Queen's Economics Department Working Paper No. 829

International Risk Sharing and Economic Growth

Michael B. Devereux Gregor W. Smith

Department of Economics
Queen's University
94 University Avenue
Kingston, Ontario, Canada
K7L 3N6

8-1991

INTERNATIONAL RISK SHARING AND ECONOMIC GROWTH

Discussion Paper # 829

Michael B. Devereux and Gregor W. Smith

August 1991

Abstract

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 standard, representative-agent and overlapping-generations economies. In the same economies diversifying away rate-of-return risk also will reduce saving and growth rates if relative risk aversion exceeds one.

Department of Economics, Queen's University, Kingston, Ontario, Canada K7L 3N6. We thank the Social Sciences and Humanities Research Council of Canada for support of this research and colleagues at Queen's for helpful criticism.

1. 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 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 competitive 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. Since 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.

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 holds despite the fact that, if the productivity distribution satisfies a 'no aggregate uncertainty' condition, then financial integration again may lead to lower growth rates.

Section 3 conducts a similar analysis for an economy with overlapping generations and endogenous growth. An advantage of this structure is that partial diversification can be studied analytically. In addition, this structure allows us to track the dynamic effects of financial integration on welfare of successive generations. Again, it is shown that financial market integration reduces economic growth. But the intergenerational welfare effects of integration show a sharp dichotomy. Early generations will gain from integration, since the growth effects in early periods will be small, and are dominated by the direct risk-sharing effects. But over time the effects of lower growth rates lead to national income levels significantly below those that would occur without integration. This will lead later generations to lose from integration.

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), Prebisch (1959), and Erlich (1960)). Economic integration can have large welfare effects if trade affects growth rates. In growth models based on human capital accumulation Stokey (1991) and Young (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. Infinite-Horizon Representative-Agent Model

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

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_{it}) \tag{2.1}$$

where $u(c_{it}) = c_{it}^{1-\sigma}/(1-\sigma)$ for $i = 1, 2, \ldots N$. 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, given by

$$y_{it} = \theta k_{it}^{\alpha}(H_{it}l_{it})^{(1-\alpha)} \tag{2.2}$$

y_{it} is output of the homogeneous good produced by a representative agent in country i. Hours l_{it} are supplied inelastically. k_{it} is the firm capital stock. 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 a Hicks 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 to 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 all 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.

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:[1]

$$\epsilon_{it} = \gamma_{it} K_{it}. \tag{2.3}$$

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 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 $\{\gamma_{1t}, \ldots, \gamma_{Nt}\}$. Let S_t be identically and independently distributed over time. For each t, S_t is uniformly distributed over the set $\{S^1, \ldots, S^N\}$, where

$$\begin{aligned} S^1 &= \{\bar{\gamma}_1, \bar{\gamma}_2, \ldots, \bar{\gamma}_N\} \\ S^2 &= \{\bar{\gamma}_N, \bar{\gamma}_1, \ldots, \bar{\gamma}_{N-1}\} \\ &\vdots \\ S^N &= \{\bar{\gamma}_{N-1}, \bar{\gamma}_N, \ldots, \bar{\gamma}_1\} \end{aligned}$$

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 over time, and the aggregate world shock 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 since 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

[1] The qualitative results of the paper do not depend on this specification of specific income risk. For instance, take a two-period example in which agents invest in the first period and there is risky income in the second period with the ϵ_i distribution not proportional to the capital stock. As long as there is an externality in the accumulation process the perverse welfare effects of risk-sharing may still arise in this example.

$S_{t+1} \in \{S^1, S^2, \ldots, S^N\}$) 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

$$c_{it}(S_t) + k_{it+1}(S_t) + \sum_{j=1}^{N} q_t(S^j, S_t) b_{it}(S^j, S_t) < w_{it}(S_t) \tag{2.4}$$

$$w_{it+1}(S_{t+1}) = \theta k_{it+1}^{\alpha} (H_{it+1} l_{it})^{1-\alpha} + \epsilon_{it+1}(S_{t+1}) + b_i(S_{t+1}, S_t) \tag{2.5}$$

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. Since all individuals within a country are alike, this means that there will be zero net trade in assets in each country. 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 extremes. Some discussion about the likely effects of intermediate asset markets structures is provided below.

