in the context of an open economy, but, to our knowledge, none incorporating trade in both manufacturing and services. For example, Xu (1993) and Ishikawa (1992) consider international trade in (manufacturing) commodities only and assume that services are non-tradeables.[3] This essay, so far, is the only exposition which incorporates both business and consumer services as tradeables in an open economy framework.

Compared to the pioneering work of Grossman and Helpman (1992) and subsequent work on trade and endogenous growth, there are two major differences. First, while most of the existing literature on growth in open economies is centered on balanced growth, or growth rates of manufacturing versus agriculture (e.g. Matsuyama (1992)), this essay allows for differential or non-balanced growth across manufacturing and service sectors and analyzes how (free) international trade in commodities and services impacts the growth performance of these sectors individually. Second, instead of characterizing how international trade may affect long-run aggregate growth rate of an economy, e.g. via resource allocation to the R&D sector producing innovation as in Grossman-Helpman's work, or what the long-run growth rate of a country will be in the trading equilibrium, as in Acemoglu and Ventura (2002) for

[3] Xu (1993) builds a capital accumulation based Solovian growth model with a constant savings rate. It has three sectors: a consumable manufacturing, an investment good which is also a manufacturing product and a *consumer service* good. The objective is to explain the rise in the relative price of services and the employment share of the services sector. Ishikawa (1992) presents a simple dynamic model with agriculture, manufacturing and *business services*. Learning by doing in the business services (intermediate) sector is the source of endogenous growth. It finds that trade is accompanied by factor reallocation which in turn changes industrial structure, comparative advantage and accelerates economic growth.

example, this exposition emphasizes growth rates *during transition periods* - which may be interpreted as the short or the medium run. In our model, long-run or asymptotic growth rate is not affected by international trade because the source of growth in our model – human capital accumulation – is unaffected by trade. Needless to say, yet important however, long term *levels* of consumption and welfare – which ultimately matter – can be substantially affected by growth rates during transition.

In standard growth models transitional dynamics results typically from adjustment costs of investment or diminishing returns to capital. In our model it stems from a completely different source, namely, the structure of preferences towards services in household consumption. As trade opens, there are static effects on resource allocation and output, which, in a dynamic framework, can be seen as initial, one-period level effects. During transition, level effects lead to growth effects having convergence properties.

In Section 5.2, we develop our model of growth for an autarkic (closed) economy, which serves as our reference economy. Free trade in commodities is introduced in Section 5.3. In Section 5.4, we analyze free trade in both commodities and services. Magnitudes of welfare gains from trade regime changes are presented and analyzed in Section 5.5. Section 5.6 concludes the essay.

5.2 Closed Economy

The framework of this chapter builds on our earlier work, Das and Saha (2013), which considered differential sectoral growth in a closed economy. Long term growth is not driven by physical capital accumulation, technology innovation or learning-by-doing. Instead, a simple process of human capital accumulation is presumed and there is one primary factor of production, namely, effective labor. The reason for choosing this source of growth, rather than accumulation of physical capital or technology innovation as in Grossman and Helpman (1992), is that it allows to focus on differences in growth rates across sectors in a simple one-primary-factor framework. This factor, which we call labor, can of course be broadly interpreted as a composite input.[4]

An economy has three sectors – manufacturing (M), services (S), and, following Mat-

[4] In this sense, it is akin to the use of a Ricardian model. Copeland and Taylor (1994) is a prominent example of how a one-primary-factor-based general equilibrium model can provide useful insights into complex issues such as international trade and environment.

suyama (2009) a “numeraire” sector (D). The presence of a third, numeraire sector allows us to consider trade in commodities (manufacturing), independent of trade in services. We assume that the economy obtains a fixed endowment of good D, say equal to E, at each instant of time.[5] We may regard D as food, although, by design, it is not meant to capture agriculture either in terms of diminishing-return-to-scale technology or less-than-unitary-income-elasticity of demand for food. Matsuyama (2009) does interpret his numeraire good as agriculture in that the income elasticity of demand for it is less than one. Kongsamut et al. (2001) also allow for a third sector, besides manufacturing and services, and interpret it as agriculture for the same reason. We refrain from doing so on the grounds that (a) our purpose is not to analyze growth over very long period of time incorporating transition from agriculture to non-agriculture sectors, and, (b) since 1970s, agriculture's share in total output and employment has remained small *and* relatively invariant in prominent developed economies.[6]

5.2.1 Household Sector

The representative household consumes all three goods: manufacturing, (consumer) services and food. At any time t, let $U_t \equiv {C_{mt}}^{\lambda_1}(C_{st}+\delta)^{\lambda_2}{C_{dt}}^{1-\lambda_1-\lambda_2},\ 0<\lambda_1,\lambda_2,\lambda_1+\lambda_2<1,\ \delta>0$ be the felicity function, where C_{mt} C_{st} and C_{dt} are consumptions of M, S and D. Note:

1. Services have been represented as such in preferences by many, including Echevarria (1997), Kongsamut et al. (2001), Ngai and Pissarides (2008), Foellmi and Zweimller (2008) and Matsuyama (2009). Matsuyama (1992) states explicitly that ‘luxurious’ goods, like services, have income elasticity higher than one. Schettkat and Yocarini (2006) provides a review of cross-country studies on services, such as personal services or in some cases all services excluding distributional services (retail trade and wholesale trade), and reports income elasticity of these services to be greater than unity.

2. Presence of the parameter δ implies:

   a. Consumer services are not “essential” and hence income elasticity of demand for

[5] More generally we may postulate a positive growth rate of E which is lower than the growth rate of outputs in manufacturing or services.

[6] For example, in the period 1970-2007, agricultural output in the U.S. fell from 4% of GDP to 1% of GDP; manufacturing output fell from 35% of GDP to 22% of GDP; and services rose from 61% of GDP 77% of GDP. Similar magnitudes of sectoral output changes were seen in developed countries like UK, Japan, etc. *Source:* World Development Indicators, World Bank Database.

such services exceeds unity. Per se, it would imply a higher growth rate of the services sector than manufacturing.

b. Intertemporal rate of substitution of the service basket over time is variable, implying transitional dynamics of output and employment in this sector. Thus it is the non-essentiality parameter δ which delivers (transitional) growth effects in our model economy.

c. The parameter δ being constant, as the economy grows, household consumption of services become more and more essential overtime relatively. Hence income elasticity of demand for consumer services declines over time towards unity and thus the services-sector growth rate would monotonically fall over time.

At each t the household's static optimization problem is: $\max U_t$ subject to $p_{mt}C_{mt} + p_{st}C_{st} + C_{dt} \leq B_t$, where B_t is the sum of wage earnings and the value of the endowment E, and p_{mt} and p_{st} are the respective relative prices in terms of good D. The first-order conditions and the indirect utility function are:

$$\frac{\lambda_1}{\lambda_2} \cdot \frac{C_{st} + \delta}{C_{mt}} = \frac{p_{mt}}{p_{st}}; \quad \frac{\lambda_1}{1 - \lambda_1 - \lambda_2} \cdot \frac{C_{dt}}{C_{mt}} = p_{mt}$$

$$V_t = \frac{A(B_t + \delta p_{st})}{p_{mt}^{\lambda_1} p_{st}^{\lambda_2}} \tag{5.1}$$

$$\text{where } A \equiv \lambda_1^{\lambda_1} \lambda_2^{\lambda_2} (1 - \lambda_1 - \lambda_2)^{1 - \lambda_1 - \lambda_2}.$$

Note that through the parameter δ, the price of the service good, p_{st}, has a *positive* effect on utility, although its overall effect on utility is negative. Two important remarks are in order.

Remarks

1. The positive effect of p_{st} on utility is like an income effect. Since δ measures the degree of how less essential services are, compared to other consumption goods (M and D), δp_{st} can be interpreted as *quasi real income* which is not spent on services because they are not essential but can be spent on other goods. Indeed it can be verified that expenditure on M or D is a constant fraction of the sum of actual income B_t and quasi income δp_{st}.

2. Notice that if δ were equal to zero, $V_t \propto B_t / p_{mt}^{\lambda_1} p_{st}^{\lambda_2}$, where the latter is real income or GDP. While this is the (standard) basis of taking real GDP as the measure of

aggregate welfare, it is not valid within the purview of our model which features non-homotheticity. In Section 5.5 we take

$$\frac{B_t + \delta p_{st}}{p_{mt}^{\lambda_1} p_{st}^{\lambda_2}} \tag{5.2}$$

as the welfare measure and call it the *real adjusted income.*

The dynamic problem of the household will be introduced later.

5.2.2 Production Sectors

Both production sectors, M and S, have constant-returns technology and perfect competition prevails in both. The former is produced by 'effective labor' and business services and the latter by effective labor and manufacturing. The term 'effective' reflects that labor embodies human capital. Modern services use various 'consumables,' which are manufactured products, not to mention computer and other machinery. Technologies are expressed in terms of unit cost functions:

$$\begin{aligned}\text{Services:}\frac{\tilde{c}_s(w_t, p_{mt})}{S} &= \frac{w_t^{\beta} p_{mt}^{1-\beta}}{S} \\ \text{Manufacturing:}\frac{\tilde{c}_m(w_t, p_{st})}{M} &= \frac{w_t^{\alpha} p_{st}^{1-\alpha}}{M},\end{aligned}$$

where S and M are the respective factor-neutral productivity parameters and w_t is the wage rate per unit of effective labor (*not* wage earning).

Since goods S and M are necessary for the production of sectors M and S respectively and additionally good M is essential in consumption, both goods must be produced in equilibrium. The following equations mark the zero-profit conditions: $\tilde{c}_s(w_t, p_{mt})/S = p_{st}$ and $\tilde{c}_m(w_t, p_{st})/M = p_{mt}$. They solve w_t and p_{st} in terms of p_{mt}:

$$w_t = \left(MS^{1-\alpha}\right)^{\frac{1}{\theta}} p_{mt}; \quad p_{st} = \phi p_{mt}, \text{where } \phi \equiv \left(\frac{M^{\beta/\alpha}}{S}\right)^{\frac{\alpha}{\theta}}; \ \theta \equiv \alpha + (1-\alpha)\beta. \tag{5.3}$$

Thus the wage rate and the price of services relative to manufacturing – or, equivalently, wage rate and the price of manufacturing relative to services – are "fixed" or time-invariant, given by technologies. Essentially, the production sector of our economy has a 2×2 structure: two sectors and two inputs (a. labor and b. services or manufacturing). It follows that input coefficients in both sectors are fixed.

5.2.3 Static General Equilibrium

From Section 5.3 onwards we consider a world economy with two countries, $k = h$ (home) or f (foreign). Static general equilibrium in country k in the absence of international trade is characterized by the following equations.

$$a_{lm}^{ka} Q_{mt}^{ka} + a_{ls}^{ka} Q_{st}^{ka} = \bar{L}_t^k \tag{5.4a}$$

$$C_{st}^{ka} + \delta = \frac{p_{mt}^{ka}}{p_{st}^{ka}} \frac{\lambda_2}{\lambda_1} C_{mt}^{ka} \tag{5.4b}$$

$$\frac{\lambda_1}{1 - \lambda_1 - \lambda_2} \cdot \frac{C_{dt}^{ka}}{C_{mt}^{ka}} = p_{mt}^{ka} \tag{5.4c}$$

$$C_{dt}^{ka} = E \tag{5.4d}$$

$$a_{sm}^{ka} Q_{mt}^{ka} + C_{st}^{ka} = Q_{st}^{ka} \tag{5.4e}$$

$$a_{ms}^{ka} Q_{st}^{ka} + C_{mt}^{ka} = Q_{mt}^{ka}, \tag{5.4f}$$

where the superscript ^{a} denotes autarky. The expressions of input coefficients are given in Appendix 5.A; note that $a_{sm}^{ka} a_{ms}^{ka} = (1 - \alpha)(1 - \beta) < 1$.

The first is the full-employment equation. The next two are the first-order conditions of household optimization. The next three respectively specify market clearing of the numeraire good, services and the manufacturing good. The price ratio, p_{mt}^{ka}/p_{st}^{ka}, being functions of technology parameters only, total outputs and household consumption of M and S are determined by (5.4a)-(5.4b) and (5.4e)-(5.4f).

We present autarky equilibrium in the familiar demand-supply diagram. In Figure 5.1, the downward sloping relative demand curve is based on (5.4c). In view of household consumption of manufacturing being determined independent of p_{mt}^{ka}, and, in equilibrium $C_{dt}^{ka} = E$, the vertical line is the relative "supply" curve of good M available for households. Autarky equilibrium is defined by the intersection of this line with the downward-sloping relative demand curve.

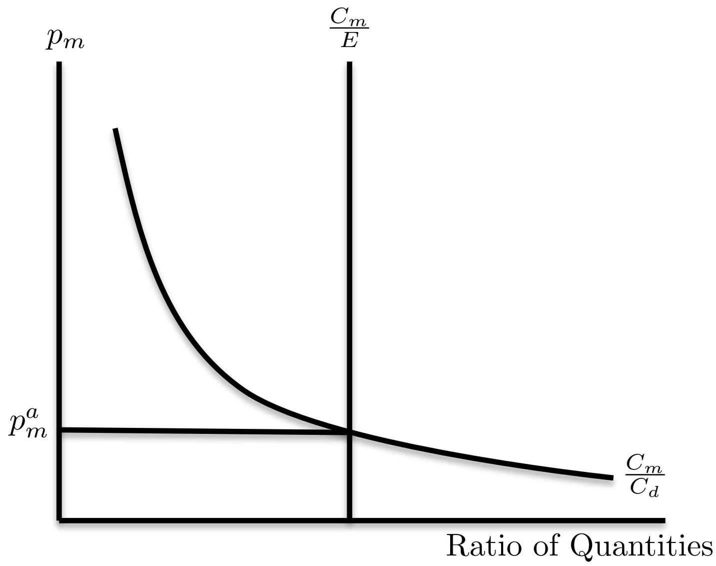


Figure 5.1: Autarky Equilibrium

5.2.4 Intertemporal Household Problem

We now turn to characterize the dynamics. At any given t, the representative household is endowed with one unit of time and inherits L_t units of effective labor or human capital. A part of this stock is used up in augmenting its human capital and the rest supplied to the production sectors. Let $H_t \in (0, 1)$ denote investment in human capital in terms of time. Within a time period, the household first commits to allocate such investment and then offers the remaining stock of effective labor to the production sectors for employment. Let

$$L_{t+1} = a_L H_t L_t, \quad a_L > 1, \tag{5.5}$$

describe the accumulation process of human capital. The tradeoff is that the higher the investment in human capital, the greater will be the stock of effective labor and hence the higher will be the total wage earnings in the future, but the less will be the total earnings in the current period.

If $t = 0$ is the initial period, given L_0, the household chooses $\{H_t\}_0^\infty$ and $\{L_t\}_1^\infty$ to maximize $\sum_0^\infty \rho^t V_t$ (where $\rho < 1$ is the discount factor and V_t is the indirect utility whose expression is given in (5.1)), subject to the human capital accumulation equation (5.5) and

$$B_t = w_t(1 - H_t)L_t + E.^7 \tag{5.6}$$

We obtain the following Euler equation:

$$\frac{B_{t+1} + \delta p_{st+1}}{w_{t+1}} \Big/ \frac{B_t + \delta p_{st}}{w_t} = \rho a_L.$$

A marginal increase in investment in human capital entails a current period loss of w_t, which translates into a marginal loss of current utility equal to $w_t/(B_t + \delta p_{st})$. It also entitles an increase in future utility equal to $a_L w_{t+1}/(B_{t+1} + \delta p_{st+1})$. The discounted value of the marginal gain is $\rho[a_L w_{t+1}/(B_{t+1} + \delta p_{st+1})]$. The Euler equation states that the marginal loss in terms of current utility is equal to the discounted value of the next-period marginal gain. Using the first-order conditions of static household optimization problem and the properties of the indirect utility function, the Euler equation can be more simply stated as

$$\frac{p_{mt+1}C_{mt+1}/w_{t+1}}{p_{mt}C_{mt}/w_t} = \rho a_L.^8 \tag{5.7}$$

We assume $\rho a_L > 1$, which ensures a positive growth rate of the economy.

