

# Using a 2-Sector Growth Model to Assess the Macroeconomic Consequences of Financial Liberalization

Yuan K. Chou and Martin S. Chin

March 18, 2002

## Abstract

This paper uses the economic growth model with a financial sector developed in Chou and Chin (2001) to examine the conditions under which financial liberalization is desirable from the perspective of a policymaker who is concerned about the well-being of domestic households. Financial liberalization raises the rate of financial innovations and the efficiency of financial intermediation, but typically causes large foreign firms from leading-edge countries to displace smaller and less efficient domestic firms. Profits are repatriated abroad instead of accruing to domestic households as dividends. This trade-off is further complicated when we allow financial firms to hire talented foreigners once liberalization has taken place.

KEYWORDS: Economic Growth, Finance, Financial Liberalization

JEL CODES: G20, G21, G25, O41

## 1 Introduction

Is financial liberalization the key to unlocking an economy's potential for growth? How long does it take for the average worker to benefit from financial liberalization, if ever? Or will financial giants from the most advanced economies drive out weaker, less efficient domestic firms and then repatriate their profits abroad? These are some of the key issues governments have to address when deciding whether to liberalize their countries' financial sectors. Developing a formal theoretical framework for studying these inherent trade-offs will therefore assist them in formulating sound and appropriate policies.

In this paper, we aim to evaluate the desirability of financial liberalization from a macroeconomic perspective. We will use an economic growth model with a financial sector to study the impact of financial liberalization on consumption, capital and output per worker, as well as its impact on the efficiency of the financial sector and consequently the interest rate. The financial sector in our model consists of financial innovators and financial intermediaries. Financial innovators use labor diverted from the production of the final, consumption good to create new financial products, taking advantage of positive spillovers from existing financial products. A larger range of financial products then allow financial intermediaries to more effectively channel the savings of households into productive investment by firms. Financial liberalization, by encouraging the entry of financial firms from leading-edge countries, raises the rate of financial innovations, thereby increasing the efficiency of financial intermediation, which in turn promotes economic growth through faster capital accumulation. We will also argue that financial liberalization encourages the hiring of talented financial workers from abroad, enabling a developing economy to access both the financial technology of leading-edge countries as well as their human capital.

Simulations of our model suggests that financial liberalization results in higher steady-state levels of consumption, capital and output per capita. However, these salubrious effects only kick in after a considerable time lag. Our simulations also demonstrate that the larger the spillovers of existing financial products on financial innovations, the greater the long-run impact of financial liberalization on per-capita consumption, capital and output. Using our augmented model with foreign talent, we show that the positive effects of financial liberalization on long-run consumption and capital stock per worker (as measured by the ratios of their pre- and post-liberalization steady-state values) are magnified the higher the relative productivity of foreign workers (holding their relative wages fixed) and the greater the learning rate of domestic workers. These two parameters are also positively related to the post-liberalization steady-state levels of consumption and capital per worker, as are the level of technology in final goods production and the percentage increase in the productivity of financial innovators.

The paper is organized as follows: the next section discusses the benefits and costs of financial liberalization, and sets forth the specific definition of financial liberalization used in this paper. Section 3 discusses the set-up of and results from the basic model, including its transitional dynamics. Section 4 examines the augmented model with foreign talent and its comparative statics, while section 5 presents a summary of the paper and its conclusions.

## 2 Benefits of Financial Liberalization

Does financial liberalization promote economic growth? If so, what are the channels through which the former affects the latter? The answer to the first question is a resounding “yes”, according to the World Bank, International Monetary Fund and the World Trade Organization, although Krugman (1993) provides a dissenting voice.

Levine (2000) finds that liberalizing restrictions on international portfolio flows tends to enhance stock market liquidity. These improvements in stock market liquidity in turn accelerate economic growth by boosting productivity growth. In addition, allowing the entry of foreign banks tends to enhance the efficiency of the domestic banking system. In turn, better banks bring about economic growth by accelerating productivity growth. He therefore concludes that international financial integration can promote economic development by encouraging improvements in the domestic financial system, with positive ramifications for long-run growth. Earlier, Levine (1996) had described in greater detail how liberalizing the entry of foreign banks may have important benefits for at least three related reasons. First, reducing impediments to foreign bank entry may improve access to international capital markets. Second, easing restrictions on foreign bank entry may improve the quality and availability of financial services by stimulating competition and contestability of domestic financial markets and by facilitating the application of more modern banking skills, management, and technology in the domestic market. Finally, openness to foreign banks may spur improvements in both domestic financial policy and the financial infrastructure, which in turn will promote domestic financial development. Elaborating on the second reason, Levine argued that easing restrictions on foreign bank entry should improve the quality, pricing, and availability of financial services as foreign banks directly bring new and better skills, management techniques, training procedures, technology, and products to the domestic market. For example, the entry of foreign banks may stimulate improvements in transaction services by introducing credit cards or improving the payments system, lower the cost of risk management mechanisms, intensify credit assessment procedures and enhance information gathering techniques, introduce improved mechanisms for monitoring firm and manager performance, and intensify the competition of mobilizing domestic resources that would expand the mobilization of domestic savings and promote better resource allocation. On the other hand, Levine acknowledged that there have been numerous concerns about foreign bank entry, such as foreign bank entry causing international capital outflows, as well as market dominance by these foreign firms which, to make matters worse, only service the most profitable market segments. However, Levine sanguinely con-

cluded that “by intensifying competition and by directly bringing new services to bear on the domestic market, foreign banks may provoke rapid improvements in the provision of growth-promoting financial services.” (p.238)

Bekaert, Harvey, and Lundblad (2001) examine the impact of liberalizing equity markets on growth rates using panel data regressions. Theoretically, they note that liberalization may lower the cost of capital thereby enticing additional investment. (This has been verified empirically in Bekaert and Harvey (2000), Henry (2000b) and Henry (2000a)). Open capital markets may mean more efficient markets and lead to financial development. Moreover, a large literature has shown how improved financial intermediation can enhance growth (for examples, see Greenwood and Jovanovic (1990), Bencivenga and Smith (1991), Saint-Paul (1992), and Bencivenga, Smith, and Starr (1996)). Financial liberalization may permit countries to benefit from frontier financial technology that lead to increased growth, in the same way that better policies and institutions may permit developing countries to benefit from frontier real technology. Bekaert *et al* (2001) find that financial liberalization leads to a one percent increase in annual real GDP per capita over a five year period, and this result is robust to alternative choices of liberalization dates, groupings of countries, weighting matrices for the calculation of standard errors and time-horizons for measuring economic growth. They show that the liberalization effect is not spuriously accounted for by macroeconomic reforms and does not reflect a business cycle effect. Liberalization also leads to a fall in the consumption to GDP ratio and a rise in the investment to GDP ratio. Finally, financial liberalization has the greatest impact on economic growth in countries with large secondary school enrollment, small government sectors and an Anglo-Saxon legal system.

In this paper, we will use a broader definition of financial liberalization, which encompasses both the liberalization of equity markets and that of the banking sector. Financial liberalization will be taken to mean an event which increases the rate at which new financial products (which we shall call “financial innovations”) are created, resulting in an increase in the efficiency of financial intermediaries in transforming household savings into productive investment by firms. This definition encompasses both the liberalization of equity markets and the banking sector as each of these two events increases the number of financial instruments through which households can invest their savings and through which firms may raise funds to finance the acquisition of new physical capital to increase future production. We do not take into account the effect of financial liberalization on productivity growth, a point which we will return to at the end of the paper.

### 3 A Growth Model with a Financial Sector

In this section, we lay out the framework which we will use to evaluate the consequences of financial liberalization. The framework comprises a Ramsey model of household optimization with an embedded financial sector as described in Chou and Chin (2001). We assume for now that financial liberalization has no effect on the ability of financial firms to attract talented workers from abroad. In fact, all workers are assumed to be homogeneous in this model. Financial liberalization is characterized by an increase in the productivity of financial innovators (resulting in an increase in the rate at which new financial products are created) and by the repatriation of the profits of financial firms to their headquarters in a foreign country. This follows from our broad assumption that liberalization will result in large foreign firms from leading-edge countries driving out weaker, less efficient domestic players. Liberalization thus presents governments with a trade-off: the rise in efficiency of financial intermediation which results in higher growth through faster capital accumulation has to be weighed against the loss in dividends from financial firms which hitherto accrued to domestic households.

#### 3.1 Model Set-Up

The final goods sector produces the consumption good  $Y$  using a Cobb-Douglas technology to combine labor  $L_Y$  (equal to  $u_Y L$ , where  $u_Y$  is the share of labor,  $L$ , devoted to final goods production) and capital  $K$ :

$$Y = K^\alpha L_Y^{1-\alpha}.$$

A representative final goods producer thus solves the following profit maximization problem:

$$\max_{u_Y, K} \pi_Y = Y - w_Y L_Y - r_K K,$$

where  $w_Y$  is the wage in the final goods sector and  $r_K$  is the rental price of capital charged by financial intermediaries. The price of the final goods has been normalized to unity.

The first-order conditions require that the wage and rental price of capital be equal to the value of their marginal products:

$$\begin{aligned} w_Y &= (1 - \alpha) \frac{Y}{L_Y}, \\ r_K &= \frac{\alpha Y}{K}. \end{aligned}$$

The financial sector is composed of financial innovators and financial intermediaries *cum* venture capitalists. The former are responsible for producing financial innovations,  $\dot{\tau}$ , which then determines the degree of sophistication of the financial sector, proxied by  $\xi$  (equal to the ratio  $\tau/L^\kappa$ , the number of financial products per “adjusted” capita, where  $0 < \kappa < 1$ ).<sup>1</sup> A greater value of  $\xi$  allows more efficient intermediation between lenders (households) and borrowers (intermediate goods producers), resulting in a higher percentage of savings being transformed into useful capital. Put simply, the investment rate equals the saving rate multiplied by  $\xi$ . In addition, a greater value of  $\tau$  also raises the rate at which new R&D designs are produced, as will be shown.

Financial innovators are monopolists who make extra-normal profits by producing new financial products, using raw labor as input, according to the production function

$$\dot{\tau} = \tilde{F} (u_\tau L)^\lambda - \delta_\tau \tau, \quad (1)$$

where  $\tilde{F} \equiv F\tau^\phi$ ,  $u_\tau$  is the share of labor devoted to the creation of financial innovations, and  $\delta_\tau$  is the rate of obsolescence for financial products (which we will take to be zero for simplicity.). In this decentralized competitive model, financial innovators do not internalize the spillover effect from the existing stock of financial products. They therefore treat  $\tilde{F}$  as exogenously given. We characterize financial liberalization as a permanent increase in the productivity parameter  $\tilde{F}$ , following the entry of more efficient and advanced foreign financial firms into the domestic financial sector. This is analogous to the Rivera-Batiz and Romer (1991) model of economic integration where allowing a free flow of ideas between countries leads to an increase in the spillovers from existing (in their case, real R&D) products on innovative activity, thereby raising the productivity of the innovation sector.

