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IN A TWO-COUNTRY WORLD-ECONOMY**

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FINANCIAL MARKETS AND FINANCIAL LEVERAGE IN A TWO-COUNTRY WORLD-ECONOMY

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Resumen

Este artículo analiza el rol e las imperfecciones del mercado financiero en una versión simplificada para un modelo con dos países. La heterogeneidad financiera entre los países es modelada a través de las diferencias de apalancamiento (*leverage*). El análisis muestra que las economías con alto apalancamiento son especialmente vulnerables frente a recesiones de la economía mundial. Hasta qué punto el apalancamiento magnifica los shocks a la economía mundial depende de la naturaleza de la perturbación. En presencia del acelerador financiero, es más probable que los shocks de oferta específicos al capital sean menos desestabilizadores que aquéllos shocks que no sean específicos al capital.

Abstract

In this paper, we consider the role of financial market imperfections in a simplified version of a two-country model. We model cross-country financial heterogeneity through differences in leverage. We show that high leverage economies are particularly vulnerable to slow-downs in the world economy. The degree to which leverage magnifies shocks to the world economy depends on the nature of the disturbance. In the presence of the financial accelerator, supply shocks that are capital specific are likely to be less destabilizing than supply shocks that are disembodied.

INTRODUCTION

This paper explores the role of financial markets in the international transmission mechanism in the context of a two-country general equilibrium model. I incorporate realistic frictions with respect to the external financing of investment, and I calibrate these frictions to reflect important differences in lending institutions between developed and developing economies. The paper focuses, in particular, on the role of leverage in transmitting shocks from developed economies to developing economies. The results imply that high-leverage economies are particularly vulnerable to external shocks, and that asymmetries between lending conditions across economies provide a strong source of transmission for shocks from developed to developing economies. Furthermore, slowdowns in economic activity are severely amplified by financial frictions. The model implies that the degree of amplification is directly related to the degree of leverage in the economy.

In many developing economies, firms face significant capital market imperfections when raising external funds to finance new investment projects. These frictions stem from underlying asymmetries of information between borrowers and lenders. To overcome these frictions, lenders must either engage in costly monitoring activities or require significant levels of collateral when financing investment projects. In such an environment, fluctuations in world demand lead to fluctuations in asset values that influence the overall level of self-financing. A contraction in demand causes asset values and hence net worth to fall relative to financing needs. As a result, borrower balance sheets deteriorate, and financial intermediaries increase the premiums on external funds. Rising premiums on external finance cause further contractions in investment spending and output. In an international setting, shocks may be rapidly transmitted across countries owing to their effect on foreign asset valuations and thus on borrower net worth.

The lending mechanism outlined above represents a transmission channel linking balance sheet conditions to real spending decisions. Countries where the share of investment financed through external funds is high are likely to experience significant amplification of shocks through such a channel. This channel is also likely to be influential in countries where the health of the financial system is weak.

In this paper, I use the two-country model outlined in Gilchrist, Hairault, and Kempf (2002) to assess the role that leverage plays in transmitting shocks across countries. Gilchrist, Hairault, and Kempf specify a two-country world economy that incorporates the financial accelerator mechanism outlined in Bernanke, Gertler, and Gilchrist (1999). Céspedes, Chang, and Velasco (2000) and Gertler, Gilchrist, and Natalucci (2003) develop models of the financial accelerator for small open-economy settings under alternative exchange rate regimes. Devereux and Lane (2001) also study the role of the financial accelerator in small open economy settings. Natalucci (2001) considers a three-country model where two small economies interact with a larger "rest of the world" economy. Faia (2001a, 2001b) develops a two-country model similar to Gilchrist, Hairault, and Kempf, focusing on the positive and normative properties of different exchange rate regimes.

Section 1 presents a two-country model of the world economy. This model is a two-country variant of the dynamic new Keynesian framework specified in Gilchrist, Hairault, and Kempf (2002). To adapt this framework to study the links between financial conditions in developing economies and the international transmission of shocks, I modify the model in two key ways. First, I allow for incomplete markets in the household sector, which implies the realistic assumption of imperfect risk sharing between the two countries.

Second, I allow for a significant degree of heterogeneity in the severity of balance sheet conditions across the two economies. Here I focus on one source of heterogeneity: the degree of leverage or, equivalently, the amount of self-financing. The specification of a world economy in which cross-country differences in financial performance reflect different degrees of leverage effectively focuses the study on what I consider to be the major source of financial vulnerability that plagues developing economies during international downturns—namely, weak balance sheets owing to over-extended credit positions.

An additional contribution of this paper is to provide a simplified and somewhat stripped down version of the Bernanke-Gertler-Gilchrist model that is relatively straightforward to calibrate and solve. In doing so, I assume away some of the steady-state complexities of the Bernanke-Gertler-Gilchrist model by assuming equal external finance premiums in steady state.¹

I further simplify the dynamic analysis by assuming that entrepreneurs consume no resources and that the direct resource loss stemming from monitoring costs does not influence macroeconomic dynamics. The latter assumption is equivalent to assuming that although the marginal cost of external funds varies over the business cycle and has important macroeconomic consequences, the inframarginal costs associated with resources consumed by monitoring firms are unlikely to have quantitatively significant effects on the economy, at least in a neighborhood of the steady state.² This stripped-down version of the Bernanke-Gertler-Gilchrist model is both much simpler to work with and more straightforward to calibrate than the original. In particular, the financial frictions can be summarized by two key parameters: the elasticity of the premium on external funds with respect to leverage and the degree of leverage itself. Both of these parameters influence model dynamics in fairly obvious ways, and both parameters are also easily understood from a calibration perspective.³

Finally, I also extend the Bernanke-Gertler-Gilchrist framework to incorporate not only the usual shocks to demand and supply through shocks to preferences and disembodied technology, but also shocks to technology that are embodied in capital. My motivation for this extension is twofold. First, numerous recent papers attribute a large fraction of both overall technological change and the recent U.S. productivity boom to technology embodied in new capital goods (Greenwood, Hercowitz, and Krussel, 1997; Gilchrist and Williams, 2002). It is interesting to study the role of such shocks in an international setting. Second, the dynamic implications of such shocks are less than straightforward in the presence of a financial accelerator. In particular, an increase in technology embodied in new capital raises asset prices through its effect on increased investment demand, but it lowers asset prices since existing capital is now worth less than new capital goods. In such a setting, the overall effect of an expansion in technology on the balance sheet is ambiguous.

1. EMPIRICAL EVIDENCE ON CROSS-COUNTRY LEVERAGE PATTERNS

This paper focuses on the role of leverage in amplifying the cross-country transmission of shocks. The model implies that high-leverage economies are

1. This may be formally justified by the introduction of steady-state subsidies that eliminate cross-country differences in capital-labor ratios owing to capital market distortions.

2. For large shocks, resources devoted to monitoring could be sizeable owing to the inherent nonlinearities in the contracting framework used by Bernanke, Gertler, and Gilchrist. Since the model is log-linearized, however, it does not capture such effects.

3. Although not reported here, a comparison of the fully articulated two-country version of the Bernanke-Gertler-Gilchrist model specified in Gilchrist, Hairault, and Kempf (2002) and the model employed in this paper produce only minor differences in model dynamics.

more prone to financial instability caused by the financial accelerator mechanism than are low-leverage economies. While formally testing this proposition empirically is beyond the scope of this paper, it is instructive to consider the variation in leverage ratios that occurs across countries. Faccio, Lang, and Young (2002) report leverage ratios for Asian versus European firms using a sample of 3,448 nonfinancial corporations for 1996, the year that preceded the Asian financial crisis (see figure 1). Asian country leverage ratios are, on average, 31.8 percent; the comparable number for European countries is 19.98 percent. With the exception of Japan, the Asian countries are all emerging market or newly industrialized countries. The three countries with the highest leverage ratios—Indonesia (35.3 percent), Thailand (40.58 percent), and South Korea (52.3 percent)—were hit particularly hard by the Asian financial crisis.

[figure 1 about here]

Similar results are obtained if the United States and other developed western economies are considered. It is harder to see a direct link between stage of development and leverage ratios, however, when the sample is expanded to include a broader base of countries from different regions. Based on the reported values in Booth and others (2001), some developing economies such as Mexico and Brazil appear to have relatively low leverage ratios, whereas others such as South Korea have extremely high leverage ratios. While many factors determine capital structure, it is plausible that an initial round of financial liberalization and growth leads to increased indebtedness, making countries such as Indonesia, Thailand, and Korea particularly vulnerable to shocks that are transmitted across countries. It is this mechanism that I explore in the model developed below⁴.

2. A TWO-COUNTRY MODEL WITH FINANCIAL ACCELERATOR

This section develops a general equilibrium framework that incorporates capital market imperfections into an international environment. I first specify a two-country model without financial frictions and then show how to incorporate financial frictions in a simple yet tractable manner. This framework allows me to analyze the effect of financial heterogeneity that characterizes financial markets in developed and developing economies. To focus on the effect of such heterogeneity, as well as to keep the analysis as simple as possible, I assume that the two countries are otherwise identical.