5.2.5 Dynamics of the Economy

The ratio, w_t^{ka}/p_{mt}^{ka}, being time-invariant, eq. (5.7) reduces to

$$\frac{C_{mt+1}^{ka}}{C_{mt}^{ka}} = \rho a_L, \tag{5.8}$$

That is, household manufacturing consumption grows at a constant gross rate of ρa_L. This will also be true in the presence of international trade, since wage in terms of manufacturing will also be time-invariant in trade regimes – as long as each country produces both goods. It follows that

Proposition 5.1 *Welfare (as defined in (5.1)) grows at the rate* $(\rho a_L)^{\lambda_1+\lambda_2}$.

[7] Note, the total labor supply is the remaining share of effective labor after investing in human capital $\bar{L}_t = (1 - H_t)L_t$

[8] We have

$$B_t + \delta p_{st} = \frac{p_{st}(C_{st} + \delta)}{\lambda_2} = \frac{p_{mt}C_{mt}}{\lambda_1}.$$

Proof: Over time, the term $B_t + \delta p_{st}$ is proportional to $p_{mt}C_{mt}$, p_{mt} is inversely proportional to C_{mt} and p_{st} is proportional to p_{mt}. Hence

$$\frac{V_{t+1}}{V_t} = \frac{C^{ka}_{mt+1}}{C^{ka}_{mt}} = (\rho a_L)^{\lambda_1+\lambda_2} .$$

■

This proposition also holds across trade regimes. In other words, the growth rate of welfare is constant irrespective of whether there is international trade or not. It means that a change in trade regimes results in a one-period change in the level of welfare, consequent to which welfare resumes its earlier growth rate.

Growth Functions

The key to understanding growth effects of trade regime changes will be the existence of the *growth functions* in our model economy, namely, the gross growth rate of a variable x at time t as a function of the level of x at that time. For the autarky regime they will be derived in three steps. First, we express sectoral outputs in terms of household consumption of services and manufacturing via eqs. (5.4e) and (5.4f):

$$Q^{ka}_{st} = \frac{C^{ka}_{st} + a^{ka}_{sm}C^{ka}_{mt}}{\theta}; \quad Q^{ka}_{mt} = \frac{a^{ka}_{ms}C^{ka}_{st} + C^{ka}_{mt}}{\theta}. \tag{5.9}$$

Second, using input-coefficient expressions, that $p^{ka}_{mt}/p^{ka}_{st} = 1/\phi^k$ and the first-order condition (5.4b) that links household consumption of manufacturing and services along the income consumption path, the output of particular sector is expressed as function of household consumption of manufacturing. For the services sector for instance,

$$Q^{ka}_{st} = \frac{\{[(1-\alpha)\lambda_1 + \lambda_2]/\phi^k\}C^{ka}_{mt} - \lambda_1\delta}{\lambda_1\theta}. \tag{5.10}$$

Third, by exploiting the model's feature that household consumption of manufacturing grows at a constant rate, the growth rate is expressed in terms of the level of a variable. For instance, in view of (5.8), (5.10) implies

$$_QG^{ka}_{st} \equiv \frac{Q^{ka}_{st+1}}{Q^{ka}_{st}} = \rho a_L + \frac{(\rho a_L - 1)\delta}{\theta Q^{ka}_{st}} \equiv {}_QG^a_s(Q^{ka}_{st}). \tag{5.11}$$

This is the growth function of the service-sector output. While the growth rate exceeds ρa_L, it declines over time obeying the growth function (5.11) and asymptotes to ρa_L. Intuitively, the growth rate is higher than ρa_L because of income elasticity for the service good being greater than unity. As the household consumption of services grows with the economy, the service good becomes less non-essential and the income elasticity of household demand for it falls, lowering the growth rate of service-sector output. It is worth noting that this resembles the convergence property of capital stock over time in the standard one-sector growth model. However, convergence in our framework stems from a very different source, namely, diminishing income elasticity of household demand for services associated with the growth of the economy.

Manufacturing output and its growth exhibit similar qualitative features since manufactures are used in producing services. We can derive

$$_{Q}G^{ka}_{mt} \equiv \frac{Q^{ka}_{mt+1}}{Q^{ka}_{mt}} = \rho a_L + \frac{(\rho a_L - 1)(1-\beta)\delta}{\theta Q^{ka}_{mt}} \equiv {}_{Q}G^{a}_{m}(Q^{ka}_{mt}). \tag{5.12}$$

Remarks

1. It is easy to establish that $Q^{ka}_{st} < Q^{ka}_{mt}/(1-\beta)$. Hence $_{Q}G^{ka}_{st} > {}_{Q}G^{ka}_{mt}$. That is, the service-sector output grows faster than manufacturing - a well-known stylized fact. It stems from the income elasticity of demand for services being higher that for manufacturing.

2. The same growth equations as those of outputs hold for sectoral employment since employment in a sector is proportional to the respective output.

3. Input coefficients being time-invariant, the business-service component of total services grows at the same rate as manufacturing output.

Proposition 5.2 *In the autarky regime, output and employment growth rate at any instant of time in the services sector is higher than that in manufacturing and the growth rates decline monotonically over time approaching ρa_L.*

Figure 5.2 depicts sectoral employment and growth rates as functions of time.

Given sectoral output dynamics, the dynamics of effective labor supply for production,

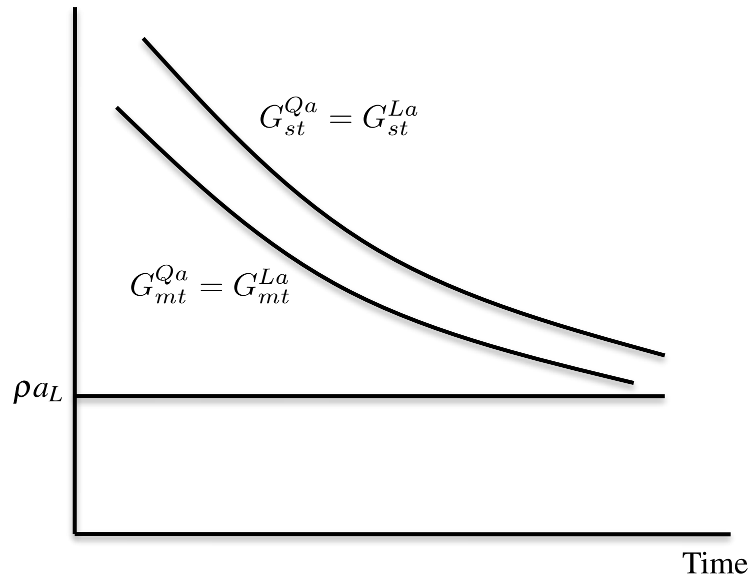


Figure 5.2: Sectoral Growth Rates in Autarky Equilibrium

$\bar{L}_t$, follows from the full employment equation. We have

$$_{\bar{L}}G^{ka} = \rho a_L + \frac{(\rho a_L - 1)\lambda_1 \delta}{M^{k\frac{1-\beta}{\theta}} S^{k\frac{1}{\theta}} \bar{L}^{ka}_t}. \tag{5.13}$$

Its growth pattern is similar to that of sectoral output and employment: it declines over time and asymptotes towards ρa_L.

What remains to be characterized is the dynamics of human capital investment. To do so, it will however be convenient to express the growth rate of $\bar{L}_t$ as a function of itself, i.e., $_{\bar{L}}G_t = {}_{\bar{L}}G(\bar{L}_t)$. We have, from (5.13), $_{\bar{L}}G'(\bar{L}_t) < 0$.We use the definition of total effective labor supply, $\bar{L}_t = (1 - H_t)L_t$ and the learning equation (5.5) to get,

$$\Delta H_t \equiv H_{t+1} - H_t = (1 - H_t)\left[1 - \frac{_{\bar{L}}G(\bar{L}_t)}{a_L H_t}\right]. \tag{5.14}$$

Figure 5.3 plots the $\Delta H_t = 0$ locus, $H_t = {}_{\bar{L}}G(\bar{L}_t)/a_L$. It is downward sloping as $_{\bar{L}}G'(\bar{L}_t) < 0$ and asymptotic to ρ since $_{\bar{L}}G(\bar{L}_t)$ asymptotes to ρa_L. Vertical arrows indicate the change in H_t as one moves away from $\Delta H_t = 0$ curve, while the horizontal arrows indicate that $\bar{L}_t$ always grows over time. It is clear that under perfect foresight the optimal path must originate and stay within region II. Along the unique saddle path, H_t declines monotonically over time, asymptotic to ρ.[9]

[9] The dynamics of H_t is analogous in the presence of international trade. We shall hence skip it for the

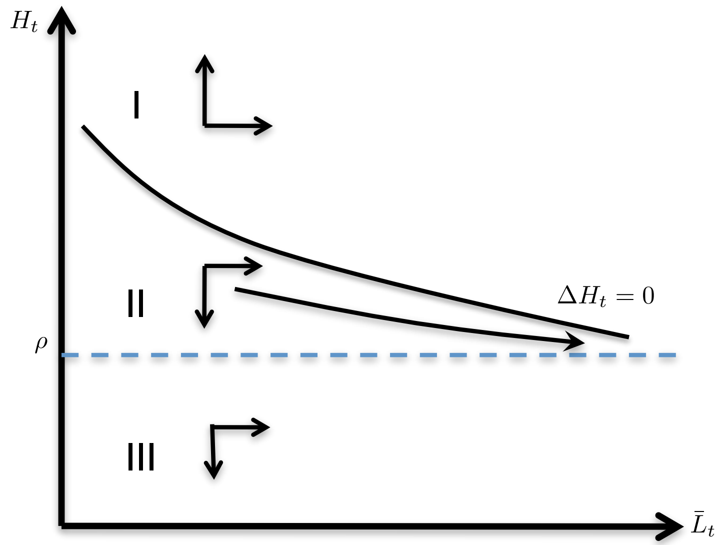


Figure 5.3: Dynamics of H_t in Autarky

We now move on to explore the static and dynamic effects of commodity trade and trade in services.

5.3 Free Trade in Commodities

Suppose the two countries, h and f, open up free trade in commodities only, that is, in manufacturing and the numeraire good, not services. We call it *Commodities Free Trade* or CFT. It happens, say, in period T, after labor is allocated to acquire human capital and as a one-shot permanent regime change rather than something gradual. Thus, L_T as well as $\bar{L}_T$ remain unchanged. There will be a one-period, static, level effects as markets for goods M and D are integrated. Dynamic effects can be deduced from growth functions and the initial level effects.

We assume that parametric differences across countries are not too large, and, accordingly, both countries produce manufacturing. Hence the same zero-profit conditions as in autarky hold in both production sectors and input coefficients remain the same.[10]

Trade equalizes the prices of traded goods. Let p^o_{mt} denote the (common) international relative price of manufacturing, where the superscript ^{o} denotes the CFT regime. Static

sake of brevity.

[10] If technologies are identical, the wage rate is equalized across countries - a 'factor price equalization' outcome.

equilibrium is characterized by:

$$a_{lm}^{ka} Q_{mt}^{ko} + a_{ls}^{ka} Q_{st}^{ko} = \bar{L}_t^k \tag{5.15a}$$

$$C_{st}^{ko} + \delta = \frac{p_{mt}^o}{p_{st}^{ko}} \frac{\lambda_2}{\lambda_1} C_{mt}^{ko} \tag{5.15b}$$

$$\frac{\lambda_1}{1-\lambda_1-\lambda_2} \cdot \frac{C_{dt}^{ko}}{C_{mt}^{ko}} = p_{mt}^o \tag{5.15c}$$

$$\sum_k C_{dt}^{ko} = 2E \tag{5.15d}$$

$$a_{sm}^{ka} Q_{mt}^{ko} + C_{st}^{ko} = Q_{st}^{ko} \tag{5.15e}$$

$$C_{mt}^{ko} + a_{ms}^{ka} Q_{st}^{ko} + \frac{C_{dt}^{ko}}{p_{mt}^o} = Q_{mt}^{ko} + \frac{E}{p_{mt}^o}. \tag{5.15f}$$

There are three changes from autarky: (a) p_{mt}^{ka} is replaced by p_{mt}^o; (b) the market for the numeraire good clears internationally, hence we have (5.15d) instead of $C_{dt}^k = E$; and (c) the manufacturing output does not just cater to domestic households and firms; thus (5.4f) is replaced by (5.15f).

These are altogether eleven equations: (5.15d) and the rest of the equations for $k = h, f$. Two sectoral outputs in each country, household consumption of the three goods in each country and p_{mt}^o are the variables.

5.3.1 Pattern of Commodity Trade and Cross-Country Comparisons

Barring the endowment of the numeraire good, depending on the initial level of development, L_T^k, $k = h, f$ and relative magnitudes of technology parameters, M^k and S^k, one country will be the net exporter and the other the net importer of manufacturing. We have

Proposition 5.3 *The country whose household consumption of manufacturing is higher in CFT equilibrium is the net exporter of manufacturing.*

Proof: Suppose country h's household consumption of manufacturing is higher. Household static optimization implies that, at any given p_{mt}^o, its consumption of good D is higher. Since each country's endowment of good D is E, in view of (5.15d) $C_{dt}^h > E > C_{dt}^f$. Hence, country h is a net importer of good D. By virtue of trade balance, it must be the net exporter of manufacturing. ■

As will be discussed later, the dynamic household optimization implies that in both countries the household manufacturing consumption grows at the same rate (ρa_L) as in autarky. Hence, if $C^{ho}_{mT} > C^{fo}_{mT}$, then $C^{ho}_{mt} > C^{fo}_{mt}$ $\forall t > T$. That is, in our model economy trade pattern reversal does not occur.

The next proposition, quite intuitive, delineates trade pattern based on differences in the level of development or technology of manufacturing production. Let country h be the more developed country, i.e., $L^h_T > L^f_T$. Based on the definition of labor supply $\bar{L}_t = (1 - H_t)L_t$, observe that a higher $\bar{L}_t$ is associated with a higher L_t. Hence, $L^h_T > L^f_T \Leftrightarrow \bar{L}^h_T > \bar{L}^f_T$.

