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TRADE-INDUCED INVESTMENT-LED GROWTH

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ABSTRACT

This paper presents five theoretical openness-and-growth links that can account for trade-induced investment-led growth. The links are all demonstrated with neoclassical growth models developed in the context of trade models that allow for imperfect competition and scale economies. This sort of old-growth-theory-in-a-new-trade-model has not been thoroughly explored in the literature since the profession skipped from old-growth-old-trade models straight to new-growth-new-trade models. Nonetheless, such models are necessary to explain several key aspects of the econometric evidence on trade and growth. For example, cross-country data suggests that openness influences growth only via its effect on investment, and suggests that openness promotes investment in all countries whatever the capital-intensive of their exports (contrary to predictions of the old-growth-old-trade models).

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NON-TECHNICAL SUMMARY

The theory of trade and growth developed in two distinct phases. In the 1970s, trade economists explored the old (neoclassical) growth theory in the context of the old (Heckscher-Ohlin) trade model. In the late 1980s and early 1990s, trade economists explored new (endogenous) growth theory in the context of new (imperfect competition) trade models. This evolution skipped an important phase - old growth theory in new trade models.

Two simple reasons make this an important omission. First, given the revival of neoclassical growth theory (eg, Mankiw, Romer and Weil 1992, De Long and Summers 1991, and Jones 1995), it is important to examine the neoclassical model in the context of modern trade models. Second, neither existing theoretical literature accounts for the econometric results on postwar trade and growth. We turn first to the shortcomings of the old-growth-old-trade literature.

Worldwide trade liberalization has been very much a win-win proposition as far as growth is concerned. However in the old-growth-old-trade literature, liberalization is intrinsically a win-lose growth proposition. It is simple to understand this prediction. In the neoclassical growth model, a policy that boosts the return to investment raises the steady-state capital-labour ratio. This triggers above-normal capital accumulation - and above-normal GDP growth - in the transition to the new steady state. In the Heckscher-Ohlin model, global trade liberalization raises capital's rental rate and the return to investment in nations that export capital-intensive goods, but lowers it in countries that import capital-intensive goods. Consequently, the old-growth-old-trade theory predicts that the massive postwar liberalization of trade should have stimulated investment in some nations and depressed it in others. This theoretical prediction contradicts econometric evidence.

Many econometric studies, including Barro (1991), Levine and Renelt (1992) and Baldwin and Seghezza (1996), have shown that openness to trade raises investment rates in a wide range of countries. In particular, it does not confirm the prediction that trade-opening encourages investment in nations that export capital-intensive goods (say rich countries), and discourages it in nations that import such goods (say poor countries). Moreover, the old trade literature is *a priori* inappropriate for studying postwar trade liberalization and growth due to three facts: (i) much of world trade is among rich countries, and (ii) consists of intraindustry trade. For instance, trade among Western European nations, North American nations and Japan accounts for half of world trade and about three-quarters of this consists of intraindustry trade. The third fact is that the bulk of the postwar trade liberalization has been confined to this intraindustry trade among rich countries. Now because the old-trade model cannot cope with such trade, it must assume away intraindustry trade (for instance, tests of the Heckscher-Ohlin model use "net trade" data, i.e. trade data in which intraindustry trade has been cancelled out). Clearly a model that assumes away most of the trade that has been liberalized since WWII is unsuitable for understanding postwar trade and growth.

The new-growth-new-trade literature has made important contributions to the study of trade and growth. It has, nonetheless, two big shortcomings as far as the study of the postwar period is concerned: (i) There is a growing body of econometric evidence contradicting the assumptions and predictions of these models, and (ii) it does not account for trade-induced investment-led growth.

Consider first the econometric evidence on the simple new-growth models employed in the new-growth-new-trade literature. Jones (1995) establishes that US growth (and that of many other advanced industrial economies) has been stationary since the industrial revolution. He then establishes that measures of R&D inputs - such as the number of scientists and engineers engaged in R&D, or real R&D expenditure - are stochastically trending upwards. Consequently, he rejects the simple linear production function for knowledge that is at the very heart of the new growth theory. As concerns trade and growth, the fundamental contradiction is that productivity in rich nations has proceeded at a steady (or even falling) rate in the postwar period, while global openness has trended upwards. Consequently, openness and productivity-led growth cannot be monotonically linked as in the new-growth-new-trade literature. Next consider the econometric evidence on the theoretical predictions of new-growth-new-trade literature.

Many cross-country econometric studies - eg Levine and Renelt (1992) and Baldwin and Seghezza (1996) - show that trade liberalization seems to promote growth only by promoting investment. That is, when investment rates are controlled for, openness has no additional impact on growth. This rejects the main prediction of the new-growth-new-trade literature - that trade affects growth by influencing the rate of productivity growth. It seems, therefore that trade-induced productivity-led growth is not empirically important, or at least not important enough to show up in cross-country data. Trade-induced investment-led growth does show up strongly in the cross-country data, but new-growth-new-trade models do not focus on this sort of openness-and-growth link.

For all these reasons, the study of trade and growth requires old-growth-new-trade models. A quotation from Levine and Renelt (1992) makes the point. In commenting on the lack of evidence for trade-induced productivity-led growth, they note: "These results suggest an important two-link chain between trade and growth through investment. Interestingly, however, the theoretical ties between growth and trade typically seem to run through improved resource allocation and not through higher physical investment shares." Plainly, Levine and Renelt are referring to the old-growth-old-trade literature and the quotation points up the missing theory, namely the theory of openness and investment-led growth.

This paper presents five theoretical openness-and-growth links that can account for trade-induced investment-led growth. The paper is organized in four sections after the introduction (Section I). Section II presents the workhorse model. Section III presents two openness-and-investment-led-growth links that appear to have a good deal of empirical support. The section also summarizes the supporting evidence. Section IV presents three more links that are based on the procompetitive effect of trade liberalization. The final section presents a summary and our concluding remarks.

The fundamental logic of the first Section-III link rests on two elements - the fact that traded goods and services are capital-intensive relative to nontraded goods and services (evidence for this is presented in Section III), and the way in which reciprocal trade liberalization encourages expansion of traded sectors at the expense of nontraded sectors. Taken together, these imply that the massive postwar liberalization of rich country's trade has systematically boosted the demand for capital and thereby fostered faster-than-normal capital accumulation. This, of course, shows up as investment-led growth. The key assumption is that the optimal expenditure share on traded goods rises as the price of traded goods falls relative to that of nontraded goods (this is true for CES preferences, for example). Given this, it is obvious that reciprocal trade liberalization will lead to a relative price change that favours the capital-intensive sector. The next link presumes that investment-goods production uses traded intermediates. In this case, liberalization lowers the marginal cost of investment goods and thereby lowers the price of capital. As a consequence, the steady-state capital stock rises and transitional growth ensues.

Section IV presents three openness-and-growth links that are driven by the procompetitive mechanism by which reciprocal trade liberalization lowers prices and expands output in all liberalizing countries. The first link focuses on a procompetitive effect in the investment-good sector. Here more competition means a lower price of capital. This raises the steady-state capital stock, thereby triggering investment-led growth in transition to the new steady state. The second link assumes that capital is used in the manufacturing of traded goods. Since the procompetitive mechanism forces an increase in the output of the traded goods sector, it boosts the derived demand for capital. This accelerates capital formation and growth in transition. The last link emphases the role of financial intermediation in determining the steady-state capital stock. If banks are imperfectly competitive and financial services are traded, the wedge between the rate savers receive and investors pay is endogenous and affected by trade policy. In particular, reciprocal liberalization of trade in financial services leads to a procompetitive effect that reduces this wedge and thereby boosts the steady-state capital stock in both countries. Above normal investment-led growth is the result.