[Figure 1 about here]

The main source of financial heterogeneity in the model is differences in cross-country leverage ratios. In the Bernanke-Gertler-Gilchrist framework, leverage is endogenous and reflects the deep parameters in the model that govern the costs of monitoring firms, the variance of unobservable shocks and the extent to which entrepreneurs discount the future relative to households. Indeed, numerical simulations of the steady state of the Bernanke-Gertler-Gilchrist model imply that leverage is directly increasing in the rate at which entrepreneurs fail for exogenous (nonfinancial) reasons. As entrepreneurs fail at a faster rate, their accumulated net worth is dissipated. The primary effect of raising entrepreneurial failure rates is thus to lower net worth and raise the amount of debt relative to equity held by the entrepreneurial sector. To the extent that developing economies have

4. Even within Europe, the countries with the highest leverage ratios over the 1981-91 period are Finland, Sweden, and Norway (Demirgüç-Kunt and Maksimovic, 1999). These countries were all subject to major contractions owing to financial instability during the late 1980s

higher exogenous failure rates, I would expect them to have higher leverage ratios according to this logic.⁵

The core model corresponds to a two-country monetary economy under a flexible exchange rate regime. Given multiple currencies, it is necessary to convert all prices in to the same currency unit. I use the domestic currency, which introduces the nominal exchange rate, e , in the foreign representative household's optimization problem. The real value of any price is then expressed in the domestic composite good using the real exchange rate, \tilde{A} , for the foreign country real aggregates.

Both countries are similar in size and structure and are characterized by a continuum of agents of equal measure. Labor is immobile. Each country is specialized in the production of one good, but consumers in any country consume both goods. Consequently, there is trade across countries.

I assume incomplete markets: households have access to real and nominal bonds but do not have access to a complete set of contingent assets. There is imperfect competition on the good markets, allowing the introduction of nominal rigidities due to price contracts à la Calvo.

2.1 Households

The representative infinitely lived household in each country chooses consumption, C , and leisure, L , where $1 - L = H$ is equal to the working period remunerated at a rate of w , which is expressed in terms of the good produced locally. Consumption, C , is a composite of the two goods indexed by 1 for the good produced in the domestic country and 2 for the good produced in the foreign country.⁶

$$C = \frac{C_1^\gamma C_2^{1-\gamma}}{\gamma^\gamma (1-\gamma)^\gamma}. \quad (1)$$

Similarly the composite good for the foreign consumers is defined as:

$$C^* = \frac{C_1^{*1-\gamma} C_2^{*\gamma}}{\gamma^\gamma (1-\gamma)^\gamma}, \quad (2)$$

with $\gamma \in [0, 1]$. I define a price index for the domestic country as

$$P = P_1^\gamma P_2^{1-\gamma},$$

and for the foreign country as

$$P^* = P_1^{*1-\gamma} P_2^{*\gamma},$$

5. This suggests that it would be useful to consider the effect of allowing entrepreneurial failure rates to differ across countries and then study the dynamic implications of such an assumption. In a closed-economy setting, it is relatively straightforward to start from such deep parameters to determine steady-state leverage ratios and how economic responses might vary accordingly. In the two-country model, such an exercise is computationally intractable, however, because it produces differences in the steady-state capital-labor ratios across countries and leads to problems with numerical convergence. In addition, other model parameters contribute to higher leverage. Since my goal is to understand the effect of leverage on the economy, it is much more straightforward to manipulate the leverage ratio that enters the log-linearized model, rather than the deeper structural parameters that influence this ratio in a less direct manner

6. The foreign country variables are denoted by an asterisk.

with P_i (P_i^*) being the price of the good i expressed in the home (foreign) currency. I assume throughout the paper that the law of one price holds.

Households are assumed to have access to international markets through one-period noncontingent bonds. To price the real interest rate, R , and the nominal interest rate, R^n , in each country, I assume the existence of noncontingent real claims, B , and nominal claims, B^n , traded in local financial markets.

The instantaneous utility, U , depends on three arguments: consumption, real balances, and leisure. The utility function is assumed to be separable:

$$U\left(C_t, \frac{M_{t-1}}{P_t}, L_t\right) = \exp(\mathbf{u}_t) \log C_t + \mathbf{q}_M \log\left(\frac{M_{t-1}}{P_t}\right) + \mathbf{q}_H \frac{L^{1-s}}{1-s}, \text{ with } \mathbf{q}_M > 0, \mathbf{q}_H > 0,$$

where M_{t-1}/P_t is the present real value of the money stock transferred from the previous period and \mathbf{u}_t represents a preference shock that influences the marginal utility of consumption.

The representative household in the domestic country is assumed to maximize the expected discounted sum of its utility flows:

$$E_t\left(\sum_{i=0}^{\infty} \mathbf{b}^i U\left(C_t, \frac{M_{t-1}}{P_t}, 1-H_t\right)\right)$$

subject to the budget constraint, denominated in local currency as

$$C_t + B_t + \frac{B_t^n}{P_t} + \frac{M_t}{P_t} \leq R_{t-1} B_{t-1} + \frac{R_{t-1}^n}{P_t} B_{t-1}^n + \frac{M_{t-1}}{P_t} + W_t H_t + \frac{\tau_t}{P_t},$$

where τ is the total lump-sum transfers received by the domestic households from the monopolistic firms and from the central bank.

The first-order conditions for leisure, consumption, real bond, and nominal bond are⁷

$$\theta_H (1 - H_t) = \lambda_t W_t, \tag{3}$$

$$u'_C = \lambda_t, \tag{4}$$

$$\beta E_t \left(\frac{\lambda_{t+1} R_t}{\lambda_t} \right) = 1, \text{ and} \tag{5}$$

$$\beta E_t \left[\frac{\lambda_{t+1} R_t^n}{\lambda_t (1 + \pi_{t+1})} \right] = 1, \tag{6}$$

where π_t represents consumer price index (CPI) inflation.

7. In what follows, I specify a monetary policy rule in terms of the nominal interest rate. Given that real balances are separable in the utility function, I can effectively ignore the first-order condition with respect to real balances.

The representative household in the foreign country maximizes the expected discounted sum of its utility flows:

$$E_t \left[\sum_{i=0}^{\infty} \beta^i U \left(C_t^*, \frac{M_{t-1}^*}{P_t^*}, 1 - H_t^* \right) \right],$$

subject to the following budget constraint, written in terms of domestic consumption goods as the numeraire:

$$\begin{aligned} \Gamma_t C_t^* + \Gamma_t B_t^* + \frac{e_t}{P_t} B_t^{n*} + \frac{e_t}{P_t} M_t^* \\ \leq \Gamma_t R_{t-1}^* B_{t-1}^* + \frac{R_{t-1}^{n*} e_t}{P_t} B_{t-1}^{n*} + \frac{e_t}{P_t} M_{t-1}^* + \Gamma_t W_t^* H_t^* + \frac{e_t}{P_t} \tau^*, \end{aligned}$$

where e denotes the nominal exchange rate and Γ denotes the real exchange rate: $\Gamma = eP^*/P$.

The analogous foreign household first-order conditions are:

$$\theta_H (1 - H_t^*) = \lambda_t^* W_t^* \Gamma_t, \quad (7)$$

$$u'_{C_t^*} = \lambda_t^* \Gamma_t, \quad (8)$$

$$BE_t \left(R_t^* \frac{\Gamma_{t+1} \lambda_{t+1}^*}{\Gamma_t \lambda_t^*} \right) = 1, \quad \text{and} \quad (9)$$

$$BE_t \left[R_t^{n*} \frac{\Gamma_{t+1} \lambda_{t+1}^*}{\Gamma_t \lambda_t^* (1 + \pi_{t+1}^*)} \right] = 1. \quad (10)$$

From equations 5, 6, 9 and 10, I obtain the Fisher formulas:

$$E_t \left[\left(\frac{\lambda_{t+1}}{\lambda_t} \right) \left(\frac{R_t^n}{1 + \pi_{t+1}} - R_t \right) \right] = 0 \quad \text{and} \quad (11)$$

$$E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \left(\frac{R_t^{n*}}{1 + \pi_{t+1}^*} - R_t^* \right) \right] = 0. \quad (12)$$

I also have the arbitrage condition,

$$E_t \left(\beta \frac{\lambda_{t+1}}{\lambda_t} \right) = E_t \left(\beta \frac{\lambda_{t+1}^*}{\lambda_t^*} \right), \quad (13)$$

which implies uncovered interest rate parity.

Production

The producers in both countries produce imperfectly substitutable goods with capital and labor. Each country specializes in the production of a single good. The production sector in each country is divided into a monopolistically competitive retail sector and a competitive wholesale sector. Wholesale firms are run by entrepreneurs who purchase capital and hire labor from households to produce a wholesale good that is sold to retail firms. Retail firms differentiate the wholesale goods at no resource cost and sell them to households. Given that the retailers are price setters, this structure allows the introduction of nominal rigidities while maintaining a constant-returns-to-scale assumption in the wholesale sector, which is necessary for aggregation when financial market imperfections are introduced.

The retail goods form the national composite aggregate that is converted into consumption and investment goods. The retail firm's price index defines the aggregate price level, P_1 and P_2^* . Profits from retail activity are rebated in lump sum to households. I model nominal rigidities by means of the Calvo pricing assumption: a given retailer is free to change his price in a given period only with probability $1 - \zeta$. The retailer pricing decision implies the new Keynesian Phillips curve:

$$p_{1,t} = \kappa m_t + \beta E_t(p_{1,t+1}),$$

where

$$\pi_{1,t} = \log\left(\frac{P_{1,t}}{P_{1,t-1}}\right) \text{ and}$$

$$P_{1,t} = \mu_t P_{1,t}^w,$$

with μ denoting the mark-up and $P_{1,t}^w$ the price of the wholesale good produced in the domestic country. As usual in Calvo-style price contracts,

$$\kappa = \frac{(1-\zeta)(1-\zeta\beta)}{\zeta}.$$

The foreign condition is analogous:

$$\pi_{2,t} = -\kappa \mu_t^* + \beta E_t(\pi_{2,t+1}),$$

where

$$\pi_{2,t} = \log\left(\frac{P_{2,t}}{P_{2,t-1}}\right) \text{ and}$$

$$P_{2,t} = \mu_t^* P_{2,t}^w,$$

with $P_{2,t}^w$ representing the price of the wholesale good produced in the foreign country.