Proposition 5.4 *The country which is more developed (and has no technological inferiority in producing either good), or, has technological superiority in producing manufacturing (together with being no less developed than the other country and with no technological inferiority in producing services) is the net exporter of manufacturing.*

Proof: Equations characterizing static CFT equilibrium can be reduced to two equations in Q^{ko}_{mt} and C^{ko}_{mt} in terms of technology and preference parameters, $\bar{L}^k_t$ and p^o_{mt}:

$$\begin{aligned} \frac{1-\beta\lambda_2}{\lambda_1} \cdot C^{ko}_{mt} - \theta Q^{ko}_{mt} &= \frac{E}{p^o_{mt}} + \delta(1-\beta)\phi^k \\ \frac{\lambda_2}{\lambda_1} C^{ko}_{mt} + \frac{\theta}{\beta} Q^{ko}_{mt} &= \frac{{M^k}^{1/\theta} {S^k}^{(1-\alpha)/\theta}}{\beta} \bar{L}^k_t + \delta\phi^k. \end{aligned} \tag{5.16}$$

Comparative statics on eqs. (5.16) yields that, at given p^o_{mt}, C^{ko}_{mt} is increasing in $\bar{L}^k_t$ and M^k. Hence, combined with 5.3 it implies that country with higher $\bar{L}_t$ or M is the net exporter of manufacturing. ■

Furthermore, it is possible that technological advantage in services production may offer comparative advantage in manufacturing since business services are inputs to manufacturing production. From eqs. (5.16), $\partial C^{ko}_{mt}/\partial S^k \gtreqless 0$, i.e. country k will have comparative advantage in manufacturing or services according as

$$S^k \gtreqless \left(\frac{\alpha}{1-\alpha}\right)^{\theta} \cdot \frac{\delta^\theta}{{M^k}^{1-\beta} {\bar{L}^k_t}^{\theta}}.$$

There are two ways in which a productivity enhancement in the service sector may affect household consumption of manufacturing. First, because services are used as input in manufacturing production, wage rate – and thus total labor income – rise in terms of manufacturing. Through an income effect, the household consumption of manufacturing will tend to increase. To see this, suppose $\delta = 0$. Then $C^{ko}_{mt} = \lambda_1[(w^k_t/p^o_{mt})\bar{L}^k_t]$; w^k_t/p^o_{mt} increases with S^k as long as services are used in producing manufacturing. Second, in the presence $\delta > 0$, as real income in terms of manufacturing increases with S^k, there is a demand bias towards household consumption of services away from its consumption of manufacturing. This is why the overall effect of an increase in S^k on C_{mt}^{ko} is ambiguous. It is worth noting however that the magnitude of the first effect is greater, the greater the magnitude of $\bar{L}_t^k$. That is, *the higher the level of development of a country, the greater is the presumption that service sector productivity acts as a source of comparative advantage in manufacturing.*

5.3.2 Static One-Period Level Effects: Autarky to CFT

Proposition 5.5 summarizes these effects.

Proposition 5.5 *As free trade in commodities opens up, the manufacturing exporting country experiences an increase in the prices of manufacturing and services, an increase in manufacturing output, a decline in services output, a decrease in the household consumption of manufacturing and services and an increase in the use of services for business. Opposite implications hold for the manufacturing importing country.*[11]

Quite intuitively, the manufacturing exporting country experiences a price and output increase of manufacturing. Given full employment, services output falls, while the increase in manufacturing output implies a higher use of business services. It follows that household consumption of services decreases. Along the income consumption path, there is less household consumption of manufacturing. As manufactures are used in producing services, a higher price of manufacturing implies a higher price of services.

5.3.3 Dynamic Effects: Autarky to CFT

Although household-level parameter values may be different, the household intertemporal optimization problem remains qualitatively the same as in autarky. The same Euler equation follows, and, $p_{mt}^o C_{mt}^k / w_t^k$, $k = h, f$, grows at the rate ρa_L. As long as incomplete specialization occurs in each country, w_t^k / p_{mt}^o is constant. Therefore, as in autarky, C_{mt}^{ko} grows at the (gross) rate ρa_L. Hence, so does $\sum_k C_{mt}^{ko}$.

As shown in Appendix 5.B,

Proposition 5.6 *Output growth functions in the CFT equilibrium are same as in autarky.*

[11]See Appendix 5.B.

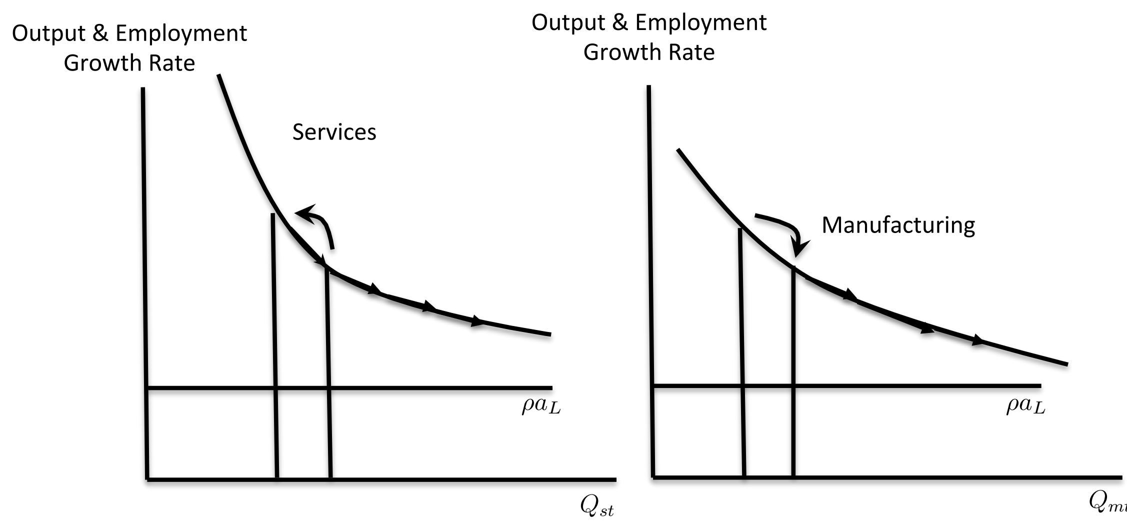


Figure 5.4: Growth Effects of Commodity Free Trade in the Manufacturing Exporting Country

It is because there is no change in the relative price between services and manufacturing (although the relative price of manufacturing in terms of the numeraire good changes from autarky to free trade in commodities) or input coefficients. Thus, at any given level of output in one production sector, there is no change in output in the other production sector, hence no (static) increase in real income and income elasticity of demand for household services, implying no shift of growth functions.

However, the initial level effects imply movements along the growth functions. In view of Proposition 5.5, in the manufacturing exporting country, $Q^{ko}_{sT} < Q^{ka}_{sT}$ and $Q^{ko}_{mT} >^{ka}_{mT}$ and just the opposite occurs in the manufacturing importing country. Thus

Proposition 5.7 *As countries move from autarky to free trade in commodities only, in the manufacturing exporting country, there is an initial increase in the growth rate of output and employment in the services sector and an initial decrease in the growth rate of output and employment in the manufacturing sector. Opposite effects take place in the manufacturing importing country. After the initial effects on growth rates, output and employment in both sectors decline monotonically along the respective growth functions.*

Figure 5.4 illustrates Proposition 5.7 for the manufacturing exporting country. Interestingly, the country having comparative advantage (resp. disadvantage) in manufacturing initially experiences a lower (resp. higher) growth rate of the manufacturing sector and a higher (resp. lower) growth rate of the services sector. It also implies that in the country which has comparative advantage (or disadvantage) in manufacturing, trade in commodities widens (or narrows) the sectoral output as well as employment growth rates.

5.3.4 Identical Technologies

In our analysis of trade in both commodities and services, which we call the grand free trade regime, in section 5.4, we shall, for most part, consider the case where technologies are same across countries, while the countries differ in their levels of development. For the sake of comparing free trade in commodities with grand free trade, we explore now the implications free trade in commodities under this assumption. Notice that, if technologies are identical, wages, relative price of services and input coefficients are same across countries. This facilitates ranking of sectoral resource allocation and growth rates across the two countries.[12]

To begin with, as one would expect,

Proposition 5.8 *If technologies are same across countries, the more developed (manufactures exporting) country will produce more of both services and manufactures than the other (manufactures importing) country.*

This is proved in Appendix 5.B.

Indeed, closed-form solutions are available for output and consumption levels, and the terms of trade (see Appendix 5.B) - which will be used in comparing the two trading regimes. In particular, the output expressions are

$$\begin{aligned} Q_{st}^{ko} &= \frac{[(1-\alpha)\lambda_1+\lambda_2]\frac{\bar{L}_t^w}{2}-\alpha\lambda_1\delta}{(\lambda_1+\lambda_2)\theta}+\frac{1-\alpha(1-\lambda_2)}{\theta}\left(\bar{L}_t^k-\frac{\bar{L}_t^w}{2}\right) \\ Q_{mt}^{ko} &= \frac{[\lambda_1+(1-\beta)\lambda_2]\frac{\bar{L}_t^w}{2}+\beta\lambda_1\delta}{(\lambda_1+\lambda_2)\theta}+\frac{1-\beta\lambda_2}{\theta}\left(\bar{L}_t^k-\frac{\bar{L}_t^w}{2}\right), \end{aligned} \tag{5.17}$$

which are same as (5.A.4).

It is instructive to note that respective equilibrium output has two components: one if countries were symmetric and the other measuring deviations due to asymmetry or comparative advantage. These are respectively the first term and the second in the right-hand side of expressions in (5.17). The "symmetry component" is, as it must, equal to

[12]It is proved in Appendix 5.B that, in the absence of technology differences, there will be no overtaking by the initially less developed country of the initially more developed country in the level of development, i.e., if $\bar{L}_T^h > \bar{L}_T^f$, then $\bar{L}_t^h > \bar{L}_t^f$ for all $t > T$.

the output under autarky, while "comparative advantage" component. is positive (resp. negative) for the more (resp. less) developed country, since at the same wage rate and relative prices of services and manufacturing, the more developed country would produce more of both goods.

With respect to dynamic effects, in view of Proposition 5.8, the growth functions in (5.A.1) imply that

Proposition 5.9 *As long as technologies across countries are identical, in the CFT regime the growth rates, at any given time period, of output and employment in both sectors in the manufacturing exporting country are less than their counterparts in the manufacturing importing country.*

5.4 Trade in Commodities and Services

Suppose the two economies open up trade in services also, and services are provided internationally in the cross-border mode. Let us call it the *grand free trade* or the GFT regime. Consumers and manufacturing-good producers in each country can now access service providers in both countries.

Services are typically viewed - and modeled - as differentiated products. Keeping this in mind, we postulate that they are differentiated across countries, while retaining our assumption that services produced within a particular country are homogeneous. That is, there are two brands in our two-country world, which are imperfect substitutes in consumption and as inputs to manufacturing. Three important implications follow immediately.

1. Free international trade in services bestows positive variety effects in both consumption and production and thus entails effects of symmetry or trade among similar countries and those of asymmetry or comparative advantage.

2. In particular, the variety effect in producer (business) services is equivalent to technical progress. Hence trade in services enhances labor productivity.[13]

3. Variety effect in consumer services reduces the price of the composite basket of consumer services and hence reduces the value of δ. Hence, services trade, by increasing the

[13] In their study of U.S. manufacturing firms over 1992-2000, Amiti and Wei (2009), for example, find that services offshoring had a significantly positive effect on and explained 11% of the labor productivity growth in their sample of manufacturing firms.

variety of services available for household consumption, makes services more essential.

Let us define *composites* of consumer and business services as

$$Z_t^k \equiv \left[\left(C_{st}^{hk}\right)^{\gamma} + \left(C_{st}^{fk}\right)^{\gamma}\right]^{1/\gamma};\ I_t^k \equiv \left[\left(I_{st}^{hk}\right)^{\eta} + \left(I_{st}^{fk}\right)^{\eta}\right]^{1/\eta},\ \gamma,\ \eta \in (0,1),$$

where the first (resp. second) superscript marks the country in which the service is produced (resp. consumed). Elasticities of substitution between home and foreign produced service brands in consumption and production are respectively $1/(1-\gamma)$ and $1/(1-\eta)$, both exceeding unity.

Let the household utility function takes the form: $U_t^k = {C_{mt}^k}^{\lambda_1}(Z_t^k + \delta)^{\lambda_2}{C_{dt}}^{1-\lambda_1-\lambda_2}$. Notice that in a closed economy or in CFT where only the domestic variety of services are available, the utility function reduces to the earlier one. Let the manufacturing production function be $Q_{mt}^k = A{L_{mt}^k}^{\alpha}{I_t^k}^{1-\alpha}$, which also reduces to the earlier production function when only domestic services are available. Household and firm optimizations yield the prices of respective service composites:

$$P_{st}^c \equiv \left({p_{st}^h}^{-\frac{\gamma}{1-\gamma}} + {p_{st}^f}^{-\frac{\gamma}{1-\gamma}}\right)^{-\frac{1-\gamma}{\gamma}};\ P_{st}^m \equiv \left({p_{st}^h}^{-\frac{\eta}{1-\eta}} + {p_{st}^f}^{-\frac{\eta}{1-\eta}}\right)^{-\frac{1-\eta}{\eta}}.$$

These are the combined, not average, cost of consuming the two service brands. If $p_{st}^h = p_{st}^f \equiv p_{st}$, then, for instance, $P_{st}^c = 2p_{st}/2^{\frac{1}{\gamma}} < 2p_{st}$, which reflects that the number of varieties available is valued.

The indirect utility function is the same as earlier, except that p_{st} substituted by P_{st}^c. Likewise, P_{st}^m substitutes p_{st} in the unit cost function of manufactures.

5.4.1 Static Equilibrium

We assume that cross-country differences in technology or the level of development are not large enough, such that incomplete specialization prevails in both economies. Zero-profit conditions in the two sectors are thus spelt by:

$$\frac{{w_t^k}^{\alpha}{P_{st}^m}^{1-\alpha}}{M^k} = p_{mt}^r; \quad \frac{{w_t^k}^{\beta}{p_{mt}^r}^{1-\beta}}{S^k} = p_{st}^k, \qquad k = h, f$$

where the superscript ^{r} denotes GFT equilibrium. These conditions imply the following expressions for the wage rate, prices of home and foreign service brands and their price indices:

$$w_t^k = \nu_1^{1-\alpha} {M^k}^{1/\alpha} p_{mt}^r;\ p_{st}^k = {\phi^k}^{\frac{\theta}{\alpha}} \nu_1^{(1-\alpha)\beta} p_{mt}^r;\ P_{st}^m = \frac{p_{mt}^r}{\nu_1^\alpha};\ P_{st}^c = \nu_1^{(1-\alpha)\beta}\nu_2 p_{mt}^r \tag{5.18}$$

$$\text{where } \nu_1 \equiv \left[\sum_k \left(\phi^k\right)^{-\frac{\eta\theta}{(1-\eta)\alpha}}\right]^{\frac{1-\eta}{\eta\theta}};\ \nu_2 \equiv \left[\sum_k \left(\phi^k\right)^{-\frac{\gamma\theta}{(1-\gamma)\alpha}}\right]^{-\frac{1-\gamma}{\gamma}}.$$

As in autarky or CFT, wages and service prices in terms of manufacturing are functions of technology coefficients only. But the functions are different. Expressions of corresponding input coefficients are given in Appendix 5.C. We observe that

Lemma 5.1 *Compared to autarky or CFT equilibrium, in GFT equilibrium, for both countries (a) the wage rate in terms of manufactures or the service brand produced in the respective country is greater, (b) labor coefficients in each sector are smaller, and (c) the price of each service brand in terms of manufactures is higher.*

Intuitively, availability of more variety of services lowers the effective price of the service input and thus acts as labor-saving technical progress in both sectors, since service is used in manufacturing and manufacturing is used in producing services. This explains (a) and (b). The wage rate in terms of each service brand being higher, the zero profit condition in the service sector implies that the price of manufactures relative to a service brand must be lower. This proves part (c).

Unlike the movement from autarky to CFT which entails the two trading countries experiencing asymmetric relative price movement (manufacturing vis-a-vis the numeraire good) depending on comparative advantage, the transition from CFT to GFT leads to *symmetric* relative price movements for both countries: both countries must face the same price movement for manufacturing as it is a traded good, and, in view of Lemma 5.1, they face an upward movement of the price of each service brand in terms of manufactures.

The static GFT equilibrium is characterized by eleven equations, (5.A.5a)-(5.A.5g), laid out in Appendix 5.C. They determine household consumption levels of all three goods, two sectoral outputs in each country and the relative price of manufacturing. The prices of service brands are proportional to the price of manufacturing and same across the two trading countries.

An important implication is that in contrast to CFT, GFT has elements of trade among similar countries. It is because of this however, the resulting model is considerably complex.

For tractability, we confine ourselves to the 'Heckscher-Ohlin' case, in which technologies are same across countries, and, countries differ in terms of their size or level of development only (L_t^k).

