Distribution services and economic growth

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Abstract

We analyze how the presence of distribution services affects an economy's long-run growth. We show that in an endogenous growth model, increases in the unit distribution requirement lower the economy's balanced growth rate by reducing the proportion of aggregate employment allocated to the manufacturing sector. This contrasts with the neutrality result in the exogenous growth case.

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1. Introduction

Multi-sector models are necessary for understanding the structure underlying economic growth, an issue that has been receiving more and more attention. Works along this line include Uzawa (1964), Galor (1992), Kongsamut, Rebelo, and Xie (2001), and Acemoglu and Guerrieri (2005), among others. In this paper, we consider an issue that has not yet been taken up in the literature: How does the presence of distribution services affect an economy's long-run growth?

Distribution services, which facilitate flow of goods from producers to consumers, are quantitatively important for an economy. Distribution is much more than transportation of goods. It also includes wholesale and retail trade, as well as marketing and advertisement, etc. Costs pertaining to distribution services create a wedge between wholesale and retail prices. As documented in Burstein, Neves, and Rebelo (2003), distribution costs are very large for the average consumer goods: they represent more than 40% of the retail prices of these goods in the US and roughly 60% of the retail prices in Argentina. Despite their importance, the role of distribution services in economic growth has been ignored in the growth literature.

In this note, we construct a dynamic general equilibrium model with two sectors each specialized in producing manufactured goods or services. Part of the service output is used in the distribution process for manufactured goods. In particular, we assume that consuming one unit of the latter goods requires certain units of distribution services. We show that in an Ak-type endogenous growth model increases in the unit distribution requirement lower the economy's balanced growth rate by reducing the proportion of aggregate employment allocated to the manufacturing sector. If growth is driven by exogenous technological changes, however, the economy's balanced growth rate is not affected at all by the demand for distribution services.

The rest of the note is organized as follows. Section 2 lays out our multi-sector endogenous growth model. The effect of distribution costs on growth is analyzed in Section 3. The last section concludes and discusses directions for future research. All proofs are relegated to the Appendix.

2. A Multi-Sector Endogenous Growth Model

Time is discrete. Producers are located in two production sectors: manufacturing (M) and service (S). The manufactured goods can be used as either consumption or investment. There are a continuum of firms of unit mass in each sector, indexed by $j \in [0,1]$. The production function of firm j in the manufacturing sector is

$$Y_{jt}^M = Z_t \left(K_{jt}^M\right)^\alpha \left(K_t^M L_{jt}^M\right)^{1-\alpha}, \quad 0 < \alpha < 1 \tag{1}$$

where Y_{jt}^M, K_{jt}^M, and L_{jt}^M are the period-t output, capital and labor inputs, respectively, of firm j in sector M. Z_t is the exogenous total-factor productivity common to both sectors. K_t^M is the average capital stock in the manufacturing sector, which represents sector-specific stock of knowledge in (1).[1] Since all firms are symmetric, we have $K_{jt}^M = K_t^M$ and $L_{jt}^M = L_t^M$ for all j in equilibrium, and the total output of the manufacturing sector is

$$Y_t^M = Z_t K_t^M \left(L_t^M\right)^{1-\alpha}. \tag{2}$$

Similarly, the individual and sectoral production functions in the service sector are

$$\begin{aligned} Y_{jt}^S &= Z_t \left(K_{jt}^S\right)^\alpha \left(K_t^S L_{jt}^S\right)^{1-\alpha}, & (3) \\ Y_t^S &= Z_t K_t^S \left(L_t^S\right)^{1-\alpha}. & (4) \end{aligned}$$