With regard to wholesale firms, the wholesale goods are produced by entrepreneurs who combine physical capital and labor with a constant-return-to-scale technology:

$$Y_t = A_t K_t^\alpha H_t^{1-\alpha}. \quad (14)$$

Variable profits for good 1 are

$$v_1(K_t, a_t) = \max_{H_t} \frac{P_{1,t}^w}{P_t} Y_{1,t} - w_t H_t.$$

I assume that K_t is chosen one period in advance, while H_t is chosen in period t . Labor demand is thus determined by

$$m_t W_t = (1-a) Z_t^{1-g} \frac{Y_t}{H_t}, \quad (15)$$

with $Z = P_1/P_2$ being the terms of trade. Given labor demand, the representative wholesale firm purchases K_{t+1} units of capital at price Q_t , to maximize its expected sum of profit flows:

$$E_t V_1(K_{t+1}, A_{t+1}) = E_t [v_1(K_{t+1}, A_{t+1}) + Q_{t+1}(1-d)K_{t+1} - Q_t K_{t+1}].$$

Given constant returns to scale and Cobb-Douglas production, the ex post return on capital associated with these profit flows is

$$R_t^K = \frac{\left[\frac{a Z_t^{1-g}}{m_t} \frac{Y_t}{K_{t-1}} + (1-d) Q_t \right]}{Q_{t-1}}. \quad (16)$$

In the absence of capital market imperfections, the return on capital is equated to the risk-free return and hence satisfies the household Euler equation:

$$1 = \beta E_t \left(\frac{\lambda_{t+1}}{\lambda_t} R_{t+1}^K \right). \quad (17)$$

Wholesale firms in the foreign country solve a similar problem, resulting in analogous conditions:

$$m_t^* W_t^* = (1-a) Z_t^{g-1} \frac{Y_t^*}{H_t^*} \quad \text{and}$$

$$R_t^{K*} = \frac{\left[\frac{a Z_t^{g-1}}{m_t^*} \frac{Y_t^*}{K_{t-1}^*} \Gamma_t + (1-d) Q_t^* \Gamma_t \right]}{Q_{t-1}^* \Gamma_{t-1}}, \quad (18)$$

where arbitrage again implies

$$1 = \beta E_t \left(\frac{\lambda_{t+1}}{\lambda_t} R_{t+1}^{K*} \right), \quad (19)$$

with R_t^{K*} the return of foreign physical capital expressed in the domestic composite good.

In the absence of capital market imperfections, equations 17 and 19, combined with the household first-order conditions, imply that the expected return on capital is equalized across countries and is equal to the risk-free interest rate.

Capital producers

I assume that investment in each country is an index of the two goods, 1 and 2, with the same structure as the consumption composite (equations 1 and 2). To allow for adjustment costs, capital evolves according to the following dynamic equation:

$$K_{t+1} = (1-d)K_t + \Phi \left(\frac{I_t}{K_t} \right) K_t.$$

The term $\Phi (I_t/K_t) K_t$ represents the production function for capital goods—the technology to convert I_t units of foregone consumption into capital. Consistent with an adjustment costs interpretation of $\Phi (I_t/K_t)$, I assume

$$\Phi' \left(\frac{I_t}{K_t} \right) > 0, \Phi'' \left(\frac{I_t}{K_t} \right) < 0.$$

To keep the analysis simple, I assume a competitive sector of capital producers that take K_t as given (that is, it is external to the firm), and I choose the input, I_t , to equate marginal revenue and marginal cost:

$$Q_t = \frac{1}{\Phi' \left(\frac{I_t}{K_t} \right)}.$$

Assuming an identical structure in the foreign country, I obtain analogous conditions characterizing foreign capital accumulation and foreign asset prices:

$$K_{t+1}^* = (1-d)K_t^* + \Phi \left(\frac{I_t^*}{K_t^*} \right) K_t^*,$$

with

$$Q_t^* = \frac{1}{\Phi\left(\frac{I_t^*}{K_t^*}\right)}.$$

In addition to influencing model dynamics in the absence of financial frictions, adjustment costs to capital cause fluctuations in asset prices—Tobin's Q will deviate from unity in the short run—which lead to fluctuations in net worth.

2.2 Monetary Policy Rules

To close the model, I assume that each country sets the nominal interest rate to target current inflation:

$$R_t^n = \rho_R R_{t-1}^n + \rho_\pi \pi_t \quad \text{and}$$

$$R_t^{n*} = \rho_R R_{t-1}^{n*} + \rho_\pi \pi_t^*.$$

The rule specified above may be viewed as a flexible inflation targeting rule. Since this paper focuses on the role of financial heterogeneity that likely characterizes developed versus developing economies, I make the simplifying assumption that both countries follow the same policy rule.

2.3 Embodied Technological Change

The model can be modified to incorporate embodied technological change by letting θ_t serve as the technology index. In this framework, it is necessary to distinguish between physical capital and effective capital units. I redefine the production function as

$$Y_t = A_t H_t^a (K_t^q)^{1-a},$$

where K_t^q denotes effective capital units that evolve according to

$$K_t^q = (1-d)K_t^q + q_t^{1/(1-a)} \Phi\left(\frac{I_t}{K_t}\right) K_t.$$

In the above expression, the term I_t/K_t is a ratio that is expressed in comparable units and is therefore stationary over time. A rise in θ_t thus acts like a technology shifter for the capital-goods-producing sector, lowering the effective cost of new capital goods. The production structure for the foreign sector is adjusted in an analogous manner.

2.4 The Log-Linearized Model and Calibration

In the absence of capital market imperfections, the resulting system of equations that describes equilibrium can be specified in log-linearized form. These equations are provided in the appendix. To calibrate the model, I set $\beta = 0.99$, and $\delta = 0.025$. I set the capital share $(1 - \alpha) = 0.5$, which is somewhat high by developed country standards but reasonable for developing countries. I set the degree of openness $\gamma = 0.65$, which implies 35 percent

imports in steady state. The elasticity of labor, denoted as η in the appendix, is set equal to 3, while the markup is set equal to 10 percent. The probability of changing prices is assumed to be 0.5. I set the steady-state elasticity of capital production, $\phi = \Phi''(\delta)/\Phi'(\delta) = 2$, allowing for a moderate degree of adjustment costs, and further assume that $\Phi(\delta) = \Phi'(\delta) = 1$, so that $Q_t = 1$ in steady state. The monetary policy rule sets $\rho_1 = 0.9$, and $\gamma_\pi = 0.2$, a moderate degree of inflation targeting.

2.5 Financial Market Imperfections

A convenient way to formalize financial frictions is by introducing a financial accelerator, as in Bernanke, Gertler, and Gilchrist (1999). The key mechanism involves a negative link between the external finance premium, s (the difference between the cost of funds raised externally and the opportunity cost of funds internal to the firm), and the net worth of borrowers, N (defined as the liquid assets plus collateral value of illiquid assets less outstanding obligations).

The inverse relationship between external finance premiums and the strength of the balance sheet arises because when borrowers have little wealth to contribute to project financing, the potential divergence of interests between the borrowers and the lenders is greater, implying increased agency costs. In equilibrium, lenders must be compensated for higher agency costs by a large premium. Because borrower net worth is procyclical through the behavior of profits and asset prices, the financial accelerator enhances swings in borrowing and thus in investment, spending, and production.

In the presence of the financial accelerator, equations 17 and 19 are modified to allow for a premium on external finance, s , that is due to the existence of monitoring costs:

$$E_t \left[\mathbf{b} \frac{I_{t+1}}{I_t} (R_{t+1}^k - s_t R_t) \right] = 0 \quad \text{and} \quad (20)$$

$$E_t \left[\mathbf{b} \frac{I_{t+1}}{I_t} \frac{\Gamma_{t+1}^*}{\Gamma_t^*} (R_{t+1}^{*k} - s_t^* R_t^*) \right] = 0. \quad (21)$$

The external finance premium is negatively related to the share of the capital investment that is financed by entrepreneurs' own net worth:

$$s_t = S \left(\frac{Q_t K_t}{N_t} \right) \quad \text{and} \quad (22)$$

$$s_t^* = S \left(\frac{Q_t^* K_t^*}{N_t^*} \right). \quad (23)$$

It can be shown that the function, S , is strictly increasing and convex over the relevant range (see Bernanke, Gertler, and Gilchrist, 1999).⁸

The evolution of entrepreneurial net worth, N_t , reflects the equity stake that entrepreneurs have in their firms. In particular, entrepreneurs borrow

8. See Bernanke, Gertler, and Gilchrist (1999) for a precise presentation of the properties of this stochastic variable and for the derivation of the optimal financial contract.