Under the assumption of identical technologies, the system of equations (5.A.5a)-(5.A.5g) reduce to eqs. (5.19a)-(5.19g) below.

$$\frac{\alpha Q_{mt}^{kr}}{2^{\pi/\beta}} + \frac{\beta Q_{st}^{kr}}{2^{\pi(1-\beta)/\beta}} = \bar{L}_t^k \tag{5.19a}$$

$$Z_{st}^{kr} + \delta = 2^{\frac{1-\gamma}{\gamma} - \pi} \cdot \frac{\lambda_2}{\lambda_1} \cdot C_{mt}^{kr} \tag{5.19b}$$

$$\frac{\lambda_1}{1 - \lambda_1 - \lambda_2} \frac{C_{dt}^{kr}}{C_{mt}^{kr}} = p_{mt}^r \tag{5.19c}$$

$$C_{dt}^h + C_{dt}^f = 2E \tag{5.19d}$$

$$\frac{1}{2^{\frac{1}{\gamma}}} \sum_k Z_{st}^{kr} + \frac{1-\alpha}{2^{\frac{\alpha\eta + (1-\alpha)\beta)}{\eta\theta}}} \sum_k Q_{mt}^{kr} = Q_{st}^{hr} \tag{5.19e}$$

$$\frac{1}{2^{\frac{1}{\gamma}}} \sum_k Z_{st}^{kr} + \frac{1-\alpha}{2^{\frac{\alpha\eta + (1-\alpha)\beta)}{\eta\theta}}} \sum_k Q_{mt}^{kr} = Q_{st}^{fr} \tag{5.19f}$$

$$C_{mt}^{kr} + \frac{Z_{st}^{kr}}{2^{\frac{1-\gamma}{\gamma} - \pi}} + \frac{C_{dt}^{kr}}{p_{mt}^r} = \alpha Q_{mt}^{kr} + 2^{\pi} \beta Q_{st}^{kr} + \frac{E}{p_{mt}^r},^{14} \tag{5.19g}$$

$$\text{where } \pi \equiv \frac{(1-\eta)(1-\alpha)\beta}{\eta\theta}.$$

The first is the full-employment equation. The next two are the first-order conditions of household optimization. These are followed by three market-clearing conditions. The last equation spells trade balance over trade in commodities and services - equivalent to an economy's budget constraint.

One striking feature immediate from eqs. (5.19e) and (5.19f) is that

Proposition 5.10 *At the GFT equilibrium, total production of services is the same across the two countries.*

Note that Proposition 5.10 holds irrespective of differences in the country sizes (as long as both countries incompletely specialize). The reason behind such *service production equalization* is that the availability of same technologies equalizes unit cost of production and hence relative prices of the distinct service brands across countries. Thus, the demands for country-specific brands are governed by same relative prices and same *world* aggregates,

[14] Derivation of (5.19a)-(5.19g) is given in Appendix 5.C.

namely, the sum of household service composites (for household demand for services) and the sum of manufacturing output (for manufacturing sector's demand for services) across countries. In equilibrium, the amount produced of each brand is same across the countries.[15]

Recall that in CFT equilibrium the less developed country produces less amount of services compared to the more developed country. Now that in GFT equilibrium both countries produce the same amount means a *service-production catch-up* by the less developed country with its more developed trade partner.

An immediate corollary of Proposition 5.10 is that

Corollary 5.1 *In the GFT equilibrium, the more developed country produces more manufacturing than does the less developed country.*

5.4.2 Pattern of Trade

In our model with three goods - services, manufacturing and the numeraire good - the question is: which country would export or import services and which would export or import manufacturing. Since there is a third good, *a priori*, a country may be a net exporter or importer of both services and manufacturing. We have the following the trade balance expressions:

$$\begin{aligned}
\text{Service trade balance of country } k\text{:} \quad & \frac{p_{st}^{kr}}{p_{mt}^{r}} Q_{st}^{kr} - \frac{P_{st}^{c}}{p_{mt}^{r}} Z_{st}^{kr} - \frac{P_{st}^{m}}{p_{mt}^{r}} a_{sm}^{kr} Q_{mt}^{kr} \\
& = 2^{\pi} Q_{st}^{kr} - \frac{1}{2^{\frac{1-\gamma}{\gamma}-\pi}} Z_{st}^{kr} - (1-\alpha) Q_{mt}^{kr} \\
\text{Manufacturing trade balance of country } k\text{:} \quad & Q_{mt}^{kr} - C_{mt}^{hr} - a_{ms}^{kr} Q_{st}^{kr} \\
& = Q_{mt}^{kr} - C_{mt}^{kr} - 2^{\pi}(1-\beta) Q_{st}^{kr}.
\end{aligned}$$

For example, country k is the net exporter of services if and only if its service trade balance is positive. As shown in Appendix 5.C,

Proposition 5.11 *The more developed country is the net importer of services and the net exporter of manufacturing. There is no trade pattern reversal for any particular country.*

[15] If the manufacturing good was differentiated, the same argument would apply to manufacturing outputs, implying that output of each good will be the same across the two countries. This will be compatible with full employment only if effective labor supply were the same in the two trading countries. Otherwise, specialization must occur, because too many local goods would face symmetric demand functions across countries.

It means that whichever country is more developed initially remains more developed than the other country in all subsequent time periods and it remains as the net importer of services and net exporter of manufacturing. The more developed country would consume more of services than the less developed country. Since both countries produce the same amount of services, it follows that the former would be a net importer of services. With regard to manufacturing, (a) because both countries produce the same amount of services, the more developed country must be producing more manufacturing than the other country; furthermore, (b) the consumption of manufacturing in the production of services is same for both countries since technologies are identical and both produce the same amount of services. (a) and (b) together tend to imply that the more developed country would a net exporter of manufacturing, although its household consumption of manufacturing is higher.

5.4.3 Static One-Period Level Effects

Whereas a regime change from autarky to commodity free trade entails a comparative advantage effect - asymmetry across countries leading to relative price changes - moving from commodity free trade to grand free trade is associated with a variety (or similar-country) effect as well as a comparative advantage effect.

An interesting feature of our model economy is that, absent the variety effect, there are no terms of trade effects, i.e., no changes in p_{mt} or p_{st}, hence standard comparative advantage effects are absent.[16] The reason behind this is the following. Without the variety effect, the terms of trade between manufacturing and services as well as wage in terms of manufacturing or services are unchanged. Hence, in the GFT equilibrium, at the relative price of manufacturing (in terms of the numeraire good) prevailing in CFT equilibrium, the real adjusted income in terms of manufacturing is same, thus quantity demanded of household manufacturing by each country is the same as in the CFT equilibrium; the world household demand for manufacturing is the same, which returns the same relative price of manufacturing. Hence, in the absence of the variety effect, both terms of trade in the GFT equilibrium are same as in the CFT equilibrium. An immediate implication is that there are no effects on welfare. That is, trading countries do not benefit (or lose) from trade in services.[17]

[16] Mathematically, variety effect is eliminated by letting $\gamma \to 1$ and $\eta \to 1$.

[17] Other implications in the absence of variety effects are as follows. Terms of trade and real adjusted income remaining the same in each country, total household consumption of manufacturing and services

We now explore the static one-period effects of free trade in commodities in the presence of variety effects. Here, we analyze the positive effects, whereas welfare gains are examined in Section 5.5; as we shall see, there are comparative-advantage effects on welfare gains as well.

Similar to case of trade in commodities only, there are closed-form solutions for quantities produced and consumed and the relative price of manufacturing - which facilitate in determining static level effects of GFT, starting from CFT. Appendix 5.C lays down the expressions for world consumption of manufacturing, the terms of trade and output expressions at the country level. We have[18]

Proposition 5.12 *Starting from free trade in commodities, free trade in services leads to (a) a higher world output of services, (b) a higher or lower world output of manufacturing and (c) a higher or lower relative price of manufacturing and services (in terms of the numeraire good).*

Intuitively, the world-wide 'technological-progress effect' of trade in services (due to availability of more variety of services) and that income elasticity of demand for services by households exceed unity both tend to push up world-level production of services. For

(sum of home and foreign varieties) in either country are the same in CFT equilibrium. Moreover, household consumption of services are equally split between domestic and foreign varieties. The world household consumption of each variety of services remains unchanged between the two regimes.

Given the world consumption of household services, world outputs of manufacturing and services in CFT equilibrium are determined from summing up (5.15a) and (5.15e) over the two countries:

$$\alpha \sum_k Q^k_{mt} + \beta \sum_k Q^k_{st} = \sum_k \bar{L}^k_t$$

$$\sum_k C^k_{st} + (1-\alpha) \sum_k Q^k_{mt} = \sum_k Q^k_{st}.$$

Note that in GFT equilibrium (5.19a), (5.19e) and (5.19f) imply the same relationships when γ and η are equal to unity. Since the world consumption of each variety of services is the same between the regimes, it follows that world outputs manufacturing and services are the same between the two regimes. This implies that the same industrial consumption - hence total world consumption - of manufacturing and services.

The only impacts of comparative advantage or asymmetry are on resource allocation within trading countries. Compared to CFT, in GFT equilibrium the manufacturing production is higher (resp. lower) in the more (resp. less) developed country, whereas the production of services is lower (resp. higher) in the more (resp. less) developed country. It can seen as follows. Since world production of manufacturing is the same, industrial consumption of services of each variety is the same. However, the less developed country's quantity demanded of more developed country's service variety is less than half of that of the more developed country. Hence the total world demand for the service variety - by households and manufacturing firms - produced in the more developed country is less in the GFT equilibrium than in the CFT equilibrium. Therefore, the service-sector production in the more developed country is less. The opposite holds for the less developed country.

[18]See Appendix 5.C. From Lemma 5.1 we already know that the relative price of each service brand in terms of manufactures rises.

manufacturing, while the technological-progress effect tends to increase world production, income elasticity of demand for manufacturing being less than one tends to shift production away from this sector. The net effect is ambiguous. For similar reasons, the world household consumption of manufacturing may increase or decrease, implying that the relative price of manufacturing may move up or down. If p_m is higher, then p_s is also higher since the latter in terms of manufacturing is greater in GFT than in CFT; but if p_m is lower, p_s in GFT may be higher or lower.

In the GFT regime, the country-level services and manufacturing outputs are equal to

$$\begin{aligned} Q_{st}^{kr} &= \frac{Q_{st}^{wr}}{2} = \frac{2^{\frac{\pi(1-\beta)}{\beta}}[(1-\alpha)\lambda_1+\lambda_2]\frac{\bar{L}_t^w}{2} - \frac{\alpha\lambda_1\delta}{2^{\frac{1-\gamma}{\gamma}}}}{(\lambda_1+\lambda_2)\theta} \\ Q_{mt}^{kr} &= \frac{2^{\frac{\pi}{\beta}}[\lambda_1+(1-\beta)\lambda_2]\frac{\bar{L}_t^w}{2} + \frac{\beta\lambda_1\delta}{2^{\frac{1-\gamma}{\gamma}-\pi}}}{(\lambda_1+\lambda_2)\theta} + \frac{2^{\frac{\pi}{\beta}}}{\alpha}\left(\bar{L}_t^k - \frac{\bar{L}_2^w}{2}\right), \end{aligned} \tag{5.20}$$

which are same as (5.A.13). Notice that

a. Because there is service output equalization across countries, the service output in either country consists of the symmetry component only, whereas that of manufactures has elements of both symmetry and comparative advantage.

b. Akin to trade in commodities only, the comparative-advantage component of manufacturing output is positive and negative respectively for the more developed and the less developed country.

Comparing with the respective expressions at the CGT equilibrium given in (5.A.4), we obtain Proposition 5.13, which delineates the effect on output and resource allocation within each country (See Appendix 5.C).

Proposition 5.13 *As countries move from CFT to GFT*

(a) services production increases in the less developed country but may increase or decrease in the more developed country,

(b) production of manufacturing may increase or decrease in either country, and,

(c) in the less developed country, employment shifts from manufacturing to the services sector, while in the more developed country employment shift can happen in either direction.

Several forces at work explain Proposition 5.13.

(i) Trade in services serving as technical progress in both sectors has a positive symmetry effect on outputs of manufacturing and services in both countries. As income elasticity of services exceeds one, the increase in real income shifts household demand away from manufacturing to services. On this account, in both countries, there is a positive symmetry effect on services output and a negative symmetry effect on manufacturing output. Thus, compared to CFT, the overall symmetry effect is greater for services output and may be greater or less for manufacturing output in both countries.

(ii) Furthermore, the comparative-advantage effect on services output was positive (resp. negative) for the more (resp. less) developed country in the CFT regime and it is zero for both countries in the GFT regime.

(iii) Finally, service trade serving as technical progress implies a higher magnitude of comparative-advantage effect on manufacturing in GFT equilibrium - which is positive for the more developed country and negative for the less developed country.

These forces together explain parts (a) and (b) of Proposition 5.13. Part (c) follows from the 'catch-up' implication of free trade in services by the less developed country - as the less developed country catches up with the more developed country in producing services, the employment in the former's service sector increases, despite that free trade in services amounts to labor saving technological progress.

Leapfrogging

Moving back to Part (a) of Proposition 5.13, it is possible that the more developed country produces more of services and yet the less developed country catches up. We may interpret this *leapfrogging* by the less developed country. Indeed,

Proposition 5.14 *If the difference in the level of development across countries is small enough, compared to CFT equilibrium, both countries will produce more - and end up producing the same amount – of services in the GFT equilibrium.*

Proof: Suppose there is no difference in levels of development, i.e., the two countries are symmetric. Comparing (5.20) with (5.17) yields that both countries will produce more of services in GFT equilibrium. By continuity, the same must hold if the difference in the level of development is small enough. ■

An Example of Leapfrogging

We can quantify the increase in the output of services in terms of two initial conditions and seven parameter parameters. Suppose that the shift from CFT to GFT regimes occurs period 1 and let $\bar{L}_1^h = 10$ and $\bar{L}_1^f = 9.5$, i.e., at the time of regime shift, the difference in the level of development between the two countries is 5%. Let $\delta = 1$. No empirical estimates of elasticities of substitution between domestic and foreign brands of *services* seem to be available a this point of time. In the absence of a better alternative, we proxy them by Armington elasticities with respect to manufactured goods. For fourteen advanced countries, Saito (2004) provides estimates of elasticities of substitution between domestic and foreign varieties of different manufactured goods in both consumption and production.[19] They range from 0.24 to 3.53. Our model, however, *requires* the Armington elasticity (in both consumption and production) to exceed unity. We choose their values between 1.1 and 3.5 (see Table 5.1) and assume further that $\gamma = \eta$. The imputed values of γ and η range from 0.09 to 0.71.

The rest of the preference parameter values and those of technology are chosen by following the methodology of Acemoglu and Guerrieri (2008) and applying to the period 1998-2011. That is, based on National Income and Product Accounts, let the parameters of the two economies be deduced from data of the U.S. economy over 1998-2011. The average labor shares over this period in value added of manufacturing and services goods give $\alpha = 0.6$ and $\beta = 0.5$. The average sectoral output shares of GDP, 0.2 for manufacturing and 0.79 for services, are assumed to proxy the preference parameters λ_1 and λ_2, i.e., $\lambda_1 = 0.20$ and $\lambda_2 = 0.79$.[20]

For each set of parameter values, we compute the output of services produced in home and foreign countries in CFT and GFT regimes. In GFT equilibrium, service output is same between the two countries. For each set of parameter values, output of services is higher in the GFT equilibrium for *both* countries, implying leapfrogging by the foreign country.