Profit maximization by individual firms yields the equilibrium wage and rental rates:

$$W_t = \overline{P}_t^M (1-\alpha) Z_t \left(\frac{K_t^M}{L_t^M}\right)^\alpha \left(K_t^M\right)^{1-\alpha} = P_t^S (1-\alpha) Z_t \left(\frac{K_t^S}{L_t^S}\right)^\alpha \left(K_t^S\right)^{1-\alpha}, \tag{5}$$

$$R_t = \overline{P}_t^M \alpha Z_t \left(\frac{K_t^M}{L_t^M}\right)^{\alpha-1} \left(K_t^M\right)^{1-\alpha} = P_t^S \alpha Z_t \left(\frac{K_t^S}{L_t^S}\right)^{\alpha-1} \left(K_t^S\right)^{1-\alpha}, \tag{6}$$

where P_t^S is the service price and $\overline{P}_t^M$ is the producer price of manufactured goods. From (5) and (6), the two sectors have the same capital-labor ratio, that is, $K_t^M/L_t^M = K_t^S/L_t^S = K_t/L_t$. Thus, the producer price of manufactured goods, relative to the price of services, is

$$\frac{\overline{P}_t^M}{P_t^S} = \left(\frac{K_t^S}{K_t^M}\right)^{1-\alpha} = \left(\frac{L_t^S}{L_t^M}\right)^{1-\alpha}. \tag{7}$$

We assume that one unit of manufactured consumption (investment) goods requires ϕ^c $\left(\phi^i\right)$ units of distribution services. For simplicity, we assume that all

[1]The Ak formulation is widely used as a growth-generating mechanism in the literature. It can be interpreted as the reduced form for a general class of endogenous growth models. Essentially, what is necessary for growth to be endogenously generated is for the marginal return to a broadly defined capital to be aymptotically bounded away from zero. That is, virtually all endogenous growth models are asymptotically Ak. See Jones and Manuelli (1990).

services, including distribution services, are homogeneous. Thus the retail price of manufactured consumption and investment goods, P_t^{MC} and P_t^{MI}, exceed the producer price by the wedge $\phi^c P_t^S$ and $\phi^i P_t^S$, respectively:

$$P_t^{MC} = \overline{P}_t^M + \phi^c P_t^S, \qquad P_t^{MI} = \overline{P}_t^M + \phi^i P_t^S. \tag{8}$$

Burstein, Neves, and Rebelo (2003) present evidence that investment goods have a distribution margin that is much smaller than the distribution margin for consumption goods. This would imply $\phi^c > \phi^i$.

The population is constant: there are a unit mass of identical consumers. Each consumer is endowed with one unit of labor which she supplies inelastically, i.e., $L_t = 1$ for all t. The representative consumer solves the following problem:

$$\max_{\left\{C_t^M,\, C_t^S,\, I_t,\, K_{t+1}\right\}} \sum_{t=0}^{\infty} \beta^t \ln\left(C_t\right), \quad 0 < \beta < 1$$

subject to

$$C_t = \left[\gamma\left(C_t^M\right)^\mu + (1-\gamma)\left(C_t^S\right)^\mu\right]^{\frac{1}{\mu}}, \tag{9}$$

$$P_t^{MC} C_t^M + P_t^{MI} I_t + P_t^S C_t^S \leq W_t + R_t K_t + \Pi_t, \tag{10}$$

$$K_{t+1} = (1-\delta) K_t + I_t. \tag{11}$$

The consumer's aggregate consumption C_t is a CES composite of consumed manufactured goods C_t^M and services C_t^S as in (9), according to which the elasticity of substitution between C_t^M and C_t^S is $1/(1-\mu)$. We assume that $\mu < 0$ so that C_t^M and C_t^S are gross complements. Equation (10) is the budget constraint which states that the consumer's consumption and investment expenditures cannot exceed her total income. Π_t represents the profit of firms which are owned by the consumers. Equation (11) describes the evolution of capital, where $\delta \in (0,1)$ is the rate of depreciation.

Let P_t be the price for aggregate consumption C_t. Consistent with (9), we have

$$P_t = \left[\gamma^{\frac{1}{1-\mu}}\left(P_t^{MC}\right)^{\frac{\mu}{\mu-1}} + (1-\gamma)^{\frac{1}{1-\mu}}\left(P_t^S\right)^{\frac{\mu}{\mu-1}}\right]^{\frac{\mu-1}{\mu}}.$$

The first-order conditions for the consumer's problem are

$$\frac{1}{C_t}\frac{P_t^{MI}}{P_t} = \beta \frac{1}{C_{t+1}}\left\{\frac{R_{t+1}}{P_{t+1}} + \frac{P_{t+1}^{MI}}{P_{t+1}}(1-\delta)\right\}, \tag{12}$$

$$\frac{\gamma}{1-\gamma}\left(\frac{C_t^S}{C_t^M}\right)^{1-\mu} = \frac{P_t^{MC}}{P_t^S}. \tag{13}$$