2.1 Financial Market Autarky

A competitive equilibrium under Financial Market Autarky (FMA) is the functional sequence $\{c_{it}(S_t), k_{it}(S_t)\}$ $i = 1, \ldots, N, t = 0, 1, \ldots.$ that satisfies the conditions:[2]

(a) Individual maximization, given by the problem: Maximize (2.1) subject to

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

[2] In this definition we model the household as both producer and consumer. We could separate the decision problems of consumers and firms but it would make no difference for the results.

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

(b) Market Clearing, given by

$$C_{it}(S_t) + K_{it+1}(S_t) = \theta K_{it}^{\alpha}(H_{it}L) + \epsilon_{it}(S_t).$$

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

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

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

The Euler equations for the investment decision are written as

$$c_{it}^{-\sigma}(S_t) = \beta\alpha E_t\theta c_{it+1}^{-\sigma}(S_{t+1}). \tag{2.6}$$

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

$$K_{it+1}(S_t) = (\beta\alpha\theta E_t(\theta + \gamma_{it}{}^{-\sigma})^{1/\sigma}K_{it}(\theta + \gamma_{it}). \tag{2.7}$$

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

Expression (2.7) has the property that the riskiness of country-specific income affects national investment. Since $(\theta + \gamma_i)^{-\sigma}$ is convex in γ_i, a mean-preserving spread in the γ distribution raises $E(\theta + \gamma_{it})^{-\sigma}$. This leads to a *rise* in the expected growth rate of capital. The explanation for this result is as follows. In models of endogenous growth, such as the present one, the average rate of growth depends on the factors that affect aggregate savings. Thus, for instance, a tax on capital income will decrease the growth rate through its effects on the rate of return and savings. In this economy, under FMA, savings behaviour is affected by the riskiness of specific income. With CRRA preferences, a rise in specific income risk tends to raise savings, since these preferences satisfy the condition of positive third derivatives. There is a precautionary motive for saving as defined by Leland (1968), Sandmo (1970), and others, with 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. Since saving is equal to investment under financial market autarky, this has the effect of raising the average growth rate of output.

Note also that the rate of growth under FMA is a random variable, given by

$$g_{\gamma it}(S_t) = \varphi(\theta + \gamma_{it}). \tag{2.8}$$

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

$$C_{it} = (1 - \varphi)K_{it}(\theta + \gamma_{it}). \tag{2.9}$$

Substituting (2.9) into (2.1), and taking expectations dated time -1, we derive an expression for unconditional welfare under FMA

$$\frac{E(\theta + \gamma_i)^{1-\sigma} K_0^{1-\sigma} (1-\varphi)^{1-\sigma}.}{(1-\sigma)[1 - \beta E(\theta + \gamma_i)^{1-\sigma} \varphi^{1-\sigma}]} \tag{2.10}$$

Note that this can be stated in the simpler form

$$\frac{EC_{i0}^{1-\sigma}.}{(1-\sigma)[1 - \beta E(g_{\gamma it})^{1-\sigma}]} \tag{2.11}$$

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 (2.11) 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 $\{c_{it}(S_t), k_{it}(S_t), b_{it}(S_t)\}$ $i = 0, 1, \ldots, N,$ $t = 0, 1, \ldots,$ and the price function $q(S_{t+1}, S_t)$ that satisfies:

(a) Individual maximization, given by the problem: Maximize (2.1) subject to (2.4) and (2.5);

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

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

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

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

The Euler equations for investment and asset holdings are given by

$$c_{it}^{-\sigma}(S_t) = \beta\alpha E_t \theta c_{it+1}^{-\sigma}(S_{t+1}) \tag{2.12}$$

$$q(S^j, S_t)c_{it}^{-\sigma}(S_t) = (1/N)\theta c_{it+1}^{-\sigma}(S^j). \tag{2.13}$$

for $i, j = 1, 2, \ldots, N$. The term $(1/N)$ in condition (2.13) 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 choose a state-invariant consumption stream. We focus on a symmetric equilibrium with perfect pooling.[3] From (2.12) and (2.13), the law of motion for capital in each country is then

$$K_{it+1} = (\beta\alpha\theta^{1-\sigma})^{(1/\sigma)}\theta K_{it} \equiv \psi\theta K_{it}. \tag{2.14}$$

[3] This requires that the initial condition $b_i(S_0) + \epsilon_i(S_0) = 0$ holds for each i. Implicitly we are assuming that asset trade at date -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 perfectly well whichever way we proceed, so we adopt the first method. It also be noted that the perfect pooling assumption is made for tractability alone. With non-perfect pooling equilibria the general characteristics of our results all remain, but the actual welfare expressions are much harder to compute.