TRADE-INDUCED INVESTMENT-LED GROWTH

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I. INTRODUCTION

The theory of trade and growth developed in two distinct phases. In the 1970s, trade economists explored the old (neoclassical) growth theory in the context of the old (Heckscher-Ohlin) trade model. In the late 1980s and early 1990s, trade economists explored new (endogenous) growth theory in the context of new (imperfect competition) trade models. This evolution skipped an important phase - old growth theory in new trade models. Two simple reasons make this an important omission. First, given the revival of neoclassical growth theory (eg, Mankiw, Romer and Weil 1992, De Long and Summers 1991, and Jones 1995), it is important to examine the implications of modern trade theory for the neoclassical growth model. Second, neither existing literature accounts for all the main stylized facts of postwar trade and growth. We turn first to the shortcomings of the old-growth-old-trade literature.

Worldwide trade liberalization has been very much a win-win proposition as far as growth is concerned. However in the old-growth-old-trade literature, liberalization is intrinsically a win-lose growth proposition. It is simple to understand this. In the neoclassical growth model, any policy change that boosts the return to investment tends to raise the steady-state capital-labour ratio. This triggers above-normal capital accumulation - and above-normal growth - during the transition to the new steady state. In the Heckscher-Ohlin model, global trade liberalization raises capital's rental rate and the return to investment in nations that export capital-intensive goods, but lowers it in countries that import capital-intensive goods. In short, the old-growth-old-trade theory predicts that the massive postwar liberalization of trade should have stimulated investment in some nations and depressed it in others. This theoretical prediction contradicts econometric evidence.

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Many econometric studies, including Barro (1991), Levine and Renelt (1992) and Baldwin and Seghezza (1996), have shown that openness to trade raises investment rates in a wide range of countries. Specifically, it does not confirm the prediction that trade-opening encourages investment in nations that export capital-intensive goods (say rich countries) and discourages it in nations that import such goods (say poor countries). Moreover, the old trade literature is *a priori* inappropriate for studying postwar trade liberalization and growth due to three facts: (i) much of world trade is among rich countries, and (ii) consists of intraindustry trade. For instance, trade among Western European nations, North American nations and Japan accounts for half of world trade and about three-quarters of this trade is intraindustry. The third fact is that the bulk of the postwar trade liberalization has been confined to this intraindustry trade among rich countries.* Because the old-trade model cannot cope with such trade, it must assume it away.** Clearly a model that assumes away most of the trade that has been liberalized since WWII is unsuitable for understanding postwar trade and growth.

The new-growth-new-trade literature has made important contributions to the study of trade and growth. It has, nonetheless, two big shortcomings: (i) There is a growing body of econometric evidence contradicting the assumptions and predictions of these models, and (ii) it does not account for trade-induced investment-led growth.

Consider first the econometric evidence on the simple new-growth models employed in the new-growth-new-trade literature. Jones (1995) establishes that US growth (and that of many other advanced industrial economies) has been stationary since the industrial revolution. He then establishes that measures of R&D inputs - such as the number of scientists and engineers engaged in R&D, or real R&D expenditure - are stochastically trended. Consequently, he rejects the simple linear production function for knowledge that is at the very heart of the new growth theory. As concerns trade and growth, the fundamental contradiction is that productivity in rich nations has proceeded at a steady (or even falling) rate in the postwar period yet these nations' openness has trended upwards. Consequently, openness and productivity-led growth cannot be monotonically linked as in the new-growth-new-trade literature. Next consider the econometric evidence on the theoretical predictions of new-growth-new-trade literature.

Many cross-country econometric studies - eg Levine and Renelt (1992), and Baldwin and Seghezza (1996) - suggest that trade liberalization promotes growth only by promoting investment. That is, when investment rates are controlled for, openness has no additional

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*Due to their small economic size and the notion of "special and differential treatment", developing countries have mostly avoided trade liberalization in the GATT Rounds that greatly liberalized rich nations' import policies.

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impact on growth. It seems, therefore that trade-induced productivity-led growth is not empirically important, or at least not important enough to show up in cross-country data. This rejects the main prediction of the new-growth-new-trade literature, namely that trade affects GDP growth by influencing productivity growth. Trade-induced investment-led growth does show up strongly in the cross-country data, but new-growth-new-trade models do not focus on this sort of openness-and-growth link.

For all these reasons, the study of trade and growth requires old-growth-new-trade models. A quotation from Levine and Renelt (1992) makes the point. In commenting on the lack of evidence for trade-induced productivity-led growth, they note: "These results suggest an important two-link chain between trade and growth through investment. Interestingly, however, the theoretical ties between growth and trade typically seem to run through improved resource allocation and not through higher physical investment shares." Plainly, Levine and Renelt are referring to the old-growth-old-trade literature and the quotation points up the missing theory, namely the theory of openness and investment-led growth.

This paper presents five theoretical links between openness and investment-led growth with a basic model that is modified to illustrate each link as simply as possible. The rest of the paper is organized as follows. The next section, section II, presents the workhorse model. Section III presents two openness-and-investment-led-growth links that appear to have a good deal of empirical support. The section also summarizes the supporting evidence. Section IV presents three more links that are based on the procompetitive effect of trade liberalization. The final section presents a summary and our concluding remarks.

II. THE BASIC MODEL

Consider two symmetric countries with two factors (labour L and physical capital K) and three sectors (X, Z and I). X-sector goods are traded with countries imposing frictional, i.e. iceberg, import barriers that are measured by $\tau \geq 1$.* Z and factors are nontraded. The L supply is fixed, but K is the accumulated output of the I (investment goods) sector. The X sector is a Dixit-Stiglitz monopolistic-competition sector with production of each X variety requiring one unit of K (regardless of output) plus "a" units of labour per unit of output (think of a unit of capital as a design for a unique variety of X embedded in the machines needed to manufacture it). Thus, π+wax is the cost function where w and π are the factor rewards of L and K. Z is a homogeneous good produced from labour according to the cost function wbZ. This extreme factor intensity simplifies calculations, but the key assumption is that the X sector is capital intensive relative to the I and Z sectors. We chose units such that a=b=1.

*Thus τ units must be shipped to sell one unit in the export market.

With ρ as the time-preference parameter, representative consumer preferences are:

$$\int_{t=0}^{\infty} e^{-\rho t} \ln C_t \, dt \,, \quad C_t = \left(C_X^{(1-\frac{1}{\theta})} + \Upsilon C_Z^{(1-\frac{1}{\theta})} \right)^{\frac{1}{(1-1/\theta)}} , \quad C_X = \left(\sum_i c_i^{(1-\frac{1}{\sigma})} \right)^{\frac{1}{(1-1/\sigma)}} \quad (1)$$

where θ and σ are elasticities of substitution between (respectively) the X composite and Z, and among X varieties, and Υ is a binary (0 or 1) parameter that we use to "turn off" the Z sector in simplified versions of the model. Full employment in both countries implies that 2K is the number of varieties. Note that the upper-tier utility function limits to Cobb-Douglas as θ approaches 1 and the optimal expenditure share on X (denoted as μ) is a decreasing function of P_X/p_Z, where P_X and p_Z are the standard CES price index and the price of Z respectively. Namely, μ equals $(1+(P_X/p_Z)^{\theta-1})^{-1}$ and $\lim_{\theta \to 1} \mu=1/2$. Total national income Y equals $wL+\pi K$. Utility optimization yields standard CES demand functions for X varieties, a demand function for Z and the Euler equation $\dot{E}/E=r-\rho$, where E is consumer expenditure and r is the rate of return on savings.

