

INTERNATIONAL RISK SHARING AND ECONOMIC GROWTH*

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International risk sharing which diversifies away income risk will reduce saving, with constant relative risk aversion. If growth arises from the external effects of human capital accumulation then reducing saving will reduce growth. Welfare also may fall with risk sharing, because endogenous growth with external effects of capital accumulation typically implies a competitive equilibrium growth rate already less than the optimal growth rate. We demonstrate these results in a standard, representative-agent economy. Diversifying away rate-of-return risk also will reduce saving and growth rates if relative risk aversion exceeds one, but this diversification always increases welfare.

I. INTRODUCTION

This paper studies the effects of international risk sharing (portfolio diversification) in a world economy in which growth rates of income are endogenous. Growth is based upon the spillover effects of human capital accumulation. As in Lucas (1988) and Romer (1986), there are positive, economy-wide spillovers of human capital intensity on individual labour productivity. In Section 2 we construct a multi-country growth model with an infinitely-lived representative agent in each country. Each country faces income risk but there is no aggregate uncertainty at the world level. We focus on two market structures. In the first structure there are no markets which allow for international diversification of country-specific income risk. In the second structure there are complete international markets for risk-sharing. With no aggregate "world" uncertainty, this completeness allows full diversification of country-specific risk.

The paper has two central results. First, growth rates in all countries are *lower* in the equilibrium with full diversification. Second, in this same structure welfare of each country may be *lower* than in an equilibrium without risk sharing. The reasoning is as follows. With external effects of capital accumulation the compet-

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itive equilibrium growth rate falls short of the optimal growth rate. In addition, with constant relative risk aversion (CRRA) in preferences riskier income leads to greater saving. With full risk sharing, income riskiness is diversified away, reducing the equilibrium savings rate in each country. Lower saving in turn tends to lower the growth rate in each country. Because the growth rate is inefficiently low to begin with, international risk sharing adds to this inefficiency. The gains from risk sharing have to be compared with the losses from a reduced growth rate. For reasonable parameter values the losses can dominate and welfare is lower. We conjecture that a partial diversification (as opposed to complete financial market integration) also will reduce growth, and may reduce welfare, to the extent that it pools income risk.

It is important that the source of national riskiness is in specific income. If, by contrast, countries differ in that they receive different draws from a common distribution of productivity disturbances, then financial market integration always raises welfare. This result holds even though financial integration again may lead to lower growth rates if the productivity distribution satisfies a "no aggregate uncertainty" condition. It also matters that there is only one technology. Integration may increase growth rates, even if it reduces savings rates, if it leads to a reallocation of savings to projects with high risk and return.

In many countries debates about economic policy reflect skepticism about the benefits of integration with the world economy. This skepticism may reflect the redistributive effects of opening international markets. But historically some opponents of international integration have argued that it would reduce growth rates: examples range from mercantilists to dependency theorists (see Heckscher 1955 and Prebisch 1959). Economic integration can have large welfare effects if trade affects growth rates. In growth models based on cross-industry spillovers in learning and on human capital accumulation respectively, Young (1991) and Stokey (1991) show that the welfare effects of integration (in the form of trade in goods) can be ambiguous—for example, small countries may be made worse off by integration. This result arises in examples in which there is an asymmetry between countries. Rivera-Batiz and Romer (1991) focus on links between similar countries and find that integration can increase growth and welfare if it encourages exploitation of increasing returns to scale in research and development, whether by trade in goods or by the flow of ideas. In this paper countries also are alike yet capital market integration can reduce growth rates and welfare for all countries.

2. INCOME RISK SHARING AND GROWTH

We first study a world economy with N countries and a single, homogeneous good. In each country there is an infinitely-lived, representative individual with CRRA preferences, given by

$$(1) \quad E_0 \sum_{t=0}^{\infty} \beta^t u(c_{it})$$

where $u(c_{it}) = c_{it}^{1-\sigma}/(1-\sigma)$ for $i = 1, 2, \dots, N$. There is no population growth. Lower case letters denote decision variables for individuals, while upper case letters denote economy-wide aggregates in country i .

Countries also have identical technologies for production. Output of the homogeneous good produced by a representative agent in country i is given by

$$(2) \quad y_{it} = \theta k_{it}^{\alpha} (H_{it} l_{it})^{1-\alpha},$$

where k_{it} is the firm capital stock. Hours l_{it} are supplied inelastically and population is normalized to $L = 1$. To simplify notation, let time zero capital stocks be equal across countries. The composite variable $H_{it} l_{it}$ denotes a human capital variable or the effective labour force. H_{it} , the stock of knowledge, acts as an Harrod-neutral technology growth parameter. To allow exact solutions for decision rules under each financial regime, we assume that capital depreciates fully within a period. Thus k_{it+1} is also time t investment for country i .