Finally, we have the following market clearing conditions:

$$\begin{aligned} C_t^M + I_t &= Y_t^M, && (14) \\ \phi^c C_t^M + \phi^i I_t + C_t^S &= Y_t^S, && (15) \\ L_t^M + L_t^S &= 1, && (16) \\ K_t^M + K_t^S &= K_t. && (17) \end{aligned}$$

Equations (14) and (15) are the market clearing conditions for manufactured goods and services, respectively. The output of the manufacturing sector can be used for consumption C_t^M and investment I_t. Part of the service sector output is used in the distribution process, while the rest is consumed. In the sequel we normalize $P_t^S = 1$ for all t.

A balanced growth path is an equilibrium path along which all variables grow at constant rates, with L_t^M, L_t^S, R_t, $\overline{P}_t^M$, P_t^{MC}, P_t^{MI}, and P_t fixed.

3. Effects of Distribution Costs on Growth

We assume that the exogenous total-factor productivity is a constant: $Z_t = Z$ for all t. The producer price of manufactured goods, relative to the price of services, is

$$\overline{P}_t^M = \left(\frac{L_t^S}{L_t^M}\right)^{1-\alpha}. \tag{18}$$

Sectoral output can be written as

$$Y_t^M = Z\left(L_t^M\right)^{2-\alpha} K_t, \quad Y_t^S = Z\left(L_t^S\right)^{2-\alpha} K_t. \tag{19}$$

We now derive the model's balanced growth path. It is straightforward to show that K_t, K_t^M, K_t^S, Y_t^M, Y_t^S, C_t^M, C_t^S, I_t, and W_t have the common (net) growth rate, which will be denoted by g. Let $c^M \equiv C_t^M/K_t$ and $c^S \equiv C_t^S/K_t$. Then the balanced growth path can be characterized by the following system of equations in g, c^M, c^S, and L^M (or $L^S = 1 - L^M$).

$$\phi^c c^M + \phi^i (g+\delta) + c^S = Z\left(L^S\right)^{2-\alpha}, \tag{20}$$

$$c^M + (g+\delta) = Z\left(L^M\right)^{2-\alpha}, \tag{21}$$

$$\frac{\gamma}{1-\gamma}\left(\frac{c^S}{c^M}\right)^{1-\mu} = \left(\frac{L^S}{L^M}\right)^{1-\alpha} + \phi^c, \tag{22}$$

$$\frac{1+g}{\beta} = \frac{\alpha Z \left(L^M\right)^{1-\alpha}}{\left(L^S/L^M\right)^{1-\alpha} + \phi^i} + (1-\delta). \tag{23}$$

Equation (20) and (21) are obtained by dividing (15) and (14) by K_t and using (19). Equation (22) comes from (8), (13), and (18). Since the derivation of (23) contains insights on the growth-generating mechanism in our model, it is worth more detailed description.

First, rewrite the Euler equation (12) for consumption/investment as

$$\frac{C_{t+1}}{C_t}\frac{P_{t+1}}{P_t} = \beta \frac{P_{t+1}^{MI}}{P_t^{MI}}\left[\frac{R_{t+1}}{P_{t+1}^{MI}} + (1-\delta)\right].$$

Note that along the balanced growth path, $C_{t+1}/C_t = 1+g$, $P_t^S = 1$ for all t (by normalization) and $\overline{P}_t^M = \left(L^S/L^M\right)^{1-\alpha}$ (from (18)) is constant. This implies that P_t^{MI} is also constant as well as the aggregate price P_t. From (6), we have

$$\frac{R}{P^{MI}} = \frac{\alpha Z \left(L^M\right)^{1-\alpha}}{\left(L^S/L^M\right)^{1-\alpha} + \phi^i}. \tag{24}$$

Thus the Euler equation can be further rewritten as (23). The right-hand side of (23) is the rate of return to capital along the balanced growth path.[2] Equation (24) makes it clear that the rate of return to capital is larger when employment in the manufacturing sector, L^M, gets larger. The intuition is that as more labor is allocated to the manufacturing sector, the marginal product of capital in that sector increases relative to the marginal product in the service sector, causing manufactured goods to become relatively cheaper (see (18)). This in turn stimulates accumulation of capital and enhances aggregate growth by lowering the cost of investment, which is an expenditure on manufactured goods. Proposition 1 follows from the above analysis.