We decompose the total changes in service output to those due to comparative advantage and those due to elements of trade among similar countries. The latter is obtained by asking what would be the changes in output if both countries were at the same level of development, equal to the average, i.e., if $\bar{L}^h = \bar{L}^f = 9.75$. The remaining is interpreted as

[19] For instance, the average estimate of elasticity of substitution between domestic and foreign textiles in consumption equals 1.22 and that between domestic and foreign paper products in production is equal to 1.37.

[20] These values of λ_1 and λ_2 imply that $1 - \lambda_1 - \lambda_2 = 0.01$, which accords with 1% share of agriculture in U.S. real GDP in the noughties.

Table 5.1: Total Service Output Changes from CFT to GFT Regime

Armington Elasticities	$\eta = \gamma$	Home			Foreign		
		Total Output Change (in %)	Decomposition of Total Output Change		Total Output Change (in %)	Decomposition of Total Output Change	
			Similar Country Effect	Comparative Advantage Effect		Similar Country Effect	Comparative Advantage Effect
1.1	0.09	49.75 (461)	100.56	-0.56	50.30 (493)	99.46	0.54
1.3	0.23	8.24 (76)	103.28	-3.28	8.78 (86)	96.92	3.08
1.5	0.33	4.28 (40)	106.31	-6.31	4.82 (47)	94.40	5.60
1.7	0.41	2.83 (26)	109.54	-9.54	3.38 (33)	91.72	8.28
1.9	0.47	2.08 (19)	113.46	-13.46	2.63 (26)	89.73	10.27
2.1	0.52	1.63 (15)	116.56	-16.56	2.17 (21)	87.56	12.44
2.3	0.57	1.32 (12)	120.45	-20.45	1.86 (18)	85.48	14.52
2.5	0.60	1.09 (10)	125.69	-25.69	1.64 (16)	83.54	16.46
2.7	0.63	0.93 (9)	129.03	-29.03	1.47 (14)	81.63	18.37
2.9	0.66	0.80 (7)	133.75	-33.75	1.34 (13)	79.85	20.15
3.1	0.68	0.69 (6)	139.13	-39.13	1.24 (12)	77.42	22.58
3.3	0.70	0.60 (6)	146.67	-46.67	1.15 (11)	76.52	23.48
3.5	0.71	0.53 (5)	152.83	-52.83	1.08 (11)	75.00	25.00

the comparative advantage effect - negative for the home country and positive for the foreign country since the latter has comparative advantage in producing services. We may however observe that for either country the effect of elements of trade among similar countries is dominant - as it must for leapfrogging to occur.

It is worth noting from Table 5.1 that as countries move from CFT to GFT,

1. the higher (or smaller) the elasticity of substitution, the greater (less) is the comparative-advantage effect on change in the service output, relative to that of trade among similar countries;

2. the increases in service output in either country are rather dramatic when the elasticity of substitution is relatively close to unity; for instance, if the Armington elasticity is 1.1, the service output increases by 461% and 493% in the home country and in the foreign country respectively.

The reason lies in that the higher the elasticity of substitution the less is the variety effect, i.e., the effect of trade among similar countries.[21] Hence the comparative advantage effect is relatively large if the elasticity of substitution is high. Recall that the variety effect induces a labor-saving technological progress effect as well as makes consumer services more essential, and, thus, if the elasticity of substitution is relatively small (closer to one), the variety effect on outputs will be large.

We now turn to growth/dynamic effects of trade in services.

5.4.4 Growth Effects

The household's dynamic optimization leads to the same Euler equation, implying that C_{mt}^{kr} grows at the gross rate ρa_L. As before, outputs can be expressed in terms of C_{mt}^{kr}, which lead to the respective growth functions. It is shown in Appendix 5.C that

$$ {}_{Q}G_{st}^{kr} = \rho a_L + \frac{(\rho a_L - 1)\delta}{2^{\frac{1-\gamma}{\gamma}} \theta Q_{st}^{kr}}; \; {}_{Q}G_{mt}^{kr} = \rho a_L + \frac{(\rho a_L - 1)(1-\beta)\delta}{2^{\frac{1-\gamma}{\gamma} - \pi} \theta Q_{mt}^{kr}}. \tag{5.21} $$

Comparing with (5.A.1), we see that there is a major difference with trade in commodities only: unlike trade in commodities only, trade in services shifts the output growth functions. More specifically,

[21] In the extreme case when home and foreign varieties are perfect substitutes, the variety effect must be zero.

Proposition 5.15 *Free trade in services shifts down growth functions of service-sector and manufacturing output.*

Intuitively, at a given level of respective output, there is a higher output in the other sector since the increase in variety of services due to trade in services acts as technological progress. The increase in real income reduces the income elasticity of demand, lowering the growth rate of the service sector, which, in turn, pulls down the growth rate of the manufacturing sector.

However, the impact of free trade in services on sectoral growth rates in the initial period is not clear from (5.21). But it is easy to check that for similar countries $2^{\frac{1-\gamma}{\gamma}} Q_{st}^{kr} > Q_{st}^{ko}$ and $2^{\frac{1-\gamma}{\gamma}-\pi} Q_{mt}^{kr} > Q_{mt}^{ko}$. Hence, growth rates fall initially, and,

Proposition 5.16 *As the two similar economies transit from free trade in commodities to free trade in both commodities and services, growth rates in both sectors in both countries fall discretely, after which they decline monotonically along the new respective growth functions.*

The preceding proposition is illustrated in Figure 5.5.

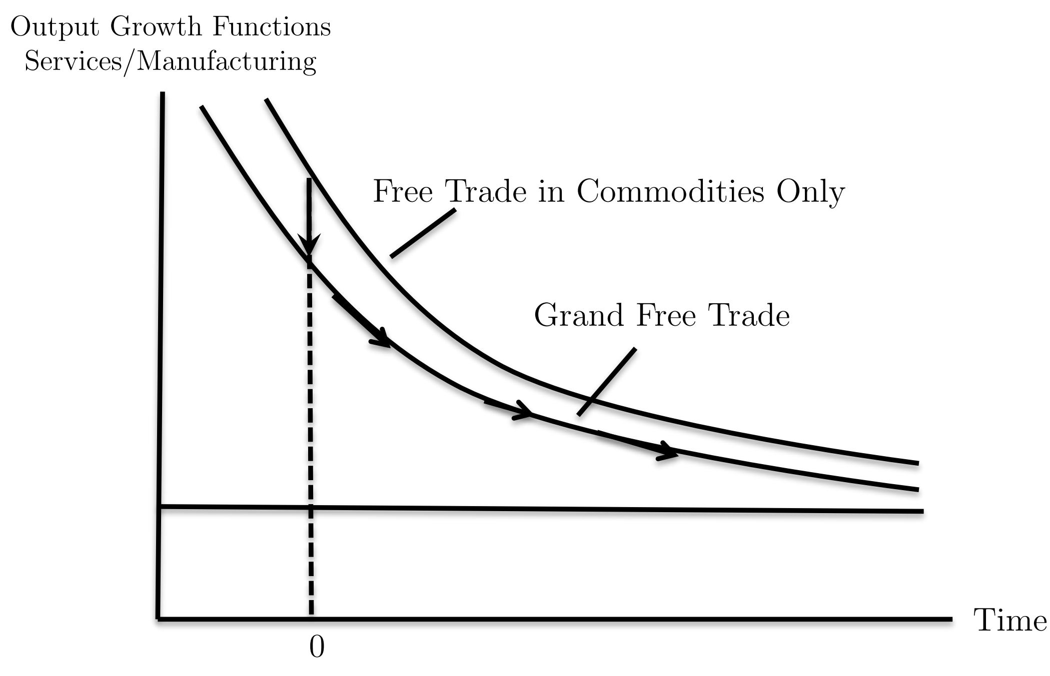


Figure 5.5: Growth Functions and Dynamics

Sectoral employments are proportional to sectoral outputs. Under the assumptions of identical technologies across countries, we get

$$L^{ko}_{st} = \beta Q^{ko}_{st}; \quad L^{kr}_{st} = \frac{\beta}{2^{\frac{\pi(1-\beta)}{\beta}}} Q^{kr}_{st}$$
$$L^{ko}_{mt} = \alpha Q^{ko}_{mt}; \quad L^{kr}_{mt} = \frac{\alpha}{2^{\frac{\pi}{\beta}}} Q^{kr}_{mt}.$$

Fixed proportionalities implies that the employment growth rate is same as output growth rate. A change in trade regime from CFT to GFT, lowers the output growth functions, and hence the employment growth functions for both countries. Thus, the immediate effect of services trade liberalization is a fall in sectoral employment growth rate. Over time, ${}_LG^{kr}_{st}$ and ${}_LG^{kr}_{mt}$ monotonically decline along their respective growth functions. The sectoral employment growth dynamics resembles Figure 5.5. The effect of services trade on inter-sectoral growth gap is not clear – differences in sectoral output (and hence employment) growth rates may widen or narrow.

5.5 A Quantitative Assessment of Gains from Trade

The competitive framework without any presence of frictions or imperfections imply that more trade must be welfare-improving to each trading country compared to less trade. In this section, we undertake simulations to quantitatively and comparatively assess welfare gains from trade in commodities and those from trade in services as implied by our model. There is a vast literature on the estimation of welfare gains (in terms of real GDP per capita) from trade, of which most studies find these gains to be quite small. Although not stated explicitly, the literature refers predominantly to trade in commodities. Estimates from computational general equilibrium (CGE) models show welfare gains to be less than 1 per cent of GDP. For example, cross country studies Deardorff and Stern (1986) and Hertel and Keeney (2006)[22] find global welfare gains from removal of tariffs to be about 0.07% and 0.27% respectively. Harrison et al. (1997) find that removal of tariff and non tariff barriers yields a global welfare gain of 0.2-0.7%. Kee et al. (2008) estimate the welfare gains from removing the existing tariff regimes, as of 2003, to be in the range of 0 (for Singapore) to 3.05% of GDP (for Egypt), the median for welfare gains being 0.17% of real GDP. While,

[22]Hertel and Keeney (2006) use the more recent GTAP 6 dataset. They find that two-thirds of the welfare gain is explained by free agricultural trade and that the gains vary by beneficiary region – highest for the developing countries (0.44%) and lowest for the high-income countries (0.23%).

Table 5.2: Parameter Values for Numerical Simulation

α	β	λ_1	λ_2	ρ	a_L	δ	$M^h = M^f$	$S^h = S^f$	E	$\eta = \gamma$
0.6	0.5	0.2	0.79	0.98	1.05	1	1	1	100	0.9

like most in the literature the preceding work assumes that domestic and foreign varieties are imperfect substitutes, a distinguishing feature of Kee et al. (2008) is that it directly estimates the import demand elasticities of different products and uses these estimates to calculate the standard (dead-weight) static welfare gains from the removal of the existing tariff structure.

Apart from reduced-form methods used in aforementioned studies, welfare gains have been calculated through structural estimation by directly estimating equations of a theoretical model. In addition to elements of comparative advantage such models typically incorporate sources of gains from trade like imperfect competition, heterogeneous firms and expansion of varieties. Estimates of welfare gains in these models are somewhat higher than those yielded by CGE models. For example, Arkolakis et al. (2012) and Melitz and Redding (2013) - both based on US data - find welfare gains from trade to be a little over 1%. Eaton and Kortum (2002) is an important exception and a landmark work in that it develops a competitive (rather than non-competitive) general equilibrium, Ricardian, model of world trade with many goods and countries. It presents estimates of welfare gains to due to change in geographical costs and tariffs. If all countries have initially imposed 5% ad valorem tariff on all imports (the average rate of tariff across manufacturing imports by OECD countries), then elimination of all tariffs results in welfare gains in the range of 0.21 to 1.31% across the OECD countries while most countries gain about 1%. Using a variation of the Eaton-Khortum model, Fernando and Lucas (2007) estimate welfare gains from tariff elimination by the largest 60 economies from the existing levels and the gains range from 0.15% to 5.16% with the simple average of 1.12% and a weighted average of 0.5%.

For our model, we choose the preference and technology parameters as in the previous numerical example, i.e., $\alpha = .6$, $\beta = .5$, $\lambda_1 = 0.2$, $\lambda_2 = 0.79$, $\delta = 1$, $E = 100$, $M^h = M^f = 1$, $S^h = S^f = 1$. The discount factor is assumed to be $\rho = 0.98$ (Acemoglu and Guerrieri (2008)). Given ρ, the value of a_L is chosen such that ρa_L matches the growth rate of the U.S. manufacturing output per worker during the period 1998-2011, equal to 1.03% annually (FRED Economic Data). For clarity, we present all parameter values in Table 5.2. Let period 1 be the initial period when both countries are in autarky with $\bar{L}_1^h = 10$, $\bar{L}_1^f = 5$. We suppose that the countries switch from autarky to commodity free trade in period 5. At this time period $\bar{L}_5^h = 11.38$ and $\bar{L}_5^f = 5.75$.

We tabulate, as the indicator of welfare, the real adjusted income per capita, as defined in (5.1), in the two regimes at $t = 5$. Their difference measures the static, one-period gain from commodity free trade.[23] Table 5.3 reports the results. The fourth and the last column show about 0.03% increase in welfare for the more developed (home) country and 0.07% for the less developed (foreign) country. As expected, the less developed country benefits more from trade in commodities than the more developed country.

Notice that in comparison to the existing literature, our (simulated) estimates are lower. This can be attributed to three reasons. First, in our model the numeraire good sector, which may be thought of as the agriculture, is assumed to be an endowment sector, and, hence, unlike, for example, Kee et al. (2008), does not capture production gain from trade liberalization in that sector. Second, in our model trade equilibrium is confined to the case of incomplete specialization; it does not capture extra gains from trade associated with complete specialization. Third, we assume that the domestic and foreign brands of traded manufacturing goods are perfect substitutes, i.e., the elasticity of substitution between these brands is infinity. Thus, compared to when the elasticity of substitution is finite, the effect of a decrease or an increase in tariff is less incident on the imported variety, entailing less welfare gain or loss.

The novelty of our analysis, however, lies in featuring trade in services along side commodity trade. There are not many studies on welfare gains from liberalization of service trade.

One main obstacle in quantifying gains from services trade liberalization has been the difficulty in measuring barriers to services trade. Unlike goods, which must cross borders and are subjected to custom duties and tariffs, services often involve direct transactions between the customer and the producer. This fact complicates the measurement in services as well as in their corresponding trade barriers (Konan and Maskus (2006)). Most empirical studies on services trade use rudimentary data on service trade barriers, and hence it is appropriate to state that the empirical literature on quantifying welfare gains from service

[23] In view of Proposition 5.1, the growth rate of each country's welfare is equal to $(\rho a_L)^{\lambda_1+\lambda_2}$ in all trade regimes including autarky.

Table 5.3: Welfare Effects of CFT: With differences in initial levels of development only. $\bar{L}_1^h = 10$, $\bar{L}_1^f = 5$.

Time	Welfare in Autarky	Welfare in CFT regime	Increase in Welfare from Autarky to CFT (in %)	Welfare in Autarky	Welfare in CFT regime	Increase in Welfare from Autarky to CFT (in %)
	Home			Foreign		
1	11.89			6.53		
2	12.25			6.72		
3	12.61			6.92		
4	12.98			7.13		
5	13.37	13.37	0.03	7.34	7.34	0.07
6	13.77	13.77	0.03	7.56	7.56	0.07
7	14.18	14.18	0.03	7.78	7.78	0.07
8	14.60	14.60	0.03	8.01	8.02	0.07
9	15.03	15.03	0.03	8.25	8.25	0.07
10	15.48	15.48	0.03	8.49	8.50	0.07

trade liberalization is at a relatively nascent stage. This literature shares two attributes: first, both consumer and business services are taken into consideration, and second, in most studies the estimated gains from services trade liberalization are higher than those from goods trade liberalization.

