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International Market Interdependence and Learning-by-Doing in a Risky World

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International Market Interdependence
and
Learning-by-Doing in a Risky World

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1. Introduction

Recent efforts around the world to liberalize markets for trade in goods and in assets highlight the need for a better understanding of the interaction among these markets. The implications of programs such as NAFTA and the creation of a single European market will reflect the dynamic adjustment of resource allocations and production that will occur in response to these new opportunities. Expanding trade on international financial markets and on commodity markets can be expected to shift trade and production patterns in favor of greater efficiency. Barriers to asset trade prevent complete international risk sharing, for example, and the presence of uncertainty interferes with a country's full exploitation of its comparative advantage.[1] The consequences of such a distortion are likely to extend not only to the current level of real income, but also to the future path of real income since today's production activities will often play a role in determining the development of tomorrow's technology.

This paper considers the importance of market completeness for the dynamic evolution of comparative advantage and growth in real income for a small economy. In particular, I focus on the risk-sharing function of international financial markets and its effect on the allocation of resources between production in two industries. This issue is addressed in a model where growth in labor's productivity arises endogenously via industry-specific learning by doing. The country's path of comparative advantage in the future is sensitive to current labor allocation decisions due to these learning-by-doing effects. When current productivity is subject to technology shocks, the completeness of international financial markets becomes critical for the determination of resource allocations and future growth.

The paper is organized as follows. Section 2 provides a description of the small economy environment, section 3 considers equilibrium labor allocation decisions for different market structures, and section 4 offers some concluding remarks.

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[1] Early work on the role of uncertainty in trade models includes Brainard and Cooper (1968), Kemp and Liviatan (1973), and Turnovsky (1974), and Batra (1975). Later contributions to this literature by Helpman and Razin (1978a,b,c) and Anderson (1981) incorporates international stock markets.

2. Productivity Risk in a Small Country

Consider a small country that produces in two industries using a single input, labor, according to technology which is subject to random disturbances. The productivity of labor in industry j, for j=X,Y, at date t is assumed to depend on the level of human capital specialized to industry j, h_{jt}, the production functions, f( ) and g( ), and on the value of the technology shock, $\Theta_{jt}(s)$, at time t in state s for s={1,2,...,S} as follows:[2]

$$(1) \qquad X_t(s) = \Theta_{xt}(s)h_{xt}f(n_{xt})$$

$$Y_t(s) = \Theta_{yt}(s)h_{yt}g(n_{yt}), \qquad n_{yt} = 1 - n_{xt}$$

where $\Theta_{xt}(s)$ and $\Theta_{yt}(s)$ are strictly positive shocks to the production of X and Y, respectively, which are identically and independently distributed over time, with means equal to one, variance σ^2, and correlation less than or equal to zero.[3,4] The fraction of the labor force allocated to industry j at date t is captured by n_{jt} and the size of the labor force is assumed constant over time and is normalized to one. The functions f( ) and g( ) are increasing, isoelastic, and strictly concave, with f'(0) and g'(0) equal to infinity. Thus, while the productivity of labor may grow without bound over time with the development of human capital, there are diminishing returns to labor at a point in time. To facilitate discussion let

$$f(n_{xt}) \equiv \frac{1}{1-a} n_{xt}^{1-a}, \quad \text{for } 0<\alpha<1, \text{ and}$$

$$g(n_{yt}) \equiv \eta f(n_{yt}), \quad \text{for } \eta>0.$$

The productivity of labor in each industry evolves over time with the accumulation of labor 'skills' or 'human capital.' These skills are acquired by learning by doing and as such are assumed to

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[2] This representation of growth by learning-by-doing follows the non-stochastic modelling of Lucas(1988) and Stokey(1988).

[3] Any positive correlation in Θ_{xt} and Θ_{yt} is omitted since only the industry-specific component of shocks affects the allocation of labor in this setting. See Feeney (1993a,b) for a comparison of the effect of aggregate versus industry-specific shocks for the determination of labor allocations.