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 (2.7) and (2.14) 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*, since the elimination of income risk reduces world savings.

Using market clearing, aggregate consumption can be written as

$$C_{it} = (1-\psi)\theta \sum_{i=1}^{N} (K_{it}/N). \tag{2.15}$$

Substituting (2.14) and (2.15) into (2.1), and employing the assumption of identical initial capital stocks, welfare in any country may be written

$$\frac{\theta^{1-\sigma} K_0^{1-\sigma} (1-\psi)^{1-\sigma}.}{(1-\sigma)[1-\beta\theta^{1-\sigma}\psi^{1-\sigma}]} \tag{2.16}$$

This is the same as expression (2.10) above, except with a zero realization of all γ_{it} terms.

Is welfare raised by moving from FMA to FMI? Standard theory would certainly lead us to expect this to be the case. 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.[4]

To show this result take the welfare expression under FMA given by (2.10). This differs from (2.16) only due to the terms pertaining to the γ_{it} distribution. By linearizing (2.10) 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 (2.10) may be written implicitly as

$$F[Ea(\gamma), Eb(\gamma)] \tag{2.17}$$

where $a(\gamma) \equiv (\theta + \gamma)^{1-\sigma}$ and $b(\gamma) \equiv (\theta + \gamma)^{-\sigma}$. Then approximate (2.17) by

$$\begin{aligned} F[Ea(\gamma), Eb(\gamma)] &\cong F[a(0), b(0)] + F_1[a(0), b(0)](Ea(\gamma) - a(0)) \\ &+F_2[a(0), b(0)](Eb(\gamma) - b(0)), \end{aligned} \tag{2.18}$$

where

$$\begin{aligned} (Ea(\gamma) - a(0)) &= \frac{1}{2}\sigma(\sigma - 1)\theta^{-(1+\sigma)}Var(\gamma) \\ (Eb(\gamma) - b(0)) &= \frac{1}{2}\sigma(\sigma - 1)\theta^{-(2+\sigma)}Var(\gamma), \end{aligned}$$

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

$$F[Ea(\gamma), Eb(\gamma)] - F[a(0), b(0)] = A[-\sigma + (1 - \alpha)B]\frac{1}{2}Var(\gamma) \tag{2.19}$$

with $A, B > 0$ defined as

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

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

How may (2.19) be interpreted? Notice from equation (2.2) that the size of the externality associated with human capital accumulation depends on the share of labour

[4] Of course this result will be less likely if there also are negative externalities from growth, such as the greenhouse effect.

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 (2.19). 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, $(1-\alpha)B$, 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 $Var(\gamma)$ 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, since 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 graphs expression (2.10) for the special case of a two-state distribution, with $S_1 = \{-\bar{\gamma}, \bar{\gamma}\}$, $S_2 = \{\bar{\gamma}, -\bar{\gamma}\}$ (and therefore a two-country example), under the parameter assumptions $\sigma = 2$, $\alpha = 0.3$, $\beta = 0.9$ and $\theta = 3.85$. 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 primarily interested in the risk sharing possibilities of financial markets in the face of 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.

Say 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

$$\frac{E(\theta_i)^{1-\sigma}K_0^{1-\sigma}(1-\vartheta)^{1-\sigma}}{(1-\sigma)[1-\beta E(\theta_i)^{1-\sigma}\vartheta^{1-\sigma}} = \frac{EC_{i0}^{1-\sigma}.}{(1-\sigma)[1-\beta E(g_{\theta i})^{1-\sigma}]} \tag{2.20}$$

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

$$\frac{\bar{\theta}^{1-\sigma}K_0^{1-\sigma}(1-\upsilon)^{1-\sigma}.}{(1-\sigma)[1-\beta\bar{\theta}^{1-\sigma}\upsilon^{1-\sigma}]} \tag{2.21}$$

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 the expression (2.20) as $U[Em(\theta)]$ where $m(\theta) \equiv \theta^{1-\sigma}$.

Expanding welfare around $m(\bar{\theta})$, we may show

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

where $C > 0$. 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, (2.11) and (2.20). In both cases, the important element is the impact of financial market integration on the effective discount factor; $E(\theta+\gamma)^{1-\sigma}\varphi^{1-\sigma}$ for the case of income uncertainty, and $E(\theta)^{1-\sigma}\vartheta^{1-\sigma}$ 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 $E((\theta+\gamma)/\theta)^{1-\sigma}(Eg_\gamma)^{1-\sigma}$ and in the second case as $E(\theta/\bar{\theta})^{1-\sigma}(Eg_\theta)^{1-\sigma}$. 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 will always 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.