Calculations are facilitated by three special features of Dixit-Stiglitz monopolistic competition. Each X-sector firm: (i) produces a unique variety, (ii) engages in "mill pricing" where $w/(1-1/\sigma)$ is the local market price and τ is fully passed on to foreign consumers, and (iii) earns operating profit equal to $(\Sigma_i s^i \mu E^i)/\sigma$, where s^i is the firm's share of market i expenditure.[1*] Given capital's variety-specificity, capital's reward is the Ricardian surplus, i.e. operating profit. Also if X-sector trade is balanced (obviously true with symmetric nations and/or Z and K nontraded), each country's consumer expenditure on X equals the producer value of output, thus from (iii):

$$\pi = \mu E \,/\, \sigma K \quad (2)$$

since symmetry means $\Sigma_i s^i = 1/K$.[2]

The perfectly competitive I sector employs L to produce new capital under constant returns and perfect competition. The I-sector marginal cost and production functions are:

$$F = \beta w \,, \qquad Q_K = \frac{wL_I}{F} \,, \qquad Q_K = \dot{K} + \delta K \quad (3)$$

where F is marginal cost, β is the unit labour requirement, Q_K is the flow output of K (gross investment), L_I is the L employed, and $\dot{K}=Q_K - \delta K$ assuming a constant rate of depreciation δ. Due to perfect competition, the price of capital (denoted as P_K) equals F.

Finally, note that the number of varieties rises with K, so capital accumulation drives real output and real consumption growth.

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* Numbered endnotes refer to the attached "Supplement to Calculations".

A. Steady-State Analysis with Tobin's q

Characterizing the transitional dynamics of this model involves well-known techniques (see appendix). The only germane result from such a characterization, however, is that the transition between steady states takes a long time (since consumers smooth consumption). For this reason, the paper focuses on comparative steady-state analysis, using the fact that an increase in the steady-state K will generate decades of above-normal growth (in this model the steady-state growth rate is zero).

In all exogenous growth models, including the simple one presented above, a constant capital-labour ratio corresponds to constant real investment (i.e. constant application of resources to capital-formation). It seems natural, therefore, to take real investment as the main state variable, although the key dynamic equation - the Euler equation - involves expenditure. Fortunately, a simple change of state variables eliminates E from the Euler equation. With I as nominal investment, nominal factor income Y equals E+I, where I equals wL_I.* We have, therefore, that $E=wL+K\pi-wL_I$, and using $\pi=\mu E/K\sigma$:

$$E = \frac{w(L-L_I)}{1-\mu/\sigma} \tag{4}$$

Taking L as numeraire and real investment (namely L_I) as a state variable, we see $\dot{E}=0$ in steady state because $\dot{L}_I=0$ by definition of steady state. From the Euler equation, $\dot{E}=0$ implies $r=\rho$. This facilitates calculation of the present value of introducing a new variety.

Tobin's q-theory of investment (Tobin 1969) focuses on the ratio of a firm's stock market value to the replacement cost of its capital - the stock market value being the present value of the π income stream (net of maintenance costs) and its replacement cost being P_K. Tobin's famous q=1 condition determines the steady-state capital stock, or equivalently given (3), the steady-state rate of real investment L_I. Labelling the stock market value of a unit of capital as J and noting that π is time-invariant in steady state, we have $J=(\pi-\delta)/\rho$.[3] By definition $q=J/P_K$, so using (2), (3), (4) and the fact that $L_I=\delta FK$ in steady state, we have:

$$q = \frac{J}{F} = \left(\frac{\mu(L-L_I)}{L_I(\sigma-\mu)} - \frac{1}{F}\right)\frac{\delta}{\rho} = \left(\frac{\mu(L-\delta FK)}{K(\sigma-\mu)} - \delta\right)\frac{1}{\rho F} \tag{5}$$

Clearly in steady state, Tobin's q is a simple monotonically decreasing function of L_I or alternatively of K. The q=1 condition therefore pins down the steady-state L_I (denoted as

*Due to zero I-sector profits, the value of the sector's output equals the value of inputs. In equilibrium all of the sector's output is purchased for investment, thus $wL_I=I$.

$\bar{L}_I$) and the steady-state K (denoted as $\bar{K}$). Specifically:

$$\bar{L}_I = \frac{\mu\delta FL}{(\rho F+\delta)(\sigma-\mu)+\delta\mu F}, \qquad \bar{K} = \frac{\mu L}{(\rho F+\delta)(\sigma-\mu)+\mu\delta F} \tag{6}$$

It is worth noting that it is I and X sector free entry that force q to unity at all times. To see this, observe that with free entry X firms create new varieties up to the point where the present value of doing so (viz. J) equals the one time cost (viz. P_K). Consequently, an I-firm producing a flow of Q_{Ki} machines earns instantaneous pure profits:

$$(J - F)\, Q_{Ki} = (q - 1)\, L_{Ii} \tag{7}$$

where L_{Ii} is the firm's employment and the second expression follows from (3) and the definition of q. With perfect competition, I-sector employment jumps to the point where $\Sigma_i L_{Ii}$ is always such that q=1. This shows that q-1 is the shadow value of moving resources into the I sector. Tobin's q is an insightful approach exactly because q-1 is the shadow value of moving more resources into capital accumulation. Trade liberalizations that create an incipient rise in a country's q will draw more resources to the accumulation sector until q is restored to unity. This results in investment-led growth during transition to the new steady state.

III. Openness-and-Growth Links with Empirical Support

The introduction asserted that traded goods and services are more physical capital-intensive than nontraded goods. Below we will present evidence on this but taking it as true for the moment, we note that any policy reform that promotes the traded sector boosts the derived demand for capital. In the short-run, this shows up in an increase in the return to capital. In the long run, it raises the steady state capital stock. During the transition to the new steady state, we have faster capital accumulation and growth. Given all this, the massive postwar reciprocal liberalization of trade would appear to be a major source of investment-led growth as long as two conditions hold: (i) traded goods and services are more capital intensive than nontraded goods and services, and (ii) global trade liberalization stimulated traded goods sectors in the liberalizing nations. We turn now to some evidence that traded goods and services are more capital-intensive than nontraded goods and services.

For the US, Japan and the UK, Table 1 shows two types of value added shares that may be interpreted as measures of capital intensity: Sectoral payments to capital as a share of sectoral value added and sectoral payments to capital plus sectoral operating surplus as a share of value added. The third column for each country shows the importance of the sector in the economy. The table shows that sectors differ widely in their capital

Figure 1

Table 1

Capital intensity for different industries, 1987

	US			Japan			UK		
	Value added shares:		Sector's	Value added shares:		Sector's	Value added shares:		Sector's
	Capital	Capital +profit	% of GDP	Capital	Capital +profit	% of GDP	Capital	Capital +profit	% of GDP
Tradables									
Agriculture	17%	88%	2%	24%	74%	3%	22%	69%	2%
Mining	46%	55%	2%	23%	75%	0%	25%	78%	4%
Manufacturing	12%	26%	19%	15%	39%	28%	11%	32%	23%
Financial Services	14%	54%	25%	20%	72%	15%	16%	62%	22%
Non Tradables									
Construction	7%	34%	5%	13%	39%	8%	3%	50%	6%
Wholesale& Retail	8%	25%	17%	8%	35%	13%	7%	36%	13%
Transport, Storage & Communications	19%	39%	6%	17%	27%	6%	22%	37%	7%
Utilities	26%	57%	3%	25%	66%	3%	33%	57%	3%
Other Private Services	6%	25%	10%	9%	40%	14%	5%	41%	5%
Government Services	10%	10%	12%	8%	8%	8%	5%	5%	14%
Other Producers	0%	0%	0%	0%	0%	2%	0%	0%	2%
Economy Average	12%	35%		14%	42%		12%	40%	
Averages by Sector Groups									
Tradables	7%	21%		8%	24%		7%	25%	
Non Tradables	5%	13%		6%	17%		4%	14%	

Source: OECD Detailed National Accounts, Tables 12,13

intensities and that there is no simple connection between tradability and capital intensity. By far the most capital intensive is mining and minerals and this is clearly a traded-good sector. The second most capital intensive is utilities (electricity, gas and water) and this is largely nontraded, at least for the countries under consideration. Ambiguity disappears when the importance of the sectors is considered. For instance, utilities plays a negligible role in the economies, while the nonfinancial service sectors (nontraded) account for between 30% and 40% of GDP and have systematically low physical capital intensities. The table also provides average capital intensities of tradable and nontradable sectors, where the sectors are weighted by their share in GDP. In all three countries considered, both measures of average capital intensity show tradables to be relatively capital intensive.