Proposition 1 *The economy's balanced growth rate increases (decreases) if the manufacturing sector's employment share rises (falls), that is,* $\frac{dg}{dL^M} > 0$.

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[2] In general, the rate of return to capital is $\left[R_{t+1} + (1-\delta)\overline{P}_{t+1}^M\right]/\overline{P}_t^M$. Along the balanced growth path of our model, $\overline{P}_{t+1}^M = \overline{P}_t^M$ for all t.

We are therefore concerned with how changes in the unit distribution requirement affect growth via their effect on the sectoral allocation of employment. The following lemma states that as long as L^M is greater than a lower bound, an increase in either ϕ^c or ϕ^i away from zero will raise L^S and reduce L^M.

Lemma 1 $\left.\frac{\partial L^M}{\partial \phi^c}\right|_{\phi^c=\phi^i=0} < 0$ *and* $\left.\frac{\partial L^M}{\partial \phi^i}\right|_{\phi^c=\phi^i=0} < 0$ *if and only if* $L^M > L^{M*}$, *where*

$$L^{M*} \equiv \frac{(1-\alpha)\,\alpha\beta\left[1-\frac{1}{1-\mu}\frac{g+\delta}{1+g-\beta(1-\delta)}\right]}{(2-\alpha)\left(1-\frac{\alpha\beta(g+\delta)}{1+g-\beta(1-\delta)}\right)+(1-\alpha)\left(\alpha\beta-\frac{1}{1-\mu}\right)} \in (0,1)\,. \tag{25}$$

We are ready to present the main result. We can show that the condition of Lemma 1 is always satisfied in the equilibrium of our model. Proposition 2 then follows.

Proposition 2 *An increase in the unit distribution requirement from zero reduces the economy's balanced growth rate, i.e.,* $\left.\frac{\partial g}{\partial \phi^c}\right|_{\phi^c=\phi^i=0} < 0$ *and* $\left.\frac{\partial g}{\partial \phi^i}\right|_{\phi^c=\phi^i=0} < 0.$

To summarize, we have shown that an increase in the unit distribution requirement lowers aggregate growth rate by reallocating labor away from the manufacturing sector toward the service sector.[3] Although Proposition 2 shows that a small increase in ϕ^c or ϕ^i from zero must reduce the economy's growth rate g, it does not tell us how g changes with ϕ^c or ϕ^i when they are significantly larger than zero. To see the effect on growth of changes in ϕ^c or ϕ^i, we resort to numerical simulation. Figure 1 and 2 plot g and L^M, L^S against ϕ^c and ϕ^i, respectively, with the parameters set as follows. The discount factor β is set to 0.99, corresponding to a real annual interest rate of 4%. The capital depreciation rate δ is 0.025. Consistent with the literature, the capital income share α takes the value of 0.36. The share parameter in aggregate consumption, γ, is chosen to be 1/2. Finally, $\mu = -1.27$, implying an elasticity of substitution between C^M and C^S of 0.44 (see Stockman and Tesar 1995). As the figure shows, both L^M and g decline when ϕ^c or ϕ^i increases.

Finally, it is straightforward to show that distribution costs have neutral effects on economic growth if growth is driven by exogenous technological changes.[4] This is

[3] The "reallocation" of labor here pertains to the comparison of different balanced growth paths corresponding to different values of the unit distribution requirements. It should be distinguished from the reallocation of labor along a given growth path as emphasized by Kuznets (1957), Kongsamut, Rebelo, and Xie (2001), and Acemoglu and Guerrieri (2005).

[4] This corresponds to the case where Z_t grows exogenously at a constant rate and K_t^M and K_t^S are absent from (1) and (3).

because the economy's balanced growth rate is solely determined by the exogenous growth of the total-factor productivity and is independent of the unit distribution requirement.