More formally, suppose that  $\tau^*$  represents the stock of financial products in some country with a leading-edge financial sector. Then post-liberalization,  $\tilde{F}_{post-liberalization} = F\tau^{*\phi}$ . We assume that the set of financial products available in the leading-edge country completely encompasses that available in the developing country, pre-liberalization.<sup>2</sup> Defining  $\varsigma \equiv \tau^*/\tau > 1$ ,  $\tilde{F}_{post-liberalization} = F(\varsigma\tau)^\phi$ . Liberalization therefore raises the productivity parameter in the financial innovations sector by a factor of  $\varsigma^\phi$ , where  $\varsigma$  is the ratio of the stock of financial products available in the leading-edge country to the stock of financial products available in our country of interest.

<sup>1</sup>If  $\kappa = 1$ , then all financial products are strictly rivalrous; if  $\kappa = 0$ , then all financial products are strictly non-rivalrous, so that the efficiency of financial intermediation is dependent only on the stock of financial products and independent of population size.

<sup>2</sup>Let  $\tau$  be the number of elements in  $\Theta$ , the set of financial products available in the developing country, and  $\tau^*$  be the number of elements in  $\Theta^*$ , the set of financial products available in the leading-edge country. We assume that  $\Theta \subset \Theta^*$ .

The profit of a representative financial innovator, to be maximized by its choice of  $u_\tau$ , the share of the labor force devoted to the creation of financial innovations, is

$$\pi_\tau = P_\tau \dot{\tau} - w_\tau u_\tau L, \quad (2)$$

where  $P_\tau$  is the price of each financial innovation. With these substitutions, the first-order condition implies that

$$P_\tau = \frac{u_\tau}{n\lambda\kappa\tau} w_\tau. \quad (3)$$

From this equation, we see that the price of each financial innovation is a function of the marginal factor cost of labor in the financial innovations sector. This equation may also be interpreted as an inverse demand function for  $\tau$ .

Downstream in the financial sector, financial intermediaries purchase innovations from financial innovators (which, in the real world, are probably sister divisions of the same financial firms) and use them in transforming savings into productive investment as well as in the funding of real R&D activities. The financial intermediaries derive their income from charging firms in the (real) intermediate sector a higher interest rate ( $r_K$ ) for renting capital than it pays out to households for their savings ( $r_V$ ). The interest rate differential, ( $r_K - r_V$ ), may be thought of as the commission charged for intermediating funds. For simplicity, we assume that financial intermediation requires no labor input. Financial intermediaries make zero profits as this sector is assumed to be perfectly competitive.

In each period, the representative financial intermediary ensures that revenues received from the real intermediate sector and R&D firms equal the cost of acquiring deposits from households and purchasing new products from financial innovators:

$$r_K K = r_V K + P_\tau \dot{\tau}. \quad (4)$$

Finally, to close the model, we examine the consumption decision of households. As usual, we assume that this decision may be characterized by a representative consumer maximizing an additively separable utility function subject to a dynamic budget constraint. We use a conventional CRRA utility function and assume that households are ultimate owners of all capital and shareholders of final goods firms, financial intermediaries and financial innovators. The optimization problem is thus:

$$\max_{c, u_Y, u_\tau} \int_0^\infty \frac{c^{1-\theta} - 1}{1-\theta} e^{-(\rho-n)t} dt, \quad (5)$$

subject to

$$\dot{V} = r_V K + w_Y u_Y L + w_\tau u_\tau L + \pi_\tau - C, \quad (6)$$

$$\dot{K} = \xi^t \dot{V}, \quad (7)$$

where  $\dot{V}$  represents the flow of households' stock of assets (i.e. saving). As discussed earlier,  $\xi$  (equal to  $\tau/L^\kappa$ ) represents the efficiency of financial intermediaries in transforming household saving into productive investment by firms. The exponent  $\iota$  indicates the degree to which the process whereby increases in the stock of financial products per capita improves financial intermediation is affected by diminishing marginal returns. To simplify the algebra, we will assume in this paper that  $\iota = 1$ , that is, the absence of such diminishing returns. The monopolistic profits of financial innovators,  $\pi_\tau$ , equal to revenue  $P_\tau \dot{\tau}$ , minus labor costs  $w_\tau u_\tau L$ , is paid out to households who are also shareholders of these firms. As explained previously, we assume that these profits are repatriated to a foreign country once the financial sector is liberalized and will then be removed from the budget constraints of domestic households. In equilibrium, wages are equal across all labor markets, i.e.  $w_Y = w_\tau = \bar{w}$ . These conditions together with equation (4) yield the following household budget constraint

$$\dot{K} = \xi(r_K K + \bar{w} u_Y L - \pi_\tau - C). \quad (8)$$

The post-liberalization Hamiltonian is therefore

$$H = \frac{c^{1-\theta} - 1}{1-\theta} e^{-(\rho-n)t} + \nu \xi (r_K K + \bar{w} u_Y L - \pi_\tau - C) + \mu \left[ \tilde{F}(u_\tau L)^\lambda - \delta_\tau \tau \right],$$

where  $c$  (per-capita consumption, equal to  $C/L$ ) and  $u_Y$  (share of labor engaged in final goods production) are control variables while  $K$  and  $\tau$  (the stock of physical capital and financial products respectively) are state variables.

The first order conditions are:

$$\begin{aligned} c^{-\theta} e^{-(\rho-n)t} &= \nu \xi L \\ \nu \xi \bar{w} L &= \mu \\ -\dot{\nu} &= \nu \xi r_K \\ -\dot{\mu} &= \nu L^{-\kappa} (r_K K + \bar{w} u_Y L - \pi_\tau - C) - \mu \delta_\tau \end{aligned}$$

while the transversality conditions are given by

$$\lim_{t \rightarrow \infty} K(t) \nu(t) = 0, \quad (9)$$

$$\lim_{t \rightarrow \infty} \tau(t) \mu(t) = 0. \quad (10)$$

We can show that the price of financial innovations is determined by the following arbitrage equation:

$$\xi r_K = \frac{\dot{V}}{P_\tau \tau} + \frac{\dot{P}_\tau}{P_\tau} \quad (11)$$

Equation (11) shows that the opportunity cost to a financial intermediary of purchasing a financial innovation,  $\xi r_K P_\tau$ , must be equal to the average flow of savings intermediated by a unit of financial product,  $\dot{V}/\tau$ , and the associated capital gain,  $\dot{P}_\tau$ .

In addition, the steady-state growth rate of the stock of financial products is

$$\gamma_\tau^* = \kappa n.$$

Using the technique outlined in Chou and Chin (2001), the steady-state solutions for the state and control variables are found to be

$$u_\tau^* = 1 - u_Y^* = \frac{\Gamma}{\Gamma + \Phi},$$

where

$$\begin{aligned} \Gamma &= \alpha \lambda n \gamma_\tau^* \\ \Phi &= (1 - \alpha) \rho (\rho - n + \gamma_\tau^*) \end{aligned}$$

$$\begin{aligned} \xi^* &= \left( \frac{F u_\tau^{*\lambda}}{\gamma_\tau^*} \right)^{\frac{1}{1-\phi}}, \\ k^* &= \left( \frac{\xi^* A \alpha}{\rho} \right)^{\frac{1}{1-\alpha}} u_Y^*, \\ c^* &= \frac{\lambda(\rho - \alpha n) u_Y^* - (1 - \lambda)(1 - \alpha) \rho u_\tau^*}{\lambda \alpha} \cdot \frac{k^*}{\xi^* u_Y^*}. \end{aligned}$$

### 3.2 The Impact of Financial Liberalization: Transitional Dynamics

What is the impact of financial liberalization (as defined above) on the key variables in the model? We first discuss the properties of the new steady state attained post-liberalization and compare it to the steady state that existed pre-liberalization. This will be followed by an analysis of the transitional dynamics of the model. The complexity of the model and its solution means that comparative statics and transitional dynamics cannot be studied analytically and dictates the use of simulations instead. The following calibrations were used in the simulations:

$\alpha$	$\rho$	$\theta$	$n$	$\lambda$	$\phi$	$A$	$\iota$	$\delta_\tau$	$F_{initial}$
1/3	0.02	1.5	0.01	2/3	0.2	0.35	1	0	0.0318

We have chosen the discount rate  $\rho$  to be 0.02, the risk-aversion parameter  $\theta$  to be 1.5, the labor force growth rate to be 0.01, the share of capital in final goods production  $\alpha$  to be 1/3, and the technology parameter in final goods production ( $A$ ) to be 0.35. The elasticity parameter in the production function for financial innovations ( $\lambda$ ) is 2/3 while the elasticity parameter for spillovers from existing financial products ( $\phi$ ) is 0.2. This implies that  $\kappa$ , which indicates the degree of rivalry in the use of financial products, is 5/6 or approximately 0.833. (Recall that  $\kappa = 1$  implies complete rivalry while  $\kappa = 0$  indicates complete non-rivalry.) As explained previously, we set  $\iota = 0$ , ruling out diminishing returns in the process by which changes in the stock of financial products affect the efficiency of financial intermediation. We also assume that financial products do not become obsolete, in the spirit of Romer (1990)'s specification of the R&D sector. Finally, the value for  $F_{initial}$  was chosen so that the pre-liberalization steady-state value of  $\xi$  is exactly 0.5 in the social planner's model. The results for simulations using alternative sets of values for  $F_{initial}$ ,  $\iota$ ,  $\lambda$ , and  $\phi$  are given in the Appendix. We will see that the results there are qualitatively similar to those presented below, although the speed of convergence differs markedly.

Our simulation results show that if liberalization is modelled as a positive shock on the productivity parameter of the financial sector  $F$ , despite the repatriation of profits to foreign countries, the steady state values of  $c$  (consumption per capita),  $k$  (capital stock per capita) and  $\xi$  (the transformative efficiency of the financial sector) are all higher in the post-liberalization steady-state than in the original steady-state. However,  $c$ ,  $k$  and output per capita  $y$  all decline for a considerable number of periods (between 50 to 90) before they surpass their initial values. The allocation of labor to the financial and financial goods sector ( $u_\tau$  and  $u_Y$ ) are unchanged from the old steady-state to the new. In addition, the interest rate for both borrowers (the cost of funds) and lenders,  $r_K$  and  $r_V$ , both fall. Investment is thus higher in the new steady state, resulting in the larger steady-state capital stock. Finally, financial liberalization leads to a lower steady-state consumption to GDP ratio and a higher investment to GDP ratio, in line with the empirical findings of Bekaert et al (2001).