A. Inter-Sectoral Expenditure Switching

In the basic model, the return to capital π increases with the share of total expenditure on the X sector, namely μ. Moreover for CES preferences over X and Z, μ increases as the price of traded goods falls relative to nontraded goods. This suggests a simple openness-and-growth link. Starting from positive levels of protection, reciprocal liberalization lowers the price index of the X-composite P_X relative to that of nontraded goods p_Z. The relative price change shifts expenditure patterns, thereby boosting π and creating an incipient increase in Tobin's q. This in turn causes r to jump up, thereby triggering faster capital accumulation and investment-led growth in the medium-run.

More precisely, (5) shows that steady-state q is increasing in μ and decreasing in $\bar{K}$, so a rise in μ forces an increase in the steady-state K. Given the μ and P_X formulae:

$$\mu = \frac{1}{1+(P_X/p_Z)^{\theta-1}}; \qquad \frac{P_X}{p_Z} = \frac{(K(1+\tau^{1-\sigma}))^{1/(1-\sigma)}}{1-1/\sigma} \tag{8}$$

we see that $d\tau<0$ raises μ and therefore $\bar{K}$ in both countries.

To summarize, global liberalization sparks investment-led growth by lowering the prices of traded goods and services relative to those of nontraded goods and services. This price change induces an intersectoral expenditure shift that favours the capital-intensive sector. As a result, rate of return to capital formation rises thus triggering investment-led growth.

The empirical support for this mechanism is twofold. First - as reviewed above - traded goods are more physical capital intensive than nontraded goods. The second type of evidence comes from the well-known fact that countries are becoming more open to international trade. For instance, exports of goods and services have expanded more rapidly than GDP since WWII.

B. Trade Liberalization and the Price of Capital

The next link works on the denominator of Tobin's q rather than the numerator. When the manufacture of capital involves traded intermediate inputs, the price of trade goods enters the I-sector's cost function. Since the level of trade barriers can lower these prices, F becomes a function of trade barriers. Consequently, global liberalization can lower P_K in both countries, thereby creating an incipient increase in q that is translated into a rise in r. This triggers faster capital accumulation and faster growth in transition to the new steady state. This openness-and-growth link is related to the literature on imported capital goods, which have long played an important role in the trade and growth literature. See, for instance, Cairncross (1962) and more recently Lee (1992, 1994).

To illustrate this link as simply as possible, we modify the basic model by assuming that the I sector employs L and traded intermediate inputs (specifically, a CES composite of all X varieties with an elasticity of substitution σ) to produce new capital under constant returns. Specifically, the assumed marginal cost and net investment functions are:

$$F = w^{\alpha} P_X^{1-\alpha} = \left(\frac{(K(1+\tau^{1-\sigma}))^{\frac{1}{1-\sigma}}}{1-1/\sigma} \right)^{1-\alpha}, \qquad \dot{K} = \frac{wL_I + P_X X_I}{F} - \delta K \tag{9}$$

where P_X is the standard CES price index, and X_I and L_I are the X-sector composite and L employed. The second expression for F follows from the first using the definition of the standard CES price index and w=1.

By inspection of (5), q is diminishing in both $\bar{K}$ and F. Therefore anything that lowers F triggers investment-led growth. From (9), a drop in τ tends to lower F and thereby tends to increase the steady-state capital stock. However F is also decreasing in $\bar{K}$ (in particular dF/F equals $-(1-\alpha)/(\sigma-1)$ times $d\bar{K}/\bar{K}$), so there exists the aberrant possibility that the liberalization lowers K enough to more than offset the F-reducing impact of the τ cut. We refer to this as aberrant since it implies that global liberalization would raise the CES price index of traded goods in all countries.* To formally characterize the openness-and-growth link, we must find sufficient conditions that rules out this aberrant case. Since the impact of $\bar{K}$ on F depends upon $1/(\sigma-1)$, it is intuitively obvious that the aberrant case disappears if σ is sufficiently large. Specifically, it can be shown that $\sigma>2$ is sufficient to ensure that $d\bar{K}/d\tau$ is negative.[4]

The empirical evidence for this openness-and-growth link comes mainly from Lee (1992). That paper estimates cross-country investment and growth regressions, showing that a measure of tariffs on imported intermediates reduces both growth and investment. The link is also indirectly supported by the evidence in De Long and Summers (1991). The main goal of De Long and Summers is to establish a link between equipment investment and GDP per capita growth. However in doing so, they find a strong negative correlation between the equipment prices and economic growth rates. Taking equipment prices to be broadly indicative of capital-goods prices, and noting that over 30% of the US equipment purchases are imported, trade may affect growth via its impact on the price on new capital.

IV. PROCOMPETITIVE EFFECTS AND GROWTH

This section considers three openness and growth links that are driven by the procompetitive effect of trade liberalization. Since the procompetitive effect is somewhat

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*This outcomes has long been recognized in the context of a unilateral liberalization - Helpman and Krugman (1989) refer to it as the home market effect. Here home liberalization forces a decrease in the number of home firms and an increase in the number of foreign firms, so even thought τ is reduced, more varieties must be imported. Depending upon parameter values, P_X may actually rise.

involved, we briefly exposit its main economic logic before turning to the trade and growth links.

To illustrate this mechanism, consider a simple partial equilibrium example of two symmetric countries engaged in Brander-Krugman reciprocal-dumping trade and imposing identical import barriers τ. That is, we assume 'n' Cournot oligopolists (in each country) are selling to the two segmented markets. The equilibrium in either market is characterized by two key conditions: (i) the first order condition for local sales by local firms $p=a/(1-s/\epsilon)$, where s is the market share of local firms in the local market, a is marginal cost and ϵ is the constant demand elasticity, and (ii) the free entry condition. Now it is easy to show - and intuitively obvious - that 's' depends negatively on the number of symmetric firms (more competitors means a lower market share per firm) and positively on the tariff (more protection raises the market share of local firms). From the first order condition, this means that p is increasing in τ and decreasing in n. It is also clear that raising n lowers operating profit while raising τ increases operating profit.[5]

Consider the impact of lowering import barriers on a reciprocal basis. On impact, lowering τ reduces s and thereby prices in both markets. However, the two-way liberalization also reduces operating profit. Since all firms were just breaking even before the τ reduction, liberalization creates incipient negative profits. The result, of course, is the exit of firms up to the point where pure profits are restored to zero. The third round of effects concerns the impact of this industrial restructuring on prices. Since lowering n tends to raise s, the restructuring tends to raise prices back up towards the preliberalization level. This mitigating effect on the first round price drop cannot, however, push prices back up to the preliberalization level. The reason is simply that if it did, firms would be making positive pure profits (the same price with fewer competitors implies pure profits). Because the post-liberalization n must equate pure profits to zero, we know that post-liberalization prices are lower than preliberalization prices.

Finally, we turn to the implication of fewer firms and lower τ's and prices. First with home and foreign prices lower, total output in each country must rise. With fewer firms this means increased exploitation of scale economies and reduced markups. Furthermore, the difference between s (local firms share in the local market) and a local firm's share in the export market is decreased by the liberalization. This de-fragmentation of international markets means that though the total number of firms drops, the degree of effective competition has increased.

A. Procompetitive Effect in the I Sector

The basic section II model assumes perfect competition in the I sector. Since real-world production of investment goods is usually subject to scale economies, the assumption of constant returns and perfect competition is rather objectionable. Moreover, it rules out the possibility that trade liberalization has a procompetitive effect on the price of capital. To allow for this, we enrich the basic model by introducing scale economies and imperfect competition into the I sector. As we shall see, this enrichment of the model generates an openness and medium-term growth link that is novel, although it is akin to the endogenous growth effects described by Baldwin (1992) and Baldwin and Forslid (1996).