The advantages of calculating these welfare measures in the representative-agent framework are that it includes a limiting case in which competitive growth is optimal and that it is often used in empirical work. A disadvantage is that solutions for intermediate market structures, with partial diversification, would require numerical methods. In studies of business cycles and asset-pricing Îmrohoroğlu (1989) and Telmer (1991) have found that riskless borrowing and lending alone can allow long-lived agents (countries) to self-insure and that completing markets may have small effects. Whether this finding applies with endogenous growth remains to be seen.

3. Overlapping Generations Model

This section develops a second analytical example, based on the Diamond model of overlapping generations with production.[5] In this model endowments of different generations may differ, but the two-period lifetimes mean that only a one-period history matters for current allocations. This simplification allows one to calculate dynamics for the transition from autarky to risk-sharing. A further advantage of the OLG model is that it simplifies solving for the equilibrium growth rate under various market structures. This is helpful because there is no reason to believe that the growth and welfare effects are monotone in the degree of international diversification. However, a disadvantage is that in this model (unlike the representative-agent model) one cannot readily nest the case in which competitive growth is efficient.

Each of the N countries is populated by an infinite sequence of overlapping generations, each of which lives for two periods. There is a constant unit measure of individuals in each generation in each country. Each individual within a generation has preferences given by

$$U_{it} = \frac{c_{it}^{1-\sigma}}{1-\sigma} + \frac{E_t \beta d_{it+1}^{1-\sigma}}{1-\sigma} \tag{3.1}$$

where $c_{it}(d_{it+1})$ is consumption of the young (old) of generation t, in country i.

An agent of generation t in each country receives income from two sources. The first source is wage income w_{it}, received in the first period of life, in return for a unit of labour, supplied inelastically. The second is a risky endowment $\epsilon_{it+1}(S_{t+1})$ received during old age. Again S denotes the state, and there is no aggregate uncertainty in the world economy. Income ϵ_{it} is identically and independently distributed over time exactly as in section 2. The young of each generation in each country can store resources in the form of capital, one-period claims on foreign residents, or possibly in state-contingent assets. All saving is done by the young.

Output in each country comprises that produced with the use of labour and capital inputs, and the endowment income of the old. The produced component of output in each

[5] Models with overlapping generations and endogenous growth also are studied by Alogoskoufis and van der Ploeg (1990) and Buiter and Kletzer (1991).

country i is associated with the technology described in equation (2.2). As in Boyd and Prescott (1987), we assume that knowledge is freely transferred across generations.[6]

In each country, competitive firms hire labour and capital so as to ensure

$$w_{it} = (1-\alpha)\theta k_{it}^{\alpha}(H_{it})^{1-\alpha} l_{it}^{-\alpha}; \qquad r_{it} = \alpha\theta k_{it}^{\alpha-1}(H_{it} l_{it})^{1-\alpha} \tag{3.2}$$

We now address the decision problem faced by young agents in each country i at any time period. Young residents of i receive wage income w_{it}. If we impose no restrictions on the number of markets that are open, a young agent can be thought of as facing the problem: maximize (3.1) subject to

$$c_{it} + k_{it+1} + q_{vt} v_{it+1} + \sum_{j=1}^{N} q_t(S^j, S_t) b_i(S^j, S_t) = w_{it} \tag{3.3}$$

$$d_{it+1}(S_{t+1}) = k_{it+1}(1 + r_{t+1}) + v_{it+1} + b_i(S_{t+1}, S_t) + \epsilon_{it+1}(S_{t+1}) \tag{3.4}$$

$$k_{it+1} > 0.$$

Equation (3.3) describes the distribution of wage income between consumption, the direct acquisition of capital, k_{it+1}, holdings of one-period riskfree bonds v_{it+1}, with price q_{vt}, and holdings of state-contingent securities. Equation (3.4) describes consumption in each state in period $t+1$. This equals the direct return on capital, riskfree bond income, state-contingent security payoffs, and risky endowment income.