[4] Henceforth, the state notation is dropped for simplicity.

be specific to an industry and develop as more work effort is devoted to that industry. The change in the level of skills over time is captured by

$$\dot{h}_{jt} = h_{jt}\delta_j n_{jt} \quad , \tag{2}$$

where a 'dot' over a variable denotes a time derivative. The maximum rate of growth in skills in each industry j is given by δ_j. It is assumed throughout that $\delta_x = \delta_y$. The benefits of the improvement in skills do not diminish over time and, consequently, learning by doing leads to perpetual growth in labor's productivity, in output, and in real income.[5] The level of human capital is generally assumed to depend on the *average* skills acquired by workers in the industry. Thus, rather than focussing on the development of a single individual's skills, learning by doing contributes to the overall proficiency in production in the industry, and that proficiency rises in proportion to the fraction of the total workforce employed therein.

The country is populated by many identical individuals with preferences of the representative individual given by,

$$E_t \int_0^\infty e^{-\mu t} u[C(x_t, y_t)] \, dt \tag{3}$$

over per capita consumption of X and Y, denoted x_t and y_t, respectively. E_t is the expectations operator and μ is the discount rate. The instantaneous utility function is assumed to be concave in the level of 'aggregate consumption,' as defined by the consumption function, $C(x_t, y_t)$, which is specified as Cobb-Douglas:

[5] It is well known that learning by doing in any one particular good is subject to diminishing returns over time. The characterization in this model is meant to represent a more complex environment wherein new goods are introduced within an industry, and the human capital acquired in producing goods within the same industry is passed on to these new goods. Thus, learning by doing at the industry level is not subject to diminishing returns. The development of goods within an industry is suppressed in this model and interested readers should see Stokey(1988).

$$(4a) \quad u[C(x_t,y_t)] \equiv \frac{1}{1-\rho} C(x_t,y_t)^{1-\rho} \qquad \text{for } \rho \neq 1 \text{ and}$$

$$\equiv lnC(x_t,y_t) \qquad \text{for } \rho = 1.$$

$$(4b) \quad C(x_t,y_t) \equiv x_t^{\alpha} y_t^{(1-\alpha)}$$

The coefficient of relative aversion to risk in the level of aggregate consumption is captured by ρ, the elasticity of substitution between goods is, of course, unity with Cobb-Douglas preferences, and α measures any taste bias in the home agent's preferences.

The rest of the world is assumed to be comprised of many countries. Technology for production in industries X and Y in each of these countries may be subject to shocks, although in the aggregate, world output levels are assumed to be constant across all states of nature. This stark contrast between the home country's risk exposure and that of the world is deliberately drawn to reveal the maximum potential benefits that would be available via *complete* risk diversification on international financial markets.

3. Market Completeness and the Evolution of Comparative Advantage

International financial markets play an important role for the determination of comparative advantage and for growth in aggregate output through their impact on labor allocations in a competitive equilibrium. Due to the presence of industry-specific technology shocks, risk averse individuals will alter the composition of the production bundle unless markets for diversification of such risk become available. Labor allocations that would arise in a closed economy are provided to establish a benchmark from which to contrast the influence of comparative advantage, uncertainty, and international financial markets for human capital accumulation, growth, and trade.

3.1 Equilibrium in a Closed Economy

The representative individual will choose to divide labor (or time) between the X and Y industries in order to maximize expected lifetime utility. Since all learning-by-doing effects are external to the individual, this choice is made with sole regard to current period tradeoffs. This combined with the assumptions of time separable preferences and non-storable goods insures that the maximization of lifetime utility collapses to a period-by-period decision problem. The infinite horizon problem, therefore, is solved as a one-period problem. At each date the agent will choose n_{xt} to maximize expected utility in period t. At the time that this decision is made, the exogenous productivity shocks remain unknown. Once n_{xt} is chosen, production takes place and the value of the technology parameter, Θ_{jt}, is revealed.

Formally, the agent solves the following problem in a closed economy:

$$\max_{n_{xt}} \; E\{u[C(x_t,y_t)]\} \tag{5}$$

$$\text{subject to} \quad x_t = X_t = \Theta_{xt} h_{xt} f(n_{xt}) \tag{6}$$

$$y_t = Y_t = \Theta_{yt} h_{yt} \eta f(1-n_{xt}) \; .$$

The first-order conditions require that

$$\frac{h_x f'(n_{xt})}{h_y \eta f'(1-n_{xt})} = \frac{E\{u_2[C(X_t,Y_t)]\theta_{yt}\}}{E\{u_1[C(X_t,Y_t)]\theta_{xt}\}} \tag{7}$$

where primes and subscripts denote partial derivatives.