$Q_{t-1}K_{t-1} - N_{t-1}$ at an expected interest rate of $E_{t-1}\{R_t^K\} = s_t R_t$ and receive the ex post return, R_t^K . Net worth evolves according to

$$N_t = R_t^K Q_{t-1} K_{t-1} - E_{t-1} R_t^K (Q_{t-1} K_{t-1} - N_{t-1}). \quad (24)$$

An analogous condition is obtained for the foreign country:

$$N_t^* = R_t^{*K} Q_{t-1}^* K_{t-1}^* - E_{t-1} R_t^{*K} (Q_{t-1}^* K_{t-1}^* - N_{t-1}^*). \quad (25)$$

Log-linearizing these expressions results in two additional equations per country to be added to the dynamic system. For the domestic economy, letting lower case values denote log-deviations, these equations are

$$s_t = \mathbf{c}(q_t + k_t - n_t) \quad \text{and} \quad (26)$$

$$n_t = \left(\frac{1}{n_k}\right) r_t^k - \left(\frac{1-n_k}{n_k}\right) (s_{t-1} + r_{t-1}) + n_{t-1}, \quad (27)$$

where

$$s_t = E_t(r_{t+1}^k) - r_t. \quad (28)$$

For the foreign economy, the equivalent expressions are

$$s_t^* = \mathbf{c}^*(q_t^* + k_t^* - n_t^*) \quad \text{and} \quad (29)$$

$$n_t^* = \left(\frac{1}{n_k^*}\right) r_t^{*k} - \left(\frac{1-n_k^*}{n_k^*}\right) (s_{t-1}^* + r_{t-1}^* + \Delta \mathbf{g}_t) + n_{t-1}^*, \quad (30)$$

where

$$s_t = E_t(r_{t+1}^k) - r_t.$$

and $\gamma_t = \log(\Gamma_t)$ is the log-real exchange rate.

I then rewrite the net worth expression for the domestic economy:

$$n_t = \left(\frac{1}{n_k}\right) \left[r_t^k - E_{t-1}(r_t^k) \right] + (s_{t-1} + r_{t-1} + n_{t-1}). \quad (31)$$

The second term in this expression is the expected return on net worth held by entrepreneurs last period. The first term is the surprise in net worth owing to fluctuations in the ex post return on capital. Such surprises are primarily determined by fluctuation in asset values rather than by fluctuations in the marginal revenue product of capital. The surprise in asset values has an effect on net worth that is inversely proportional to the degree of self financing, $(1/n_k) = K/N$. Leverage, $(K - N)/N = (1/n_k - 1)$, thus plays a key role in propagating shocks to this economy.

To calibrate the model, I assume that credit frictions have no impact on steady-state behavior. This can be justified by the assumption that

governments provide fiscal subsidies to capital as a factor of production to eliminate the average distortion created by credit frictions. To determine dynamics, I then need to choose two parameters: χ , the elasticity of the premium on external funds with respect to leverage ($q_t + k_t + n_t$); and $n_k = N/K$, the degree of self-financing, or equivalently $(K - N)/N$, the leverage ratio, defined as the steady-state debt-equity ratio.

To determine the steady-state value of v , I rely on the calibration used in Bernanke, Gertler, and Gilchrist (1999), which suggests numbers on the order of 0.05 to 0.066 based on realistic values for monitoring costs and bankruptcy rates. I accordingly set $v = v^* = 0.065$, implying that a 1 percent reduction in net worth relative to capital expenditures leads to a 6.5 basis point increase in the premium for external funds. Raising v increases the amplification obtained from the financial accelerator. By choosing 0.065, the model delivers an external premium response to net worth that is slightly high for developed economies but very reasonable for a developing economy. To avoid numerical difficulties in the simulation, I constrain the elasticities to be equal across countries.⁹

With regard to choosing n_k , note that debt-equity ratios for the U.S. economy are on the order of 0.8. For high-leverage economies such as Korea, the debt-equity ratio is on the order of 60-70 percent higher than U.S. ratios. I therefore set $n_k = 0.7$ and $n_k^* = 0.4$ as reasonable values for the low-leverage and high-leverage economies, respectively¹⁰.

3. THE ROLE OF THE FINANCIAL ACCELERATOR IN THE INTERNATIONAL PROPAGATION OF SHOCKS

I start by considering the effect of a reduction in the level of disembodied technology relative to trend (a decrease in A_t) in the domestic country. I then trace out the effect of this contraction on the world economy. Figures 2 through 5 plot the impulse response functions of variables of interest to this shock. In each plot, the solid line represents the model response in the presence of the financial accelerator, while the dashed line represents the response without the financial accelerator.

[figures 2, 3, 4, and 5 about here]

An α percent reduction in A_t represents a negative supply shock to the domestic economy and a negative demand shock to the foreign economy. In the absence of a financial accelerator mechanism, domestic output falls by less than the size of the shock, as labor rises slightly in response to the negative wealth effect. The contraction in output causes a reduction in domestic consumption and investment, a fall in the real interest rate, and a rise in inflation.

In the model without the financial accelerator, the contraction in the domestic economy causes a depreciation in the domestic terms of trade, an appreciation of the foreign currency, a slight reduction in foreign output and labor, and a drop in foreign consumption. The cross-country transmission mechanism through standard expenditure-switching channels is modest, however.

9. In the two-country model, I am unable to obtain convergence if the degree of heterogeneity in financial markets is severe. Because I am more interested in the effect of leverage on the economy, I constrain the elasticities to be equal and allow leverage to vary. Model simulations that constrain leverage and allow the elasticity to vary also produce qualitatively interesting asymmetries across the two countries, but they are less interesting from a quantitative perspective.

10. Again, numerical issues limit my ability to allow financial conditions to diverge too much across countries and still obtain a stable numerical solution to the two-country model. These numbers are reasonably consistent with the debt-capital differentials between European and Asian countries reported above.

In the model with the financial accelerator, the cross-country transmission mechanism is greatly enhanced. The reduction in foreign output and labor is double the response of that obtained in the model without the financial accelerator. The source of this transmission mechanism is the 10 basis point rise in the premium on external funds. As world output falls, domestic and foreign asset values contract, and net worth falls relative to investment spending. The premium on external funds increases as a result, causing an even greater contraction in investment and output.

The primary effect of the financial accelerator is to transmit the shock from the domestic country to the foreign country. This transmission reflects the fact that the foreign country has higher leverage and therefore a stronger financial accelerator mechanism. The high leverage of the foreign country implies that a shock to domestic supply is transmitted partially as a reduction in foreign aggregate demand and partially through a change in the effective price of consumption relative to investment. The relative price effect occurs because a rise in the foreign external finance premium increases the cost associated with foreign investment goods relative to foreign consumption goods. The contraction in foreign investment is twice as large as the contraction in domestic investment, despite the fact that the domestic economy received the negative supply shock. Owing to the strength of the cross-country transmission, the reduction in domestic output is actually less with the financial accelerator than without it. Overall, these findings imply that the financial accelerator provides a strong cross-country transmission mechanism and that leverage is a key determinant of the overall strength of the transmission mechanism.

The role of leverage in the transmission channel is explored through symmetric shocks to the world economy. In the exercises that follow, the response of the domestic and foreign economies differs only because the foreign economy has higher leverage and therefore a stronger financial accelerator. This exercise incorporates three separate shocks: a shock to disembodied technology, a shock to preferences, and a shock to embodied technology. The first shock is a positive supply shock of the type usually associated with a worldwide boom in productivity. The second shock represents a demand shock that raises desired consumption spending. The third shock is also a supply shock, but this time it occurs through a reduction in the effective price of capital goods in the world economy. Such a shock is arguably more closely related to the positive supply shocks that have produced recent gains in productivity in the U.S. economy.

Figure 6 plots the effect of the symmetric shock to disembodied technology. In the absence of a financial accelerator mechanism, this shock has the familiar dynamics of a disembodied technology shock in a closed-economy framework. The boom in technology causes an immediate increase in output and hours, an increase in consumption, and a rise in investment as the world economy seeks to smooth the benefits of the shock through increased capital accumulation.

[figure 6 about here]

The increase in disembodied technology is magnified by the financial accelerator. The magnification effect is stronger for the foreign economy. The differential response between the domestic and foreign economies is solely due to the different degrees of leverage in both economies. The high-leverage foreign economy experiences a large increase in output (30 percent greater) and an even larger increase in investment (150 percent greater) relative to the model without the financial accelerator mechanism. Interestingly, the financial accelerator has only a modest impact on output and investment in the low-leverage economy. These results again confirm the key role that leverage plays in the transmission of supply shocks.

Figure 7 plots the response of investment and output for the domestic and foreign economies to a shock to preferences (u_t). Again, I assume that the shock is autocorrelated with a rho of 0.95. In the absence of the financial accelerator, this shock raises consumption demand relative to investment demand, causing an expansion of output but a contraction in investment. In the presence of the financial accelerator, the positive demand shock reduces the premium on external funds, causing a boom in investment in the high-leverage foreign economy. The falling premiums imply that world output is substantially higher in the model with the financial accelerator than in the model without. There is very little difference in the level of output between the high- and low-leverage economies, however. Again, this finding can be associated with a relative price effect. The large reduction in the foreign premium on external funds leads to a switch away from investment goods and toward consumption goods in the low-leverage economy. The opposite occurs in the high-leverage economy. As a result, domestic households benefit more than foreign households in response to a worldwide increase in demand.

[figure 7 about here]

The final exercise considers an increase in technology embodied in capital goods. These results are presented in figure 8. Again, the shock is symmetric, but the responses across the two countries differ owing to the degree of leverage and hence the severity of financial constraints. In the absence of financial market imperfections, an increase in embodied technology is equivalent to a reduction in the price of new investment goods. Because the shock is persistent, the positive wealth effect limits the expansion of output, hours, and investment spending in the short run. Over time, output rises as the existing capital stock reflects the newer, more productive technologies. Investment tracks output along the path, keeping the investment output ratio relatively constant.

[figure 8 about here]

In the presence of the financial accelerator, the reduction in new capital goods prices has very little effect on the premium for external funds. Again, there are offsetting effects. The positive shock to technology raises demand for new investment goods, but it has very little effect on net worth. The intuition here is straightforward. An increase in investment demand raises the value of capital in place and hence of net worth. A reduction in the price of new investment goods reduces the value of existing assets relative to new investment, however, causing a deterioration in net worth. These two effects largely cancel each other. In effect, the advent of the new technology reduces the value of capital in place and dampens the financial accelerator. The financial accelerator thus does not substantially alter the dynamic response of either the domestic or foreign economy.