Francois (1999) provides the first cross-country estimates on barriers to services trade for selected services like business, financial and construction. Hertel (2000) uses these estimates to analyze the impact of post Uruguay round removal of services trade barriers on global welfare using a GTAP model. He finds that gains from services trade liberalization are about half of the gains from elimination of agricultural or manufacturing trade barriers. This is however contrary to what is seen in other studies and is probably because he considers services liberalization in selected service industries and omits services industries which had high tariff barriers (like transport and communication, R&D, health). Robinson et al. (2002) use a multi-country CGE model. The services trade protection data for the six services sectors, namely, utilities, construction, trade and transport, private service, public service, and housing, are obtained from Dee (1998). Welfare gains for the world economy as a whole from a 50% cut of protection in the service sectors are estimated to be five times larger than those from non-service sector trade liberalization (the former trade liberalization yields welfare gains of 1.05% compared to 0.20% from latter).[24]

There are papers on country specific gains from service trade liberalization. Using a CGE model, Chadha et al. (2003) estimate the annual gains for India from services liberalization (of 33% cut in services tariff) to be around 1.6%, compared to 0.4% from goods liberalization. Konan and Maskus (2006), who also use a CGE framework, compare goods versus services liberalization for Tunisia, and, find that elimination of goods tariff increases welfare by 1.5%, whereas services liberalization yields a welfare gain of 5.3%.[25,26]

Note that, consistent with the existing empirical literature, our model incorporates both business and consumer services. In our baseline simulation exercise, we fix the Armington

[24] Robinson et al. (2002) also consider trade-induced technology transfer, and, accounting for such transfers, find that the gains from services trade liberalization are about 2.99% and higher than gains from non-service sector trade liberalization (0.27%).

[25] Among various channels of services liberalization, Konan and Maskus (2006) consider two: removal of border barriers on tradable services and investment liberalization in services (i.e. allowing FDI in services). The gains are higher from the second channel (4%) than the first channel (1.22%)

[26] In a working paper, Jouini and Rebei (2013) also analyze welfare gains from services liberalization in Tunisia, based on a two-sector small open economy dynamic and stochastic general equilibrium model. Using Bayesian techniques, the estimated gains from services trade (via investment liberalization) ranges from 1.12% to 5.22%.

Table 5.4: Welfare Effects of GFT: With differences in initial levels of development only. $\bar{L}_1^h = 10$, $\bar{L}_1^f = 5$

Time	Home			Foreign		
	Total Welfare Change (%)	Decomposition of Welfare Change		Total Welfare Change (%)	Decomposition of Welfare Change	
		Similar Country Effect	Comparative Advantage Effect		Similar Country Effect	Comparative Advantage Effect
15	14.54	97.86	2.14	13.67	104.15	-4.15
16	14.54	97.86	2.14	13.67	104.15	-4.15
17	14.54	97.86	2.14	13.67	104.15	-4.15
18	14.54	97.86	2.14	13.67	104.15	-4.15
19	14.54	97.86	2.14	13.67	104.15	-4.15
20	14.54	97.86	2.14	13.67	104.15	-4.15

elasticities of both business and consumer services at 6.2 (which implies $\eta = \gamma = 0.8$)[27]. The two countries are same as described earlier in Table 5.2. It is supposed that they switch from CFT to GFT regime in period 15. At $t = 15$, $\bar{L}_{15}^h = 15.64$ and $\bar{L}_{15}^f = 8.08$. Table 5.4 reports one-period (static) welfare change of these countries. Observe that as the two countries move from CFT to GFT,

1. The gains from transition from CFT to GFT regime (about 14%) exceed those from autarky to goods trade liberalization (0.03% for the manufacturing-exporting (home) country and 0.07% for the manufacturing-importing (foreign) country). While this is qualitatively similar to the empirical evidence, quantitative differences are huge: 14% gains from service trade liberalization in our model, as compared to 3 to 5% in the papers cited above. Such large welfare gains mainly stem from the increase in the variety of services from one to two in both consumption and production, which would be absent when one compares some (restricted) trade to free trade in services.

2. Service trade liberalization leads to higher welfare gains (14.54%) for the more developed

[27] In a review paper, McDaniel and Balistreri (2003) note that the Armington elasticities in manufacturing range from 0.53 to 13. We choose the Armington elasticity of services to be the midpoint of this range.

(home) country than those (13.67%) for the less developed (foreign) country. This is unusual. Unlike in a standard comparative-advantage based model of trade, in our model world economy relative prices and real wages move in the same direction and with same magnitude for *both* trading countries; thus, the same real wage increase per unit of effective labor bestows more real income gain and hence higher welfare gain to the more human-capital-rich country.

3. Table 5.4 provides a decomposition of total gains from services trade to the variety (similar-country) effect and the comparative advantage effect (differing levels of the stock of human capital). We see that the variety effect 'drives' the gains from services trade. It is because, as discussed in the beginning of Section 5.4.3, welfare gains accrue to trading countries due to comparative advantage i.e. asymmetry, *only* in the presence of variety effects which lead to changes in the terms of trade when countries move from CFT to the GFT regime. Otherwise, without any variety effect, there are no changes in terms of trade despite asymmetry and hence no welfare gains - or losses.

Sensitivity Analysis

How robust are our simulated welfare gains? Of eleven parameters which fully specify the world economy (see Table 5.2), technology and preferences parameters (α, β, λ_1 and λ_2) are obtained from actual data - which is a standard practice. The value of discount factor that we have taken is also standard in the literature. The growth parameter, a_L, is induced from data. These parameters are not varied in our sensitivity analysis. Regarding the productivity parameters, in GFT regime we had assumed them to be equal across the two countries (i.e., $M^h = M^f$ and $S^h = S^f$). We find that under this scenario (of identical technologies), welfare gains are not sensitive to variations in technology parameters. The same holds for the endowment parameter E. The remaining parameters are δ, the non-homotheticity parameter, and $\eta = \gamma$, the Armington elasticity. In our model these parameters 'define' service goods as opposed to commodities. Hence, sensitivity of welfare gains with respect to these two parameters is of special interest.

We find that welfare gains (from both commodities and services free trade) are not sensitive to the non-homothecity parameter (δ). As Tables 5.5 and 5.6 depict, a 20% variation in δ from its bench-mark value of unity reduces welfare gains of trading countries from

Table 5.5: Sensitivity Analysis: Autarky to CFT

Parameter (% Change)		Change in Welfare Gains from Baseline Model (in percentage points)[30]	
		Home	Foreign
δ	+20%	- 0.001	- 0.004
	-20%	0.002	0.004
$\bar{L}_1^h$	+20%	0.010	0.052
	-20%	- 0.014	- 0.041

commodities trade by negligible percentage points and those from services trade by 0.2 to 0.3 percentage points. However, welfare gains from free services trade are quite sensitive to Armington elasticities.[28] A 20% deviation in these elasticities leads a change in welfare gains to the tune of 3-5 percentage points.

Besides some of the parameters of the model, we also checked the robustness of welfare gains to initial conditions on the levels of human capital.[29]

Table 5.6: Sensitivity Analysis: CFT to GFT

Parameter (% Change)		Change in Welfare Gains from Baseline Model (in percentage points)[31]	
		Home	Foreign
δ	+20%	- 0.18	-0.32
	-20%	0.20	0.33
$\frac{1}{1-\eta} = \frac{1}{1-\gamma}$	+20%	-2.96	-2.79
	-20%	5.01	4.61
$\bar{L}_1^h$	+20%	0.17	0.00
	-20%	-0.23	-0.01

An increase in $\bar{L}_1^h$ by 20% (which, at given $\bar{L}_1^f$, widens the developmental gap between the two countries by 40%) implies almost double welfare gains (0.068% to 0.12%) from commodity free trade for both countries. This reflects higher gains from greater comparative advantage.

[28]In their review paper, McDaniel and Balistreri (2003) also find that the values of Armington elasticities have a significant effect on the magnitudes of welfare gains.

[29]We also found that variations in the dates of trade regime shifts have little impact on welfare gains.

[30]The baseline welfare gains from commodities trade were 0.030% for home country and 0.068% for foreign country.

[31]The baseline welfare gains from services trade were 14.54% for home country and 13.67% for the foreign country.

However, welfare gains from services free trade are not sensitive to the developmental gap (i.e. comparative advantage) - since, as discussed earlier, it is the variety effect, not asymmetry in the level of development which effectuates terms of trade movements.

5.6 Concluding Remarks

This essay has formulated a competitive model of trade in services alongside trade in goods or commodities. In contrast to goods, services are distinguished by the income elasticity of household demand for them being greater than unity, and, across countries, services being more differentiated than goods. Antecedents of both characteristics of services are contained in the existing trade, development and growth literature. We consider consumer as well as producer services, and, analyze static as well as dynamic effects of trade in commodities and trade in services. Trade in services has become more pronounced in relatively recent years. We thus consider the following sequence: starting from autarky the two countries in our model first open trade in commodities (free trade in commodities only) and then open trade in services (grand free trade). In all three regimes, the service sector output grows faster than manufacturing, because the income elasticity of demand for services by households exceeds unity.

In terms of static effects, trade in commodities are founded on comparative advantage, while that in services contain elements of comparative advantage as well as those of trade among similar countries. The larger or the more developed country possesses comparative advantage in manufacturing and comparative disadvantage in services. In the absence of trade in services, technological superiority in producing manufacturing is a source of comparative advantage in manufacturing while, higher services productivity may serve as a basis of comparative advantage in manufacturing. In case of identical technologies across the two countries, trade in services features a service-output-equalization outcome: that is, despite differences in sizes or the level of development, both economies will produce the same amount of service output in equilibrium. It is because, individually, the world demand functions for service brands across countries are identical. Our model predicts leapfrogging by smaller or less developed economies in terms of producing services as service trade becomes freer in the world economy. Our numerical analysis points to strong and robust welfare gains from trade in services, compared to meager gains from commodities trade liberalization and the large gains from trade in services stem mainly from larger variety effects which directly benefits household utility and also enhances productivity across production sectors.

Absent factors such as technological progress through R&D, learning by doing etc., long-run growth in our model economy is unaffected by shifts in trade regime. Non-homotheticity of preferences implies transitional growth however, which is influenced by trade-regime changes. The growth rate of a sector is dependent on the level of output or employment and we call this the ‘growth function.’ Furthermore, the growth rate is negatively related to output or employment in that sector, and, in this sense there is ‘convergence.’ Trade in commodities leads to movements along the growth functions, whereas trade in services implies both a shift and a movement along a functions. The shift occurs since trade in services leads to (one-time) productivity increase in both manufacturing and services sectors.

Although the literature on trade in services is burgeoning, most of it is empirical. The current essay is an initial attempt to formulate a theoretical framework which allows for and distinguishes between trade in commodities and trade in services. Among the four modes of service provision across countries, the essay deals with Mode 1 - cross-border trade in services, which is ‘disembodied.’ Although this form of service trade has grown rapidly over the decades, so have service trade in other modes, notably mode 3: through commercial presence; see, Francois et al. (2009). Since service trade via mode 3 is associated with FDI in service, FDI must be an integral part in developing a more representative model of trade in services.

Appendix 5.A

This refers to Autarky. The input-coefficient expressions are:

$$a_{lm}^{ka} = \frac{\alpha(p_s^k/w^k)^{1-\alpha}}{M^k} = \frac{\alpha}{(M^k S^{k\,1-\alpha})^{1/\theta}};\ a_{sm}^{ka} = \frac{(1-\alpha)(w^k/p_s^k)^{\alpha}}{M^k} = \frac{1-\alpha}{\phi^k}$$
$$a_{ls}^{ka} = \frac{\beta(p_m^k/w^k)^{1-\beta}}{S^k} = \frac{\beta}{M^{k\,(1-\beta)/\theta} S^{k\,1/\theta}};\ a_{ms}^{ka} = \frac{(1-\beta)(w^k/p_m^k)^{\beta}}{S^k} = (1-\beta)\phi^k,$$

where ϕ is defined in (5.3).

Appendix 5.B

This refers to Free Trade in Commodities Only.

Proof of Proposition 5.5

Eqs. (5.16) yield that (i) C_{mt}^h is decreasing, (ii) Q_{mt}^h is increasing and (iii) $p_{mt}^o C_{mt}^h$ is increasing in p_{mt}^o; (iii) implies that C_{dt}^h increases with p_{mt}^o.

Consider the manufacturing-exporting country, say h. It is already shown that in CFT equilibrium $C_{dt}^{ho} > E$, while E equals the amount consumed of good D in autarky. That is, as free trade in commodities opens up, the manufacturing-exporting country's consumption of good D increases. Since C_{dt}^h increases with p_{mt}^o, it follows that the manufacturing-exporting country sees an increase in p_{mt} as the economies move from autarky to CFT. In view of (i) and (ii), it experiences a decrease in C_{mt}^h and an increase in Q_{mt}^h. An increase in p_{mt} implies an increase in p_{st}. As Q_{mt}^h increases, Q_{st}^h must fall, so that full employment ensured, and, use of services as input to manufacturing must increase. In the light of (5.15b), C_{st}^h falls as C_{mt}^h decreases. ■

Proof of Proposition 5.6

In view of (5.15c) and (5.15d)

$$\frac{\lambda_1}{1-\lambda_1-\lambda_2} \cdot \frac{2E}{\sum_k C_{mt}^{ko}} = p_{mt}^o.$$

Substituting the above into the first equation in (5.16) and eliminating E, defining $\mu^k =$

$\sum_k C^{ko}_{mt}/(2C^{ko}_{mt})$ and utilizing (5.4b) give rise to

$$Q^{ko}_{st} = \frac{[(1-\alpha)\lambda_1 + \lambda_2 + (1-\alpha)(1-\lambda_1-\lambda_2)(1-\mu^k)]C^{ko}_{mt} - \lambda_1\delta\phi^k}{\lambda_1\theta\phi^k}$$

$$Q^{ko}_{mt} = \frac{[\lambda_1 + (1-\beta)\lambda_2 + (1-\lambda_1-\lambda_2)(1-\mu^k)]C^{ko}_{mt} - (1-\beta)\lambda_1\delta\phi^k}{\lambda_1\theta}.$$

These expressions imply

$$_QG^{ko}_{st} = \rho a_L + \frac{(\rho a_L - 1)\delta}{\theta Q^{ko}_{st}} = {_QG^a_s}(Q^{ko}_{st});\ {_QG^{ko}_{mt}} = \rho a_L + \frac{(\rho a_L - 1)(1-\beta)\delta}{\theta Q^{ko}_{mt}} \equiv {_QG^a_m}(Q^{ko}_{mt}), \tag{5.A.1}$$

which are same as (5.11) and (5.12). ■

Proof of No Overtaking of the Level of Development in Case of Identical Technologies

Normalizing $M^k = S^k = 1$, from the output expressions,

$$\begin{aligned} \bar{L}^k_0 &= a^{ka}_{lm}Q^{ho}_{m0} + a^{ka}_{ls}Q^{ho}_{s0} = \alpha Q^{ho}_{m0} + \beta Q^{ho}_{s0} \\ &= \frac{[1-(1-\lambda_1-\lambda_2)\mu^k]C^{ko}_{m0} - \lambda_1\delta}{\lambda_1} \\ \Rightarrow \frac{\bar{L}^h_0}{\bar{L}^f_0} &= \frac{[1-(1-\lambda_1-\lambda_2)\mu^h]C^{ho}_{m0} - \lambda_1\delta}{[1-(1-\lambda_1-\lambda_2)\mu^f]C^{fo}_{m0} - \lambda_1\delta} \end{aligned}$$