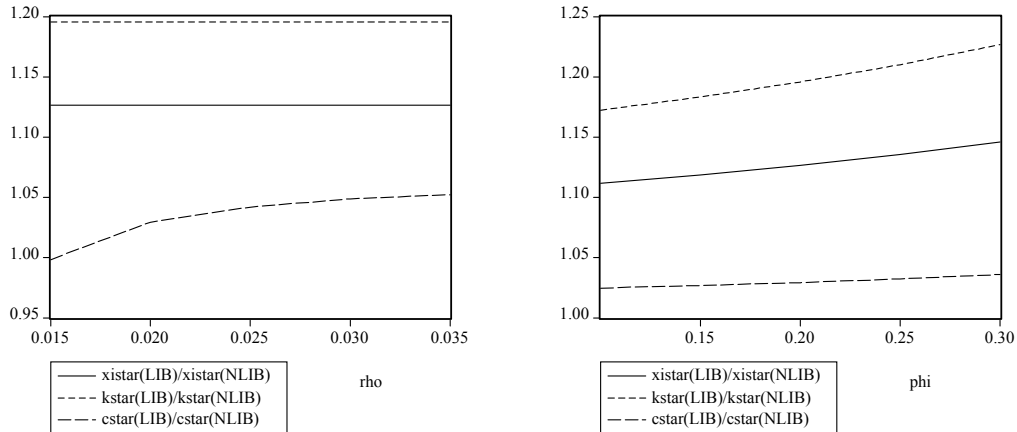


Figure 1: The effect of financial liberalization on  $\xi^*$ ,  $k^*$  and  $c^*$  for various levels of  $\rho$  and  $\phi$ .

Now let us turn to the impact of the parameters  $\rho$ ,  $\theta$  and  $\phi$  on the magnitude of liberalization effects. An increase in the discount rate  $\rho$  results in financial liberalization having a larger effect on steady state per-capita consumption  $c^*$ , but does not alter liberalization's impact on  $k^*$  or  $\xi^*$ . In other words, the ratio  $c_{post-liberalization}^*/c_{pre-liberalization}^*$  is increasing in  $\rho$ . Why is this so? The larger the discount rate, the more impatient economic agents are in the economy - current consumption is greatly valued even if it means sacrificing future output and consumption. These sacrifices evidently become less costly with financial liberalization, as the increase in efficiency of financial intermediation leads to higher output and consumption in the new steady state. The degree of risk-aversion or desire for consumption smoothing,  $\theta$ , however has no bearing on liberalization's impact on  $c^*$ ,  $k^*$  or  $\xi^*$ . This result arises from the fact that, without endogenous technological progress or human capital accumulation, per capita consumption is constant in the steady state, so the desire for consumption smoothing is irrelevant. Finally, an increase in  $\phi$  (which measures the spillover effect of existing financial products on the creation of financial innovations) increases the impact of financial liberalization on  $c^*$ ,  $k^*$ ,  $\xi^*$ , wages and interest rates. In other words, the ratios  $\frac{c_{post-lib}^*}{c_{pre-lib}^*}$ ,  $\frac{k_{post-lib}^*}{k_{pre-lib}^*}$ ,  $\frac{\xi_{post-lib}^*}{\xi_{pre-lib}^*}$  and  $\frac{w_{post-lib}^*}{w_{pre-lib}^*}$  are increasing in  $\phi$  while  $\frac{r_{V post-lib}^*}{r_{V pre-lib}^*}$  and  $\frac{r_{K post-lib}^*}{r_{K pre-lib}^*}$  are decreasing in  $\phi$ . The larger the spillover effect of financial innovations on future innovations, the stronger the case for financial liberalization.

The relatively large dimensionality of the model, with 2 control variables ( $c$  and  $u_Y$ ) and 2 state variables ( $k$  and  $\xi$ ), necessitates the use of numerical methods when investigating its transitional dynamics. Specifically, we convert the model from continuous to discrete time and use the “shooting” method

(implemented in a C-language computer program) to guess the magnitude of the jumps in the control variables  $c$  and  $u_Y$  occurring in the instant a shock impacts the system. “Correct” jumps ensure the system moves along the stable manifold until the new steady state is reached while incorrect jumps lead to dynamic paths which eventually violate the transversality conditions.

The four discretized, dynamic (difference) equations governing the behavior of the state and control variables may be written as:

$$\begin{aligned}
c_{t+1} &= c_t - \frac{1}{\theta} \left( \rho - \xi_t A \alpha k_t^{\alpha-1} u_{Y,t}^{1-\alpha} + F u_{Y,t}^\lambda \xi_t^{\phi-1} - \frac{\lambda n}{1-\phi} \right) c_t, \\
u_{Y,t+1} &= u_{Y,t} + \left[ \left( \left[ \frac{\lambda}{1-\alpha} \frac{F(1-u_{Y,t})^\lambda \xi_t^{\phi-1}}{A k_t^{\alpha-1} u_{Y,t}^{1-\alpha}} \left( \frac{u_{Y,t}}{1-u_{Y,t}} \right) + \alpha \xi \right] \right. \right. \\
&\quad \times \left. \left\{ A k_t^{\alpha-1} u_{Y,t}^{1-\alpha} \left[ 1 - \frac{(1-\lambda)(1-\alpha)}{\lambda} \left( \frac{1-u_{Y,t}}{u_{Y,t}} \right) \right] - \frac{c_t}{k_t} \right\} \right. \\
&\quad \left. - \xi A \alpha k_t^{\alpha-1} u_{Y,t}^{1-\alpha} + (1-\phi) F (1-u_{Y,t})^\lambda \xi_t^{\phi-1} \right. \\
&\quad \left. + (1-\phi) F (1-u_{Y,t})^\lambda \xi_t^{\phi-1} - \frac{\lambda n}{1-\phi} + (1-\lambda-\alpha)n \right) \\
&\quad \left. \times \frac{1-u_{Y,t}}{(1-\lambda)u_{Y,t} + \alpha(1-u_{Y,t})} \right] u_{Y,t}, \\
k_{t+1} &= k_t + \left[ \xi_t \left( A k_t^{\alpha-1} u_{Y,t}^{1-\alpha} \frac{1-(1-\lambda)(1-\alpha)(1-u_{Y,t})}{\lambda u_{Y,t}} - \frac{c_t}{k_t} \right) - n \right] k_t, \\
\xi_{t+1} &= \xi_t + \left[ F (1-u_{Y,t})^\lambda \xi_t^{\phi-1} - \frac{\lambda n}{1-\phi} \right] \xi_t.
\end{aligned}$$

Figure 2 depicts the paths of  $c$ ,  $k$ ,  $y$ ,  $\xi$ ,  $u_Y$  and the cost of capital  $r_K$  following liberalization programs which result in: (a) a 10 per cent increase in the financial sector productivity parameter  $F$ ; and (b) a 20 per cent increase in  $F$ . In each case, profits of financial firms which accrued to domestic households pre-liberalization are repatriated abroad post-liberalization.

Output, consumption and capital per worker ( $y$ ,  $c$ , and  $k$  respectively) exhibit similar dynamic paths. In each case, the rise in productivity of the financial sector at the moment of liberalization results in labor being diverted from final goods production into financial innovation. The production of final goods therefore falls initially, resulting in both lower consumption and investment. However, the resources poured into financial innovation results in an increase in the financial sector’s transformative efficiency, represented by  $\xi$ . Over time, capital accumulation picks up and rises above its pre-liberalization baseline value. The increase in capital raises final goods production and consumption, both of which then become permanently higher than their pre-liberalization

levels. Eventually, the share of labor devoted to final goods production is restored to its pre-liberalization value. The cost of capital  $r_K$  jumps downwards immediately after liberalization as the exodus of labor from the final goods sector lowers the marginal product of capital (which is only used in final goods production). The decline in the (per-capita) capital stock  $k$  then causes the marginal product of capital and  $r_K$  to rise again, until the rising stock of financial products increases the transformative efficiency of the financial sector. The cost of capital thereafter declines to its new steady-state level.

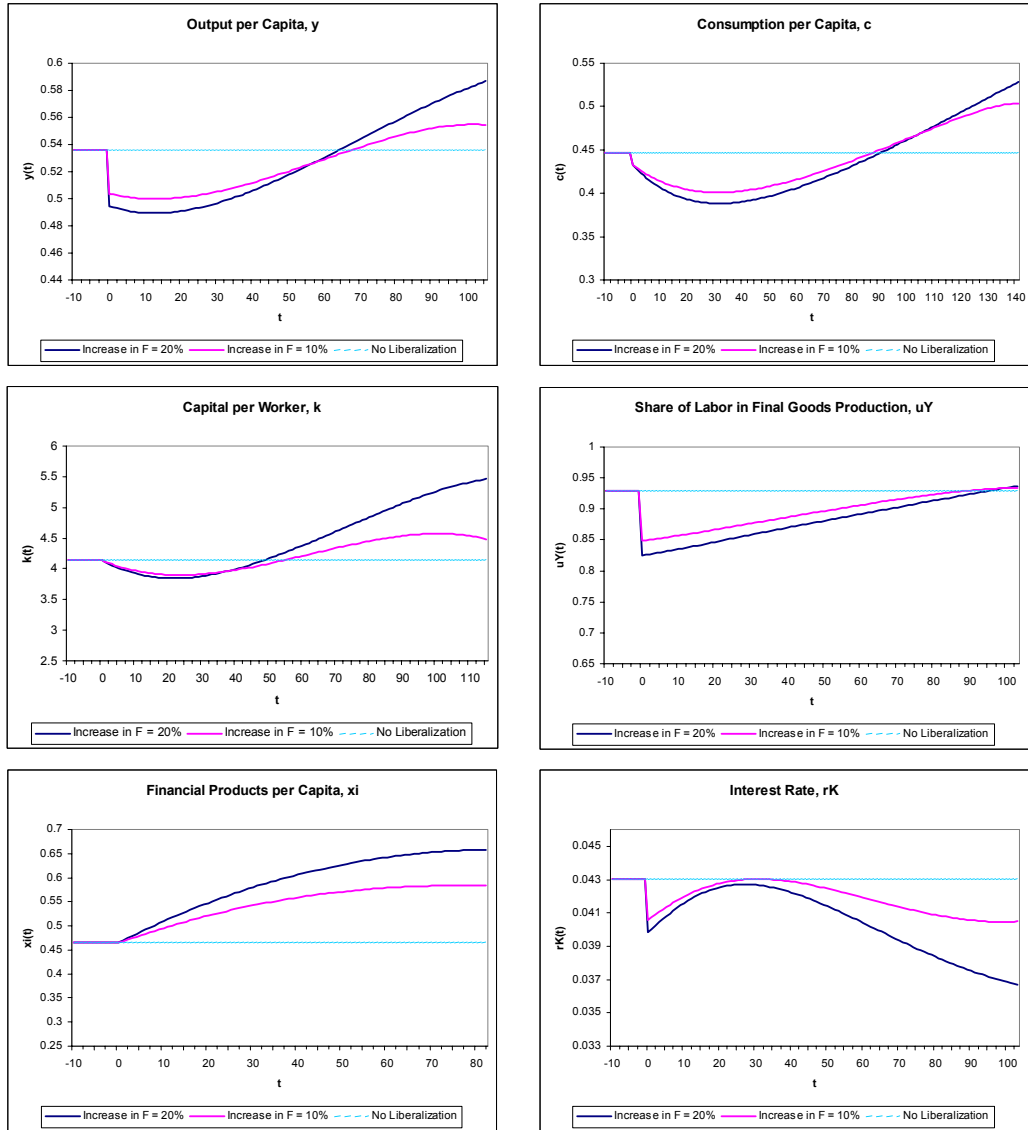


Figure 2: Transitional dynamics for 10 and 20 per cent increases in  $F$ .