Following Arrow (1962) and Sheshinski (1967), we take the H_{it} term to be a function of the economy-wide stock of capital, denoted K_{it} . Following Romer (1986, 1987) and Hercowitz and Sampson (1991), we assume specifically that in equilibrium $H_{it} = K_{it}$ so that there are aggregate constant returns to scale in capital alone. This introduces an externality into the competitive economy in that the private return to capital is less than the social return. Consequently the competitive equilibrium rate of growth is inefficiently low, as in Romer (1987). This is central to our results. Modifying the model to make the stock of knowledge proportional to the world capital stock, instead of the national capital stock, would not affect the qualitative results.²

Residents of each country receive a country-specific, random endowment shock ε_{it} (in addition to produced output) in each period. This is the only source of uncertainty in the world economy. Moreover, it is this internationally diversifiable riskiness that generates a role for financial market integration. In order to introduce random, specific income shocks into a model with endogenous growth in produced output, the distribution of ε_{it} must be growing in proportion to output. If this were not the case, then the impact of these shocks would become negligible as growth in produced output continued but the moments of the shocks remained constant. In that case the only balanced growth equilibrium would be one in which the country-specific uncertainty plays no role. A simple way to allow for growth in the ε_{it} distribution is to assume that these shocks are proportional to the economy-wide capital stock in each country:³

$$(3) \quad \varepsilon_{it} = \gamma_{it} K_{it}.$$

² Similar externalities have been shown by Baxter and King (1991) and Klenow (1990) to be helpful in explaining business cycles.

³ The qualitative results of the paper do not depend on this specification of specific income risk. We have numerically investigated multi-period models in which there exists an externality of the type explored in the paper, but in which the externality is not large enough to generate endogenous growth. There the distribution of each country's capital stock is stationary, and hence we do not require income shocks to be proportional to the capital stock. We found that there are parameter values for which welfare falls with increased risk sharing.

The aim of the paper is to model only the effect of idiosyncratic country risk. Therefore the distribution of γ_{it} is chosen so that each country i faces an independent, mean-zero distribution of endowment shocks relative to its capital stock in each period, and, in a symmetric competitive equilibrium, aggregating across all countries, the world endowment shock is identically equal to zero at all times and states. To satisfy these requirements, the distribution of γ_{it} is parameterized in the following way. Define S_t as the vector $\{\gamma_{1t}, \dots, \gamma_{Nt}\}$. Let S_t be identically and independently distributed over time. For each t , S_t is uniformly distributed over the set $\{S^1, \dots, S^N\}$ where

$$S^1 = \{\bar{\gamma}_1, \bar{\gamma}_2, \dots, \bar{\gamma}_N\}$$

$$S^2 = \{\bar{\gamma}_N, \bar{\gamma}_1, \dots, \bar{\gamma}_{N-1}\}$$

⋮

$$S^N = \{\bar{\gamma}_{N-1}, \bar{\gamma}_N, \dots, \bar{\gamma}_1\}$$

and the $\bar{\gamma}_i$ parameters satisfy $\sum_{i=1}^N \bar{\gamma}_i = 0$. Thus, there are N possible, equally likely states for the realization of endowment shocks across countries, each country faces a mean zero, i.i.d. process for its income risk (in proportion to its capital stock) over time, and the aggregate world shock in a symmetric equilibrium is zero. The conditional expectation operator is defined with respect to this information. We may thus define the function $\gamma_{it} = \gamma_i(S_t)$ [e.g. $\gamma_1(S^1) = \bar{\gamma}_1$, etc.], which must satisfy $E_{t-1} \gamma_{it} = 0$, and $\sum_{i=1}^N \gamma_{it} = 0$. These conditions ensure that each country faces the same distribution of endowment risk (in a symmetric equilibrium with identical capital stocks across countries), and financial markets can fully diversify all risk because there is no aggregate uncertainty.

Individuals in country i choose consumption, investment, and asset holdings to maximize lifetime utility. Assume that individuals may trade state-contingent, one-period bonds. $q_t(S_{t+1}, S_t)$ is the price of a bond that pays one unit of output in state S_{t+1} (where $S_{t+1} \in \{S^1, S^2, \dots, S^N\}$) one period hence, given state S_t today. $b_{it}(S_{t+1}, S_t)$ is the total number of such bonds held by residents of country i . w_{it} is income of an individual in country i . We may then write the budget constraint of an individual in country i as

$$(4) \quad c_{it}(S_t) + k_{it+1}(S_t) + \sum_{j=1}^N q_t(S^j, S_t) b_{it}(S^j, S_t) < w_{it}(S_t)$$

$$(5) \quad w_{it+1}(S_{t+1}) = \theta k_{it+1}^\alpha (H_{it+1} l_{it})^{1-\alpha} + \varepsilon_{it+1}(S_{t+1}) + b_{it}(S_{t+1}, S_t).$$

We focus on two extreme financial market regimes. These regimes are differentiated by the degree to which state-contingent bonds are internationally tradeable. In the first environment, there is complete financial market autarky and no trade in assets between countries. This means that there will be zero net trade in assets in each country, because all individuals within a country are alike. This environment is termed "Financial Market Autarky." In the second environment, we allow all

state-contingent assets to be traded. Since there are N independent assets, international financial markets are complete, and therefore, with no aggregate uncertainty, each country can fully diversify away all income risk. We denote this environment "Financial Market Integration." There are clearly many intermediate cases of asset market arrangements between these two extremes. But the central aim of the paper, to show the welfare effects of financial market integration, is most clearly highlighted by comparing these two regimes.