4. CONCLUSION

This paper develops a fully articulated model of a world economy with two countries and a financial accelerator mechanism. The financial accelerator provides a strong cross-country propagation mechanism: a slowdown in output relative to trend in the financially developed economy causes a contraction in asset values, rising external finance premiums, and a slowdown in economic activity in the developing economy.

The severity of the slowdown is directly tied to health of the developing economy's balance sheet, as measured by the degree of leverage in the economy. The results in this paper suggest that reasonable differences in leverage across countries provide quantitatively significant variations in response to worldwide shocks to demand and supply. The strength of the financial accelerator depends on both the degree of leverage and the source

of the shock. In particular, supply shocks that are specific to the capital sector, owing to embodied technological change, are less destabilizing than supply shocks that affect the entire production structure.

APPENDIX

The Log-Linearized Model

Log-linearizing the model results in the following system of equations.

A.1 Resource constraints

$$y_t = a_t + \mathbf{a}h_t + (1 - \mathbf{a})k_t^q$$

$$k_t = (1 - \mathbf{d})k_t + \mathbf{d}i_t$$

$$k_t^q = (1 - \mathbf{d})k_t^q + \frac{\mathbf{d}}{1 - \mathbf{a}}q_t + \mathbf{d}i_t$$

$$y_t^* = a_t^* + \mathbf{a}h_t^* + (1 - \mathbf{a})k_t^{q*}$$

$$k_t^{q*} = (1 - \mathbf{d})k_t^{q*} + \frac{\mathbf{d}}{1 - \mathbf{a}}q_t^* + \mathbf{d}i_t^*$$

$$k_t^* = (1 - \mathbf{d})k_t^* + \mathbf{d}i_t^*$$

A.2 Household first-order conditions

$$\lambda_t = -c_t + v_t$$

$$h_t = \mathbf{h}(w_t + I_t)$$

$$\lambda_t - E_t \lambda_{t+1} = r_t$$

$$\lambda_t^* = -c_t^* - \gamma_t + v_t^*$$

$$h_t^* = \mathbf{h}(w_t^* + I_t^*)$$

$$I_t^* - E_t I_{t+1}^* = r_t^* + E_t (\Delta \mathbf{g}_{t+1})$$

A.3 Foreign versus domestic demand

$$c_t = \mathbf{g}c_{1,t} + (1 - \mathbf{g})c_{2,t}$$

$$i_t = \mathbf{g}i_{1,t} + (1 - \mathbf{g})i_{2,t}$$

$$i_{1,t} = i_{2,t} - z_t$$

$$c_{1,t} = c_{2,t} - z_t$$

$$y_t = \mathbf{g} \left(\frac{c}{y} \right) c_{1,t} + (1 - \mathbf{g}) \left(\frac{c}{y} \right) c_{1,t}^* + \mathbf{g} \left(\frac{i}{y} \right) i_{1,t} + (1 - \mathbf{g}) \left(\frac{i}{y} \right) i_{1,t}^*$$

$$c_t^* = \mathbf{g}c_{1,t}^* + (1-\mathbf{g})c_{2,t}^*$$

$$i_t^* = \mathbf{g}i_{1,t}^* + (1-\mathbf{g})i_{2,t}^*$$

$$i_{1,t}^* = i_{2,t}^* - z_t$$

$$c_{1,t}^* = c_{2,t}^* - z_t$$

$$y_t^* = \mathbf{g}\left(\frac{c}{y}\right)c_{2,t}^* + (1-\mathbf{g})\left(\frac{c}{y}\right)c_{2,t}^* + \mathbf{g}\left(\frac{i}{y}\right)i_{2,t}^* + (1-\mathbf{g})\left(\frac{i}{y}\right)i_{2,t}^*$$

A.4 Factor demand

$$u_t + w_t = (1-\mathbf{g})z_t + y_t - h_t$$

$$r_t^k = \left(\frac{r+\mathbf{d}}{1+sr}\right)[(1-\mathbf{g})z_t + y_t - k_t] + \left(\frac{1-\mathbf{d}}{1+r}\right)q_t - q_{t-1}$$

$$i_t - k_t = \frac{1}{\phi}q_t$$

$$u_t^* + w_t^* = (\mathbf{g}-1)z_t + y_t^* - h_t^*$$

$$r_t^{*k} = \left(\frac{r+\mathbf{d}}{1+sr}\right)[(\mathbf{g}-1)z_t + y_t^* - k_t^*] + \left(\frac{1-\mathbf{d}}{1+r}\right)q_t^* - q_{t-1}^* + \left(\frac{r}{1+r}\right)\mathbf{g}_t$$

$$i_t^* - k_t^* = \frac{1}{\phi}q_t^*$$

A.5 Inflation Dynamics

$$\mathbf{p}_{1,t} = -\mathbf{k}u_t + \mathbf{b}E_t(\mathbf{p}_{1,t+1})$$

$$\mathbf{p}_t = \mathbf{p}_{1,t} - (1-\mathbf{g})\Delta z_t$$

$$\mathbf{p}_{2,t} = -\mathbf{k}u_t^* + \mathbf{b}E_t(\mathbf{p}_{2,t+1})$$

$$\mathbf{p}_t^* = \mathbf{p}_{2,t} + (1-\mathbf{g})\Delta z_t$$

A.6 Credit Markets

$$q_t + k_t - n_t = \chi s_t$$

$$n_t = \left(\frac{1}{n_k} \right) r_t^k - \left(\frac{1-n_k}{n_k} \right) (s_{t-1} + r_{t-1}) + n_{t-1}$$

$$q_t^* + k_t^* - n_t^* = \chi s_t^*$$

$$n_t^* = \left(\frac{1}{n_k^*} \right) r_t^{*k} - \left(\frac{1-n_k^*}{n_k^*} \right) (s_{t-1}^* + r_{t-1}^* + \Delta \mathbf{g}_t^*) + n_{t-1}^*$$

A.7 Financial arbitrage

$$r_t^n = r_t + E_t(\mathbf{p}_{t+1})$$

$$r_t^{*n} = r_t^* + E_t(\mathbf{p}_{t+1}^*)$$

$$E_t(r_{t+1}^k) = s_t + r_t$$

$$E_t(r_{t+1}^{*k}) = s_t^* + r_t^*$$

$$r_t - r_t^* = E_t(\Delta \mathbf{g}_{t+1})$$

A.8 Terms of trade

$$\mathbf{g}_t = (1 - 2\mathbf{g})z_t$$

A.9 Monetary policy

$$r_t^n = \rho_r r_{t-1}^n + \gamma_\pi \pi_t$$

$$r_t^{*n} = \rho_r r_{t-1}^{*n} + \gamma_\pi \pi_t^*$$

A.10 Shocks

$$a_t = \rho_a a_{t-1} + \varepsilon_t^a$$

$$v_t = \rho_v v_{t-1} + \varepsilon_t^v$$

$$\theta_t = \rho_\theta \theta_{t-1} + \varepsilon_t^\theta$$

$$a_t^* = \rho_a a_{t-1}^* + \varepsilon_t^{*a}$$

$$v_t^* = \rho_v v_{t-1}^* + \varepsilon_t^{*v}$$

$$\theta_t^* = \rho_\theta \theta_{t-1}^* + \varepsilon_t^{\theta}$$

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Figure 1. Leverage Ratio: Europe vs Asia