## 4 Financial Liberalization and Foreign Talent

We now enrich our basic model by allowing financial liberalization to affect growth through an additional channel: the ability to hire talented foreigners in the financial sector. These foreign workers are more productive than their domestic counterparts (we can think of them as embodying more human capital) and are compensated accordingly. In addition, we allow for the diffusion of knowledge from foreign financial workers to domestic financial workers. Although local financial firms prior to financial liberalization may in principle attract talented (that is, highly productive) foreign workers, in practice they may face several hurdles. Firstly, they may lack the infrastructure for such overseas recruiting exercises. Secondly, talented foreign workers will seldom want to work for a relatively small and parochial firm with little international renown. A reputable multinational financial firm, such as Merrill Lynch or Goldman Sachs, on the other hand, seldom encounters problems in posting their talented employees abroad to their branch offices. Once these firms are allowed to compete in the financial sector post-liberalization, the number of highly productive financial workers from abroad will surely rise. Financial liberalization therefore enables a developing country to access both best-practice operating procedures as well as human capital from the world's most sophisticated economies (which are at the global financial-technology frontier.) Once again, profits of financial firms are assumed to be remitted to their overseas headquarters after the financial sector is liberalized.

### 4.1 The Model with Foreign Talent

#### 4.1.1 The Financial Sector

A representative firm in the financial sector produces financial innovations by hiring both foreign and domestic workers:

$$\dot{\tau} = \tilde{F}a^{\varepsilon\lambda} \left[ L_{\tau}^{\lambda} + (a^{1-\varepsilon}L_f)^{\lambda} \right], \quad (12)$$

where  $\tilde{F} \equiv F\tau^{\phi}$ ,  $L_{\tau} \equiv u_{\tau}L$ ,  $L_f \equiv \Omega L_{\tau}$ ,  $\{a, b\} > 1$ ,  $\varepsilon \in [0, 1]$  and  $\lambda \in (0, 1)$ .  $a$  denotes the relative productivity of foreign workers compared to domestic workers while  $\varepsilon$  measures the degree of skill diffusion from foreign workers to domestic workers. When  $\varepsilon = 1$  full diffusion takes place so that domestic workers become as productive as foreign ones.  $\Omega$  denotes the ratio of foreign workers to domestic workers employed in the financial sector.  $a^{1-\varepsilon}$  (which we shall denote as  $\hat{a}$ ) can therefore be interpreted as the relative productivity of foreign workers vis-a-vis domestic workers after taking into account the

learning rate  $\varepsilon$ . The financial innovator seeks to

$$\max_{L_\tau, L_f} \pi_\tau = P_\tau \tilde{F} a^{\varepsilon\lambda} \left[ L_\tau^\lambda + (a^{1-\varepsilon} L_f)^\lambda \right] - w_\tau L_\tau - w_f L_f, \quad (13)$$

where  $w_f = b w_\tau$ , so that  $b$  is the ratio of the foreign workers' wage to the domestic workers' wage. The first-order conditions  $\partial\pi_\tau/\partial L_\tau = 0$  and  $\partial\pi_\tau/\partial L_f = 0$  yield the following wage equations for the two types of workers:

$$w_\tau = \frac{\lambda P_\tau \tilde{F} a^{\varepsilon\lambda}}{L^{1-\lambda}}, \quad (14)$$

$$w_f = \frac{\lambda P_\tau \tilde{F} a^\lambda}{L^{1-\lambda}}. \quad (15)$$

Given the equilibrium condition  $w_\tau = w_Y = \bar{w}$ , we can obtain an equation for  $P_\tau$  through equation (14) and then substitute it into equation (15) to get

$$\Omega = \left[ \frac{a^{(1-\varepsilon)\lambda}}{b} \right]^{\frac{1}{1-\lambda}}.$$

Substituting the equations for  $P_\tau$  and  $\Omega$  into equation (13) yields the following equilibrium profits for the financial sector:

$$\pi_\tau = \frac{(1-\lambda) \bar{w} u_\tau L}{\lambda} (1 + b\Omega). \quad (16)$$

where  $b\Omega \equiv (a^{1-\varepsilon}/b)^{\frac{\lambda}{1-\lambda}}$ . In the steady state, we need to write the price of each financial innovation as

$$p_\tau \equiv \frac{P_\tau}{L^{1-\kappa}} = \frac{\bar{w} u_\tau (1 + b\Omega)}{\lambda \gamma_\tau \xi}, \quad (17)$$

where  $\kappa = \lambda/(1-\phi)$ ,  $\gamma_\tau \equiv \dot{\tau}/\tau$  and  $\xi \equiv \tau/L^\kappa$ . Note that at every point in time, the following intermediation condition must again hold:

$$r_K K = r_V K + P_\tau \dot{\tau}. \quad (18)$$

#### 4.1.2 The Final Goods Sector

As in the basic model, the representative firm in the final goods sector seeks to

$$\max_{L_Y, K} \pi_Y = A K^\alpha L_Y^{1-\alpha} - r_K K - w_Y L_Y, \quad (19)$$

where  $L_Y \equiv u_Y L$  and  $\alpha \in (0, 1)$ . The first-order conditions  $\partial\pi_Y/\partial K = 0$  and  $\partial\pi_Y/\partial L_Y$  yield the following equations respectively:

$$r_K = \alpha A k^{\alpha-1} u_Y^{1-\alpha}, \quad (20)$$

$$w_Y = \bar{w} = (1-\alpha) A k^\alpha u_Y^{-\alpha}, \quad (21)$$

where  $k \equiv K/L$ .

### 4.1.3 Domestic Households

A representative domestic worker seeks to

$$\max_{c_d, u_Y} U_{d,0} \equiv \int_0^\infty \frac{c_d^{1-\theta_1} - 1}{1 - \theta_1} e^{-(\rho_1 - n)t} dt, \quad (22)$$

where  $c_d \equiv C_d/L$ , subject to

$$\dot{K}_d = \tilde{\xi} (r_v K_d + w_Y u_Y L + w_\tau u_\tau L - C_d), \quad (23)$$

$$\dot{\tau} = \tilde{F} a^{\varepsilon\lambda} (1 + b\Omega) (u_\tau L)^\lambda, \quad (24)$$

$$r_K K = r_V K + P_\tau \dot{\tau}, \quad (25)$$

$$K = K_d + K_f, \quad (26)$$

$$1 = u_Y + u_\tau, \quad (27)$$

where  $\tilde{\xi} \equiv \tau/\tilde{L}^\kappa$ ,  $\tilde{L} \equiv L + L_f = (1 + \Omega u_\tau) L$ ,  $K_d \equiv k_d L$  and  $K_f \equiv k_f L_f = k_f \Omega u_\tau L$ .  $K_d$  is the capital stock owned by domestic workers, while  $K_f$  is the aggregate capital stock of foreign workers.

### 4.1.4 Foreign Households

A representative foreign worker seeks to

$$\max_{c_f} U_{f,0} \equiv \int_0^\infty \frac{c_f^{1-\theta_2} - 1}{1 - \theta_2} e^{-(\rho_2 - \tilde{n})t} dt, \quad (28)$$

where  $c_f \equiv C_f/L_f$  and  $\tilde{n} \equiv \dot{u}_\tau/u_\tau + n$ , subject to

$$\dot{K}_f = \tilde{\xi} (r_v K_f + w_f L_f - C_f), \quad (29)$$

$$r_K K = r_V K + P_\tau \dot{\tau}, \quad (30)$$

$$K = K_d + K_f, \quad (31)$$

$$1 = u_Y + u_\tau. \quad (32)$$

### 4.1.5 Domestic Households' Optimization Problem

The Hamiltonian for this optimization problem is given by

$$\begin{aligned} \mathbf{H}_d \equiv & \frac{c_d^{1-\theta_1} - 1}{1 - \theta_1} e^{-(\rho_1 - n)t} \\ & + \nu_d \tilde{\xi} \left[ r_K K_d - \frac{w_\tau u_\tau L (1 + b\Omega)}{\lambda} \frac{K_d}{K_d + K_f} + w_Y u_Y L + w_\tau u_\tau L - C_d \right] \\ & + \mu \tilde{F} a^{\varepsilon\lambda} (1 + b\Omega) (u_\tau L)^\lambda. \end{aligned} \quad (33)$$

The control variables are  $c_d$  and  $u_Y$ , the state variables are  $K_d$  and  $\tau$ , and the costate variables are  $\nu_d$  and  $\mu$ . The first-order conditions for the control variables  $\partial \mathbf{H}_d / \partial c_d = 0$  and  $\partial \mathbf{H}_d / \partial u_Y = 0$  yield the following equations respectively:

$$\frac{\dot{c}_d}{c_d} = -\frac{1}{\theta_1} \left( \rho_1 + \frac{\dot{\nu}_d}{\nu_d} + \frac{\dot{\tilde{\xi}}}{\tilde{\xi}} \right), \quad (34)$$

$$\frac{\nu_d}{\mu} = \frac{\lambda \tilde{F} a^{\varepsilon \lambda} (1 + b\Omega) (u_\tau L)^\lambda}{\tilde{\xi} \left[ \frac{\kappa \Omega u_\tau}{1 + \Omega u_\tau} \dot{V}_d + \frac{\bar{w} u_\tau L (1 + b\Omega)}{\lambda} \left( \frac{K_d}{K} \right)^2 \right]}, \quad (35)$$

where  $\dot{V}_d = r_v K_d + w_Y u_Y L + w_\tau u_\tau L - C_d$ . The first-order conditions for the state variables are given by equations (23) and (24). The first-order conditions for the costate variables  $\partial \mathbf{H}_d / \partial K_d = -\dot{\nu}_d$  and  $\partial \mathbf{H}_d / \partial \tau = -\dot{\mu}$  yield the following equations :

$$-\frac{\dot{\nu}_d}{\nu_d} = \tilde{\xi} \left[ r_K - \frac{\bar{w} u_\tau L (1 + b\Omega) K_f}{\lambda K^2} \right], \quad (36)$$

$$-\frac{\dot{\mu}}{\mu} = \frac{\lambda \tilde{F} a^{\varepsilon \lambda} (1 + b\Omega) (u_\tau L)^\lambda \tau^{\phi-1} \dot{V}_d}{\frac{\kappa \Omega u_\tau}{1 + \Omega u_\tau} \dot{V}_d + \frac{\bar{w} u_\tau L (1 + b\Omega)}{\lambda} \left( \frac{K_d}{K} \right)^2}. \quad (37)$$