To illustrate the link, consider a symmetric-country version of the basic model with the I-sector cost function generalized to include an overhead cost (i.e. a flow of fixed costs) of G units of labour beyond the variable cost F. Moreover, we allow trade in K, assuming that the home and foreign markets are segmented. Trade in K, however, is hindered by a range of cost-raising import barriers (imposed by both countries) whose magnitude is captured by $\Gamma \geq 1$. Γ represents a broad class of common real-world barriers, but standards provides a concrete example. Most new product needs to be certified as meeting industrial, health, safety and/or environmental standards. The certifying boards are typically influenced by local industries for whom the new product constitutes a threat. It is quite common, therefore, for standards to provide *de facto* discrimination against foreign varieties. In keeping with the standards-certification example, we model these barrier as posing a one-time cost. That is, Γ raises nonlocal firms' costs of selling machines in the local market without affecting the π earned from varieties produced with imported K. Lastly, to simplify the algebra, we "turn off" the Z sector (i.e. $\Upsilon=0$ so $\mu=1$).

I-sector output is homogeneous in the sense that machines are perfect substitutes even though they produce a unique variety. The point is that with symmetry of varieties, X-firms do not care which variety they produce. With this homogeneity, the most natural market structure assumption for the I sector is a Cournot oligopoly with segmented markets and free entry. With free entry, nominal investment equals the nominal I-sector costs, so $E=L-L_I-nG+\pi K=(L-L_I-nG)/(1-1/\sigma)$, where n is the number of machine-making firms per country. The profit maximization problem of a typical I-sector firm is to choose Q_{Ki} and Q_{Ki}^* (sales of K to the local and nonlocal markets) to maximize the sum of $(P_K-F)Q_{Ki}$ plus $(P_K^*-\Gamma F)Q_{Ki}^*$, where P_K and P_K^* are the prices of designs sold in the local and export markets. Using symmetry, $P_K=P_K^*$, so the first-order conditions are:

$$P_K\left(1-\frac{s}{\epsilon}\right)=F, \qquad P_K\left(1-\frac{s^*}{\epsilon}\right)=\Gamma F \tag{10}$$

where s and s* are the shares of a typical firm in its local and nonlocal markets (eg, $s=Q_{Ki}/Q_K$ where Q_K is total sales in the local market), and ϵ equals $1-\delta K(\sigma-1)/(L-\delta FK-nG)$ in steady state.[6] Using symmetry, $ns+ns^*=1$, so from the first order conditions, we have $s=(1-n\epsilon(1-\Gamma))/n(1+\Gamma)$ and s* is $(n^{-1}-s)$.[7] To close the model we determine n with the free-entry condition. I-sector firms enter up to the point where pure profits disappear. Given the oligopoly market structure, this requires n to be such that:

$$G = (s^2 + s*^2)E/\epsilon \tag{11}$$

Nonlinearity of (10) and (11) rules out analytic solution, but the long-run equilibrium levels of the state variables L_I (or alternatively K) and n are easily found graphically or numerically.

This trade in K is analogous to the reciprocal dumping trade of Brander and Krugman (1983). Once this analogy has been established, the long-run outcome of reciprocal liberalization is obvious from the discussion of the procompetitive effect. Heuristically, reciprocal liberalization reduces the average markup of P_K over F, thereby lowering the replacement cost of capital. If K were constant, the steady-state $q=\pi/\rho P_K$ would rise - implying pure profits in the I-sector. Instead r and L_I rise and this creates a growth effect in transition to the long run steady state.

B. Procompetitive Effect in the X Sector

The next openness and growth link rests on a procompetitive effect in the X sector and can be thought of as a simplified version of Baldwin and Seghezza (1996). The basic idea is simple once one accepts the assumption that the X sector is capital intensive. As discussed above, reciprocal liberalization of an oligopolistic sector can lead to a procompetitive effect that lowers prices and expands output in both countries. If capital is used in the manufacture of X, the output expansion raises capital's rental in the short run. This, of course, induces capital-formation that in the long-run pushes capital's rental rate back down to its steady-state level.

This link depends crucially on the procompetitive effect and the fact that capital is used in manufacturing, so we must modify the basic model in two important ways. First we need an X-sector market structure in which more competition has an effect on prices. Unfortunately, while the Dixit-Stiglitz monopolistic competition assumed in the basic model is convenient, it rules out a procompetitive effect. The basic point is that firms are already atomistic in that framework, so more competition has no effect. More precisely, the Dixit-Stiglitz framework assumes a continuum of varieties with one firm producing each variety. There are therefore, an uncountable infinity of infinitely small X-sector firms with the measure of these firms being "n". To get away from this polar case, we assume that X-sector goods are homogeneous (formally, this case is already imbedded in the preferences, since as σ limits to infinity, X limits to a homogeneous good) and produced by Cournot oligopolists selling to segmented markets.

The second important modification is to assume that K is used in X-sector manufacturing as well as in the setup cost. Specifically, the X-sector cost function is assumed to be $a(\phi+x)$ where $a=w^{1-\theta}R^{\theta}$, R is the rental rate on capital and ϕ is the fixed cost. This corresponds to a Cobb-Douglas production function $x=\Omega L^{1-\theta}K^{\theta}$ where Ω equals $\theta^{-\theta}(1-\theta)^{-(1-\theta)}$ and ϕ units of x pay for overhead costs. For simplicity, the I-sector reverts to its perfect-competition-constant-returns form as in the basic model. Also the algebra is streamlined by taking $\Upsilon=\delta=0$ (this turns off the Z sector and rules out depreciation for the steady state $L_I=\delta FK=0$).

X-sector firms choose local and export sales to maximize profits, so taking p_x as the price of X:

$$p_x(1-s) = a \ , \quad p_x^*(1-s^*) = a\tau \ ; \quad s = \frac{1+n(\tau-1)}{n(1+\tau)} \ , \quad s* = \frac{\tau-n(\tau-1)}{n(1+\tau)} \tag{12}$$

are the first order conditions for one of the "n" identical firms located in a typical country and the expressions for s and s* follow from the first-order conditions, symmetry of prices and the fact that $ns+ns^*=1$.[8] Rearranging (12), we get that operating surplus is $(s^2+s^{*2})E$. Additionally, the first order condition for K demand is:

$$R = p_x(1-s)\theta\Omega(L_X/K)^{1-\theta} = a\theta\Omega(L_X/K)^{1-\theta} \tag{13}$$

where $L_X=L-L_I$ is total X-sector employment.

To derive the steady-state capital stock $\bar{K}$, we first determine the steady-state r. Expenditure is nominal income less investment, viz. $L-L_I+RK$. Taking labour as numeraire $a=R^{\theta}$, so $RK=(\theta\Omega)^{1/(1-\theta)}L_X$. Thus $E=(1+(\theta\Omega)^{1/(1-\theta)})(L-L_I)=(L-L_I)/(1-\theta)$. Taking L_I as the state variable, we see that $\dot{E}=0$ in steady state, so from the Euler equation $r=\rho$ in steady state. This result simplifies calculation of the steady-state stock market value of a unit of capital. In particular, J equals R/ρ. The steady-state condition $q=J/P_K=J/F=1$ therefore implies that the steady state $R=\rho F$.

In this version of the basic model, the state variables are L_I, K and n. However the steady-state L_I is pinned down independently by $\bar{L}_I=\delta FK=0$, so $E=L/(1-\theta)$. $\bar{K}$ and the steady-state n, $\bar{n}$, are determined from the free entry (zero profit) condition $(s^2+s^{*2})E=\phi$ and the trade balance condition $E=p_xX$, where X is steady-state aggregate output, namely $\Omega\bar{K}^{\theta}L^{1-\theta}$.