In the absence of uncertainty, where $\Theta_{xt}=\Theta_{yt}=1$ for all states of nature (state notation suppressed) and time periods, t, the Cobb-Douglas aggregate consumption function guarantees that labor will be allocated according to the taste parameter, α. In such a non-stochastic environment, the first-order conditions imply

$$\frac{h_x f'(n_{xt})}{h_y \eta f'(1-n_{xt})} = \frac{u_2[C(\bar{X}_t,\bar{Y}_t)]}{u_1[C(\bar{X}_t,\bar{Y}_t)]} \; , \tag{8}$$

where $\bar{X}_t = h_{xt}\, f(n_{xt})$ and $\bar{Y}_t = h_{yt}\, \eta\, f(1-n_{xt})$. This can be expressed for the previously specified utility and production functions as

$$\frac{h_{xt}\; n_{xt}^{\;-a}}{h_{yt}\eta\;(1-n_{xt})^{-a}} = \frac{1-\alpha}{\alpha}\,\frac{\bar{X}_t}{\bar{Y}_t} \; . \tag{9}$$

This gives rise to the familiar solution for labor with Cobb-Douglas preferences:

(10) $n_{xt}/n_{yt} = \alpha/(1-\alpha)$.

When technology is stochastic, as originally introduced, the labor allocation will depend on the relative importance of aversion to risk in aggregate consumption, ρ, and on the elasticity of substitution between goods. A useful benchmark case appears when utility is isoelastic and separable in x and y ($u_{12}[C(x_t,y_t)]=0$). For the aforementioned specifications on C( ) and u[ ], this requires that ρ be set to unity (and log utility is assumed). In such a case, the labor allocation that arises in the world with uncertain productivity is identical to that chosen in a non-stochastic world:

$$(11) \qquad \frac{h_{xt} f'(n_{xt})}{h_{yt}\eta f'(1-n_{xt})} = \frac{E\{u_2[C(X_t, Y_t)]\theta_{yt}\}}{E\{u_1[C(X_t, Y_t)]\theta_{xt}\}} = \frac{u_2[C(\bar{X}_t, \bar{Y}_t)]}{u_1[C(\bar{X}_t, \bar{Y}_t)]},$$

for $X_t = \Theta_{xt} h_{xt} f(n_{xt})$, $Y_t = \Theta_{yt} h_{yt}\ \eta\ f(1-n_{xt})$, $\bar{X}_t = h_{xt}\ f(n_{xt})$, and $\bar{Y}_t = h_{yt}\ \eta\ f(1-n_{xt})$.[6] Consequently, a closed economy with a taste bias for X ($\alpha > .5$), for example, would devote more than half its labor force to the X industry. This in turn would cause human capital to grow more rapidly in that industry ($\hat{h}_{xt}$ would exceed $\hat{h}_{yt}$ in all periods), while the fraction of labor employed in each industry would remain constant by equation (10). The relative price of Y would rise over time.

3.2 Equilibria with International Markets

a. Labor allocation decisions

Initially, consider the impact on the labor allocation and on output growth of access to world spot markets for trade in goods. If this small country trades with the rest of the world at the non-stochastic world terms of trade, then all uncertainty regarding the *composition* of the consumption bundle disappears. The aggregate value of total production, however, continues to vary with the realizations of

[6] See Appendix for proof.

the productivity shocks.[7] The presence of this risk may serve either to reinforce comparative advantage in its effect on the labor allocation, or it may drive labor in a direction opposite to that dictated by comparative advantage. By contrast, the availability of international markets for risk sharing eliminates uncertainty in aggregate income so that the labor allocation is determined solely by the forces of comparative advantage. Since aggregate production in the rest of the world is non-stochastic, asset trade permits the home agent to diversify fully by trading state-contingent claims to output ex ante.[8] The labor allocations that arise for each of these market structures shall be considered in turn.