Finally, the transversality conditions are

$$\lim_{t \rightarrow \infty} K_d(t) \nu_d(t) = 0, \quad (38)$$

$$\lim_{t \rightarrow \infty} \tau(t) \mu(t) = 0. \quad (39)$$

#### 4.1.6 Foreign Households' Optimization Problem

The appropriate Hamiltonian is

$$\begin{aligned} \mathbf{H}_f &\equiv \frac{c_f^{1-\theta_2} - 1}{1 - \theta_2} e^{-(\rho_2 - \bar{n})t} \\ &+ \nu_f \tilde{\xi} \left[ r_K K_f - \frac{w_\tau u_\tau L (1 + b\Omega)}{\lambda} \frac{K_f}{K_d + K_f} + w_f L_f - C_f \right], \quad (40) \end{aligned}$$

where the control variable is  $c_f$ , the state variable is  $K_f$ , and the costate variable is  $\nu_f$ . The first-order condition for the control variable  $\partial \mathbf{H}_f / \partial c_f = 0$  yields the following equation:

$$\frac{\dot{c}_f}{c_f} = -\frac{1}{\theta_2} \left( \rho_2 + \frac{\dot{\nu}_f}{\nu_f} + \frac{\dot{\tilde{\xi}}}{\tilde{\xi}} \right). \quad (41)$$

The first-order condition for the state variable is given by equation (29). The first-order condition for the costate variable  $\partial \mathbf{H}_f / \partial K_f = -\dot{\nu}_f$  yields the following equation:

$$-\frac{\dot{\nu}_f}{\nu_f} = \tilde{\xi} \left[ r_K - \frac{\bar{w}u_\tau L (1 + b\Omega)}{\lambda} \frac{K_d}{K^2} \right]. \quad (42)$$

Finally, the transversality conditions dictate that

$$\lim_{t \rightarrow \infty} K_f(t) \nu_f(t) = 0. \quad (43)$$

#### 4.1.7 Steady-State Equations

In the steady-state,  $k_d$ ,  $c_d$ ,  $k_f$ ,  $c_f$ ,  $\tilde{\xi}$  and  $u_Y$  are all constant. This fact enables us to generate the following steady-state equations respectively:

$$\tilde{\xi} \left[ r_K - \frac{\bar{w}u_\tau (1 + b\Omega)}{\lambda k} + \frac{\bar{w}}{k_d} - \frac{c_d}{k_d} \right] = n, \quad (44)$$

$$\tilde{\xi} \left[ r_K - \frac{\bar{w}u_\tau (1 + b\Omega)}{\lambda k} \frac{K_f}{K} \right] = \rho_1, \quad (45)$$

$$\tilde{\xi} \left[ r_K - \frac{\bar{w}u_\tau (1 + b\Omega)}{\lambda k} + \frac{b\bar{w}}{k_f} - \frac{c_f}{k_f} \right] = n, \quad (46)$$

$$\tilde{\xi} \left[ r_K - \frac{\bar{w}u_\tau (1 + b\Omega)}{\lambda k} \frac{K_d}{K} \right] = \rho_2, \quad (47)$$

$$\frac{F a^{\varepsilon\lambda} (1 + b\Omega) u_\tau^\lambda \tilde{\xi}^{\phi-1}}{(1 + \Omega u_\tau)^\lambda} = \gamma_\tau^*, \quad (48)$$

$$-\frac{\dot{\mu}}{\mu} = -\frac{\dot{\nu}_d}{\nu_d} + \gamma_\tau^* - n, \quad (49)$$

where  $\gamma_\tau^* = \kappa n$ . Using equations (20), (21), (45), (47), and the constraint given by equation (26), we have

$$k_d = \frac{\alpha (\rho_1 - \rho_2) + M \rho_2}{(\rho_1 + \rho_2) M} k, \quad (50)$$

$$k_f = \frac{k - k_d}{\Omega u_\tau}, \quad (51)$$

where

$$M \equiv \frac{1 - \alpha}{\lambda} \frac{u_\tau}{u_Y} (1 + b\Omega). \quad (52)$$

Using equations (20), (21), (47) and (50), we have

$$k = \left[ \frac{A \tilde{\xi} (2\alpha - M)}{\rho_1 + \rho_2} \right]^{\frac{1}{1-\alpha}} u_Y. \quad (53)$$

From equation (48), we have

$$\tilde{\xi} = \left[ \frac{F a^{\varepsilon \lambda} (1 + b \Omega) u_{\tau}^{\lambda}}{(1 + \Omega u_{\tau})^{\lambda} \gamma_{\tau}^*} \right]^{\frac{1}{1-\phi}}. \quad (54)$$

Using equations (20), (21) and (44), we have

$$c_d = A k^{\alpha-1} u_Y^{1-\alpha} \left[ \alpha - M + \frac{k}{k_d} \frac{1}{u_Y} - \frac{n}{\tilde{\xi}} \right] k_d. \quad (55)$$

Using equations (20), (21) and (46), we have

$$c_f = A k^{\alpha-1} u_Y^{1-\alpha} \left[ \alpha - M + \frac{k}{k_f} \frac{b}{u_Y} - \frac{n}{\tilde{\xi}} \right] k_f. \quad (56)$$

Substituting equations (44), (45), (47), (48) and (50) into equation (49) gives us the following implicit function:

$$f(u_Y) \equiv \frac{\lambda n \gamma_{\tau}^*}{\rho_1 - n + \gamma_{\tau}^*} - \frac{\gamma_{\tau}^* \Omega u_{\tau}}{1 + \Omega u_{\tau}} - \frac{\alpha (\rho_1 - \rho_2) + M \rho_2}{2\alpha - M},$$

which we can use to solve numerically for the steady-state value of  $u_Y$  by setting  $f(u_Y) = 0$ .

## 4.2 Comparative Statics and Model Implications

We present in graphical form the results of our comparative statics exercise. These are divided into two broad categories. The first category analyses the effect of changes in the parameters  $\hat{a}$ ,  $\varepsilon$ ,  $b$ ,  $A$  as well as a percentage increase in  $F$  on the impact of financial liberalization. In particular, we show how varying these parameters affect the *ratios* of post-liberalization/pre-liberalization steady-state values of  $u_{\tau}^*$ ,  $u_Y^*$ ,  $\tilde{\xi}^*$ ,  $c_d^*$  and  $k_d^*$ . For example, the solid line in the graph on the top left corner of Figure 3a shows the effect of changing  $\hat{a}$  (which measures the relative productivities of foreign versus domestic workers) on the post-liberalization steady state value of  $u_{\tau}^*$  (the fraction of the total labor force that is working in the financial sector) divided by its pre-liberalization value. If this ratio is one, then financial liberalization has no effect on the steady-state value of  $u_{\tau}^*$ . The second category, illustrated in Figures 4a and 4b, analyses the impact of varying levels of  $\hat{a}$ ,  $\varepsilon$ ,  $b$ ,  $A$  and a percentage rise in  $F$  on post-liberalization *levels* of  $u_Y^*$ ,  $u_{\tau}^*$ ,  $\Omega^* u_{\tau}^*$ ,  $c_d^*$ ,  $k_d^*$  and  $\tilde{\xi}^*$ . The composite variable  $\Omega^* u_{\tau}^*$  measures the size of foreign workers as a proportion of the domestic population. Note that these comparative statics are performed by altering the value of one parameter at a time while keeping the others constant. The baseline values for all the parameters are shown below:

$\alpha$	$\rho_1, \rho_2$	$\theta_1, \theta_2$	$n$	$\varepsilon$	$\lambda$	$\phi$	$A$	$F_{initial}$	$a$	$b$
1/3	0.02	1.5	0.01	0.2	2/3	0.2	0.35	0.0291	2.3784	2.0