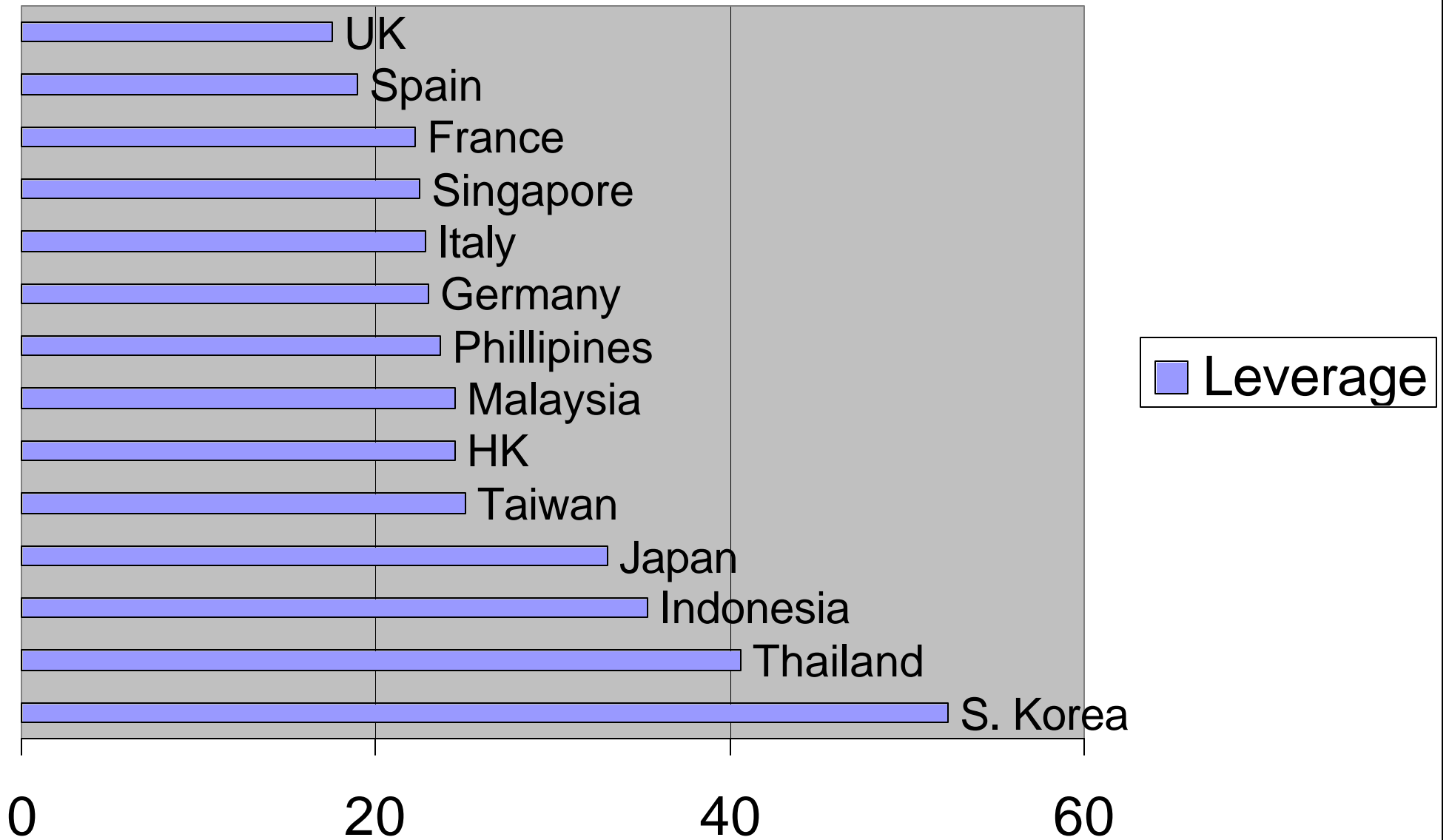


Figure 2. Effect of an Asymmetric Shock to Disembodied Technology on Output and Labor

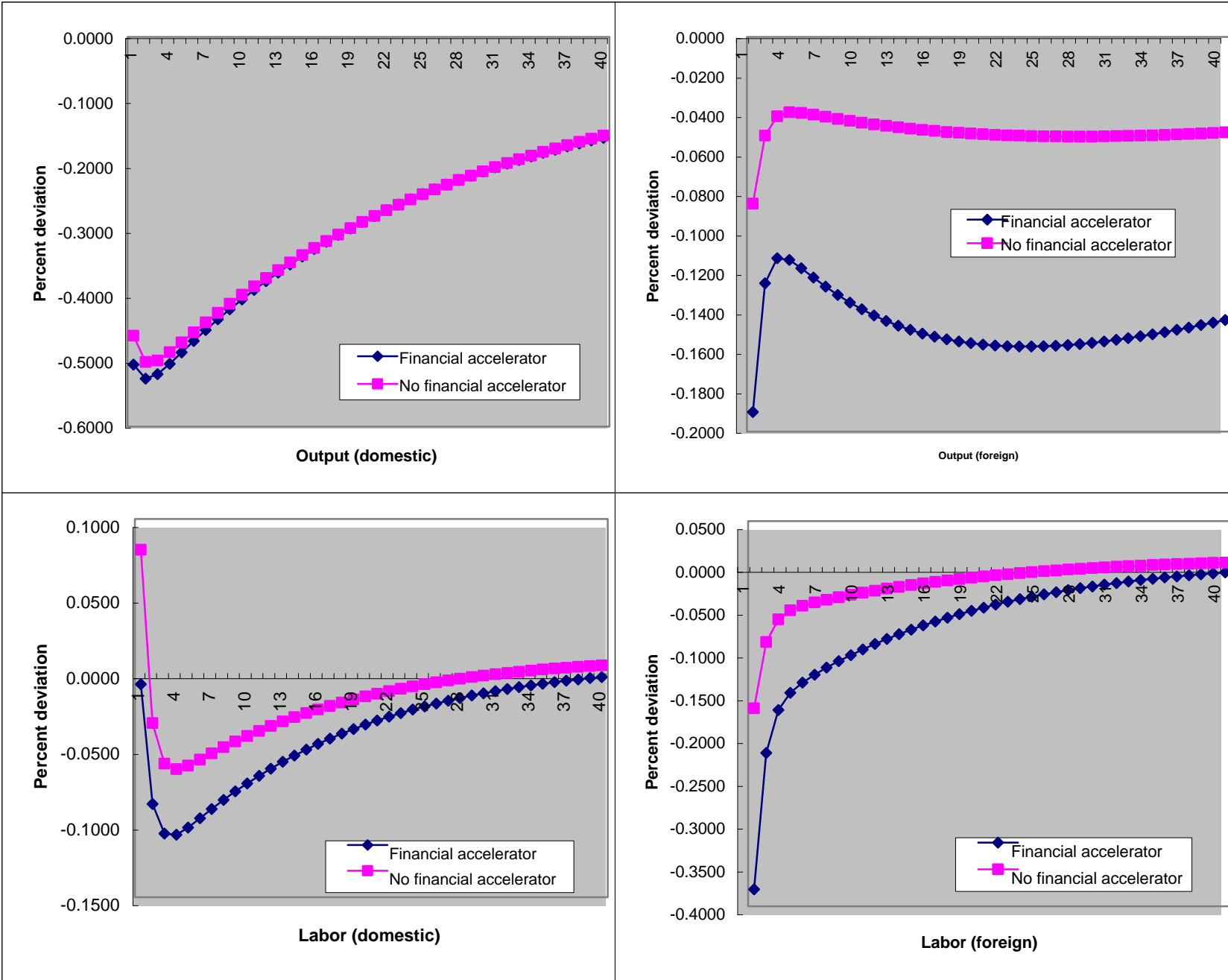


Figure 3. Effect of an Asymmetric Shock to Disembodied Technology on Consumption and Investment

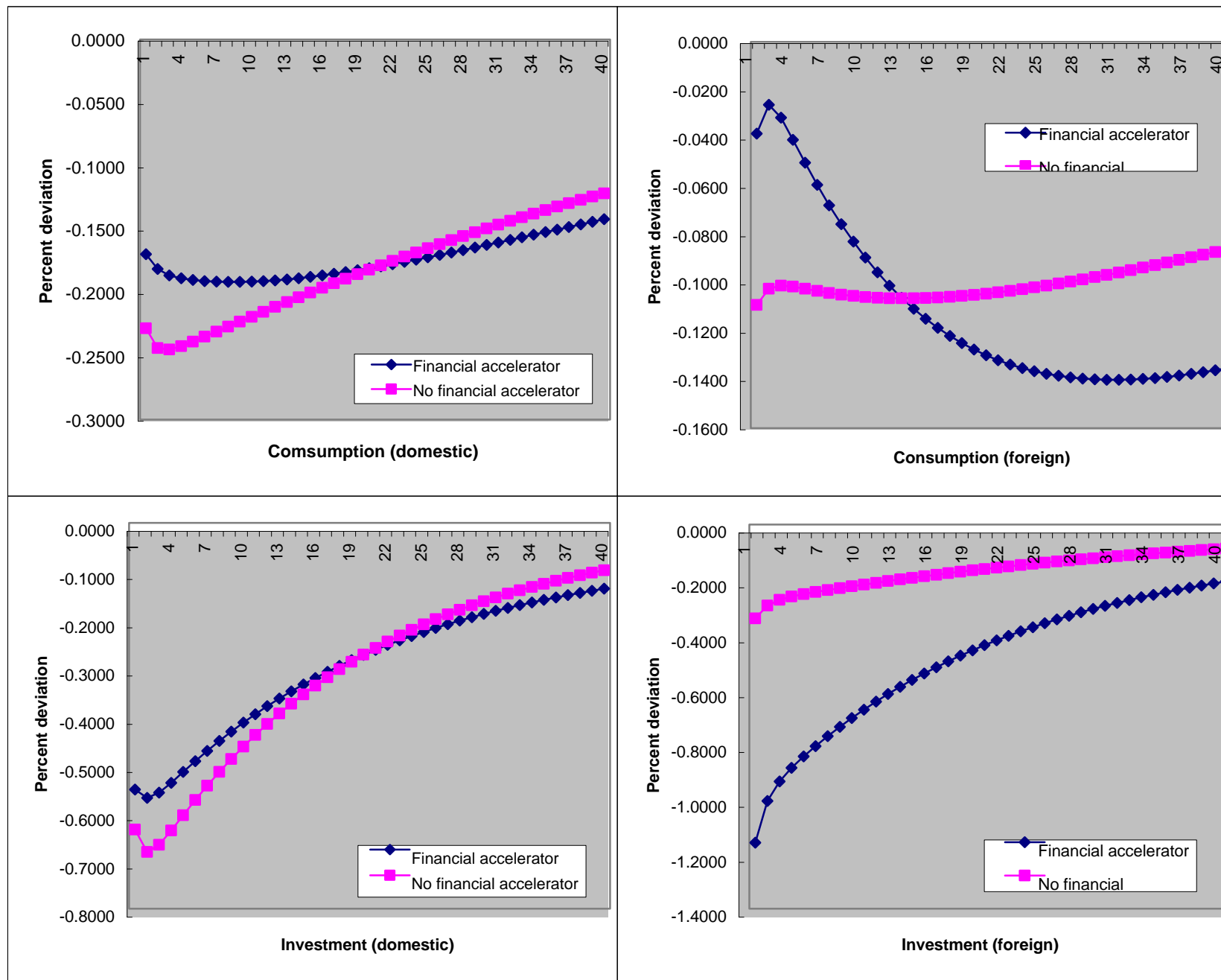


Figure 4. Effect of an Asymmetric Shock to Disembodied Technology on the Real Interest Rate and the Finance Premium