With access only to ex-post markets for trade in goods, the home agent faces uncertainty in aggregate income which can be mitigated to some degree by the choice of the allocation of labor between industries. Doing so, however, may reduce the extent to which the country's comparative advantage is exploited with trade. The term 'comparative advantage' itself becomes ambiguous when productivity shocks are introduced. The relevant concept for this discussion centers on the ex-ante expectation of labor's productivity across industries. In a non-stochastic setting, the country's comparative advantage would be determined by contrasting the domestic value of its autarky consumption bundle with its world value. With uncertainty, the values at home and in world trade of the *expected* levels of (autarky) consumption in the two industries are compared. Thus, the country is said to have a comparative advantage in X if

$$\frac{u_2[C(\bar{X}_t, \bar{Y}_t)]}{u_1[C(\bar{X}_t, \bar{Y}_t)]} > p_t \quad , \tag{12}$$

where $\bar{X}$ and $\bar{Y}$ denote the expected values of output in the two industries and p_t represents the known world relative price of Y in period t.

[7] For a discussion of the distinction between aversion to risk in composition and aversion to risk in aggregate income in a model with non-traded goods see Feeney and Jones (1994).

[8] A more simple asset structure -- one where equity is traded -- supports complete risk sharing as well. The small home country would sell all equity in its own firms on the world market and buy shares in the riskless world portfolio of equities.

Since the home agent can trade ex post (after production takes place and aggregate income becomes known), the decisions regarding the allocation of time spent working in each industry and that of choosing consumption over X and Y can be made sequentially. In the first stage, the agent allocates labor before the state of nature is revealed. Production then takes place, the productivity shocks become known, and the individual's level of real income is determined for the given terms of trade. In the second stage, trade occurs with the rest of the world to acquire the desired composition of consumption between x_t and y_t.

Solving the second-stage problem first, x and y will be chosen to

(13) $$\max_{x_t,\, y_t} \; u[C(x_t\,,\, y_t)]$$

$$\text{subject to } I_t \equiv \Theta_{xt} h_{xt} f(n_{xt}) + p_t \Theta_{yt} h_{yt} \eta f(1-n_{xt}) = x_t + p_t y_t$$

where n_{xt} is determined by the solution to the first-stage problem and where the level of income is state-dependent. The first-order conditions require that

(14) $$\frac{u_2[C(x_t, y_t)]}{u_1[C(x_t, y_t)]} = p_t \;.$$

where the composition of the consumption bundle is chosen optimally given the deterministic world terms of trade, p_t.

Letting $V[I_t, p_t]$ denote the indirect utility function that arises from this problem, the home agent allocates labor in the first stage, and prior to the resolution of uncertainty, to

(15) $$\max_{n_{xt}} \; E\left\{V[I_t, p_t]\right\}$$

$$\text{subject to} \qquad I_t = \Theta_{xt} h_{xt} f(n_{xt}) + p_t \Theta_{yt} h_{yt} \eta f(1-n_{xt}) \;,$$

where I_t varies across states. This gives rise to the following first-order condition:

(16) $$E\left\{V_I[I_t, p_t]\, [\Theta_{xt} h_{xt} f'(n_{xt}) - p_t\, \Theta_{yt} h_{yt} \eta f'(1-n_{xt})]\right\} = 0$$

where $V_I\,[I_t, p_t]$ is the marginal utility of income in state s at date t. Alternatively, this can be expressed as:

(16') $E\{V_I[I_t,\ p_t]\}[h_{xt}f'(n_{xt}) - p_t\, h_{yt}\eta f'(1-n_{xt})] + Cov\{V_I[I_t,\ p_t],\ [\Theta_{xt}h_{xt}f'(n_{xt}) - p_t\, \Theta_{yt}h_{yt}\eta f'(1-n_{xt})]\} = 0.$

This latter characterization will more clearly illustrate how the choice of labor allocation in the first stage problem will be influenced by aversion to risk in aggregate income in addition to the usual forces of comparative advantage. Before proceeding with a discussion of the sensitivity of the labor allocation to these two factors, the opportunities that arise with complete markets for international trade in goods and in assets are considered.

The opening of asset markets would not only allow the home agent to diversify the risk associated with the existing bundle of produced goods, but would also encourage a change in the composition of that bundle -- one that will be more risky. The home agent trades contingent claims and allocates labor prior to the resolution of uncertainty to

(17) $$Max\ E\ \{u[C(x_t(s), y_t(s))]\}$$

$$\text{subject to}\quad \sum_{s=1}^{n}\left[\tau_t(s)\Theta_{xt}(s)h_{xt}f(n_{xt}) + \phi_t(s)\Theta_{yt}(s)h_{yt}\eta f(1-n_{xt})\right] = \sum_{s=1}^{n}\left[\tau_t(s)x_t(s) + \phi_t(s)y_t(s)\right]$$

where $\tau_t(s)$ and $\phi_t(s)$ are world prices of claims to X and Y in state s at date t.