4. Concluding Remarks

This note presents a dynamic equilibrium model where there is a demand for distribution services. Whether such demand matters for economic growth depends on the mechanism that generates sustained growth. Although distribution services do not matter in the exogenous growth case, they do exert a negative influence on growth by altering the sectoral composition of aggregate employment in our multi-sector endogenous growth model.

It should be emphasized that we regard our analysis as a first step in a broader research agenda that aims at understanding the roles of distribution services in economic growth. In this note, we have focused on the effects of demand for distribution services. The unit distribution requirements, ϕ^c and ϕ^i, are taken as reflecting the efficiency of an economy's distribution system. Our results indicate that economies that have less efficient distribution systems tend to have lower growth. An interesting extension of our analysis is to investigate deeply what determines the value of the unit distribution requirements. Potential factors include, for example, an economy's production, wholesale, and retail structures, cultural traditions, and development of infrastructures.

Moreover, the distribution requirements might be endogenously related to the level of economic development. This implies that economic growth and distribution efficiency can be thought of as influencing each other, an issue that is beyond the scope of this note but is definitely worth exploring in future research. In sum, we view our note as attempting to initiate a new research program.

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Uzawa, Hirofumi (1964), "Optimal growth in a two-sector model of capital accumulation", *Review of Economic Studies*, **31**, 1–24. Effects on L^M, L^S and g of changes in ϕ^c. g is expressed as annual rates.

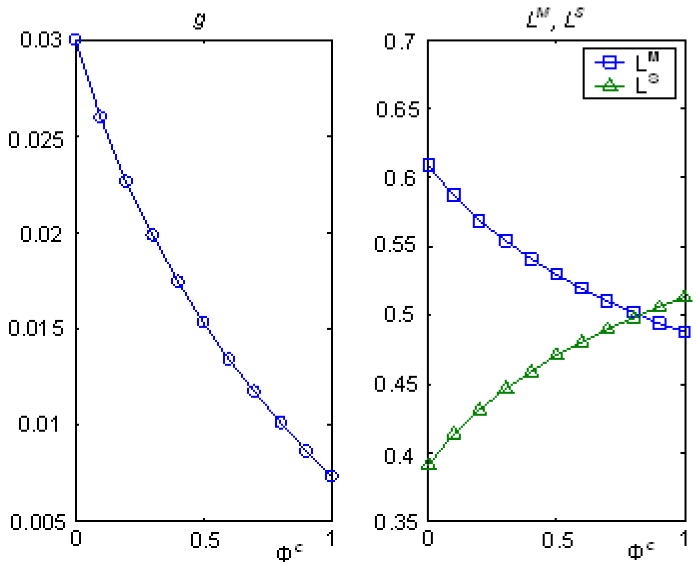

Figure 1: Effects on L^M, L^S and g of changes in ϕ^c. g is expressed as annual rates.

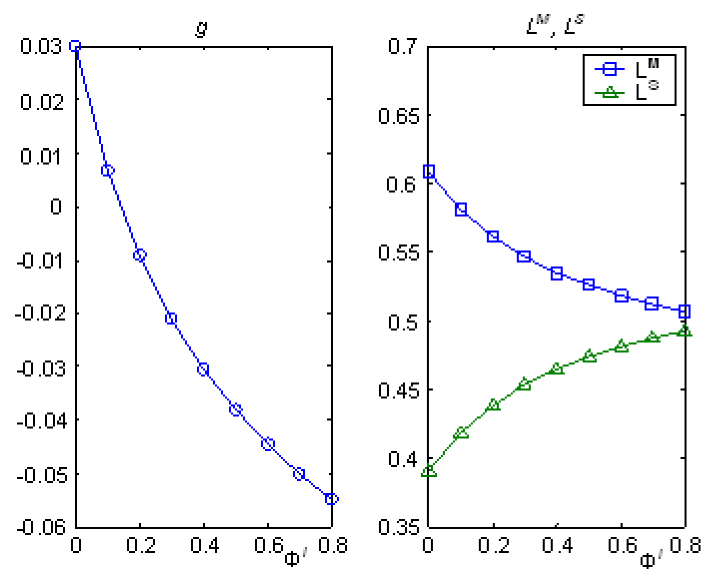

Figure 2: Effects on L^M, L^S and g of changes in ϕ^i. g is expressed as annual rates.