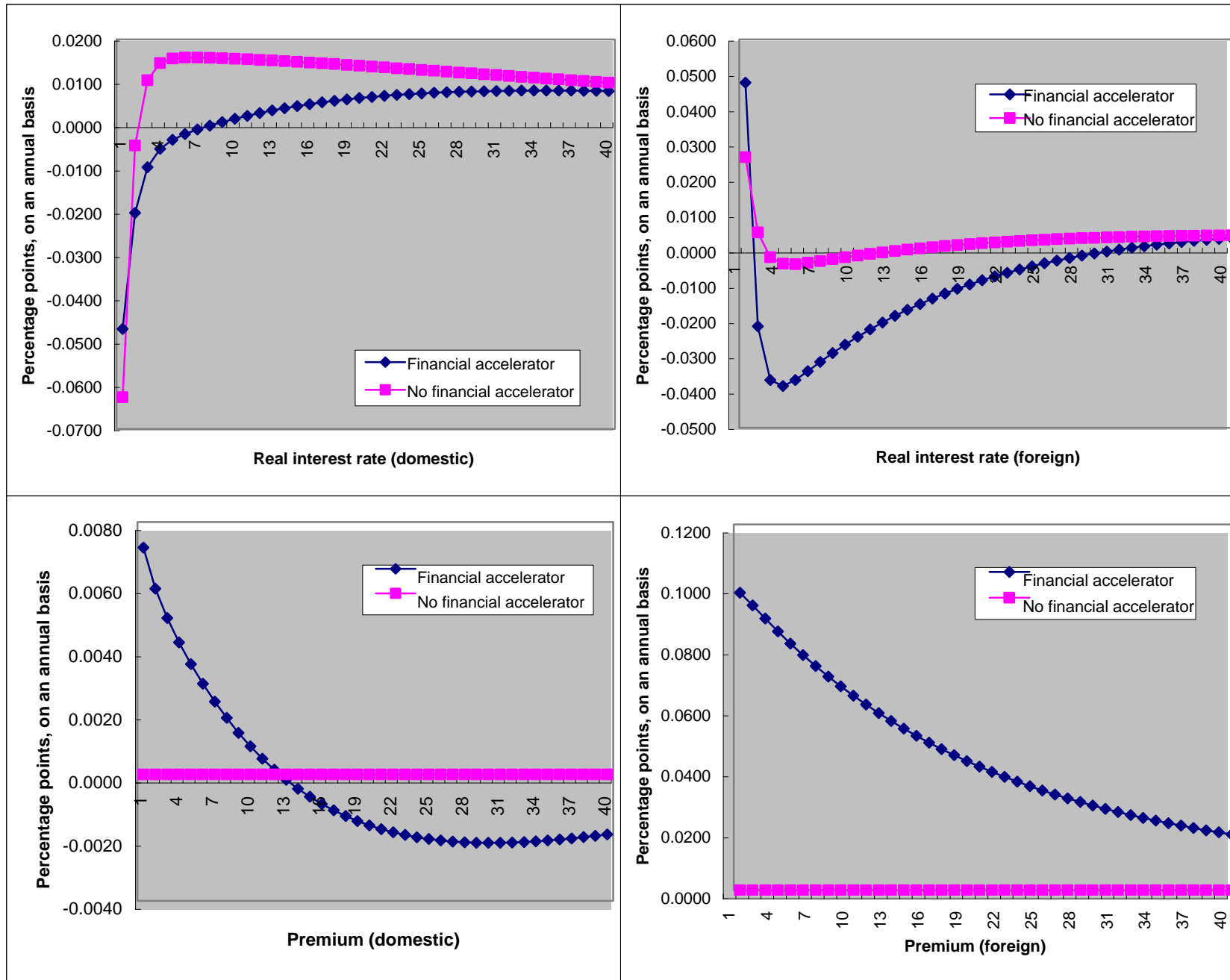


Figure 5. Effect of an Asymmetric Shock to Disembodied Technology on Inflation and the Terms of Trade