2.1. *Financial Market Autarky.* A competitive equilibrium under Financial Market Autarky (FMA) is the functional sequence $\{c_{it}(S_t), k_{it+1}(S_t)\}$ $i = 1, \dots, N, t = 0, 1, \dots$ that satisfies the conditions:⁴

(a) Individual maximization, given by the problem: Maximize utility (1) subject to

$$c_{it}(S_t) + k_{it+1}(S_t) < w_{it}(S_t)$$

$$w_{it+1}(S_{t+1}) = \theta k_{it+1}^\alpha (H_{it+1} l_{it})^{1-\alpha} + \varepsilon_{it+1}(S_{t+1}),$$

(b) Market Clearing, given by

$$C_{it}(S_t) + K_{it+1}(S_t) = \theta K_{it}^\alpha (H_{it} L)^{1-\alpha} + \varepsilon_{it}(S_t),$$

(c)
$$H_{it} = K_{it},$$

(d)
$$\varepsilon_{it} = \gamma_i(S_t) K_{it},$$

(e)
$$k_{it} = K_{it}.$$

The Euler equations for the investment decision are written as

(6)
$$c_{it}^{-\sigma}(S_t) = \beta \alpha E_t \theta c_{it+1}^{-\sigma}(S_{t+1}).$$

Now substituting in the conditions (b), (c) and (d) of the definition gives the following decision rule for investment under FMA:

(7)
$$K_{it+1}(S_t) = [\beta \alpha \theta E_t (\theta + \gamma_{it+1})^{-\sigma}]^{1/\sigma} K_{it} \cdot (\theta + \gamma_{it}).$$

Define $\varphi \equiv [\beta \alpha \theta E_t (\theta + \gamma_{it+1})^{-\sigma}]^{1/\sigma} = [\beta \alpha \theta E (\theta + \gamma_{it})^{-\sigma}]^{1/\sigma}$, the first part of the right-hand side, which is a time-invariant function of the distribution of γ .

Expression (7) has the property that the riskiness of country-specific income affects national investment. A mean-preserving spread in the γ distribution raises $E(\theta + \gamma_{it})^{-\sigma}$, because $(\theta + \gamma_i)^{-\sigma}$ is convex in γ_i . This leads to a rise in the expected growth rate of capital. The explanation for this result is as follows. In this model of endogenous growth the average rate of growth depends on the factors that affect aggregate savings. Under FMA, savings behaviour is affected by the riskiness of specific income. A rise in specific income risk tends to raise savings, because with CRRA preferences (with positive third derivatives) there is a precautionary motive for saving as defined by Leland (1968), Sandmo (1970), and others, with

⁴ In this definition we model the household as both producer and consumer. Separating the decision problems of consumers and firms would not affect the results.

more recent contributions by Kimball (1990) and Caballero (1990). Thus, a mean-preserving spread in the distribution of country-specific income risk will raise the equilibrium savings rate of each country. This raises the average growth rate of output, because saving is equal to investment under financial market autarky.

The rate of growth under FMA is a random variable, given by

$$(8) \quad g_{\gamma_{it}}(S_t) = \varphi \cdot (\theta + \gamma_{it}).$$

The realization of country-specific income will affect the amount of saving and investment carried out in any period. Again using market clearing we may derive the solution for aggregate consumption

$$(9) \quad C_{it} = (1 - \varphi)K_{it} \cdot (\theta + \gamma_{it}).$$

Substituting consumption (9) into utility (1), and taking expectations dated $t = 0$, we derive an expression for unconditional welfare under FMA:

$$(10) \quad \frac{E(\theta + \gamma_i)^{1-\sigma} K_0^{1-\sigma} (1 - \varphi)^{1-\sigma}}{(1 - \sigma)[1 - \beta E(\theta + \gamma_i)^{1-\sigma} \varphi^{1-\sigma}]}$$

This can be stated in the simpler form

$$(11) \quad \frac{EC_{i0}^{1-\sigma}}{(1 - \sigma)[1 - \beta E(g_{\gamma_{it}})^{1-\sigma}]}$$

Utility is a function of expected first-period consumption, and the expectation of a function of the growth rate. Because each country faces an i.i.d. distribution of shocks, the expected growth rate is time invariant. We postpone further discussion of (11) until we derive the equilibrium under Financial Market Integration.