The first-order conditions for this problem imply

(18) (a) $$\frac{u_2[x(s), y(s)]}{u_1[x(s), y(s)]} = \frac{\phi(s)}{\tau(s)} = p$$

(b) $$\frac{u_2[x(j), y(j)]}{u_2[x(i), y(i)]} = \frac{\phi(j)}{\phi(i)} \qquad \forall\ s = i, j$$

(c) $$\frac{u_1[x(j), y(j)]}{u_1[x(i), y(i)]} = \frac{\tau(j)}{\tau(i)} \qquad \forall\ s = i, j$$

(d) $$E\{\lambda(s)[\tau(s)\Theta_x(s)h_xf'(n_x) - \phi(s)\Theta_y(s)h_y\eta f'(1-n_x)]\} = 0$$

where λ is the Lagrange multiplier which is equal to the marginal utility of income, $V_I[I(s),\ p]$.[9] Since uncertainty in the rest of the world is assumed to be purely idiosyncratic, the prices of contingent claims

[9] Time subscripts have been suppressed for notational simplicity.

to X and Y are constant across states and all risk in aggregate income is pooled. Since income is constant over states, $V_I[\ ]$ is known and (18d) becomes

$$(19) \qquad V_I[I,p]\ E\{\tau\Theta_x h_x f'(n_x) - \phi\Theta_y h_y \eta f'(1-n_x)\} = V_I[I,p][h_x f'(n_x) - p h_y \eta f'(1-n_x)]\tau = 0.$$

Consequently, labor is allocated so as to equate the value of labor's (expected) marginal product across industries. Note that this would be the condition for utility maximization when production is non-stochastic. With international financial markets, a comparative advantage in X will be fully exploited as in the absence of uncertainty.

b. Dynamics

Growth in real income depends on the rates of human capital accumulation across industries. Real income, when the small country has access to world goods markets but to not asset markets, is measured as the world value of its aggregate output:

$$I = \Theta_{xt} h_{xt} f(n_{xt}) + p_t \Theta_{yt} h_{yt}\, \eta f(1-n_{xt})\ .$$

The change over time in expected real income, $E\{I_t(s)\} = h_{xt} f(n_{xt}) + p_t\, h_{yt} f(n_{yt})$ reflects the average growth rate of real income since the productivity shocks are purely temporary. The change in expected real income is expressed as

$$(20) \qquad E\dot{I}_t = \dot{h}_{xt} f(n_{xt}) + h_{xt}\dot{f}(n_{xt}) + p_t \dot{h}_{yt} f(n_{yt}) + p_t h_{yt} \dot{f}(n_{yt}) \quad ,$$

and the *rate* of growth becomes

$$(21) \qquad \frac{E\dot{I}_t}{EI_t} \equiv E\hat{I}_t = \gamma_{xt}(\hat{h}_{xt} + \hat{f}(n_{xt})) + \gamma_{yt}(\hat{h}_{yt} + \hat{f}(n_{yt}))$$

where a 'hat' over a variable denotes proportional change. Fluctuations around this path will arise with the technology shocks. This indicates that the growth rate of aggregate output is a function of the rate of accumulation of human capital in each industry, $\hat{h}_{jt}$, by an amount that depends on the contribution of each industry to the national income, γ_{jt}. The effect of any changes in the allocation of labor across industries, $\hat{f}(n_j)$, will be insignificant since the total stock of labor is fixed and $\hat{f}(n_j)$ reflects only reallocations of this fixed stock between the two. Henceforth, these terms are set to zero.

