

Globalization, the Volatility of Intermediate Goods Prices and Economic Growth

Thomas M. Steger (ETH Zurich)¹

Lucas Bretschger (ETH Zurich)

May 2005

We set up a dynamic stochastic model of a stylized economy comprising a final output sector (with traditional and modern firms) and an intermediate goods sector. It is shown that market integration reduces the volatility of the rate of return of capital invested in modern firms. The induced portfolio decision of households then leads to a reallocation of capital from traditional to modern firms. Despite the presence of a reverse precautionary saving channel, the growth rate unambiguously increases due to the reallocation of capital. Empirical estimates for OECD countries confirm the theoretical results.

Keywords: Globalization, trade in intermediate goods, portfolio decisions, economic growth

JEL Classification: F1; O4

¹Corresponding author: ETH Zurich, WIF - Institute for Economic Research, ETH Zentrum, ZUE F 13, CH-8092 Zurich, Tel. +41 (0)44 632 24 27, Fax +41 (0)44 632 13 62, tsteger@ethz.ch.

1 Introduction

The question of whether and how globalization affects economic growth is one of the most fundamental questions in economics. For a long time, there seemed to be a consensus that market integration is unambiguously good for growth (Dollar, 1992; Edwards, 1998). However, after having reexamined the bulk of recent empirical evidence, Rodríguez and Rodrik (2000) conclude that one should be sceptical about a generally positive relationship. They do not deny that market integration may affect economic growth favorably. Instead, it is argued that the openness growth nexus is quite complex and, therefore, in-depth research aimed at the identification of specific channels is called for.

We follow this proposition at the level of theoretical research. The focus is on a specific channel which highlights the general importance of intermediate goods as a chain link in the globalization growth nexus. In addition, we subject the impact of intermediate goods price volatility on growth to econometric testing, using data on intermediate goods prices and economic growth for OECD countries from 1960 to 2000.

There are a number of important reasons to highlight the significance of intermediate goods when trying to understand better the relationship between goods market integration and growth:

First, it is well known that the importance of goods trade relative to output in major OECD countries rose substantially during the last three decades.² Moreover, trade in intermediate goods is quantitatively substantial. The average share of trade in intermediate goods to overall goods trade for major OECD countries during the last three decades was about 50 % (Kleinert, 2003). This number has been remarkably stable. As a result, the relative importance of imported inputs in production has increased steadily as documented in Campa and Goldberg (1997).³

Second, data from the OECD input output tables (OECD, 2004) show that the share of intermediate goods in production ranges from 19% to 82% across different sectors; the median is at 57%.⁴ This variation indicates that intermediate goods are extremely important in some sectors and of minor importance in other sectors. Based on this stylized fact, we will distinguish between modern final output firms (which produce intermediate goods intensive) and traditional final output firms (which use the second input factor, capital, intensively).

²This can be readily seen by inspecting the series "openness" for OECD economies available from the Penn World Tables.

³Campa and Goldberg focus on major industrialized economies.

⁴The numbers refer to averages over the 6 major OECD countries in 1995.

Third, a large number of endogenous growth models assign intermediate goods a prominent role in the production process. Especially important in this context are the gains from specialization. By combining intermediate goods with other input factors (capital and labor), firms can take advantage of specialization. As a consequence, the productivity of capital and labor increases (e.g. Romer 1990; Grossman and Helpman, 1991, chapter 3). Moreover, the use of intermediate goods enables an additional roundaboutness in production (von Böhm-Barwerk, 1921), which might increase the productivity of the complementary factors.⁵

Finally, there is empirical evidence for a negative (partial) correlation between the volatility of intermediate goods prices and economic growth. To illustrate this empirical relationship, consider the scatter plot in Figure 1. The respective points show the combination of the standard deviation of intermediate goods prices across time (within 5 years subperiods) and the growth residuals (resulting from a basic growth regression as explained in Section 7) for 9 OECD countries. The negative slope of this fitted regression line is statistically significant across a large set of empirical specifications. This piece of empirical evidence points to the fact that there is a specific mechanism through which a reduction in the volatility of intermediate goods prices fosters economic growth.

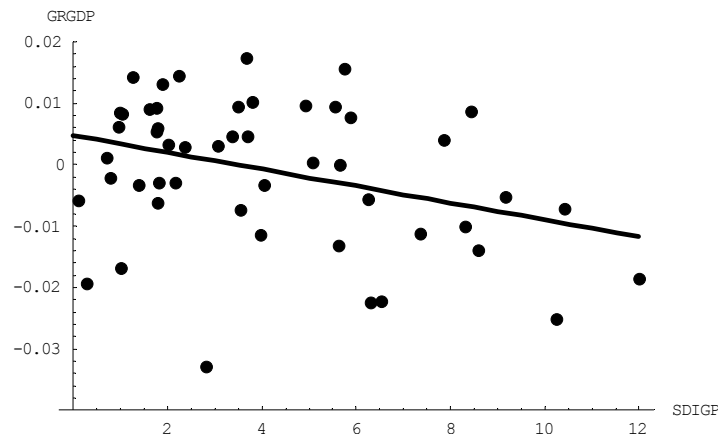


Figure 1: Growth rate of GDP per capita (GRGDP) and the standard deviation of intermediate goods prices (SDIGP)

We set up a model of a stylized economy, which allows us to investigate the nexus between market integration, trade in intermediate goods and economic growth. The

⁵This is analogous to roundaboutness in production in standard (neoclassical) growth models, in which the productivity of labor increases due to capital accumulation.

model comprises two sectors: a final output sector and an intermediate goods sector. Production in the intermediate goods sector is subject to random shocks. Moreover, there are two types of firms in the final output sector: the representative traditional firm employs capital only, whereas the representative modern firm combines intermediate goods together with capital, i.e. produces intermediate goods intensive.