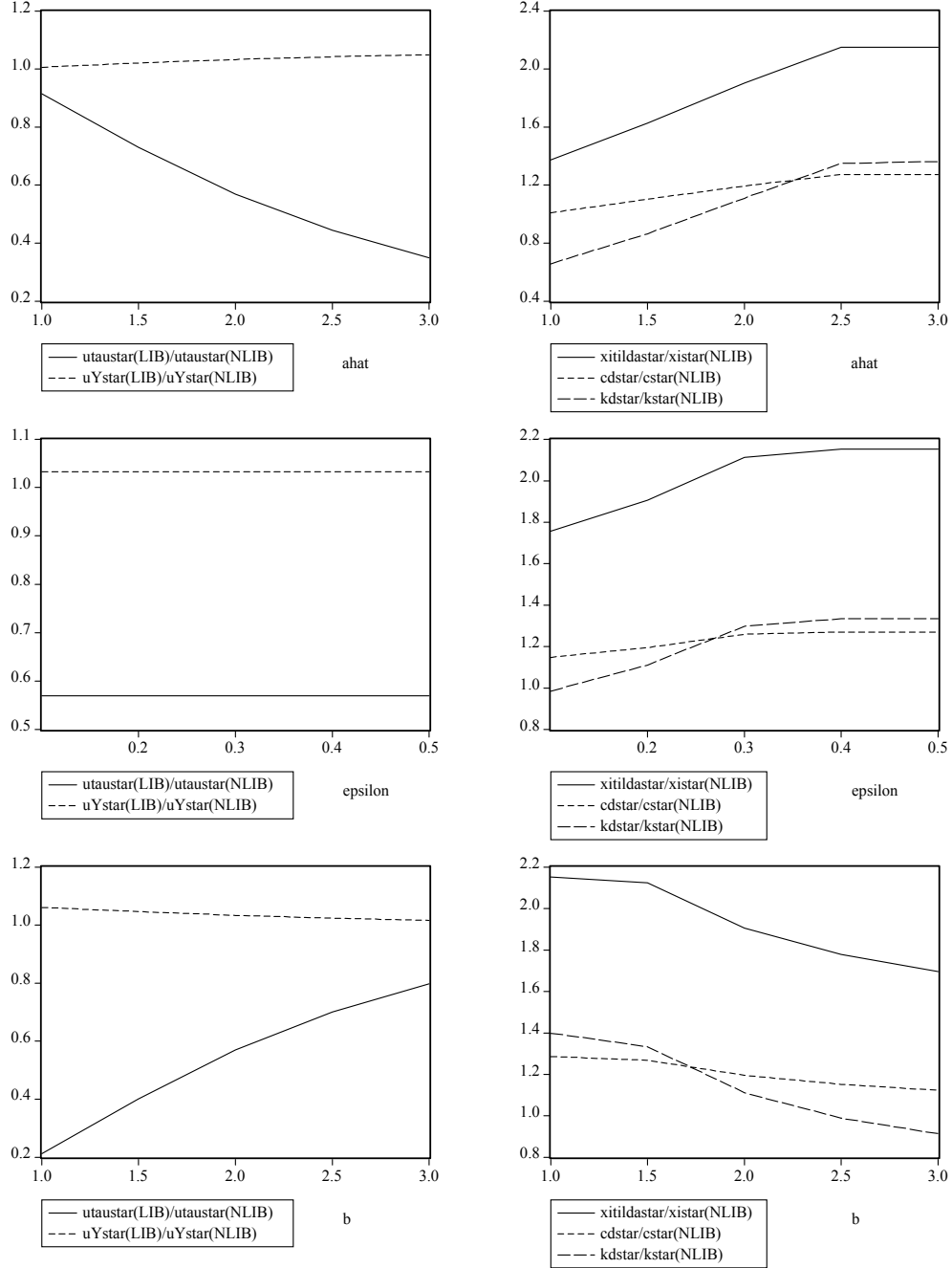


Figure 3a: The effect of financial liberalization on  $u^*$ ,  $u_Y^*$ ,  $\tilde{\xi}^*$ ,  $c_d^*$  and  $k_d^*$  for various levels of  $\hat{a}$ ,  $\varepsilon$  and  $b$ .

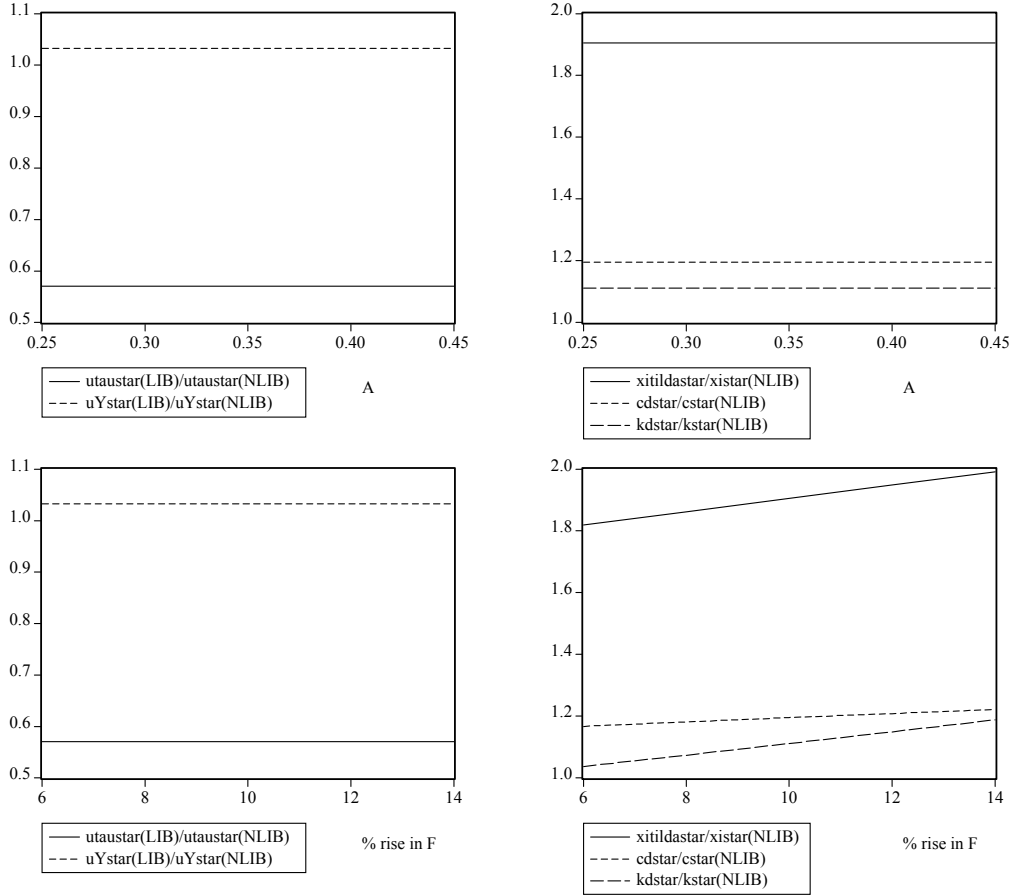


Figure 3b: The effect of financial liberalization on  $u_{\tau}^*$ ,  $u_Y^*$ ,  $\tilde{\xi}^*$ ,  $c_d^*$  and  $k_d^*$  for various levels of  $A$  and percentage rise in  $F$ .

For the first category, we find that financial liberalization accompanied by an inflow of foreign talent raises  $u_Y^*$  but lowers  $u_{\tau}^*$ . For the given set of baseline parameter values, the changes in these two variables are approximately 3.26% and negative 43% respectively. The introduction of foreign talent to the financial sector invariably results in a relocation of domestic workers from the financial to the final goods sector. The proportion of change in these two variables depends, however, on the values of  $\hat{a}$  and  $b$ . Our results indicate that a higher relative level of foreign worker's ability is associated with a larger percentage change in  $u_Y^*$  and  $u_{\tau}^*$  while the converse is true for a higher foreign wage rate relative to the domestic wage rate. In other words, more domestic workers in the financial sector will be displaced by foreign workers if the latter are relatively more productive; fewer domestic workers will be displaced when foreign workers are relatively more costly to hire, *ceteris paribus*.

The comparative statics for  $\tilde{\xi}^*$ ,  $c_d^*$  and  $k_d^*$  are more complicated. For the range of values considered for each of the five parameters, financial liberalization when accompanied by an inflow of foreign talent raises the level at which savings are transformed into productive capital,  $\tilde{\xi}^*$ , and consumption per domestic worker,  $c_d^*$ . The effect on physical capital per domestic worker,  $k_d^*$ , however, is ambiguous. For low values of  $\hat{a}$  and high values of  $b$ , the effect will be negative for  $k_d^*$  and vice-versa. For the given set of baseline parameter values, the changes in  $\tilde{\xi}^*$ ,  $c_d^*$  and  $k_d^*$  are approximately 90.5%, 19.4% and 11%. The proportionate change in these variables depends on the values of the parameters  $\hat{a}$ ,  $\varepsilon$  and  $b$ , and the percentage rise in  $F$ . The results show that a higher level of  $\hat{a}$ ,  $\varepsilon$  or percentage rise in  $F$  is associated with a larger percentage change in  $\tilde{\xi}^*$  and  $c_d^*$  post-liberalization while the converse is true for a higher level of  $b$ . In general, the economy can benefit from a higher rate of transformation of savings and domestic workers are more likely to experience an increase in their levels of consumption and physical assets following the liberalization of the financial sector when foreign workers are relatively more able, relatively less costly to hire, the learning rate of domestic workers is higher, and the rise in the level of technology in the financial sector,  $F$ , is higher.

The next set of diagrams, Figures 4a and 4b, show the effect of various parameters on the post-liberalization steady state values of the state and control variables, and are drawn with two vertical axes. The axis on the left measures the first variable in the legend while the one on the right measures the second and third. For the variables  $u_Y^*$ ,  $u_\tau^*$  and  $\Omega^*u_\tau^*$ , the results indicate that only  $\hat{a}$  and  $b$  have a systematic impact on them. The impact of a positive change in the former is positive on  $u_Y^*$  and  $\Omega^*u_\tau^*$  but negative on  $u_\tau^*$  while the converse is true for the impact of a positive change in the latter. In other words, holding the cost of hiring talented foreigners constant, the higher the relative level of ability of these workers, the more of them will be hired and the more domestic workers in the financial sector will be displaced. On the other hand, for a given relative level of ability, the more costly foreign workers are, the less of them will be hired and fewer domestic workers in the financial sector will be displaced.

As for the variables  $\tilde{\xi}^*$ ,  $c_d^*$  and  $k_d^*$ , our results indicate that the parameters  $\hat{a}$ ,  $\varepsilon$  and  $A$ , and the percentage rise in  $F$  have a positive impact on them while the opposite is true of  $b$ . The only exception is the impact of  $A$  on  $\tilde{\xi}^*$ , where there exists no systematic relationship between the two. In this model, we see that any economy regardless of its level of technology,  $A$ , can benefit from liberalizing its financial sector and hiring foreign workers. An economy with a higher level of technology enjoys higher levels consumption and physical capital per domestic worker regardless of the state of its financial sector.