Nonlinearity in these two conditions prevents analytic solutions, but demonstration of the openness-and-growth link only requires us to demonstrate that $d\bar{K}/d\tau$ is negative. To this end note that trade balance requires $\Omega\bar{K}^{\theta}L^{1-\theta}=L/(1-\theta)p_x$, so if p_x falls, $\bar{K}$ must rise. Intuitively it is obvious that reciprocal liberalization lowers p_x (via the procompetitive mechanism) raising total X-sector production and therefore $\bar{K}$. More precisely, starting from $\tau>1$, we know $s>s^*$. Reciprocal liberalization defragments the markets regardless of changes in n, i.e. it reduces the difference between s and s*. Because free entry requires $(s^2+s^{*2})E=\phi$ and E is unaffected by τ, we know that $d\tau<0$ must lower s. From (12), this implies p_x falls, which is - as we argued above - sufficient to show that $d\bar{K}/d\tau<0$.

C. Imperfect Competition in Financial Intermediation

Given the rapid expansion of international trade in financial services, it seems appropriate to investigate a model in which financial services trade is allowed to play a role in capital formation. As we shall see, enrichment of the basic model in this direction establishes an interesting openness-and-growth link. This link was first formally shown by Francois (1995) in an overlapping generations model of a small open economy where foreign financial institutions are assumed to be more efficient. Thus Francois' model can be thought of as applying most directly to developing countries. The model presented here extends Francois's results by positing a North-North model (home and foreign banks are equally efficient) and by explicitly considering barriers to trade in financial services. The basic logic is quite simple. Imperfectly competitive home and foreign banks lend in the local and nonlocal markets, but frictional barriers (eg spurious regulation) hinder nonlocal lending. Reciprocal financial services liberalization has a procompetitive effect on banks' markups. Since these markups put a wedge between what savers' earn and investors pay, reciprocal liberalization lowers the cost of borrowing. This boost the stock market value of typical unit of capital and thereby creates and incipient rise in q; The rise is avoided by a rise in r and L_I. As usual, this leads to a medium-run growth effect.

To illustrate this link simply, we use the basic model modified in three ways. First we assume the existence of a banking sector. Investors (i.e. firms that wish to introduce a new X variety) must borrow from banks since individuals deposit their savings in banks. To keep the model as streamlined as possible, we rely on a simple motive for banking. Namely, we assume that if loans are to be paid off, they must be monitored. Monitoring is costless on the margin but requires a flow of overhead costs of B units of labour. Since B is finite yet consumers/savers are atomistic, savers never lend money directly to X-sector firms. Also because banking involves an overhead cost B (not related to the volume of loans), the sector is marked by increasing returns and imperfect competition. The second modification is to assume the existence of riskless government bonds (in fixed supply) that provide a return without monitoring. Since consumers/savers can always invest in bonds, banks are price-takers in the market for savings. The natural market structure for the banking sector is a Cournot oligopoly since banks "sell" a homogeneous product that they "produce" at a variable cost (the interest rate that they must pay to savers). In short, the cost function for a typical bank is $B+rFK_i$, where r is the return on savings and FK_i is its volume of loans. The third modification is to allow trade in financial services, to assume the markets for loans are segmented, and to assume that this trade is impeded by frictional barriers. This cost is meant to reflect real and regulatory barriers to trade in financial services.* We measure it with the parameter $\psi \geq 1$ ($\psi = 1$ indicates free trade in financial services). As before, algebra is reduced by turning off the Z sector and assuming away depreciation.

In this model, the I-sector makes machines and sells them (at marginal cost) to the X-sector. Each machine produces a unique variety of X. New X-sector firms borrow F to buy the machine that is necessary to produce their unique variety. Banks, which are Cournot oligopolists (as far as the Cournot conjectures are concerned, the value of loans is the 'output' of the banking sector), maximize the return on their portfolios less overhead costs:

$$\max_{K_i, K_i^*} \ (R - r)FK_i + (R^* - \psi r)FK_i^* - B \tag{14}$$

where FK_i and FK_i^* are the values of loans made to the local and nonlocal markets, and R and R* are the local and nonlocal lending rates. To solve this problem, we must first find the inverse demand function for loans. X-sector firms demand loans to buy machines that produce a stream of income π. Since R times F is the carrying cost of such a loan, the flow of pure profits in the X-sector is π-RF. With free entry in the X sector, this must be zero; So in steady state, the inverse demand function for loans is therefore $R=\pi/F$, where π equals $E/\sigma K$ and $E=\pi K+L-L_I=(L-L_I)/(1-1/\sigma)$.** The inverse demand function of loans is therefore $R=E/\sigma KF$. Assuming that banks take economy-wide expenditure as given, the first order conditions for a typical bank in steady state are:

$$R(1 - s) = \rho, \quad R(1 - s^*) = \psi\rho \tag{15}$$

where s and s* are the local and export market shares, and we use the fact that $r=\rho$ in steady state.[9] The formulae for s and s* are $s=(1-m(1-\psi))/m(1+\psi)$ and $s^*=(m^{-1}-s)$, where m is the number of banks operating in a typical country.

Given this set up it is obvious that "reciprocal dumping" of financial services occurs for $\psi>1$. It is also obvious that reciprocal liberalization of financial services trade (i.e. $d\psi<0$) will have a procompetitive effect that will lower the equilibrium markup of R over ρ. This leads to an incipient rise in both countries' Tobin q, thereby stimulating capital accumulation worldwide. More specifically, K does not change but R falls due to the procompetitive effect in banking. This raises the stock market value of a typical machine since the same income stream is discounted at a lower rate. In the short run, this rise

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*We suppose that the cost is per-loan. An interesting extension would be to consider a per-bank market-entry cost.

**Free entry eliminates pure profits in banking, so E depends only on L and L_I.

boosts the demand for loans and bids up r up above ρ. In the long-run $r>\rho$ stimulates extra savings that is translated into a higher steady-state K. While K accumulates to its new steady-state level, output growth is above its steady-state level (which is zero in this simple model).

V. CONCLUDING REMARKS

This paper presents five theoretical openness-and-growth links that can account for trade-induced investment-led growth. The links are all demonstrated in a basic neoclassical growth model that incorporates various imperfect-competition trade models. These sorts of old-growth-theory-with-new-trade-models have not been thoroughly explored in the literature since the profession skipped from old-growth-old-trade models straight to new-growth-new-trade models. Nonetheless, such models are necessary to explain several key aspects of the econometric evidence on trade and growth. For example, the result that in cross-country data openness seems to affect growth only via its effect on investment, and the result that openness seems to promote investment in all countries whatever the capital-intensive of their exports (eg, see Levine and Renelt 1992, and Baldwin and Seghezza 1996).

The fundamental logic of the first link rests on two elements - the fact that traded goods and services are capital-intensive relative to nontraded goods and services, and the way in which reciprocal trade liberalization encourages expansion of traded sectors at the expense of nontraded sectors. Taken together, these imply that the massive postwar liberalization of rich country's trade has systematically boosted the demand for capital and thereby fostered faster-than-normal capital accumulation. This, of course, shows up as investment-led growth. Apart from the capital-intensities, the key assumption is that the optimal expenditure share on traded sectors rises as the price of traded goods falls relative to that of nontraded goods (this is true for CES preferences, for example). Given this, it is obvious that reciprocal trade liberalization will lead to a relative price change that favours the capital-intensive sector. The second section-III link presumes that investment-goods are produced using traded intermediates. In this case, liberalization lowers the marginal cost of investment goods (by lowering the cost of inputs) and thereby lowers the price of capital. As a consequence, the steady-state capital stock rises and transitional growth ensues.