First consider the regime without risk sharing. This involves rewriting (3.3) and (3.4) without the option to trade in contingent securities, but unlike the previous section there may still exist international markets in riskfree bonds. First-order conditions for the consumer's problem are easily shown to be

$$c_{it}^{-\sigma} = E_t \beta d_{it+1}^{-\sigma}(1 + r_{t+1}) \tag{3.5}$$

$$q_{vt} c_{it}^{-\sigma} = E_t \beta d_{it+1}^{-\sigma}. \tag{3.6}$$

A world competitive equilibrium without risk sharing is a sequence of
$\{c_{it}, d_{it}(S_t), k_{it}, r_{it}, q_{vt}, v_{it}\}$ $i = 1, 2, \ldots, N, t = 0, 1, \ldots$ which satisfies:

---

[6] Boyd and Prescott in fact assume that this transfer takes place within coalitions of agents.

(a) Utility maximization for each generation in each country; *i.e.* (3.3)-(3.6) and $b_{it} \equiv 0$;

(b) Profit Maximization by firms in each time period; (3.2);

(c) Market Clearing:

$$\sum_{i=1}^{N}(C_{it} + D_{it} + K_{it}) = \sum_{i=1}^{N} Y_{it}, \sum_{i=1}^{N} v_{it} = 0$$

(*d*)

$$\epsilon_{it} = \gamma_i(S_t)K_{it}$$

(*e*)

$$k_{it} = H_{it} = K_{it}.$$

Here the economy with trade only in one-period bonds is equivalent to that with autarky. With identical, nonstochastic technology, and similar initial conditions across countries, there will be no net trade in bonds, since each country's decision-maker faces the same distribution of risky income, and has the same period t wage income and direct return on investment. Substituting into (3.5) from (3.2)-(3.4) gives (for each i)

$$((1-\alpha)\theta k_{it}^{\alpha}(H_{it})^{1-\alpha})/l_{it} - k_{it+1})^{-\sigma} =$$

$$E_t\beta(\alpha\theta k_{it+1}^{\alpha}(H_{it+1})^{1-\alpha} + k_{it+1} + \epsilon_{it+1}(S_{t+1}))^{-\sigma}(1 + \alpha\theta k_{it+1}^{\alpha-1}(H_{it+1})^{1-\alpha}). \tag{3.7}$$

Now use equation (2.3) and impose the aggregate equilibrium condition $k_{it} = K_{it}$, and $L_{it} = 1$, (since each young person supplies one unit of labour), and rearrange (3.7) to derive the competitive equilibrium growth rate of capital in the absence of risk-sharing. This is given by

$$K_{t+1} = \frac{(1-\alpha)\theta K_t}{(1 + (\beta(1+\alpha\theta)\Gamma)^{-1/\sigma})} \tag{3.8}$$

where $\Gamma = E_t(1 + \alpha\theta + \gamma_{it+1})^{-\sigma}$. Since γ_{it+1} is an i.i.d. process across time periods, equation (3.8) gives the stationary growth rate of the capital stock in an economy without international risk-sharing. Define this as g_γ, where the subscript denotes the source of non-diversified risk.

Aggregate consumptions of the young and old generations in each country are:

$$C_{it} = (\beta(1+\alpha\theta)\Gamma))^{-1/\sigma}\frac{(1-\alpha)\theta K_{it}}{(1 + (\beta(1+\alpha\theta)\Gamma)^{-1/\sigma}} \tag{3.9}$$

$$D_{it} = (1+\alpha\theta)K_{it} + \gamma_{it}K_{it}. \tag{3.10}$$

Actual consumption of the young, and expected consumption of the old, grow at rate g_γ.

Next, consider an economy with full international risk sharing (*i.e.* FMI). The definition and derivation of a competitive equilibrium under FMI is very similar to that in section 2.2. Following the same procedures as before, we may derive the equilibrium growth rate of the capital stock (in any country) as

$$K_{it+1} = \frac{(1-\alpha)\theta K_t}{(1+(\beta(1+\alpha\theta)^{1-\sigma})^{-1/\sigma}}. \tag{3.11}$$

The growth rate of the capital stock, denoted g, again leads to a similar growth rate for consumption of the young, and since the old are fully insured now, also for consumption of the old.

Now compare (3.11) with (3.8). Since Γ is a convex function of g, a rise in income riskiness again leads to a rise in savings and therefore in growth. Thus financial market integration again reduces growth, as in section 2. In this case a fall in income riskiness following the opening up of insurance markets will reduce the savings propensity of young agents equally in all countries.