2.2. Financial Market Integration. A competitive equilibrium under Financial Market Integration (FMI) is defined as the set $\{c_{it}(S_t), k_{it+1}(S_t), b_{it}(S_{t+1}, S_t)\}$ $i = 1, \dots, N, t = 0, 1, \dots$, and the price function $q_t(S_{t+1}, S_t)$ that satisfies:

(a) Individual maximization, given by the problem: Maximize utility (1) subject to budget constraints (4) and (5),

(b) Market Clearing, given by

$$\sum_{i=1}^N C_{it}(S_t) + \sum_{i=1}^N K_{it+1}(S_t) = \sum_{i=1}^N \theta K_{it}^\alpha (H_{it} L_{it})^{1-\alpha},$$

$$(c) \quad H_{it} = K_{it},$$

$$(d) \quad \varepsilon_{it} = \gamma_i(S_t) K_{it},$$

$$(e) \quad k_{it} = K_{it},$$

$$(f) \quad \sum_{i=1}^N b_{it}(S^j, S_t) = 0 \quad \forall S_t, S^j.$$

The Euler equations for investment and asset holdings are given by

$$(12) \quad c_{it}^{-\sigma}(S_t) = \beta \alpha E_t \theta c_{it+1}^{-\sigma}(S_{t+1})$$

$$(13) \quad q_t(S^j, S_t) c_{it}^{-\sigma}(S_t) = (1/N) c_{it+1}^{-\sigma}(S^j),$$

for $i, j = 1, 2, \dots, N$. The term $(1/N)$ in condition (13) denotes the probability of each state.

The absence of aggregate uncertainty ensures that the price function q is a constant. This means that each country will chose a state-invariant consumption stream. We focus on a symmetric equilibrium with perfect pooling.⁵ Using symmetry with the market-clearing conditions in the definition of FMI gives $c_{it} = \theta k_{it} - k_{it+1}$. Combining this with the Euler equation (12) gives the law of motion for capital in each country:

$$(14) \quad K_{it+1} = (\beta \alpha \theta^{1-\sigma})^{(1/\sigma)} \theta K_{it} \equiv \psi \theta K_{it},$$

with ψ defined implicitly. This is the same as the solution under FMA, except for the absence of the γ distribution. By eliminating country-specific income risk, financial market integration eliminates the impact of this risk on savings, and therefore on economic growth. A comparison of equations (7) and (14) shows that financial market integration has two effects on the growth rate of income in each country. First the variance of the growth rate is eliminated. Second, the average growth rate is *reduced*, because the elimination of income risk reduces world savings.

Using market clearing, aggregate consumption can be written as

$$(15) \quad C_{it} = (1 - \psi) \theta \sum_{i=1}^N (K_{it}/N).$$

Substituting (14) and (15) into utility (1), and employing the assumption of identical initial capital stocks, welfare in any country may be written

⁵ This requires that the initial condition $b_t(S_0) + \varepsilon_t(S_0) = 0$ holds for each i . Implicitly we are assuming that asset trade at date $t - 1$ allows full diversification of specific income risk, including the risk from shocks that occur at date 0. We must make this assumption because of the artificial nature of the beginning of time. An alternative way to proceed would be to imagine that each market structure has been in place arbitrarily far back in the past, and welfare measures are taken only with respect to some starting date 0. But this would have the immediate consequence of making the capital stocks K_0 differ between the FMI and FMA case. In fact, our results outlined below follow whichever way we proceed, so we adopt the first method. The perfect pooling assumption is made for tractability alone. With nonperfect pooling equilibria the general characteristics of our results all remain, but the actual welfare expressions are much harder to compute.

$$(16) \quad \frac{\theta^{1-\sigma} K_0^{1-\sigma} (1-\psi)^{1-\sigma}}{(1-\sigma)[1-\beta\theta^{1-\sigma}\psi^{1-\sigma}]}$$

This is the same as expression (10) above, except with a zero realization of all γ_i terms.

Under FMI the parameter values which yield positive growth, positive consumption, and convergence of welfare must satisfy two restrictions. First, for positive growth we need $\psi\theta > 1$. From the definition of ψ , this requires that $\theta > (1/\alpha\beta)$. Second, if $\sigma < 1$ then $\theta < (1/\beta\alpha^{1-\sigma})^{1/(1-\sigma)}$. This region is nonempty and always includes $\theta = 1$, for example. We assume that under FMI θ is strictly interior to this region. Compared to FMI, FMA involves an increase in the growth rate, but there clearly is a region of the parameter space (for any value of σ) in which we can study either regime.

Is welfare raised by moving from FMA to FMI? Standard theory certainly would lead us to think so. Risk averse individuals should gain from the diversification of country-specific income risk. In this economy risk diversification has secondary effects on the average growth rate however. By reducing growth, diversification tends to reduce the mean as well as the variance of a country's income. The effect of reducing the mean, in itself, will tend to reduce welfare.

Despite the negative effects on growth, we might still expect that the overall effect of FMI would be to raise welfare. But this implicitly presumes that the only deviation from optimality in the FMA regime is the absence of financial markets. In fact, there is a second inefficiency; the competitive equilibrium growth rate is inefficiently low, due to the external effects of human capital. When this is taken into account, there is no longer an immediate presumption that financial market integration will raise welfare. While financial market integration allows for full risk sharing, raising average welfare, it also leads to a fall in the growth rate, moving it away from the Pareto efficient rate. It may be that the second effect dominates and average welfare falls in response to a financial market integration.