If $\bar{L}^h_0 > \bar{L}^f_0$, then

$$\begin{aligned} &[1-(1-\lambda_1-\lambda_2)\mu^h]C^{ho}_{m0} > [1-(1-\lambda_1-\lambda_2)\mu^f]C^{fo}_{m0} \\ \Rightarrow &[1-(1-\lambda_1-\lambda_2)\mu^h]C^{ho}_{m1} > [1-(1-\lambda_1-\lambda_2)\mu^f]C^{fo}_{m1} \text{ since } C^{ko}_{m1} = \rho a_L C^{ko}_{m0} \\ &\Rightarrow \frac{\bar{L}^h_1}{\bar{L}^f_1} > 1. \end{aligned}$$

By repetition, $\bar{L}^h_t > \bar{L}^f_t$ for all t. ■

Proof of Proposition 5.8

For simplicity, let $M^k = S^k = 1$. Thus

$$\phi^k = 1;\ \frac{p^{ka}_{mt}}{p^{ka}_{st}} = 1;\ a^{ka}_{lm} = \alpha;\quad a^{ka}_{sm} = 1-\alpha;\quad a^{ka}_{ls} = \beta;\quad a^{ka}_{ms} = 1-\beta.$$

We eliminate C^{ko}_{st}, C^{ko}_{mt} and C^{ko}_{dt} from eqs.(5.15c)-(5.15e) and obtain

$$-\frac{(1-\alpha)(1-\beta\lambda_2)}{\lambda_2}\cdot Q^{ko}_{mt}+\frac{1-\beta\lambda_2}{\lambda_2}\cdot Q^{ko}_{st}=\frac{E}{p^o_{mt}}-\frac{(1-\lambda_2)\delta}{\lambda_2}. \tag{5.A.2}$$

Eqs. (5.A.2) and (5.15a) imply

$$\frac{\partial Q^{ko}_{st}}{\partial \bar{L}^k_t}>0;\quad \frac{\partial Q^{ko}_{mt}}{\partial \bar{L}^k_t}>0.$$

Hence the country having a higher endowment of $\bar{L}^k_t$ will produce more of both goods. ■

Closed Form Solutions When Technologies are Identical Across Countries

Using the same normalizations for notational simplicity and summing up over two countries the equations representing static CFT equilibrium, we obtain

$$\begin{aligned}\alpha Q^{wo}_{mt}+\beta Q^{wo}_{st}&=\bar{L}^w_t\\(1-\alpha)Q^{wo}_{mt}+C^{wo}_{st}&=Q^{wo}_{st}\\C^{wo}_{mt}+(1-\beta)Q^{wo}_{st}&=Q^{wo}_{mt}\\Q^{wo}_{st}+2\delta&=\frac{\lambda_2}{\lambda_1}C^{wo}_{mt},\end{aligned}$$

where the superscript ^{w} denote the world level. These equations explicitly solve world-level production and consumption of manufacturing and services. In particular

$$\begin{aligned}Q^{wo}_{st}&=\frac{[(1-\alpha)\lambda_1+\lambda_2]\bar{L}^w_t-2\lambda_1\alpha\delta}{(\lambda_1+\lambda_2)\theta}\\Q^{wo}_{mt}&=\frac{[\lambda_1+(1-\beta)\lambda_2]\bar{L}^w_t+2\lambda_1\beta\delta}{(\lambda_1+\lambda_2)\theta}\\C^{wo}_{mt}&=\frac{\lambda_1(\bar{L}^w_t+2\delta)}{\lambda_1+\lambda_2}\\p^o_{mt}=p^o_{st}&=\frac{\lambda_1+\lambda_2}{1-\lambda_1-\lambda_2}\cdot\frac{E}{\bar{L}^w_t/2+\delta}.\end{aligned} \tag{5.A.3}$$

Production and consumption of manufactures and services can then be solved from (5.15a), (5.15b), (5.15e) and (5.15f). We have the following expressions for equilibrium outputs:

$$
\begin{aligned}
Q_{st}^{ko} &= \frac{[(1-\alpha)\lambda_1+\lambda_2]\frac{\bar{L}_t^w}{2}-\alpha\lambda_1\delta}{(\lambda_1+\lambda_2)\theta}+\frac{1-\alpha(1-\lambda_2)}{\theta}\left(\bar{L}_t^k-\frac{\bar{L}_t^w}{2}\right)\\
Q_{mt}^{ko} &= \frac{[\lambda_1+(1-\beta)\lambda_2]\frac{\bar{L}_t^w}{2}+\beta\lambda_1\delta}{(\lambda_1+\lambda_2)\theta}+\frac{1-\beta\lambda_2}{\theta}\left(\bar{L}_t^k-\frac{\bar{L}_t^w}{2}\right).
\end{aligned}
\tag{5.A.4}
$$

Appendix 5.C

This section refers to Grand Free Trade.

Input Coefficient Expressions

Using (5.18),

$$
a_{lm}^{kr}=\frac{\alpha}{M^k}\left(\frac{P_s^m}{w^k}\right)^{1-\alpha}=\frac{\alpha}{\nu_1^{1-\alpha}M^{k\frac{1}{\alpha}}};\; a_{sm}^{kr}=\frac{1-\alpha}{M^k}\left(\frac{w^k}{P_s^m}\right)^{\alpha}=(1-\alpha)\nu_1^{\alpha}
$$

$$
a_{ls}^{kr}=\frac{\beta}{S^k}\left(\frac{p_m^r}{w^k}\right)^{1-\beta}=\frac{\beta}{\nu_1^{(1-\alpha)(1-\beta)}M^{k\frac{1-\beta}{\alpha}}S^k};\; a_{ms}^{kr}=\frac{1-\beta}{S^k}\left(\frac{w^k}{p_m^r}\right)^{\beta}=(1-\beta)\nu_1^{(1-\alpha)\beta}\frac{M^{k\frac{\beta}{\alpha}}}{S^k}.
$$

$$
a_{lm}^{kr}Q_{mt}^{kr}+a_{ls}^{kr}Q_{st}^{kr}=\bar{L}_t^k \tag{5.A.5a}
$$

$$
Z_{st}^{kr}+\delta=\frac{p_{mt}^r}{P_{st}^c}\cdot\frac{\lambda_2}{\lambda_1}\cdot C_{mt}^{kr} \tag{5.A.5b}
$$

$$
\frac{\lambda_1}{1-\lambda_1-\lambda_2}\frac{C_{dt}^{kr}}{C_{mt}^{kr}}=p_{mt}^r \tag{5.A.5c}
$$

$$
\sum_k C_{dt}^{kr}=2E \tag{5.A.5d}
$$

$$
\left(\frac{p_{st}^h}{P_{st}^c}\right)^{-\frac{1}{1-\gamma}}\sum_k Z_{st}^{kr}+\left(\frac{p_{st}^h}{P_{st}^m}\right)^{-\frac{1}{1-\eta}}\sum_k a_{sm}^{kr}Q_{mt}^{kr}=Q_{st}^{hr} \tag{5.A.5e}
$$

$$
\left(\frac{p_{st}^f}{P_{st}^c}\right)^{-\frac{1}{1-\gamma}}\sum_k Z_{st}^{kr}+\left(\frac{p_{st}^f}{P_{st}^m}\right)^{-\frac{1}{1-\eta}}\sum_k a_{sm}^{kr}Q_{mt}^{kr}=Q_{st}^{fr} \tag{5.A.5f}
$$

$$
C_{mt}^{kr}+\frac{P_{st}^c}{p_{mt}^r}Z_{st}^{kr}+\frac{C_{dt}^{kr}}{p_{mt}^r}=\alpha Q_{mt}^{kr}+\frac{\beta p_{st}^k}{p_{mt}^r}Q_{st}^{kr}+\frac{E}{p_{mt}^r}, \tag{5.A.5g}
$$

where $k=h,f$.

Derivation of System (5.19a)-(5.19g)

We have

$$\frac{P^c_{st}}{p^r_{mt}} = \nu_1^{(1-\alpha)\beta}\nu_2;\ \frac{P^m_{st}}{p^r_{mt}} = \frac{1}{\nu_1^\alpha};\ \frac{p^k_{st}}{p^r_{mt}} = \phi^{k\frac{\theta}{\alpha}}\nu_1^{(1-\alpha)\beta};\ \frac{p^k_{st}}{P^c_{st}} = \frac{\phi^{k\frac{\theta}{\alpha}}}{\nu_2};\ \frac{p^k_{st}}{P^m_{st}} = \phi^{k\frac{\theta}{\alpha}}\nu_1^\theta. \tag{5.A.6}$$

Using (5.A.6) and the expressions of input coefficients above, the system (5.A.5a)-(5.A.5g) can be expressed as

$$\begin{aligned}
\frac{\alpha Q^k_{mt}}{\nu_1^{1-\alpha}M^{k\frac{1-\alpha}{\alpha}}} + \frac{\beta Q^k_{st}}{\nu_1^{(1-\alpha)(1-\beta)}M^{k\frac{1-\beta}{\alpha}}} &= \bar{L}^k_t \\
\frac{\lambda_1}{1-\lambda_1-\lambda_2}\frac{C^k_{dt}}{C^k_{mt}} &= p^r_{mt} \\
Z^k_{st} + \delta &= \frac{1}{\nu_1^{(1-\alpha)\beta}\nu_2}\cdot\frac{\lambda_2}{\lambda_1}C^k_{mt} \\
C^h_{dt} + C^f_{dt} &= 2E \\
\left(\frac{\nu_2}{\phi^{h\frac{\theta}{\alpha}}}\right)^{\frac{1}{1-\gamma}}\sum_k Z^k_{st} + \frac{(1-\alpha)\nu_1^\alpha}{\left(\phi^{h\frac{\theta}{\alpha}}\nu_1^\theta\right)^{\frac{1}{1-\eta}}}\sum_k M^{k\beta/\alpha}Q^k_{mt} &= Q^h_{st} \\
\left(\frac{\nu_2}{\phi^{f\frac{\theta}{\alpha}}}\right)^{\frac{1}{1-\gamma}}\sum_k Z^k_{st} + \frac{(1-\alpha)\nu_1^\alpha}{\left(\phi^{f\frac{\theta}{\alpha}}\nu_1^\theta\right)^{\frac{1}{1-\eta}}}\sum_k M^{k\beta/\alpha}Q^k_{mt} &= Q^f_{st} \\
C^k_{mt} + \nu_1^{(1-\alpha)\beta}\nu_2 Z^k_{st} + \frac{C^k_{dt}}{p^r_{mt}} &= \alpha Q^k_{mt} + \beta\phi^{k\frac{\theta}{\alpha}}\nu_1^{(1-\alpha)\beta}Q^k_{st} + \frac{E}{p^r_{mt}},
\end{aligned} \tag{5.A.7}$$

where $k = h, f$.

Under our assumption of identical technologies across countries, we take

$$\begin{aligned}
& M^k = S^k = 1 \\
\Rightarrow\ & \phi^k = 1;\ \nu_1 = 2^{\frac{1-\eta}{\eta\theta}};\ \nu_2 = \frac{1}{2^{\frac{1-\gamma}{\gamma}}} \\
& a^{kr}_{lm} = 2^{-\frac{(1-\eta)(1-\alpha)}{\eta\theta}}\alpha,\ a^{kr}_{sm} = 2^{\frac{\alpha(1-\eta)}{\eta\theta}}(1-\alpha) \\
& a^{kr}_{ls} = \frac{\beta}{2^{\frac{(1-\eta)(1-\alpha)(1-\beta)}{\eta\theta}}},\ a^{kr}_{ms} = (1-\beta)2^{\frac{(1-\eta)(1-\alpha)\beta}{\eta\theta}}.
\end{aligned} \tag{5.A.8}$$

Using (5.A.8), the system (5.A.7) reduces to equations (5.19a) through (5.19g).

Proof of Proposition 5.11

Suppose country h is more developed when GFT occurs at time τ, i.e., $\bar{L}_\tau^h > \bar{L}_\tau^f$. Turn to the expressions for Q_{st}^{kr} and Q_{mt}^{kr} as given in (5.A.17) and (5.A.18). Using these, the full-employment equation (5.19a) implies

$$\bar{L}_t^k = \mathcal{A}^h C_{mt}^{kr} + \mathcal{B}\frac{C_{mt}^{wr}}{2} - \mathcal{C}, \tag{5.A.9}$$

where

$$\mathcal{A}^k \equiv \frac{\theta - \{(1-\alpha)\beta + \alpha[1 - \lambda_1 - (1-\beta)\lambda_2]\}\mu^k}{2^{\frac{\pi}{\beta}}\lambda_1\theta}$$
$$\mathcal{B} \equiv \frac{\beta[(1-\alpha)\lambda_1 + \lambda_2]}{2^{\frac{\pi}{\beta}}\lambda_1\theta}; \quad \mathcal{C} \equiv \frac{\delta}{2^{\frac{1-\gamma}{\gamma}+\frac{\pi(1-\beta)}{\beta}}}.$$

Hence

$$\begin{aligned}
&\bar{L}_\tau^h > \bar{L}_\tau^f \\
\Rightarrow &\mathcal{A}^h C_{m\tau}^{hr} + \mathcal{B}\frac{C_{m\tau}^{wr}}{2} > \mathcal{A}^f C_{m\tau}^{fr} + \mathcal{B}\frac{C_{m\tau}^{wr}}{2} \\
\Rightarrow &\mathcal{A}^h \rho a_L C_{m\tau}^{hr} + \mathcal{B}\rho a_L\frac{C_{m\tau}^{wr}}{2} - \mathcal{C} > \mathcal{A}^f \rho a_L C_{m\tau}^{fr} + \mathcal{B}\rho a_L\frac{C_{m\tau}^{wr}}{2} - \mathcal{C} \\
\Rightarrow &\mathcal{A}^h C_{m\tau+1}^{hr} + \mathcal{B}\frac{C_{m\tau+1}^{wr}}{2} - \mathcal{C} > \mathcal{A}^f C_{m\tau+1}^{fr} + \mathcal{B}\frac{C_{m\tau+1}^{wr}}{2} - \mathcal{C}, \text{ since } C_{mt}^{kr} \text{ grows at the rate } \rho a_L \\
\Rightarrow &\bar{L}_{\tau+1}^h > \bar{L}_{\tau+1}^f
\end{aligned}$$

Thus, if country h is more developed than country f when GFT occurs it remains more developed for all time periods afterwords.

Let country h be the more developed country. Since both countries produce the same amount of services, country h must be producing a higher amount of manufacturing, i.e., $Q_{mt}^{hr} > Q_{mt}^{fr}$.