Again the welfare effect of risk-sharing may be of either sign. Using (3.1)-(3.4) and (3.8), we may derive the expected utility of a representative young agent of generation t without risk sharing. This is written as

$$U_t = (1-\sigma)^{-1}[C_t^{1-\sigma} + E_t\beta D_{t+1}^{1-\sigma}] = \Omega_\gamma K_t$$

$$= (1-\sigma)^{-1}K_t^{1-\sigma}[[(1-a)\theta - g_\gamma] + \beta E_t[(1+\alpha\theta+\gamma)g_\gamma]^{1-\sigma}] \tag{3.12}$$

with the parameter Ω_γ defined implicitly. An unanticipated, permanent financial market integration at date t can be evaluated by setting $\gamma = 0$ and $g_\gamma = g$ in (3.12).

There is no natural welfare index to evaluate the effects of integration, since generations have no altruistic link between them. However, we can gain some insight into the process of integration by comparing the welfare of successive generations following an initial integration at date t. Begin with equation (3.12) for some arbitrary initial capital stock K_t. Holding K_t constant, the welfare of the first generation is measured by the change in the Ω_γ expression. For successive generations we must update by the capital stock according to the growth rule for the FMI economy, *i.e.* (3.11).

Figure 2A graphs the welfare of the first two generations following the financial market integration for the same parameter values used in Figure 1: $\alpha = 0.3$, $\sigma = 2$, $\theta = 3.85$, $\beta = 0.9$. We again assume a symmetric, two-state distribution for the γ shock, where $\bar{\gamma} = .5$. With these values the standard deviation of specific income is approximately ten percent of total income. The growth rate under FMA is 11 percent. This falls to 5.8 percent under FMI. Figure 2A shows that the first generation gains from the integration because the pure risk sharing effects dominate any growth effects. However, the second and all succeeding generations will be worse off than if the economy had remained in FMA.

This result raises an interesting question in political economy. If economic policy is formulated by the current generation, ignoring the welfare of their descendants, then each generation will have an incentive to have full financial market integration. Conditional on the capital stock inherited, the currently alive young of any generation will desire to have access to full international insurance markets. But, at least for our numerical example, each generation after the first is worse off under FMI than under continued FMA, because the capital stock they inherit is smaller than under autarky.

Another way to evaluate the welfare impact of financial market integration is to use agents' two-period discount rate over an infinite number of periods. Using this criterion and the growth rate g_γ defined in equation (3.8) gives social welfare under FMA:

$$V_t = E_t \sum_{p=0}^{\infty} \beta^p U_{t+p} = \frac{K_t^{1-\sigma}\Omega_\gamma}{[1-\beta g_\gamma^{1-\sigma}].} \tag{3.13}$$

The criterion for the case of full risk-sharing is found simply by setting $\gamma_{it+1} = 0$ in the expression for Γ. For the generation young at the time of the integration utility rises from -1.0286 to -1.0056. But V_t falls from -5.4205 to -6.7359. Thus social welfare falls under risk-sharing, by this measure. Figure 2B shows the equivalent and compensating variations, measured as percentages of the initial capital stock, for the regime change. The horizon shows the number of future generations whose discounted utilities are included in the welfare function. For these parameter values the variation based on (3.13) is approximately 20 percent of the initial capital stock.

5. Extensions and Conclusions

The exercise in section 2 could be extended by calibrating the growth model and undertaking empirical measurement. Cole and Obstfeld (1989) and Obstfeld (1990) 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. Similar methods could be used to estimate the empirical variations in the model with endogenous growth; the link between risk and growth suggests that they could be much larger. Moreover, related methods could be used to study the effects of risk-sharing between individuals within countries.

The main finding of this paper is that integrating financial markets internationally may reduce growth and welfare in a standard model of endogenous growth. In assessing the empirical relevance of this result one also should consider other features of financial market integration that we have not modelled, including possibly scale effects of the type identified by Romer and Rivera-Batiz (1991) for the case of economic integration. These features might conflict with, and possibly overturn the welfare results developed above. Likewise, the negative welfare effects found here could be reversed if governments were to subsidize investment at the appropriate rate. The environment here (in which autarky can be preferred to risk-sharing) features a second-best problem. Thus, like most second best problems, there are a number of tax-subsidy policies that could be implemented to achieve first-best allocations.

But the results do highlight the implications of growth models that are based on external effects. A model which is appropriate for studying growth also should be appropriate for studying welfare. If one finds implausible the negative effects of financial market integration on growth and welfare which are described in this paper then one interpretation is that they cast doubt on the importance of the externality underlying the specific model of endogenous growth. Thus a further extension would be to study international integration and risk-sharing in alternative models.

References

Arrow, K.J. (1962) The Economic Implications of Learning By Doing. *Review of Economic Studies* 29, 155-173.