To show this result take the welfare expression under FMA given by (10). This differs from (16) only due to the terms pertaining to the γ_{it} distribution. By linearizing (10) around the point $\gamma_{it}(S_t) = 0$, the welfare impact of a small increase in the variability of specific income, beginning with a welfare equal to that under FMI, can be computed. The function (10) may be written implicitly as

$$(17) \quad F[Ea(\gamma), Ed(\gamma)]$$

where $a(\gamma) \equiv (\theta + \gamma)^{1-\sigma}$ and $d(\gamma) \equiv (\theta + \gamma)^{-\sigma}$. Then approximate (17) by

$$(18) \quad F[Ea(\gamma), Ed(\gamma)] \approx F[a(0), d(0)] + F_1[a(0), d(0)](Ea(\gamma) - a(0)) \\ + F_2[a(0), d(0)](Ed(\gamma) - d(0)),$$

where

$$(Ea(\gamma) - a(0)) = \frac{1}{2} \sigma(\sigma - 1) \theta^{-(1+\sigma)} \text{Var}(\gamma)$$

$$(Ed(\gamma) - d(0)) = \frac{1}{2} \sigma(\sigma - 1)\theta^{-(2+\sigma)} \text{Var}(\gamma),$$

and subscripts denote partial derivatives. Second-order terms in the F approximation are ignored, since they give expressions in $\text{Var}(\gamma)^2$, which is of a second-order magnitude. By computing the derivatives of the F function it may be shown that

$$(19) \quad F[Ea(\gamma), Ed(\gamma)] - F[a(0), d(0)] = A[-\sigma + (1 - \alpha)D] \frac{1}{2} \text{Var}(\gamma)$$

with $A, D > 0$ defined as

$$A = [1 - (\beta\alpha\theta^{1-\sigma})^{(1/\sigma)}]^{1-\sigma} \theta^{-(1+\sigma)} / [1 - (\beta\alpha\theta)^{1-\sigma}]^{1/\sigma}]^2,$$

$$D = (1 + \sigma)(\beta\alpha\theta^{1-\sigma})^{1/\sigma} / \alpha [1 - (\beta\alpha\theta)^{1-\sigma}]^{1/\sigma}.$$

How may equation (19) be interpreted? Notice from equation (2) that the size of the externality associated with human capital accumulation depends on the share of labour in production. The larger is α , the smaller is the difference between the social and the private returns to capital. In the limit, as α goes to one, the private and social returns coincide, because there is *no* externality due to human capital. In that case, the model becomes a linear “AK-type” model (see Rebelo 1991), and the competitive growth rate is efficient. But for $\alpha < 1$, the competitive growth rate falls short of the socially optimal growth rate. Thus, the α parameter is a useful measure of the degree to which the human capital externality plays a role. For a given growth rate of capital, altering the α parameter has no other effects because labour is supplied inelastically.

Bearing this discussion in mind, we may return to equation (19). The term inside the large parentheses is of ambiguous sign. The first expression, $-\sigma$, captures the direct impact of increasing income riskiness on welfare, holding the average growth rate constant. This is clearly negative, as long as agents are risk averse (*i.e.* $\sigma > 0$). The second term, $(1 - \alpha)D$, captures the welfare effects of the secondary change in the average growth rate. This is positive. For $\alpha = 1$ the second term is zero, because when the competitive growth rate is efficient the impact of changes in the growth rate (caused by the investment response to changes in income riskiness) is, to a first order, zero. In that case, the only effect on welfare is the direct effect of income riskiness. Then a small increase in $\text{Var}(\gamma)$ reduces welfare in each country. Therefore, FMI can only increase welfare, despite the negative impact on the average rate of growth.

However, for $\alpha < 1$, this result is no longer assured. An increase in the growth rate due to an increase in income riskiness has a first-order effect on welfare, because the rate of investment is inefficiently low. It may be possible for this secondary, growth effect of an increase in income riskiness to offset the direct effect, and therefore for welfare to increase in response to a small increase in idiosyncratic national income risk.

Figure 1 bears out this result. It is based on the special case of a two-state distribution for endowment risk, with $S^1 = \{-\bar{\gamma}, \bar{\gamma}\}$, $S^2 = \{\bar{\gamma}, -\bar{\gamma}\}$ and therefore