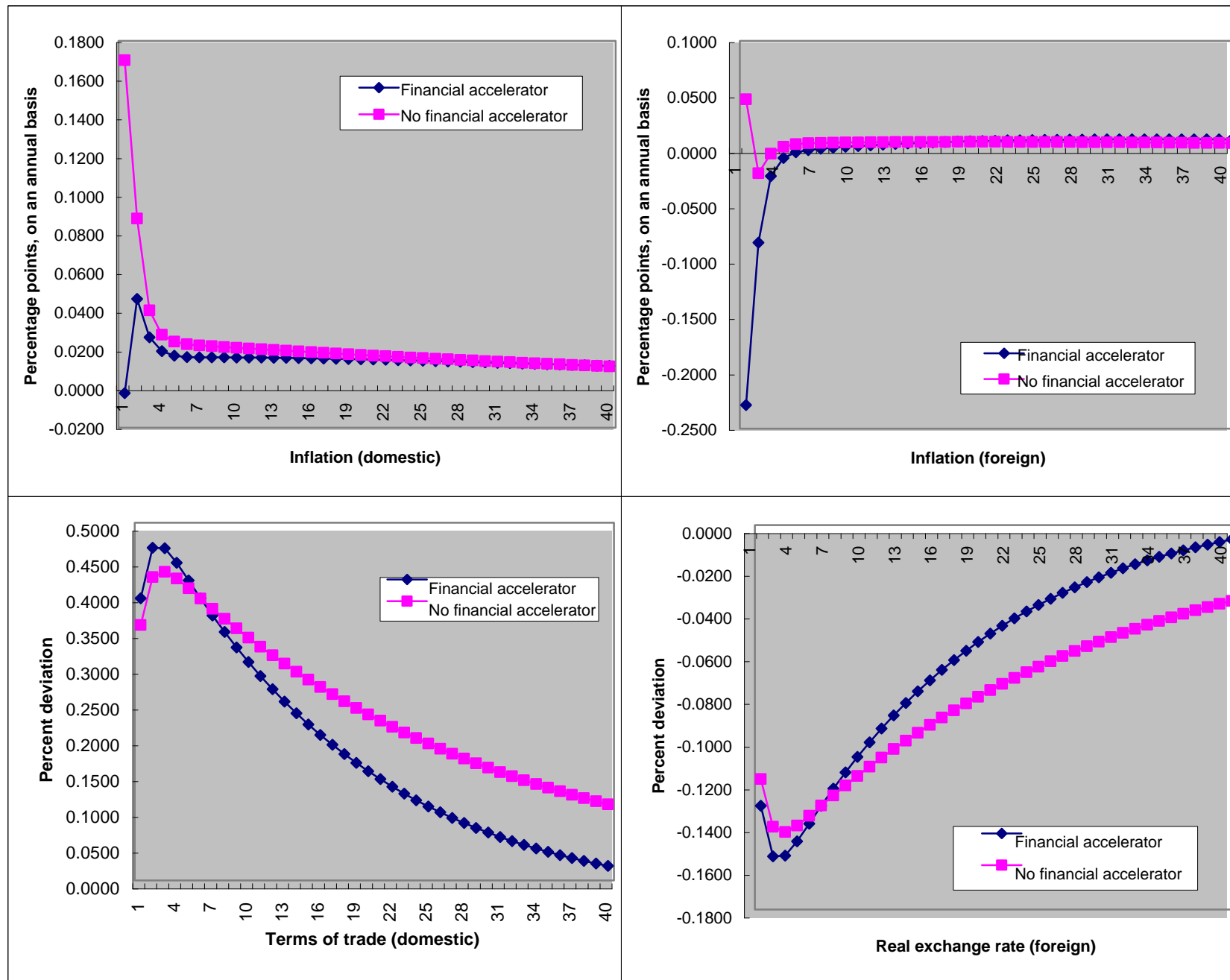


Figure 6. Effect of a Symmetric Shock to Disembodied Technology

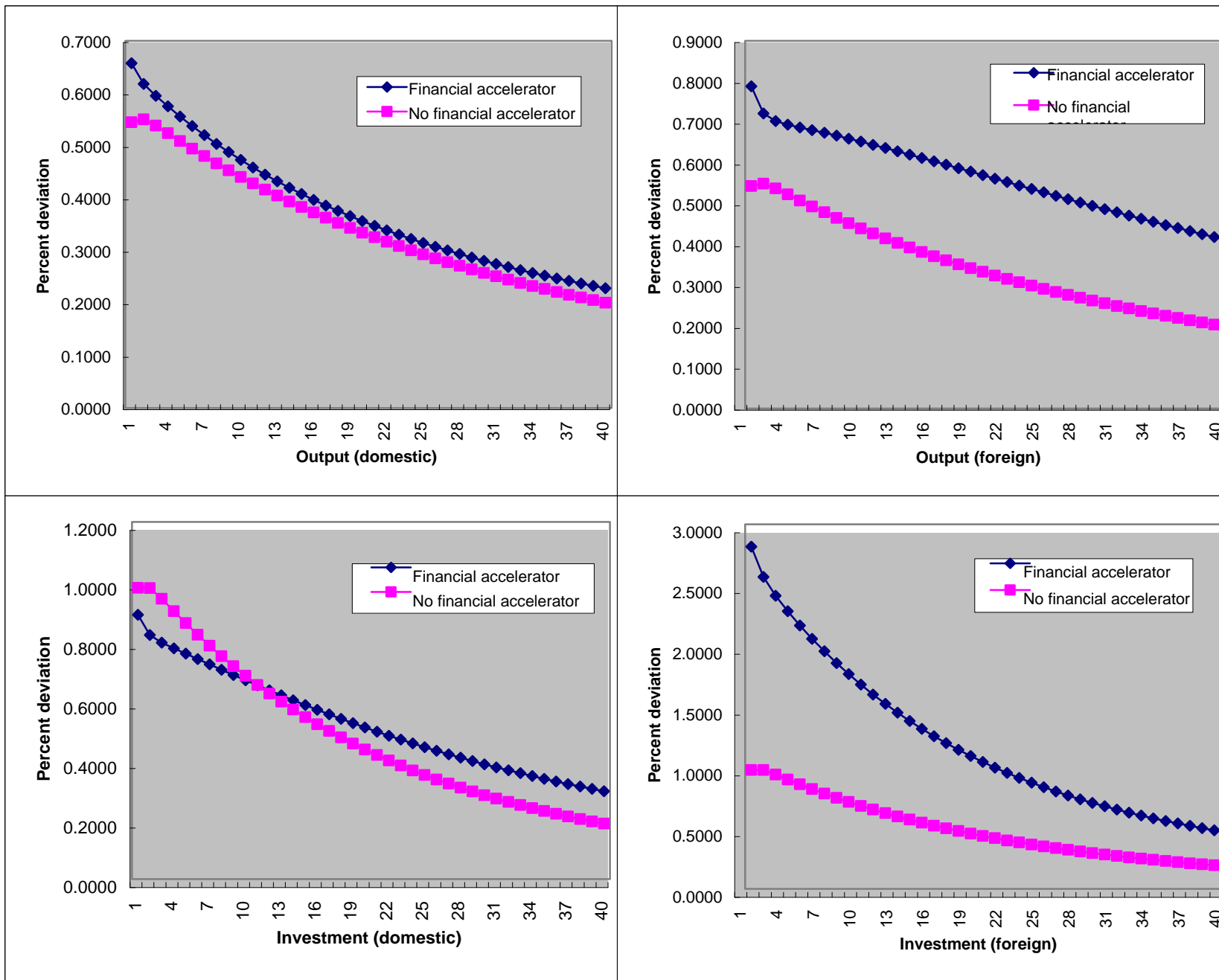


Figure 7. Effect of a Symmetric Shock to Preferences

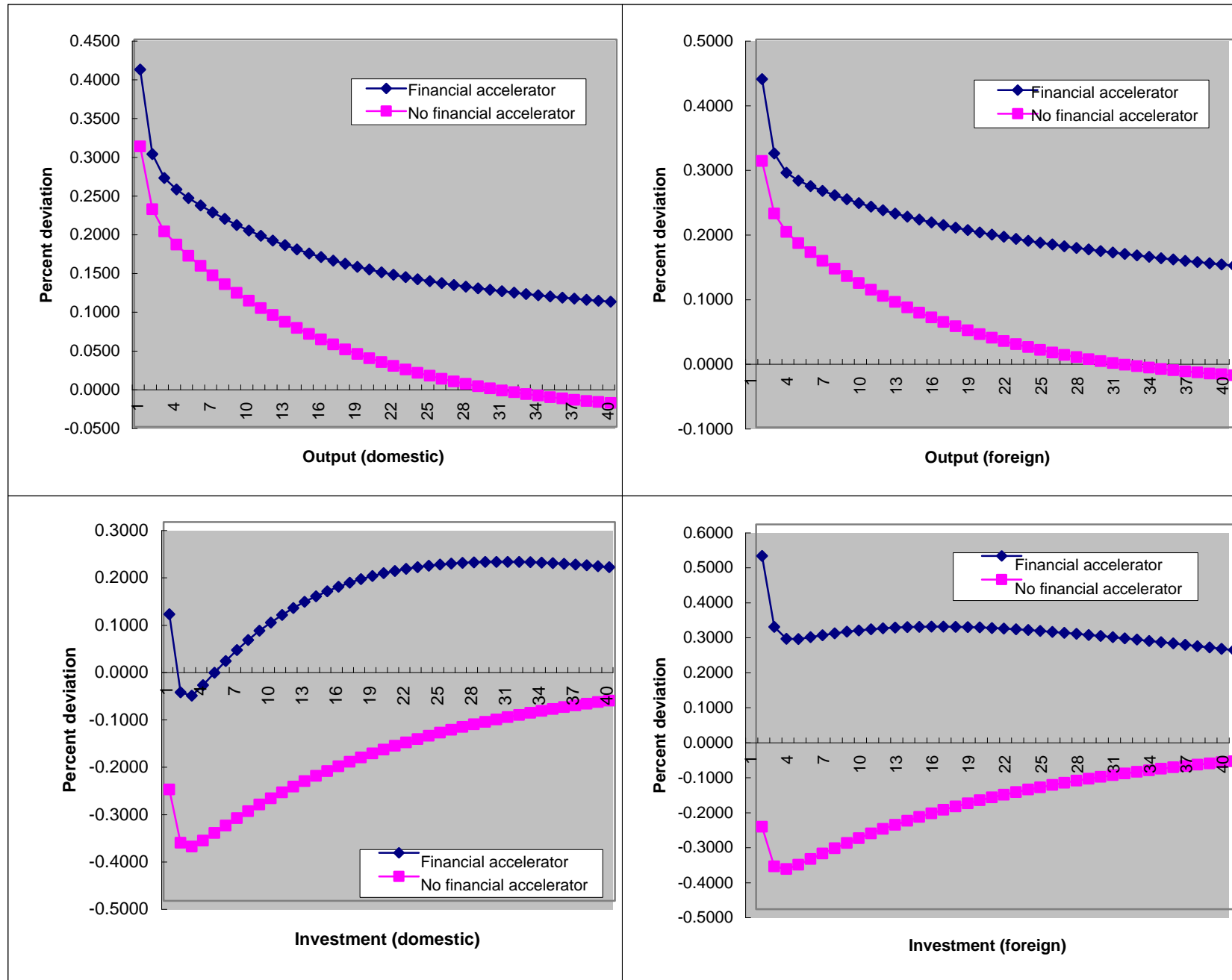
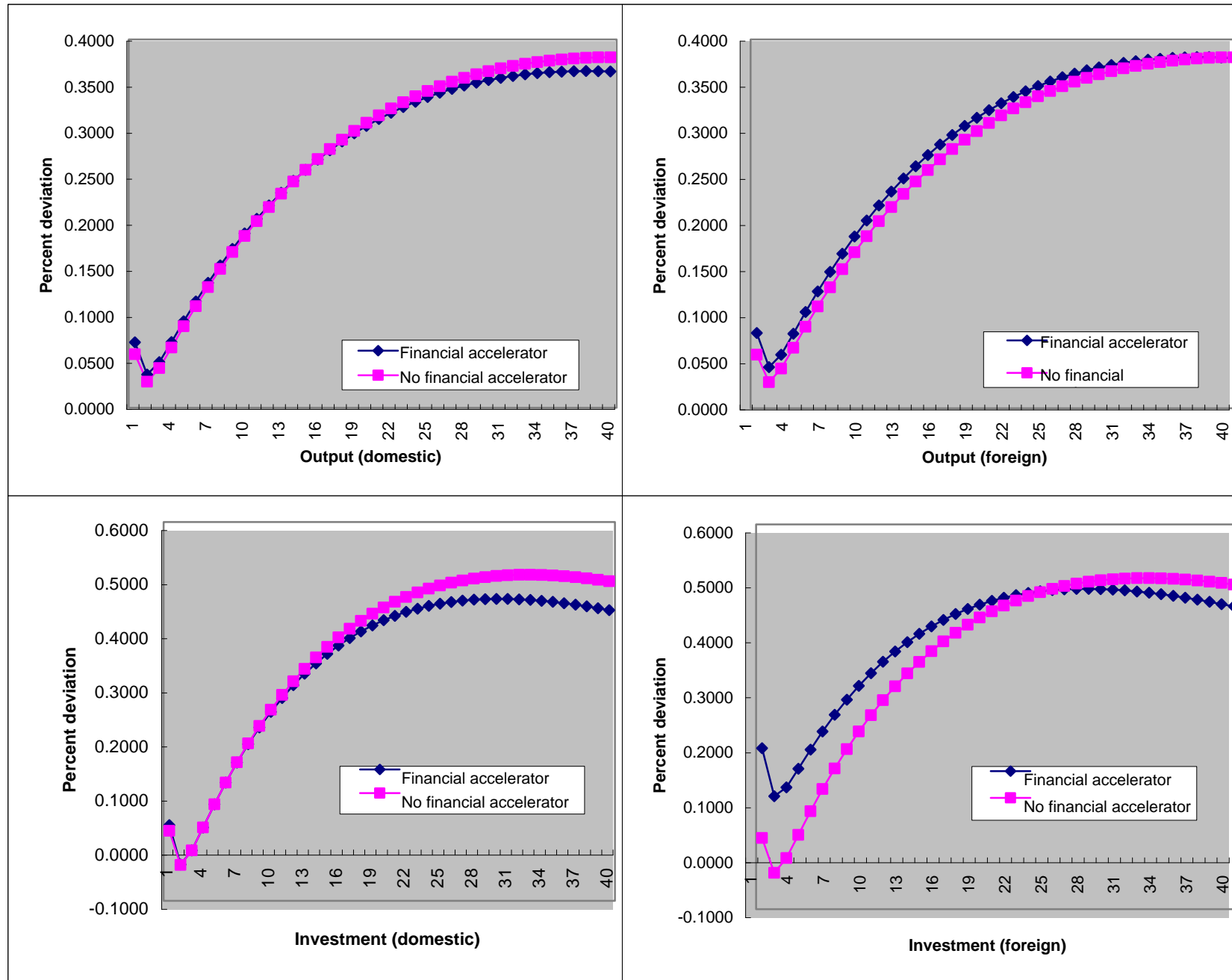


Figure 8. Effect of a Symmetric Shock to Embodied Technology



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