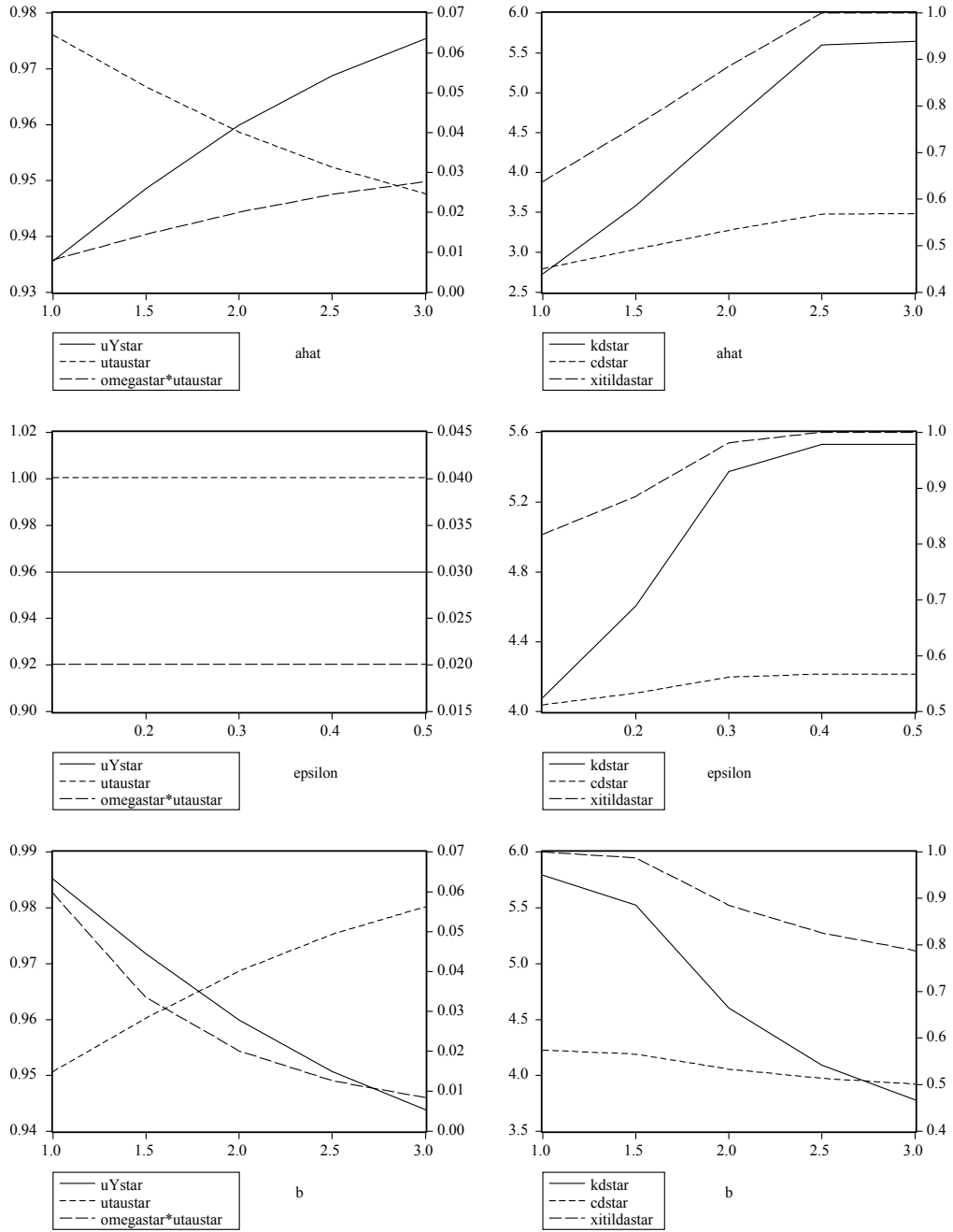


Figure 4a: The impact of varying levels of  $\hat{a}$ ,  $\epsilon$  and  $b$  on  $u_Y^*$ ,  $u_\tau^*$ ,  $\Omega^*u_\tau^*$ ,  $c_d^*$ ,  $k_d^*$  and  $\tilde{\xi}^*$ .

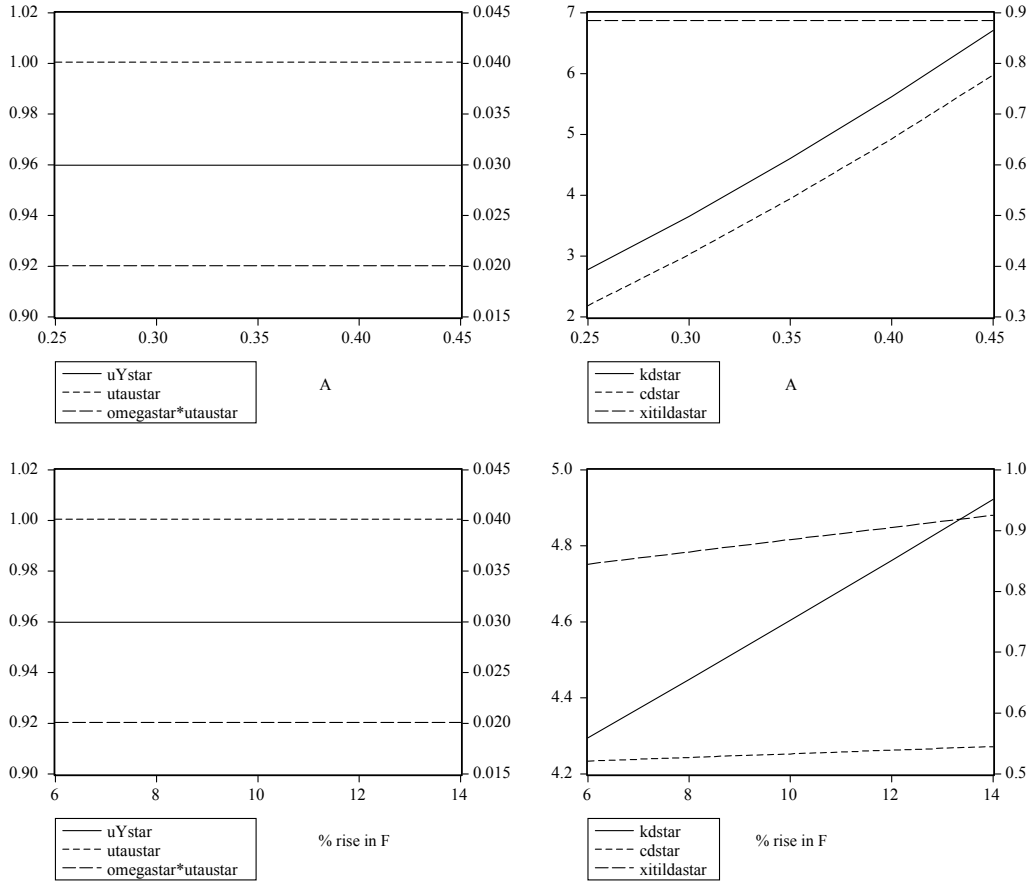


Figure 4b: The impact of varying levels of  $A$  and percentage rise in  $F$  on  $u_Y^*$ ,  $u_\tau^*$ ,  $\Omega^* u_\tau^*$ ,  $c_d^*$ ,  $k_d^*$  and  $\tilde{\xi}^*$ .

Furthermore, a more sophisticated and developed financial sector has no bearing at all on the level of technology used in final goods production. We can envisage an economy where the financial sector plays an important role in the development of new and better technologies via the R&D sector, as in the more advanced model explored in Chou and Chin (2001). This entails specifying an R&D equation of the following form:

$$\dot{A}(t) = B [(1 - u_Y(t) - u_\tau(t)) L(t)]^\eta \tau(t)^\beta A(t)^\psi,$$

where  $A$  denotes the state of technology in final goods production,  $B$  is a constant,  $1 - u_Y(t) - u_\tau(t)$  is the share of labor devoted to R&D, and  $\eta$ ,  $\beta$  and  $\psi$  are elasticity parameters. The stock of financial products,  $\tau$ , which increases with financial innovation, determines the rate at which new technical blueprints,  $\dot{A}$ , are produced. There is thus a spillover effect from financial innovation on real, technological innovation. Under such circumstances, the

liberalization of the financial sector coupled with the hiring of talented foreign workers will raise long-run growth by affecting total factor productivity.

## 5 Summary and Conclusion

In this paper, we set out to study the macroeconomic impact of financial liberalization using a two-sector growth model. In addition to a final goods sector, the model incorporates a financial sector comprising financial innovators and financial intermediaries. Financial innovators use labor and spillovers from existing financial products to create financial innovations. The stock of financial products then determines the efficiency of financial intermediaries in transforming the savings of households into productive investment by firms. While we discussed the latest empirical research focusing on the liberalization of the stock market and banking sectors, we define financial liberalization in the context of our growth model as an event which raises the marginal productivity of financial innovators (the magnitude of which is initially exogenously determined) but also one that causes the products of these innovators, which previously accrued to domestic households, to be repatriated to the countries in which the foreign financial firms originate. Financial liberalization therefore affects the efficiency of financial intermediation by raising the rate at which new financial products are created, which in turn impacts growth through the capital accumulation process. Opening the financial sector to greater foreign participation in both the stock market and the banking sectors is thus consistent with our definition of financial liberalization.

Our results suggests that financial liberalization results in higher steady-state levels of consumption, capital and output per capita. However, these salubrious effects only kick in after a considerable period of time has elapsed (up to ninety periods in our simulations). During the transition to the new steady state, these per capita variables decline below their pre-liberalization levels. This is not only because financial liberalization results in the loss of the financial sector's profits from the domestic households' perspective, but also because the rise in productivity of financial innovations causes a reallocation of labor from the final goods sector to the financial sector. Final goods production thus falls, along with consumption (of these final goods) and capital accumulation. There is a considerable lag before the rise in transformative efficiency of financial intermediaries (due to increased financial innovation) reverses the decline in per-capita consumption, capital and output. Although the share of labor devoted to final goods production jumps downwards immediately after liberalization, it eventually returns to its pre-liberalization value. The cost of capital or the interest rate exhibits a cycling effect before it declines to

its post-liberalization steady-state value, which is below its pre-liberalization counterpart. Our simulations also demonstrate that the larger the spillovers of existing financial products on financial innovations, the greater the long-run impact of financial liberalization on per-capita consumption, capital and output.

The second half of this paper looked at a more sophisticated version of our model where financial liberalization endogenously affects the rate of financial innovation through the addition of “talented” foreign workers whose productivity (and wage) are higher than that of domestic workers. We also allowed for the diffusion of expertise from foreign to domestic workers, so that their productivities converge through learning effects. The results of our comparative statics exercise show that the positive effects of financial liberalization on long-run consumption and capital stock per worker (as measured by the ratios of their pre- and post-liberalization steady-state values) are magnified the higher the relative productivity of foreign workers (holding their relative wages fixed) and the greater the learning rate of domestic workers. These two parameters are also positively related to the post-liberalization steady-state levels of consumption and capital per worker, as are the level of technology in final goods production and the percentage increase in the productivity of financial innovators.

Possible extensions of the model include modelling the real R&D process (as in Romer (1990), Jones (1995), Grossman and Helpman (1991c), etc.) and allowing the state of development of the financial sector (proxied by the stock of financial products) to affect the endogenous rate of technological progress, and to allow for the diffusion of expertise from foreign workers to domestic workers to depend on the stock of human capital, which is to be modelled endogenously.

## 6 Appendix

Display and discuss results of simulations for alternative values of  $\iota$ ,  $\lambda$  and  $\phi$ . Check speed of convergence to the new steady state after liberalization.

To be completed.

## References

ACEMOGLU, D., AND F. ZILIBOTTI (1997): “Was Prometheus Unbound by Chance? Risk, Diversification and Growth,” *Journal of Political Economy*, 105, 709–751.