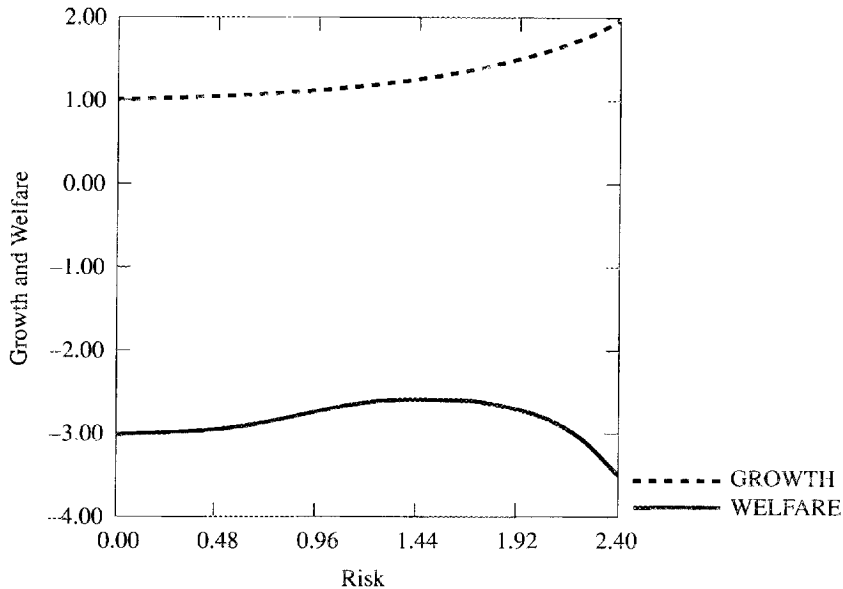


FIGURE 1

GROWTH AND WELFARE AS INCOME RISK INCREASES

a two-country example. The parameter values are $\sigma = 2$, $\alpha = 0.3$, $\beta = 0.9$ and $\theta = 3.85$, with an initial condition $K_0 = 1$. The horizontal axis measures $\bar{\gamma}$ so that risk increases to the right. The vertical axis measures FMA welfare (equation (10)) and the gross growth rate (equation (8)) averaged across the two countries. Figure 1 illustrates that welfare increases in $\bar{\gamma}$, starting at $\bar{\gamma} = 0$. This can be thought of as a transition from FMI to FMA, for successively increasing variances of country-specific income risk. Figure 1 also illustrates the effect on the growth rate of the same experiment.

2.3. Stochastic Technology. The fact that country risk is in specific income rather than in the technology is important for our results. Imagine that countries differed only in that they experienced different realizations of a Hicks-neutral technology shock θ . It can then be shown that, even in the presence of the human capital externality, financial market integration always will enhance welfare. Moreover, this is the case even when financial market integration reduces world growth rates.

In reality we would expect to see a joint distribution of the θ shocks that exhibited both a high degree of persistence and cross country correlation between the shocks. We are interested primarily in the potential of financial markets to pool technology shocks, however, so we proceed as in the last section to choose a highly specific distribution of θ which satisfies a “no aggregate uncertainty” property.

Similar results could be derived from a model in which national technology shocks were independent, as the number of countries grew without bound.

Suppose that each country receives a specific shock θ_{it} but that $\sum_{i=1}^N \theta_{it} = \bar{\theta}$, and $E_{t-1}(\theta_{it}) = \bar{\theta}$. Using the same approach as in Sections 2.1 and 2.2 one can show that under FMA the growth rate for any country i is $\vartheta\theta_{it}$, where $\vartheta \equiv [\beta\alpha E(\theta_i)^{1-\sigma}]^{1/\sigma}$. Welfare is

$$(20) \quad \frac{E(\theta_i)^{1-\sigma} K_0^{1-\sigma} (1 - \vartheta)^{1-\sigma}}{(1 - \sigma)[1 - \beta E(\theta_i)^{1-\sigma} \vartheta^{1-\sigma}]} = \frac{EC_{t0}^{1-\sigma}}{(1 - \sigma)[1 - \beta E(g_{\theta i})^{1-\sigma}]}$$

Under FMI the growth rate is $v\bar{\theta}$, where $v \equiv (\beta\alpha\bar{\theta}^{1-\sigma})^{1/\sigma}$. Welfare is

$$(21) \quad \frac{\bar{\theta}^{1-\sigma} K_0^{1-\sigma} (1 - v)^{1-\sigma}}{(1 - \sigma)[1 - \beta \bar{\theta}^{1-\sigma} v^{1-\sigma}]}$$

Financial integration will have an ambiguous effect on the growth rate in this case. When $\sigma > 1$ ($\sigma < 1$) the growth rate will fall (rise), relative to the growth rate under FMA. This arises because of the familiar ambiguity over the savings response to rate-of-return risk. This response will be positive when $\sigma > 1$, and therefore only in this case will financial integration, by reducing riskiness in the technology, lead to lower growth rates. The case of $\sigma > 1$ is probably the most relevant empirically, nevertheless.

But whatever the effect on growth, it is always the case that financial integration raises welfare. To show this write FMA welfare (expression (20)) as $U[Em(\theta)]$ where $m(\theta) \equiv \theta^{1-\sigma}$. Expanding welfare around $m(\bar{\theta})$, we may show

$$U[Em(\theta)] - U[m(\bar{\theta})] = -M \left[\frac{1}{(1 - v)} + \frac{v(1 - \sigma)}{\sigma(\alpha - v)(1 - v)} \right] \frac{1}{2} \text{Var}(\theta),$$

where $M > 0$. This is unambiguously negative (the expression $(\alpha - v)$ must be positive if utility is to converge). Thus, starting from full integration, a small amount of technology risk always reduces welfare. Equivalently, financial market integration must raise welfare when risk is due to technology shocks alone.