Section IV presented three openness-and-growth links that are driven by the procompetitive mechanism (this is a mechanism by which reciprocal trade liberalization lowers prices and expands output in all liberalizing countries). The first link focuses on a procompetitive effect in the investment-goods sector. Here more competition means a lower price of capital. This raises the steady-state capital stock, thereby triggering investment-led growth in transition to the new steady state. The second link assumes that capital is used in the manufacturing of trade goods. Since the procompetitive mechanism forces an increase in the output of the traded goods sector, it boosts the derived demand for capital. This accelerates transitional capital formation and growth. The last link emphases the role of financial intermediation in determining the steady-state capital stock. If banks are imperfectly competitive and financial services are traded, the wedge between the rate savers receive and investors pay is endogenous and affected by trade policy. In particular, reciprocal liberalization of trade in financial services leads to a procompetitive effect that reduces this wedge and thereby boosts the steady-state capital stock in both countries. Investment-led growth is the result.

APPENDIX: *Transitional Dynamics with Tobin's q*

Due to I-sector perfect competition and X-sector free entry, we have that q=1 at all moments, so J=F at all moments. The stock market value is, by definition:

$$J(t) \;=\; \int_{s=t}^{\infty} e^{-\bar{r}[s](s-t)}\,(\pi[s]-\delta)\,ds \quad ; \qquad \bar{r}[s] \;=\; (1/s)\int_{v=t}^{s} r[v]dv \qquad \text{(A-1)}$$

Differentiating J with respect to time and recalling that F is time invariant (F=β), we have that $r_t J_t=\pi_t-\delta+\dot{J}_t=\pi_t-\delta$ or equivalently $r_t=(\pi_t-\delta)/F$ using time subscripts instead of the usual x(t) notation. We see from this that changes in π show are instantaneously transmitted to changes in r. The two state variables are real investment L_I (a jumper) and K (a nonjumper). Taking ϒ=0 so μ=1 to simplify the algebra, the two system equations are the

$$\dot{L}_I \;=\; (L-L_I)(\rho - r_t) \;=\; \frac{L-L_I}{F}\left(\rho F+\delta - \frac{L-L_I}{(\sigma-1)K_t}\right) \qquad \text{(A-2)}$$

Euler equations (with a change of variables to eliminate E)[10] since:

$$r_t \;=\; \frac{\pi_t-\delta}{F} \;=\; \frac{E_t}{\sigma F K_t} - \frac{\delta}{F} \;=\; \frac{L-L_I}{F(\sigma-1)K_t} - \frac{\delta}{F} \qquad \text{(A-3)}$$

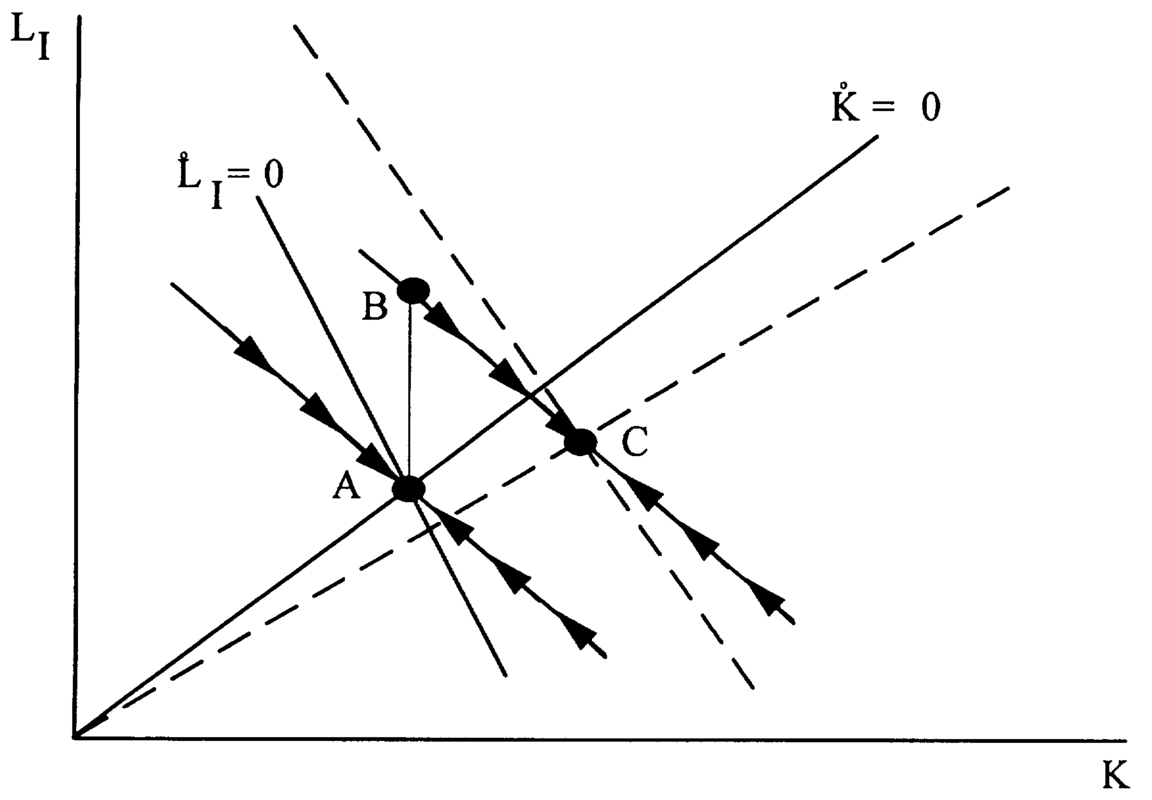
and K's law of motion:

$$\dot{K} = \frac{L_I}{F} - \delta K \qquad \text{(A-4)}$$

Clearly the isokines $\dot{L}_I=0$ and $\dot{K}=0$ are negatively and positively sloped as shown by the solid lines in figure 1. The stable arm is negatively sloped as drawn.

Supposing that the system starts in steady-state, a policy shock - such as an I-sector production subsidy (paid for with lump-sum taxation) - that lowers F will shift the isokines to those shown with dashed lines in Figure 1.

Figure 1



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SUPPLEMENT TO CALCULATIONS

1. Fact 1 comes from the fact that it is always more profitable to be a monopolist in a new product than to be a duopolist in an existing product. Facts 2 and 3 follow from the first-order conditions $p(1-1/\sigma)=w$ and $p^*(1-1/\sigma)=w\tau^*$, where "*" indicates export-market variables. Rearranging the local first order condition, $(p-w)c=pc/\sigma=s\mu E/\sigma$, where s is the local market share and c is local consumption of local varieties. Fact 3 follows from this and a similar rearrangement of the export market first-order condition. For more details see Helpman and Krugman (1985). The mill pricing term reflects the fact that firms charges the same price "at the mill" regardless of a good's destination.

2. By symmetry of nations, operating profit is:

$$\pi = \frac{s\mu E}{\sigma} + \frac{s^*\mu E^*}{\sigma} = (s + s^*)\frac{\mu E}{\sigma}$$

By symmetry of firms and nations, $Ks+Ks^*$ must equal unity, so $s+s^*=1/K$.