Access to international financial markets alters the labor allocation chosen in the competitive equilibrium. The effect on the growth rate of real income, therefore is captured by

$$\text{(22)} \qquad \frac{\partial \hat{EI}}{\partial n_{xt}} = \frac{\partial \gamma_{xt}}{\partial n_{xt}} \hat{h}_{xt} + \gamma_{xt} \left[\frac{\partial \hat{h}_{xt}}{\partial n_{xt}} \right] + \frac{\partial \gamma_{yt}}{\partial n_{xt}} \hat{h}_{yt} + \gamma_{yt} \left[\frac{\partial \hat{h}_{yt}}{\partial n_{xt}} \right] ,$$

which can be rewritten as

$$\text{(22')} \qquad \frac{\partial \hat{EI}}{\partial n_{xt}} = h_{xt} f'(n_{xt})\, \hat{h}_{xt} - p_t h_{yt} \eta f'(n_{yt})\, \hat{h}_{yt} + \gamma_{xt}\, \delta_x - \gamma_{yt}\, \delta_y \quad .$$

3.3 Uncertainty, Asset Markets, and Comparative Advantage

The role of uncertainty and of international financial markets depends on the initial structure of production when goods and asset markets become available. Some of the possibilities that are discussed below may be more likely than others, but none can be ruled out on *a priori* grounds. The autarky equilibrium presented in Section 3.1 provides a useful benchmark to distinguish the forces of comparative advantage from those of risk aversion. Of primary interest, however, is the impact of liberalizing international financial markets in a world where trade in goods occurs. Two cases will be examined to capture the range of alternative dynamic paths that comparative advantage would follow with and without international financial markets. Given the home agent's taste bias for X, it seems natural to consider first the possibility that the accumulation of skills in the X industry that would have taken place in autarky would give this country a comparative advantage in the X industry with the opening of goods markets.

With a unitary elasticity of substitution between X and Y in consumption, the Y industry will not have disappeared and may even have remained quite large. This leads to a consideration of two cases: (i) an initially small X industry, as measured in terms of its expected share in (expected) aggregate output, and (ii) an initially large X industry. This distinction will be shown to be significant for the impact of international financial markets on the evolution of comparative advantage.

(i) If the home country, upon entering international commodity trade, finds itself with a comparative advantage in the X industry, then labor will have this incentive to move to the X industry, although uncertainty in the level of aggregate output will affect this shift. Expected utility will be maximized when equation (16') holds. The first half of this expression reveals the influence of comparative advantage on labor, while the second half captures the effect of uncertainty. Given a comparative advantage in X, the first half of (16') must be positive at the *autarky* labor allocation. Thus, labor would seek out this higher expected return in the X industry. If productivity were known, labor in X would rise until the (known) marginal products were equated. In the presence of the technology shocks, however, the uncertainty in the value of aggregate output becomes important. To derive this effect on the labor allocation, consider the hypothetical situation wherein labor is chosen to equate expected marginal utilities, so that the first term is zero. For this to be the competitive equilibrium, the covariance term must be zero. When the expected marginal utilities are equated, real income, I(s), will vary across states of nature whenever the two industries are of different sizes, since the shocks to productivity are drawn from the same distribution and are imperfectly correlated. In this case, it is assumed that X is the relatively small industry; i.e., $\gamma_x < \gamma_y$, where γ_j measures the expected share of industry j in expected aggregate income, $\gamma_x \equiv h_x f(n_x)/E\{I\}$ and $\gamma_y \equiv h_y \eta f(n_y)/E\{I\}$. In this case aggregate income covaries positively with the shock to the larger Y industry. Consequently, the covariance term will become positive at this allocation of labor since whenever the shock to Y is high the second term in the covariance will lie below its expected value, while the associated high level of income causes the marginal utility of income to fall below its expected value. In the absence of international financial markets, which would allow the diversification of this income risk, the home agent will be able to reduce this uncertainty only by shifting resources into the smaller X industry. As n_x rises the expected marginal product of labor in the X industry falls and the first term in (16') becomes negative, while the magnitude of the (positive) covariance term shrinks. Thus, by better diversifying the production bundle, the home agent mitigates the effect of the industry-specific technology shocks on real income.