The difference between the welfare here and those of Section 2.2 may be seen by examining the expressions for utility, (11) and (20). In both cases, the important element is the impact of financial market integration on the effective discount factor; $\beta E(\theta + \gamma_i)^{1-\sigma} \varphi^{1-\sigma}$ for the case of income uncertainty, and $\beta E(\theta_i)^{1-\sigma} \vartheta^{1-\sigma}$ in the case of technology uncertainty (the effect of FMI through the $E(C_0)^{1-\sigma}$ term will always raise welfare). In the first case, write this term as $E[(\theta + \gamma_i)/\theta]^{1-\sigma} (Eg_\gamma)^{1-\sigma}$ and in the second case as $E(\theta_i/\bar{\theta})^{1-\sigma} (Eg_\theta)^{1-\sigma}$. This highlights the fact that FMI affects welfare by altering the mean growth rate Eg , and the riskiness of the growth rate, (captured by the first term in each expression of the previous sentence). In the case of income riskiness, the negative welfare effect of FMI on the mean growth rate always will dominate the positive effect on the riskiness of the growth rate, so that when taking the impact on $E(C_0)^{1-\sigma}$ into account, welfare may fall. But it is easily shown that with technology risk, the opposite holds. The fall in the riskiness of growth in response to FMI *always*

dominates the effect on the mean growth rate. Thus welfare always rises, despite the possibility that the mean growth rate falls.⁶

The economic rationale for the differing welfare effects of the two shocks is straight-forward. With either income (additive) shocks or rate-of-return (multiplicative) shocks the equilibrium technology is linear in the capital stock. But for an income shock, the private rate of return is simply $\theta\alpha$, which is unaffected by the shock. For a rate-of-return shock the private rate of return is $\theta_i\alpha$, which is affected by the multiplicative shock. The two shocks give the same technology in the aggregate, but do not affect private returns and decisions in the same way.

Growth rates are determined by combining this equilibrium technology with the standard Euler equation. With a multiplicative shock private returns and future consumption covary positively, so that returns will covary negatively with the marginal utility of future consumption. That makes growth (brought about by a mean-preserving spread in the shock density) in the case with multiplicative shocks *riskier* where risk refers to this covariance, as in standard asset-pricing. That risk accounts for the fact that welfare always falls with increasing risk in the case with stochastic technology; the private return correctly reflects part of the shock, so that the externality is not as marked as in the case of income risk.

3. DISCUSSION

In the example of this paper the direct, positive, welfare effect of risk sharing can be outweighed by the negative effect of reduced precautionary saving, because the competitive quantity of saving and investment is suboptimal to begin with. The suboptimality arises from an externality which remains after integration, so that a second-best problem exists. The effect of risk sharing on welfare (whether for countries or for individuals within a country) is ambiguous in the case of endowment uncertainty but is always positive in the case of rate-of-return uncertainty.

The negative welfare effects found here could be reversed if governments were to subsidize investment at the appropriate rate. The environment here (in which

⁶ A two-period example that does not rely on approximation may help to convey the intuition with respect to the impact of financial market integration in the presence of stochastic technology. Let the environment be exactly the same as in the text, but assume there are only two periods. Define $W_0 = \theta_0 K_0$. Then it is easy to derive the optimal level of investment for the two-period economy as

$$K_1 = \frac{\vartheta}{(1 + \vartheta)} W_0,$$

where ϑ is defined in the text. Substituting into the two-period utility function, the expression for expected utility under FMA is

$$\frac{W_0^{(1-\sigma)(\alpha + \vartheta)}}{\alpha(1-\sigma)(1+\vartheta)^{(1-\sigma)}}.$$

A reduction in the variability of the technology will reduce (increase) ϑ as $\sigma > 1$ ($\sigma < 1$), by Jensen's inequality. It is then immediate from this expression that welfare will rise in either case. (For the case $\sigma = 1$ the result is the same, but must be derived by applying the logarithmic utility function at the start.)

autarky can be preferred to risk sharing) features a second-best problem. Thus there are a number of tax-subsidy policies that could be implemented to achieve first-best allocations.

Devereux and Smith (1991) conduct a similar analysis for an economy with overlapping generations (OLG) and endogenous growth. An advantage of that structure is that partial diversification can be studied analytically. In addition, it allows us to track the dynamic effects of financial integration on welfare of successive generations. Again, it is shown that financial market integration (with income risk) reduces economic growth. But the intergenerational welfare effects of integration show a sharp dichotomy (similar to that noted by Fried 1980). Early generations gain from integration, because the growth effects in early periods are small, and are dominated by the direct risk-sharing effects. But over time lower growth rates lead to national income levels significantly below those that would occur under autarky. Later generations thus lose from integration.