Alogoskoufis, G.S. and van der Ploeg, F. (1990) Endogenous Growth and Overlapping Generations. Discussion Paper 26/90, Birkbeck College, University of London.

Boyd, J.H. and Prescott, E.C. (1987) Dynamic Coalitions, Growth, and the Firm. In E.C. Prescott and N. Wallace, eds. *Contractual Arrangements for Intertemporal Trade*. Minneapolis: University of Minnesota Press.

Buiter, W.H. and Kletzer, K.M. (1991) Persistent Differences in National Productivity Growth Rates with a Common Technology and Free Capital Mobility. NBER Working Paper No. 3637.

Caballero, R.J. (1990) Consumption Puzzles and Precautionary Savings. *Journal of Monetary Economics* 25, 113-136.

Cole, H.L. and Obstfeld, M. (1989) Commodity Trade and International Risk Sharing: How Much Do Financial Markets Matter? NBER Working Paper No. 3027.

Erlich, A. (1960) *The Soviet Industrialization Debate 1924-1928*. Cambridge, Ma.: Harvard University Press.

Heckscher, E. (1955) *Mercantilism*. trans. M. Shapiro, first pub. 1931. New York: Macmillan.

Hercowitz, Z. and Sampson, M. (1991) Output Growth, the Real Wage, and Employment Fluctuations. forthcoming in the *American Economic Review*.

Îmrohoroğlu, A. (1989) Cost of Business Cycles with Indivisibilities and Liquidity Constraints. *Journal of Political Economy* 97, 1364-1383.

Kimball, M.S. (1990) Precautionary Saving in the Small and in the Large. *Econometrica* 58, 53-73.

Leland, H.E. (1968) Saving and Uncertainty: The Precautionary Demand for Saving. *Quarterly Journal of Economics* 82, 465-473.

Lucas, R.E. (1988) On the Mechanics of Economic Development. *Journal of Monetary Economics* 22, 3-42.

Obstfeld, M. (1990) International Risk Sharing and Capital Mobility: Another Look. mimeo, Department of Economics, University of California, Berkeley.

Prebisch, R. (1959) Commercial Policy in the Underdeveloped Countries. *American Economic Review* (P) 49, 251-273.

Rebelo, S. (1991) Long-Run Policy Analysis and Long-Run Growth. *Journal of Political Economy* 99, 500-521.

Rivera-Batiz, L.A. and Romer, P.M. (1991) Economic Integration and Endogenous Growth. *Quarterly Journal of Economics* 106, 531-555.

Romer, P. (1986) Increasing Returns and Long-Run Growth. *Journal of Political Economy* 94, 1002-1037.

Romer, P.M. (1987) Growth Based on Increasing Returns Due to Specialization. *American Economic Review* 77, 56-62.

Sandmo, A. (1970) The Effect of Uncertainty on Savings Decisions. *Review of Economic Studies* 37, 353-360.

Sheshinski, E. (1967) Optimal Accumulation with Learning By Doing. In K. Shell, ed. *Essays on the Theory of Optimal Growth.* M.I.T. Press.

Stokey, N.L. (1991) Human Capital, Product Quality, and Growth. *Quarterly Journal of Economics* 106, 587-616.

Telmer, C.I. (1991) Asset Pricing Puzzles and Incomplete Markets. mimeo, Department of Economics, Queen's University.

Young, A. (1991) Learning by Doing and the Dynamic Effects of International Trade. *Quarterly Journal of Economics* 106, 369-405.