The dynamic effects on comparative advantage and growth are sensitive to the initial direction of comparative advantage and to the effect of the uncertainty. Relative to the autarky benchmark situation, wherein n_x was already greater than n_y due to the taste bias, a comparative advantage in X raises work effort in the X industry. Thus, by this effect, the learning by doing that occurs in the X industry accelerates (see equation (2)). In addition, the desire to diversify the production bundle so as to reduce uncertainty in aggregate income further raises the fraction of the work force in the X industry. This causes human capital in the X industry to grow even faster and the comparative advantage in X will become more pronounced over time. As h_x increases, labor will continue to flow into X.[10]

If the home country engages in trade on international financial markets, then all risk can be pooled via asset trades and labor can be allocated strictly on the basis of comparative advantage. Thus, labor will be allocated so as to equate expected marginal products. This will affect both the dynamic path of comparative advantage and the rate of growth in aggregate output. In case (i) the presence of international financial markets will cause n_x to be lower than with goods markets alone. A *lower* degree of specialization will be associated with asset market liberalization which implies that the expected volume of trade on goods markets will be reduced. In addition, the expected gains from trade on goods markets will shrink when the composition of the production bundle becomes more similar to that of the consumption bundle. In this situation, therefore, it appears that the presence of asset markets serves to

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[10] Eventually, the (expected) share of the X industry in the national income will surpass that of Y. This is discussed in case (ii).

reduce trade on goods markets, and goods and asset markets play the role of substitutes in that sense.[11]

The degree of comparative advantage in X will still be increasing, but at a slower rate than with goods markets alone. The effect on the growth rate of income, however, will be ambiguous since lowering n_x would reduce labor in the faster growing industry (and thus reduce the weight on $\hat{h}_x$, γ_x, which lowers aggregate output growth), while raising n_y would increase the rate of growth in the larger industry (so growth in aggregate output would rise by this effect). Consequently, when goods and asset markets act as substitutes (which they will until the long-run equilibrium wherein γ_x exceeds γ_y is reached), the effect on the growth rate of real income remains ambiguous.

(ii) With a comparative advantage in X and $\gamma_x > \gamma_y$, if labor is chosen to equate its expected marginal products, the first term in (16') will be zero while the covariance term will be negative: income would lie above its expected value (and thus $V_1(\cdot)$ would lie below *its* expected value) whenever Θ_x exceeds Θ_y, while the difference in labor's marginal products would exceed its expected value of zero (and thus the second term in the covariance would exceed its mean) and vice versa. A reduction in the riskiness of real income is achieved through a reallocation of labor away from the larger X industry and towards Y. While the comparative advantage encourages labor to move into X, risk aversion reduces the desired fraction of the work force in the X industry. If the uncertainty or risk aversion is sufficiently severe, n_x will fall relative to the autarky benchmark. Despite this, n_x may remain greater than n_y. If so, then the degree of comparative advantage in X will increase over time ($\hat{h}_x > \hat{h}_y$), albeit at a slower rate. It is possible, however, for n_x to fall below n_y. In such a case, accumulation of human capital would occur more rapidly in the Y industry which would lead, eventually, to a reversal in the direction of the home country's comparative advantage. Thus, the presence of uncertainty, and the absence of markets for its diversification, could lead to a permanent shift in the country's pattern of trade.

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[11] For a discussion of the interdependence between international goods and asset markets in a static environment, see Feeney (1993a).

If instead, international financial markets are available, a greater share of labor would be driven to the X industry and the growth in human capital in X will accelerate. For an economy with a comparative advantage in the larger (X) industry, this case characterizes the long-run equilibrium growth path; with the world relative price constant, the small country will forever export X.[12,13] The rate of growth of aggregate output increases unambiguously: more labor is devoted to the higher growth industry (raising γ_x) and the larger industry (X) will now grow at a faster rate. Notice that asset markets encourages greater specialization in production. This will cause the composition of the production bundle to diverge further from that of the consumption bundle, causing the expected volume of trade in goods rises along with the expected gains from trade in goods. The higher growth rate of real income that arises with complete international financial markets reflects this complementary relationship between asset market liberalization and international goods trade.

4. Concluding Remarks

This paper has shown that the development of comparative advantage for a small economy depends on the availability of international markets for trade in goods and trade in assets. Without markets for risk diversification, industry-specific technology shocks encourages a reallocation of resources so as to diversify the production bundle. If the export industry is newly emerging, and so is relatively small, this response will speed the development of comparative advantage in that industry. Alternatively, if the export industry dominates aggregate output, then diversification is achieved by shifting resources to the import-competing sector and the rate of growth in comparative advantage is slowed. Opening international financial markets in the former case, causes a reduction in labor in the export sector,

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[12] If the world terms of trade were shifting over time, then this characterizatio of the long-run equilibrium remains valid when the rate of change in relative price does not exceed the home country's (relative) rate of human capital growth.