- AGHION, P., AND P. HOWITT (1992): “A Model of Growth Through Creative Destruction,” *Econometrica*, 60, 323–351.
- ARESTIS, P., AND P. O. DEMETRIADES (1997): “Financial Development and Economic Growth: Assessing the Evidence,” *Economic Journal*, 107, 783–799.
- BARRO, R., G. MANKIW, AND X. SALA-I-MARTIN (1995): “Capital Mobility in Neoclassical Models of Growth,” *American Economic Review*, 85, 103–115.
- BEKAERT, G., AND C. R. HARVEY (2000): “Foreign Speculators and Emerging Equity Markets,” *Journal of Finance*, 55, 565–614.
- BEKAERT, G., C. R. HARVEY, AND C. LUNDBLAD (2000): “Emerging Equity Markets and Economic Development,” NBER Working Paper No. 7763.
- BEKAERT, G., C. R. HARVEY, AND C. LUNDBLAD (2001): “Does Financial Liberalization Spur Growth,” NBER Working Paper No. 8245.
- BENCIVENGA, V. R., AND B. D. SMITH (1991): “Financial Intermediation and Endogenous Growth,” *Review of Economic Studies*, 58, 195–209.
- (1993): “Some Consequences of Credit Rationing in an Endogenous Growth Model,” *Journal of Economic Dynamics and Control*, 17, 97–122.
- BENCIVENGA, V. R., B. D. SMITH, AND R. M. STARR (1995): “Transaction Costs, Technological Choice and Endogenous Growth,” *Journal of Economic Theory*, 67, 153–177.
- (1996): “Equity Markets, Transactions Costs and Capital Accumulation: An Illustration,” *World Bank Economic Review*, 10, 241–265.
- BENHABIB, J., AND M. M. SPIEGEL (2000): “The Role of Financial Development in Growth and Investment,” *Journal of Economic Growth*, 5, 341–360.
- BERTHELMY, J. C., AND A. VAROUDAKIS (1996): “Economic Growth, Convergence Clubs and the Role of Financial Development,” *Oxford Economic Papers*, 48, 300–328.
- BETTS, C., AND J. BHATTACHARYA (1998): “Unemployment, Credit Rationing and Capital Accumulation: A Tale of Two Frictions,” *Economic Theory*, 12(3), 489–518.
- BIS (1986): *Recent Innovations in International Banking*. Bank of International Settlements, Basel.

- BLACKBURN, K., AND V. T. Y. HUNG (1998): "A Theory of Growth, Financial Development and Trade," *Economica*, 65, 107–124.
- BOSE, N., AND R. COTHREN (1996): "Equilibrium Loan Contracts and Endogenous Growth in the Presence of Asymmetric Information," *Journal of Monetary Economics*, 38, 363–376.
- BOYD, J., AND B. D. SMITH (1996): "The Coevolution of the Real and Financial Sector in the Growth Process," *World Bank Economic Review*, 10, 371–396.
- BUITER, W. H., AND K. M. KLETZER (1995): "Capital Mobility, Fiscal Policy and Growth under Self-Financing of Human Capital Formation," *Canadian Journal of Economics*, 28, S163–S194.
- CASS, D. (1965): "Optimum Growth in an Aggregative Model of Capital Accumulation," *Review of Economic Studies*, 32, 233–240.
- CHOU, Y. K., AND M. CHIN (2001): "Why Wall Street Matters for Long-Term Prosperity: Financial Innovations and Growth," Mimeo. (University of Melbourne, Australia).
- CHRISTOU, C. (1993): "Credit Market Imperfections and Investment in Human Capital," Mimeo. (Maryland University, College Park, MD).
- DE GREGORIO, J. (1996): "Borrowing Constraints, Human Capital Accumulation and Growth," *Journal of Monetary Economics*, 37, 49–71.
- DE LA FUENTE, A., AND J. M. MARIN (1996): "Innovation, Bank Monitoring and Endogenous Financial Development," *Journal of Monetary Economics*, 38, 269–301.
- DEMETRIADES, P. O., AND K. A. HUSSEIN (1996): "Does Financial Development Cause Economic Growth? Time-Series Evidence from 16 Countries," *Journal of Development Economics*, 51, 387–411.
- DEMURGÜÇ-KUNT, A., AND R. LEVINE (1996a): "Stock Market Development and Financial Intermediaries: Stylized Facts," *World Bank Economic Review*, 10, 291–322.
- (1996b): "Stock Markets, Corporate Finance, and Economic Growth: An Overview," *World Bank Economic Review*, 10, 223–240.

- DEMURGÜÇ-KUNT, A., R. LEVINE, AND H. G. MIN (1998): “Opening to Foreign Banks: Issues of Stability, Efficiency, and Growth,” in *The Implications of Globalization of World Financial Markets*, ed. by S. Lee, pp. 83–115. The Bank of Korea, Seoul, Korea.
- DEVEREUX, M. B., AND G. W. SMITH (1994): “International Risk Sharing and Economic Growth,” *International Economic Review*, 35, 535–550.
- DIXIT, A., AND J. E. STIGLITZ (1977): “Monopolistic Competition and Optimum Product Diversity,” *American Economic Review*, 67, 297–308.
- GERTLER, M. (1988): “Financial Structure and Aggregate Economic Activity: An Overview,” *Journal of Money, Credit and Banking*, 20, 559–588.
- GREENWOOD, J., AND B. JOVANOVIĆ (1990): “Financial Development, Growth and the Distribution of Income,” *Journal of Political Economy*, 98, 1076–1107.
- GREENWOOD, J., AND B. D. SMITH (1997): “Financial Markets in Development and the Development of Financial Markets,” *Journal of Economic Dynamics and Control*, 21, 145–181.
- GROSSMAN, G. M., AND E. HELPMAN (1991a): *Innovation and Growth in the Global Economy*. MIT Press, Cambridge, Massachusetts.
- (1991b): “Quality Ladders and Product Cycles,” *Quarterly Journal of Economics*, 106, 557–586.
- (1991c): “Quality Ladders in the Theory of Growth,” *Review of Economic Studies*, 58, 43–61.
- HENRY, P. (2000a): “Do Stock Market Liberalizations Cause Investment Booms,” *Journal of Financial Economics*.
- (2000b): “Stock Market Liberalization, Economic Reform, and Emerging Market Equity Prices,” *Journal of Finance*, 55, 529–564.
- JAPELLI, T., AND M. PAGANO (1994): “Saving, Growth and Liquidity Constraints,” *Quarterly Journal of Economics*, 108, 83–109.
- JONES, C. I. (1995): “Research and Development Based Models of Economic Growth,” *Journal of Political Economy*, 103, 759–784.
- KING, R. G., AND R. LEVINE (1993a): “Finance and Growth: Schumpeter Might Be Right,” *Quarterly Journal of Economics*, 108, 717–737.

- (1993b): “Finance, Entrepreneurship and Growth: Theory and Evidence,” *Journal of Monetary Economics*, 32, 513–542.
- KOOPMANS, T. C. (1965): “On the Concept of Optimal Economic Growth,” in *The Economic Approach to Development Planning*. North-Holland, Amsterdam.
- KRUGMAN, P. (1993): “International Finance and Economic Development,” in *Finance and Development: Issues and Experience*, ed. by A. Giovannini, pp. 11–24. Cambridge University Press, Cambridge, United Kingdom.
- LAEVEN, L. (2000): “Financial Liberalization and Financing Constraints: Evidence from Panel Data on Emerging Economies,” World Bank Working Paper.
- LEVINE, R. (1996): “Foreign Banks, Financial Development, and Economic Growth in International Financial Markets: Harmonization versus Competition,” in *International Financial Markets: Harmonization versus Competition*, ed. by C. E. Barfield, pp. 224–254. AEI Press, Washington, D.C.
- (1997): “Financial Development and Economic Growth: Views and Agenda,” *Journal of Economic Literature*, 35, 688–726.
- (2000): “International Financial Liberalization and Economic Growth,” *Review of International Economics*, forthcoming.
- LEVINE, R., N. LOAYZA, AND T. BECK (1999): “Financial Intermediation and Growth: Causality and Causes,” Mimeo. (World Bank).
- LEVINE, R., AND S. ZERVOS (1996): “Stock Market Development and Economic Growth,” *World Bank Economic Review*, 10, 323–240.
- (1998): “Stock Markets, Banks, and Economic Growth,” *American Economic Review*, 88(3), 537–558.
- LLEWELLYN, D. (1992): “Financial Innovation: A Basic Analysis,” in *Financial Innovation*, ed. by H. Cavanna. Routledge, London.
- MA, C. H., AND B. D. SMITH (1996): “Credit Market Imperfections and Economic Development: Theory and Evidence,” *Journal of Development Economics*, 48, 351–387.
- OBSTFELD, M. (1994): “Risk-Taking, Global Diversification and Growth,” *American Economic Review*, 84, 1310–1329.

- PAGANO, M. (1993): “Financial Markets and Growth: An Overview,” *European Economic Review*, 37, 613–622.
- RIVERA-BATIZ, L. A., AND P. M. ROMER (1991): “Economic Integration and Endogenous Growth,” *Quarterly Journal of Economics*, 106, 531–555.
- ROMER, P. M. (1990): “Endogenous Technological Change,” *Journal of Political Economy*, 98, S71–S102.
- ROUSSEAU, P. L., AND P. WACHTEL (1998): “Financial Intermediation and Economic Performance: Historical Evidence from Five Industrial Countries,” *Journal of Money, Credit, and Banking*, 30, 657–678.
- ROUSSEAU, P. L., AND P. WACHTEL (2000): “Equity Markets and Growth: Cross-Country Evidence on Timing and Outcomes, 1980-1995,” *Journal of Banking and Finance*, pp. 1933–1958.
- SAINT-PAUL, G. (1992): “Technological Choice, Financial Markets and Economic Development,” *European Economic Review*, 36, 763–781.
- SHI, S. (1996): “Asymmetric Information, Credit Rationing and Economic Growth,” *Canadian Journal of Economics*, 29, 665–687.
- SOLOW, R. M. (1956): “A Contribution to the Theory of Economic Growth,” *Quarterly Journal of Economics*, 70, 65–94.
- STIGLITZ, J. E. (1989): “Financial Markets and Development,” *Oxford Review of Economic Policy*, 5, 55–68.
- SWAN, T. W. (1956): “Economic Growth and Capital Accumulation,” *Economic Record*, 32, 334–361.
- TSIDDON, D. (1992): “A Moral Hazard Trap to Growth,” *International Economic Review*, 33, 299–321.
- VAALE, P. M. (2001): “A Tale of Two Cities: Understanding the Paradox of Product Innovation and Imitation Strategies in Multinational Financial Institutions,” in *Financial Innovations and the Welfare of Nations*, ed. by L. L. Jacque, and P. M. Vaaler. Kluwer, Boston.