FIGURE 1: Growth and Welfare Effects of Increasing Risk

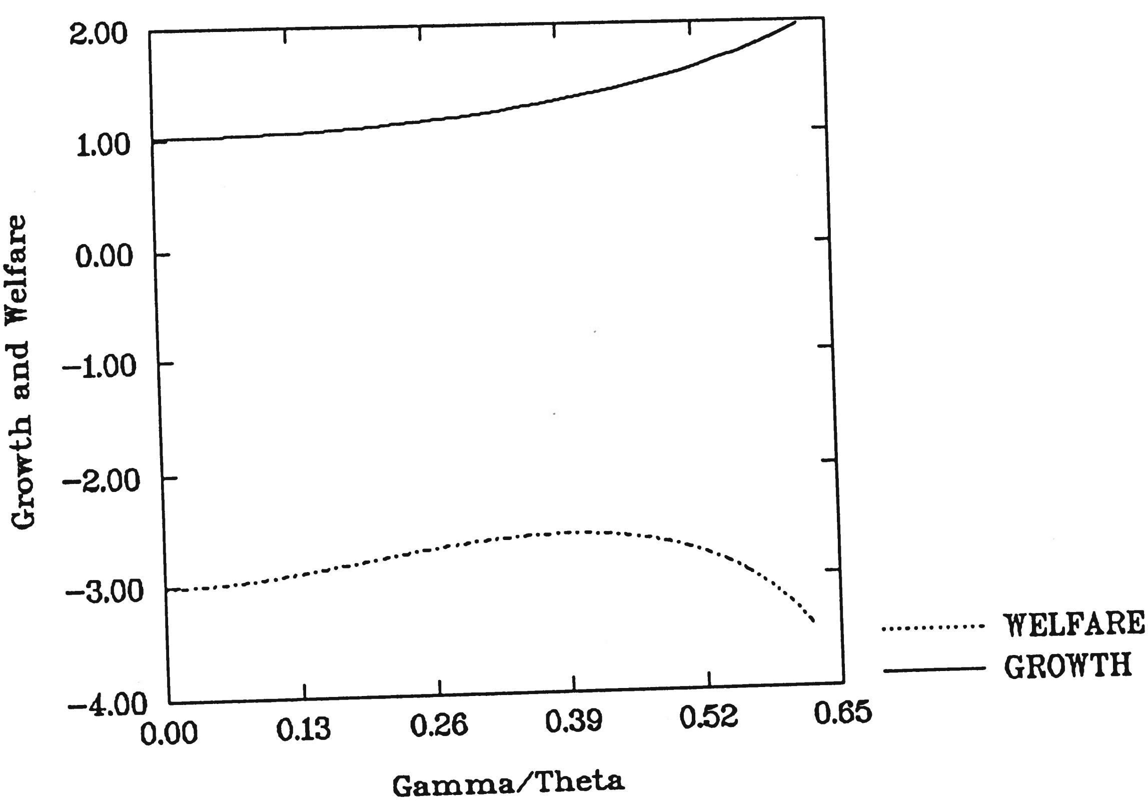

FIGURE 2A: Welfare under Autarky and Diversification

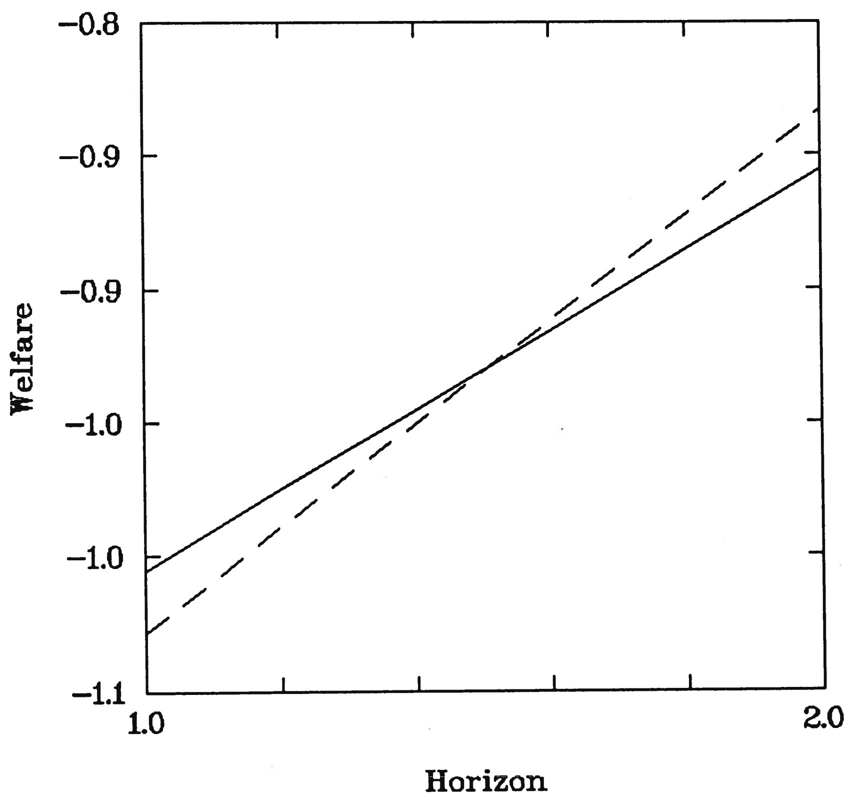

FIGURE 2B: Equivalent and Compensating Variations