Kohn and Marion (1992) also study an OLG economy with growth based on an externality (knowledge), which acts between generations rather than across firms. As in this study, the technology affects one's evaluation of trade in assets. Capital flows respond to interest rates, which do not reflect country-specific externalities. They find that opening capital markets can make some countries better off and others worse off. In our case all countries can be made worse off from free trade in assets, even if the externality is international. Buiter (1991) outlines the effects of fiscal policy and demographic change on savings, and hence growth, in OLG economies.

The analysis here can be thought of as a simple counterexample to the presumption that risk sharing raises welfare. It isolates a pure, risk-sharing effect, without scale effects, specialization, or portfolio reallocation. The main finding of this paper is that integrating financial markets internationally may reduce growth and welfare in a standard model of endogenous growth. More generally, financial integration or other financial development may affect growth by affecting saving rates, by affecting the allocation of saving, or by affecting the marginal product of capital. Pagano (1993) surveys recent studies of these effects.

Financial integration may affect savings rates as a result of risk sharing, as we have shown. Jappelli and Pagano (1994) study an alternative means by which savings rates might change. If young agents are liquidity constrained and hence over-save then financial liberalization which loosens constraints may lower saving and growth rates (unless the young invest largely in education).

Several studies have focussed on the effect of risk sharing on the allocation of savings. Domar and Musgrave (1944) used mean-variance analysis to show that proportional taxes, with full loss offset, may promote investment in risky assets. Stiglitz (1969) showed the same effect for the CRRA utility used here. Eaton (1981) studied this issue in the general equilibrium setting of the neoclassical one-sector growth model. He found that lowering taxes on the risky component of returns may decrease mean growth rates by adding to private risk. Elmendorf and Kimball (1991) showed that policies which reduce income risk (in their case an income tax as opposed to FMI) will reduce savings (with a precautionary savings motive) but also will change the composition of savings, increasing the demand for (independ-

dently) risky assets. The CRRA utility function used in studying balanced growth displays both decreasing absolute risk aversion and decreasing absolute prudence. These properties are necessary and sufficient for standard risk aversion (see Kimball 1993), so that a reduction in income risk makes agents willing to face more of another, independent risk. Diversifying rate-of-return risk also has this allocative effect.

The reallocation of savings to projects with high risk and return promotes growth. In our case there is only one investment technology. But if there are others, then FMI may encourage a substitution of investment towards risky technologies, by pooling income or return risk. This effect has been discussed in various contexts by Bencivenga and Smith (1991), Greenwood and Jovanovic (1990), Levine (1991), Obstfeld (1994), and Saint-Paul (1992). In these studies the positive effect on growth of a reallocation of savings dominates the negative effect of any reduction in savings rates. In Levine's (1991) study the savings rate is constant, because young (three-period lived) agents do not consume. Saint-Paul (1992) has a coefficient of relative risk aversion below one so that insuring rate-of-return risk raises saving.

Obstfeld (1994) studies endogenous growth brought about by nondiminishing private returns to capital, rather than by an externality; in our case the externality accounts for the possibility that risk sharing reduces welfare. With isoelastic utility he finds that a decrease in rate-of-return risk brought about by FMI will reduce savings if relative risk aversion exceeds one (as in Section 2.3) but that this effect is outweighed by a portfolio shift into risky assets, so that growth increases. In this case, the welfare gains from financial market integration are potentially very large.

The general ideas in this paper require that savings rates depend on income risk and rate-of-return risk. The use of time-separable, CRRA preferences determines that dependence and thus affects the specific examples. The same issues could be studied under alternative preferences. Weil (1990) shows that, with generalized isoelastic preferences which do not satisfy the axioms of expected utility and in which risk aversion can be distinguished from (the inverse of) intertemporal substitution, the response of saving to interest-rate risk depends in sign only on intertemporal substitution, though risk aversion affects the magnitude. With the technology here, FMI could then be expected to reduce savings and growth rates if the elasticity of intertemporal substitution is less than one. With such preferences and with portfolio reallocation possible, Obstfeld (1994) relates the effect of FMI on growth to both intertemporal substitution and risk aversion, for rate of return shocks. As for income risk, recent closed-form solutions for consumption functions under a variety of environments (e.g. Weil 1993, van der Ploeg 1993) show that the precautionary savings motive may be affected by a number of features of preferences and technology.

In assessing the empirical relevance of any of these results one also should consider other features of international integration that we have not modelled, including possibly scale effects of the type identified by Rivera-Batiz and Romer (1991) in trade in goods and in the flow of ideas. Again, these features might conflict with, and possibly overturn, the welfare results developed above.

Other research involves calibrating the growth model and undertaking empirical measurement. Cole and Obstfeld (1991) and Obstfeld (1992) calculate compensating and equivalent variations for international diversification for calibrated economies

without endogenous growth. They find the welfare gains from risk sharing to be very small. van Wincoop (1991) finds large gains to international risk sharing, with nontradeable income risk. Similar methods could be used to estimate the empirical welfare variations in models with endogenous growth; the link between risk and growth suggests that they could be much larger, as Obstfeld (1994) finds. Moreover, related methods could be used to study the effects of risk sharing between individuals within countries.

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