3. Here we use the facts that in steady state, $r=\rho$, and K and E are time invariant in steady state.

4. Log total differentiating (2-5):

$$\hat{q} = 0 = q_K\hat{K} + q_F\hat{F} \iff \frac{\hat{K}}{\hat{F}} = \frac{-q_F}{q_K} < 0$$

where the two partial elasticities q_F and q_K are:

$$q_F \equiv \left(\frac{\partial q}{\partial F}\right)\left(\frac{F}{q}\right) = \frac{-\delta\mu F}{\mu L/K-\delta\mu F-\delta(\sigma-\mu)} - 1 < 0$$

$$q_K \equiv \left(\frac{\partial q}{\partial K}\right)\left(\frac{K}{q}\right) = \frac{-\mu L/K}{\mu L/K-\delta(\mu(F-1)+\sigma)} < 0$$

(the signs are established by noting that both numerator and denominator of q are positive). Log total differentiating (3-2), we have:

$$\hat{F} = (1-\alpha)\left(\frac{\hat{K}}{1-\sigma} + \frac{\tau^{1-\sigma}}{1+\tau^{1-\sigma}}\hat{\tau}\right) \iff \frac{\hat{F}}{\hat{\tau}} = (1-\alpha)\left(\frac{\hat{K}}{(1-\sigma)\hat{\tau}} + \frac{\tau^{1-\sigma}}{1+\tau^{1-\sigma}}\right)$$

Thus:

$$\frac{\hat{K}}{\hat{\tau}} = \left(\frac{\hat{K}}{\hat{F}}\right)\left(\frac{\hat{F}}{\hat{\tau}}\right) = \frac{-q_F}{q_K}(1-\alpha)\left(\frac{\hat{K}/\hat{\tau}}{(1-\sigma)} + \frac{\tau^{1-\sigma}}{1+\tau^{1-\sigma}}\right)$$

$$<=> \quad \frac{\hat{K}}{\hat{\tau}} = \frac{q_F(1-\alpha)\tau^{1-\sigma}(\sigma-1)/(1+\tau^{1-\sigma})}{q_F(1-\alpha)-q_K(\sigma-1)}$$

The numerator of $\dot{K}/\hat{\tau}$ is negative since q_F is negative. Thus $\dot{K}/\hat{\tau}$ is negative (this is sufficient to establish the openness-and-growth link) when its denominator is positive. Investigating the denominator more closely, we see that:

$$q_F(1-\alpha)-q_K(\sigma-1) > 0 \quad <=> \quad \frac{(1-\alpha)}{(\sigma-1)} < \frac{q_K}{q_F}$$

From expressions for the two partial elasticities q_F and q_K:

$$\frac{(1-\alpha)}{(\sigma-1)} < \frac{q_K}{q_F} = \frac{-\mu L/K}{-\delta\mu F-\mu L/K+\delta\mu F+\delta(\sigma-\mu)}$$

$$<=> \quad \delta(1-\alpha)(\sigma/\mu-1) + (\alpha+\sigma-2)\frac{L}{K} > 0$$

Since L/K must be positive and the first term is positive, a sufficient condition for $\dot{K}/\hat{\tau}$ to be negative $\sigma+\alpha>2$. Lastly, since $0\leq\alpha\leq 1$, we know that $\sigma>2$ will always be sufficient to ensure that $\dot{K}/\hat{\tau}$ is negative.

5.More formally the first order conditions are:

$$p = \frac{a}{1-s/\epsilon}, \quad p^* = \frac{a\tau}{1-s^*/\epsilon}$$

By symmetry ns+ns*=1, so:

$$s = \frac{n\epsilon(\tau-1)+1}{n(1+\tau)}, \quad s* = \frac{1}{n} - s$$

Plainly s is falling in n and rising in τ. Rearranging the first order conditions, we have:

$$\pi = (p-a)x + (p-a\tau)x = s\left(\frac{px}{\epsilon}\right) + s^*\left(\frac{p^*x^*}{\epsilon}\right) = \left(\frac{s^2+s^{*2}}{\epsilon}\right)E$$

since E=E* by symmetry.

6. The intermediate steps for the first-order condition are as follows. Using the facts that

$$\pi = \frac{\mu E}{\sigma K} = \frac{E}{\sigma K}, \quad J = \frac{\pi-\delta}{\rho} = \frac{E/\sigma - \delta K}{\rho K}$$

in long-run equilibrium (steady state) and the fact that $J=P_K$, a typical I-firm's problem is to choose Q_{Ki} and Q_{Ki^*} to maximize $(J\text{-}F)Q_{Ki}+(J^*\text{-}\Gamma F)Q_{Ki}^*$. The first order conditions are:

$$J + Q_{Ki}\frac{dJ}{dK}\frac{dK}{dQ_{Ki}} = F\ , \quad J^* + Q_{Ki}^*\frac{dJ^*}{dK^*}\frac{dK^*}{dQ_{Ki}^*} = \Gamma F$$

where I-firms are assumed to take E as unaffected by their decision. Recalling that one unit is capital is produced from $F=\beta$ units of labour, using the fact that in steady-state $Q_K=\delta K$, and defining $1/\epsilon=-(dJ/dK)(K/J)$the local first order condition can be arranged:

$$J + Q_{Ki}(\frac{dJ}{dK})(\frac{K}{J})(\frac{J}{K})(\frac{dK}{dQ_{Ki}}) = F \iff J - Q_{Ki}(\frac{1}{\epsilon})(\frac{J}{Q_K})) = F$$

$$\iff J(1 - \frac{s}{\epsilon}) = F$$

because $\Sigma_i Q_{Ki}=\delta K$, so $dK/dQ_{Ki}=1/\delta$. The first order conditions in the text follows from symmetry. The expression for ϵ follows from:

$$\frac{1}{\epsilon} \equiv -(\frac{dJ}{dK})(\frac{K}{J}) = (\frac{E/\sigma K}{E/\sigma K - \delta}) = (\frac{E}{E - \delta\sigma K})$$

Plugging in the expression for E

$$\frac{1}{\epsilon} \equiv -(\frac{dJ}{dK})(\frac{K}{J}) = (\frac{\frac{L-L_I-nG}{1-1/\sigma}}{\frac{L-L_I-nG}{1-1/\sigma} - \delta\sigma K}) = (\frac{L-L_I-nG}{L-L_I-nG - \delta(\sigma-1)K})$$

$$\iff \epsilon = -(\frac{dJ}{dK})(\frac{K}{J}) = (1 - \frac{\delta(\sigma-1)K}{L-L_I-nG})$$

The expression in the text follows from symmetry.

7. We find this share as usual in an oligopoly model. Defining S=ns,

$$\frac{J(1-s^*/\epsilon)}{J(1-s/\epsilon)} = \frac{\Gamma F}{F} \iff (1-s^*/\epsilon)=\Gamma(1-s/\epsilon) \iff (1-S^*/n\epsilon)=\Gamma(1-S/n\epsilon)$$

$$\iff n\epsilon-1+S=\Gamma n\epsilon-\Gamma S \iff S=\frac{n\epsilon(\Gamma-1)+1}{1+\Gamma} \iff s=\frac{n\epsilon(\Gamma-1)+1}{n(1+\Gamma)}$$

8. The first order conditions are:

$$p(1-s) = a\ , \quad p^*(1-s^*) = a\tau$$

Since the demand for x is isoelastic given (2-1) with $\Upsilon=0$, $\sigma=\infty$. Using $p=p^*$, and defining S=ns,

$$\frac{p^*(1-s^*)}{p(1-s)} = \frac{a\tau}{a} \quad <=> \quad (1-\frac{1-S}{n}) = (1-\frac{S}{n})\tau \quad <=> \quad s = \frac{1+n(\tau-1)}{n(1+\tau)}$$

s* is therefore:

$$ns* = 1-n\frac{1+n(\tau-1)}{n(1+\tau)} \quad <=> \quad ns* = \frac{\tau-n(\tau-1)}{1+\tau} \quad <=> \quad s* = \frac{\tau-n(\tau-1)}{n(1+\tau)}$$

9. We have that:

$$\pi = \frac{E}{\sigma K}, \quad R = \frac{E}{\sigma F(\Sigma_i K_i)}$$

So the total demand elasticity for loans is unity. Thus the perceived elasticity for a typical bank is "s" and "s*", where s and s* are the bank's shares in its local and nonlocal markets.

10. The intermediate steps are:

$$\dot{L}_I = (L-L_I)(\rho - r_t)$$

$$r_t = \frac{\pi_t-\delta}{F} = \frac{E_t/(\sigma K_t) - \delta}{F} = \frac{E_t}{\sigma F K_t} - \frac{\delta}{F} = \frac{L-L_I}{F(\sigma-1)K_t} - \frac{\delta}{F}$$