We express eq. (5.19g) as

$$\frac{1}{\lambda_1}C_{mt}^{kr} - \frac{\delta}{2^{\frac{1-\gamma}{\gamma}-\pi}} = \alpha Q_{mt}^{kr} + 2^\pi \beta Q_{st}^{kr} + \frac{E}{p_{mt}^r} \tag{5.A.10}$$

$$\Rightarrow Q_{mt}^{kr} - C_{mt}^{kr} = \left(\frac{1}{\lambda_1 \alpha} - 1\right) C_{mt}^{kr} - \frac{\delta}{2^{\frac{1-\gamma}{\gamma}-\pi}\alpha} - \frac{2^\pi\beta}{\alpha}Q_{st}^{kr} - \frac{E}{\alpha p_{mt}^r}. \tag{5.A.11}$$

From (5.A.10), since $Q^{hr}_{mt} > Q^{fr}_{mt}$ and $Q^{hr}_{st} = Q^{fr}_{st}$, we have $C^{hr}_{mt} > C^{fr}_{mt}$. In turn, in the light of (5.A.5b), $C^{hr}_{mt} > C^{fr}_{mt}$ implies $Z^{h}_{st} > Z^{f}_{st}$. The last two inequalities together with $Q^{hr}_{st} = Q^{fr}_{st}$ imply that the service trade balance of country h is less than that of country f and hence negative. In view of (5.A.11), $Q^{hr}_{mt} - C^{hr}_{mt} > Q^{fr}_{mt} - C^{fr}_{mt}$, as $C^{hr}_{mt} > C^{fr}_{mt}$ and $Q^{hr}_{st} = Q^{fr}_{st}$. Hence, $Q^{hr}_{mt} - C^{hr}_{mt} - 2^{\pi}(1-\beta)Q^{hr}_{st} > Q^{fr}_{mt} - C^{fr}_{mt} - 2^{\pi}(1-\beta)Q^{fr}_{st}$, that is, country h will have a positive manufacturing trade balance. ■

Closed-Form Solutions of the System (5.19a)-(5.19g)

Aggregating the equations over the two countries, world-level quantities and relative price of manufacturing in terms of the numeraire good can be solved: Particularly,

$$
\begin{aligned}
Q^{wr}_{st} &= \frac{2^{\frac{\pi(1-\beta)}{\beta}}[(1-\alpha)\lambda_1+\lambda_2]\bar{L}^w_t - \frac{2\alpha\lambda_1\delta}{2^{\frac{1-\gamma}{\gamma}}}}{(\lambda_1+\lambda_2)\theta} \\
Q^{wr}_{mt} &= \frac{2^{\frac{\pi}{\beta}}[\lambda_1+(1-\beta)\lambda_2]\bar{L}^w_t + \frac{2\beta\lambda_1\delta}{2^{\frac{1-\gamma}{\gamma}-\pi}}}{(\lambda_1+\lambda_2)\theta} \\
C^{wr}_{mt} &= \frac{\lambda_1}{\lambda_1+\lambda_2}\left(2^{\frac{\pi}{\beta}}\bar{L}^w_t + \frac{2\delta}{2^{\frac{1-\gamma}{\gamma}-\pi}}\right) \\
p^r_{mt} &= \frac{\lambda_1}{1-\lambda_1-\lambda_2}\cdot\frac{2E}{C^{wr}_{mt}} = \frac{\lambda_1+\lambda_2}{1-\lambda_1-\lambda_2}\cdot\frac{E}{2^{\frac{\pi}{\beta}}\cdot\frac{\bar{L}^w_t}{2} + \frac{\delta}{2^{\frac{1-\gamma}{\gamma}-\pi}}} \\
p^r_{st} &= \frac{\lambda_1}{1-\lambda_1-\lambda_2}\cdot\frac{2E}{C^{wr}_{mt}} = \frac{\lambda_1+\lambda_2}{1-\lambda_1-\lambda_2}\cdot\frac{E}{2^{\frac{\pi}{\beta}-\pi}\cdot\frac{\bar{L}^w_t}{2} + \frac{\delta}{2^{\frac{1-\gamma}{\gamma}}}}.
\end{aligned}
\tag{5.A.12}
$$

For respective countries

$$
\begin{aligned}
Q^{kr}_{st} &= \frac{Q^{wr}_{st}}{2} = \frac{2^{\frac{\pi(1-\beta)}{\beta}}[(1-\alpha)\lambda_1+\lambda_2]\frac{\bar{L}^w_t}{2} - \frac{\alpha\lambda_1\delta}{2^{\frac{1-\gamma}{\gamma}}}}{(\lambda_1+\lambda_2)\theta} \\
Q^{kr}_{mt} &= \frac{2^{\frac{\pi}{\beta}}[\lambda_1+(1-\beta)\lambda_2]\frac{\bar{L}^w_t}{2} + \frac{\beta\lambda_1\delta}{2^{\frac{1-\gamma}{\gamma}-\pi}}}{(\lambda_1+\lambda_2)\theta} + \frac{2^{\frac{\pi}{\beta}}}{\alpha}\left(\bar{L}^k_t - \frac{\bar{L}^w_2}{2}\right).
\end{aligned}
\tag{5.A.13}
$$

Proof of Proposition 5.12

Solution expressions for world-level output and price of manufacturing in CFT and GFT regimes are given in (5.A.3) and (5.A.12). On subtraction,

$$
\begin{aligned}
Q_{st}^{wr} - Q_{st}^{wo} &= \frac{\left[2^{\frac{\pi(1-\beta)}{\beta}} - 1\right][(1-\alpha)\lambda_1 + \lambda_2]\bar{L}_t^w + \left(1 - \frac{1}{2^{\frac{1-\gamma}{\gamma}}}\right)2\alpha\lambda_1\delta}{(\lambda_1+\lambda_2)\theta} > 0 \\
Q_{mt}^{wr} - Q_{mt}^{wo} &= \frac{\left(2^{\frac{\pi}{\beta}} - 1\right)[\lambda_1 + (1-\beta)\lambda_2]\bar{L}_t^w - \left(1 - \frac{1}{2^{\frac{1-\gamma}{\gamma}-\pi}}\right)2\beta\lambda_1\delta}{(\lambda_1+\lambda_2)\theta} \gtrless 0 \\
p_{mt}^{wr} - p_{mt}^{wo} &= \frac{(\lambda_1+\lambda_2)E}{1-\lambda_1-\lambda_2}\cdot\left(\frac{1}{2^{\frac{\pi}{\beta}}\cdot\frac{\bar{L}_t^w}{2} + \frac{\delta}{2^{\frac{1-\gamma}{\gamma}-\pi}}} - \frac{1}{\frac{\bar{L}_t^w}{2}+\delta}\right) \gtrless 0 \\
p_{mt}^{wr} - p_{mt}^{wo} &= \frac{(\lambda_1+\lambda_2)E}{1-\lambda_1-\lambda_2}\cdot\left(\frac{1}{2^{\frac{\pi}{\beta}-\pi}\cdot\frac{\bar{L}_t^w}{2} + \frac{\delta}{2^{\frac{1-\gamma}{\gamma}}}} - \frac{1}{\frac{\bar{L}_t^w}{2}+\delta}\right) \gtrless 0
\end{aligned}
\qquad (5.A.14)
$$

Proof of Proposition 5.13

Subtracting (5.A.4) from (5.A.13)

$$
\begin{aligned}
Q_{st}^{kr} - Q_{st}^{ko} &= \frac{\left[2^{\frac{\pi(1-\beta)}{\beta}} - 1\right][(1-\alpha)\lambda_1 + \lambda_2]\frac{\bar{L}_t^w}{2} + \left(1 - \frac{1}{2^{\frac{1-\gamma}{\gamma}}}\right)\alpha\lambda_1\delta}{(\lambda_1+\lambda_2)\theta} \\
&\quad - \frac{1-\alpha(1-\lambda_2)}{\theta}\left(\bar{L}_t^k - \frac{\bar{L}_t^w}{2}\right) \\
Q_{mt}^{kr} - Q_{mt}^{ko} &= \frac{\left(2^{\frac{\pi}{\beta}} - 1\right)[\lambda_1 + (1-\beta)\lambda_2]\frac{\bar{L}_t^w}{2} - \left(1 - \frac{1}{2^{\frac{1-\gamma}{\gamma}-\pi}}\right)\beta\lambda_1\delta}{(\lambda_1+\lambda_2)\theta} + \frac{2^{\frac{\pi}{\beta}}}{\alpha}\left(\bar{L}_t^k - \frac{\bar{L}_2^w}{2}\right).
\end{aligned}
\qquad (5.A.15)
$$

We have $\bar{L}_t^k \gtrless \bar{L}_t^w/2$ as country k is more or less developed. From the above expressions, $Q_{st}^{kr} > Q_{st}^{ko}$ if $\bar{L}_t^k < \bar{L}_t^w/2$ and $Q_{st}^{kr} \gtrless Q_{st}^{ko}$ if $\bar{L}_t^k > \bar{L}_t^w/2$, and, Q_{mt}^{kr} and Q_{mt}^{ko} cannot be compared irrespective of whether $\bar{L}_t^k \gtrless \bar{L}_t^w/2$.

From output expressions,

$$\frac{\alpha}{2^{\frac{\pi}{\beta}}} Q^{kr}_{mt} - \alpha Q^{ko}_{mt} = \frac{\beta - \alpha\beta(1-\lambda_2)}{\theta}\left(\bar{L}^k_t - \frac{\bar{L}^w_t}{2}\right) - \frac{\alpha\beta\lambda_1\delta\left(1 - \frac{1}{2^{\frac{1-\gamma}{\gamma}-\pi}}\right)}{(\lambda_1+\lambda_2)\theta} \tag{5.A.16}$$
$$< 0 \text{ if } \bar{L}^k_t < \frac{\bar{L}^w_t}{2}.$$

■

Derivation of Growth Functions Given in (5.21)

From the expressions of C^{wr}_{mt} in (5.A.12) and Q^{kr}_{st} in (5.A.13),

$$Q^{kr}_{st} = \frac{[(1-\alpha)\lambda_1 + \lambda_2]C^{wr}_{mt}/2}{2^{\pi}\lambda_1\theta} - \frac{\delta}{2^{\frac{1-\gamma}{\gamma}}\theta}. \tag{5.A.17}$$

Substituting the above expression into (5.A.5g) and making substitutions based on (5.A.5b)-(5.A.5d),

$$Q^{kr}_{mt} = \frac{\theta - \{(1-\alpha)\beta + \alpha[1-\lambda_1-(1-\beta)\lambda_2]\}\mu^k}{\alpha\lambda_1\theta} \cdot C^{kr}_{mt} - \frac{(1-\beta)\delta}{2^{\frac{1-\gamma}{\gamma}-\pi}\theta}. \tag{5.A.18}$$

Using the fact that C^{kr}_{mt} grows at the constant rate ρa_L, the above expressions of Q^{kr}_{st} and Q^{kr}_{mt} lead to their growth rate expressions.

6 The Finale

This thesis has developed three essays on non-balanced sectoral growth, particularly in relation to the services sector. To briefly summarize, the first essay (Chapter 3) develops the hypothesis that the higher growth of the services sector in terms of both output and employment vis-a-vis manufacturing stems from relatively higher returns to scale in the services sector and greater presence of employment frictions in manufacturing compared to the services sector. Both assumptions are empirically motivated and the essay provides a supply side explanation for the services sector outpacing the manufacturing sector. These assumptions also imply that within the services sector the business service sub-sector grows faster than the consumer service sub-sector.

The second essay (Chapter 4) offers a different explanation for non-balanced growth, namely, differences in the intensity of land use in production across services, manufacturing and agriculture sectors. Critical is the assumption that the services sector is least intensive in the use of land, while manufacturing is more intensive and agriculture is the most intensive in the use of land. All else the same, it implies that the services sector would grow faster than manufacturing and the latter would grow faster than agriculture. The model also incorporates exogenous TFP and labor growth, capital accumulation as well as differences in capital intensity across sectors. A major contribution of this essay is to formulate a decomposition of sectoral growth rate differences into TFP growth differences, capital intensity differences as well as land intensity differences across sectors. We show that in long run the contribution of capital intensity differences on output growth gaps is much higher than the contribution of other two factors. However, in short run, the land intensity differentials have the largest explanatory power. This is because the more available factor of production (land in short run and capital in long run) has a larger scope for change and hence has a larger contribution towards sectoral output growth differences.

The third essay (Chapter 5) develops a dynamic, two-country model of international trade, which distinguishes between trade in services and trade in commodities. It characterizes and compares between the following regimes in sequence, no trade (autarky), free trade in commodities only and finally free trade in commodities and services. In terms of static effects, trade in commodities are founded on comparative advantage, while that in services contain elements of comparative advantage as well as those of trade among similar countries. The larger or the more developed country possesses comparative advantage in manufacturing and comparative disadvantage in services. In the absence of trade in services, technological superiority in producing manufacturing is a source of comparative advantage in manufacturing while, higher services productivity may serve as a basis of comparative advantage in manufacturing. In case of identical technologies across the two countries, trade in services features a service-output-equalization outcome: that is, despite differences in sizes or the level of development, both economies will produce the same amount of service output in equilibrium. Our numerical analysis points to strong and robust welfare gains from trade in services, compared to meager gains from commodities trade liberalization and the large gains from trade in services stem mainly from larger variety effects which directly benefits household utility and also enhances productivity across production sectors. Absent factors such as technological progress through R&D, learning by doing etc., long-run growth in our model economy is unaffected by shifts in trade regime. Non-homotheticity of preferences implies transitional growth however, which is influenced by trade-regime changes. Trade in commodities leads to movements along the growth functions, whereas trade in services implies both a shift and a movement along a functions. The shift occurs since trade in services leads to (one-time) productivity increase in both manufacturing and services sectors.

This thesis concludes by suggesting a couple of avenues for future research towards a richer understanding of services driven growth of an economy.

6.1 Information Technology in Services

In a cross country study, Eichengreen and Gupta (2012) find that demand for services has grown in two waves with income per capita. The second wave of the burgeoning share of the services sector in an aggregate economy has been attributed to IT infrastructure and to increased use of computer capital. A theoretical model incorporating this relationship would lay out the micro (firm level) as well as macro (market or country level) structures which have propelled the growth of services sector. While both computer capital and standard capital are derived from machines, the former helps in network formation between its users while the latter does not. The more firms or consumers use computer capital, it increases the productivity of computer capital in production of goods. This is because computer capital promotes exchange of ideas and information and thus has spillover effects. In this computer era, the IT capital is equally, or perhaps more, important than traditional capital and hence there is an urgent need to understand this IT-driven growth. One way to model this is through a production function of the kind

$$Q_{jt} = F((1 + C_{-jt})C_{jt}, K_{jt}, L_{jt})$$

where j denotes an industry, Q denotes output, C is computer capital, K is capital and L is labor. The productivity of computer capital is increasing in the computer capital used by the other sectors, C_{-jt}. This captures the productivity gains from networking that come from use of computer capital and not from capital or labor. In a multi-sector growth framework, where one sector (say services) uses computer capital more intensively than the other sector, this may explain the higher growth of the more computer capital intensive sector. As the computer capital of the economy grows, it would propel the growth of the more computer capital intensive sector. This may also explain the higher number of firm start-ups and the greater innovation activity in the services sector.

Another way to model IT use in production is to directly capture computer capital use in R&D sector for innovation which may lower the start-up costs of a firm. This may potentially generate higher growth of the more computer capital intensive sector viz-a-viz the other sector.

6.2 Services in Public Policy

There is an ongoing debate regarding the role of services as engines of growth in developing Asia and Africa. Several economists believe that development of the services sector would promote growth in Asia (Park and Noland (2013)). In Africa, agricultural development is needed to eradicate hunger and poverty but it also requires financial, telecommunication, health and education services for growth of the economies. The question is whether an economy can develop on the basis of a growing tertiary sector? And even if services sector is the engine for an under-developed country's growth, is such a growth desirable? One can think of modelling a two-sector (manufacturing and services) economy along with government. Services may be business services or consumer services. The sectoral production functions are

$$Q_{it} = A_{it}F(K_{it}, L_{it}), \qquad i = \{m, s\}$$

where i denotes sector, Q is output, A is TFP, F is production function in two inputs capital (K) and labor (L) and the two sectors are manufacturing (m) and services (s). Sector m also produces capital. The government taxes the representative agent and builds sector specific infrastructure, which affects the productivity growth of the sector.

$$\frac{A_{it+1}}{A_{it}} = H(G_{it})$$

where G is government spending. Intuitively it means that suppose government invests in telecommunications infrastructure, this would enable faster increase in the productivity of the services sectors. Government spending on a sector may negatively affect that sector's capital and labor allocations. If preferences are homothetic, then in this economy the sector with more government investment would be the leading sector. However it is not clear which sector would constitute a larger share in government spending. Further if the sectoral productivities were different, i.e. $A_m(G_{it})$ and $A_s(G_{it})$ were no longer same, how would it affect the sectoral growth and hence the economy's growth? Analyzing this model will yield under what conditions should the government invest in services-specific or manufacturing-specific infrastructure. The role of government in promoting sectoral growth is an interesting topic for future research.

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