[13] The effects on long-run equilibrium growth are the subject of Feeney (1993b).

hampering the learning by doing in that industry which reduces the development of comparative advantage and the extent of trade on goods markets. By contrast, in the latter case, international risk sharing leads to greater production in the faster growing export sector, enhances comparative advantage and raises the growth rate of real income.

Appendix

Equivalence in Stochastic and non-Stochastic Closed Economies

The first-order conditions for the consumer's autarky maximization problem imply

$$\text{(A1)} \qquad \frac{h_{xt} f'(n_{xt})}{h_{yt}\eta f'(1-n_{xt})} = \frac{E\{u_2[C(x_t,y_t)]\Theta_{yt}\}}{E\{u_1[C(x_t,y_t)]\Theta_{xt}\}}$$

where $x_t(s) = \Theta_{xt}(s)h_{xt}f(n_{xt})$ and $y_t(s) = \Theta_{yt}h_{yt}\eta f(1-n_{xt})$ in autarky.

Initially, examine the optimal employment decision when the productivity parameters, Θ_x and Θ_y are known to equal unity. Then, the choice of labor allocation must satisfy the necessary condition that

$$\text{(A2)} \qquad \frac{h_{xt} f'(n_{xt})}{h_{yt}\eta f'(1-n_{xt})} = \frac{u_2[C(h_{xt}f(n_{xt}),h_{yt}\eta f(1-n_{xt}))]}{u_1[C(h_{xt}f(n_{xt}),h_{yt}\eta f(1-n_{xt}))]} \;.$$

The question then arises as to how and whether the presence of uncertainty affects the labor allocation.[14] If the labor allocation in a non-stochastic economy were to continue to be optimal in the stochastic economy, then it must be the case that both equations (A1) and (A2) hold for the same labor allocation so that:

$$\text{(A3)} \qquad \frac{u_2[C(h_{xt}f(n_{xt}),h_{yt}\eta f(n_{yt}))]}{u_1[C(h_{xt}f(n_{xt}),h_{yt}\eta f(n_{yt}))]} = \frac{E\{u_2[C(\Theta_{xt}h_{xt}f(n_{xt}),\Theta_{yt}h_{yt}\eta f(n_{yt}))]\Theta_{yt}\}}{E\{u_1[C(\Theta_{xt}h_{xt}f(n_{xt}),\Theta_{yt}h_{yt}\eta f(n_{yt}))]\Theta_{xt}\}} \;.$$

The certainty labor allocation will remain optimal under uncertainty (i.e., equation (A3) holds) when preferences are separable in x and y and when marginal utility can be expressed as the product of two functions:

(A4) $u'(\epsilon c) = k'(\epsilon)u'(c)$

where $k'(\epsilon)>0$, $k'(1)=1$, and $k''(\epsilon)<0$. In this case ϵ represents the technology shock and c denotes the expected consumption of x or y, $h_{xt}f(n_{xt})$ or $h_{yt}\eta f(n_{yt})$, respectively. Constant elasticity of substitution

[14] More specifically, the exercise is one of comparing two different economies: one with non-stochastic productivity and the other with technology shocks.

(CES) utility functions, for example, satisfy this condition wherein $g'(\alpha) \equiv u'(\alpha)$. Due to the imposition of separability the second argument in utility can be ignored. Equation (A3) then becomes

$$\text{(A5)} \qquad \frac{u'[h_{yt}\eta f(n_{yt})]}{u'[h_{xt}f(n_{xt})]} = \frac{E\left\{k'(\Theta_{yt})u'[h_{yt}\eta f(n_{yt})]\Theta_{yt}\right\}}{E\left\{k'(\Theta_{xt})u'[h_{xt}f(n_{xt})]\Theta_{xt}\right\}}$$

$$= \frac{u'[h_{yt}\eta f(n_{yt})]E\left\{k'(\Theta_{yt})\Theta_{yt}\right\}}{u'[h_{xt}f(n_{xt})]E\left\{k'(\Theta_{xt})\Theta_{xt}\right\}} = \frac{u'[h_{yt}\eta f(n_{yt})]}{u'[h_{xt}f(n_{xt})]}$$

since Θ_{xt} and Θ_{yt} are drawn from the same distribution.

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