The basic idea underlying this paper is fairly simple and can be sketched as follows: Provided that productivity shocks are not perfectly correlated across countries, market integration leads to a reduction in the volatility of intermediate goods prices.⁶ As a result, the volatility of the rate of return (ROR) of capital allocated to modern firms decreases. The induced portfolio decision of households then leads to a reallocation of capital from traditional firms to modern firms. Despite the presence of a precautionary saving channel (according to which, using empirically plausible calibrations, a reduction in volatility depresses growth), the growth rate can be shown to unambiguously increase due to the reallocation of capital.

Turning to the related literature, the paper is probably closest to Obstfeld (1994), who studies the consequences of financial market integration on risk taking and long run growth. There are, however, a number of important differences:⁷ First, the paper at hand investigates the consequences of goods market integration and is hence devoted to the real side of the economy. Second, we set up a general equilibrium model distinguishing between households and firms, whereas Obstfeld employs a partial equilibrium framework to study the problem of the representative household. Moreover, Obstfeld assumes that there are two linear investment projects: one safe low-yield and one risky high-yield project. In the setup below, the ROR differential (and to some extent the riskiness of investments) arises endogenously. This is due to specialization as well as an additional roundaboutness in production, both made possible by the use of intermediate goods.⁸

We do not explicitly model the causes of trade in intermediate goods. Since the economies under consideration possess the same constant returns to scale technologies and the same factor endowments, there is no reason for international specialization.⁹ The possible explanations behind trade in intermediate goods have recently been investigated by Kleinert (2003).

⁶This assumption is critical. However, it is also fairly reasonable.

⁷We will return to a detailed comparison between the real channel (developed in this paper) and the financial channel described in Obstfeld (1994) in Section 6 below.

⁸In addition, one should mention Devereux and Smith (1994) who employ a multinational endogenous growth framework to show that international risk sharing can lower both growth and welfare. This is, of course, due to the basic second-best character of their model.

⁹However, trade between residents of the economies under study does arise in the integration equilibrium.

The present paper contributes also to the literature on volatility and growth. Ramey and Ramey (1995) have shown that volatility and growth are negatively correlated. In the wake of this influential paper, a strand of literature has developed which investigates empirically the volatility growth nexus more deeply. For instance, Kose et al. (2004) argue that the volatility growth relationship might be affected by vigorous development trends such as globalization. In this context, the authors state that there is little theoretical evidence in this respect: "*... neither theoretical studies nor empirical ones have rigorously examined the effects of increased trade and financial linkages on the growth-volatility relationship*" (Kose et al., 2004, p. 6). The paper at hand contributes to this strand of literature by showing that goods market integration unfolds a tendency to reduce volatility and speed up growth. Moreover, it is shown that the model is consistent with the basic finding of Ramey and Ramey.

The paper is structured as follows: Section 2 introduces the basic deterministic model. Section 3 is devoted to the consequences of market integration for intermediate goods prices. In Section 4, the basic setup is extended to allow for productivity shocks in intermediate goods production. Section 5 discusses the main implications of market integration with respect to intermediate goods price volatility and economic growth. Section 6 treats the similarities and differences of the basic channel derived in this paper and the international portfolio diversification mechanism. Section 7 provides empirical results on the channel under study based on panel data for 9 OECD countries. Finally, Section 8 summarizes and concludes. All derivations are relegated to an appendix (available upon request).

2 The deterministic economy

2.1 Firms

In the final output sector, there are two types of firms. Output of the representative traditional firm is denoted as y_T , while output of the representative modern firm is labelled y_M . The production technologies of the two types of firms read as follows:

$$y_T = A(1 - \theta)k \tag{1}$$

$$y_M = A(\theta k)^\alpha x^{1-\alpha}, \tag{2}$$

where $A > 0$ denotes a constant technology parameter, $0 \leq \theta \leq 1$ is the share of capital allocated to modern firms (implying that the share $1 - \theta$ is allocated to traditional firms), $0 < \alpha < 1$ a constant technology parameter and x is a (homogenous) intermediate input. Both type of firms produce under constant returns to scale. The

traditional firm employs capital only, whereas the modern firm uses an intermediate input in addition to capital. This additional roundaboutness in production may lead to a more efficient production process, as will be shown below.

There is a large number of intermediate goods producers. The typical intermediate goods producer can convert $\eta > 0$ units of $y := y_M + y_T$ into one unit of x . Final output y serves as numeraire, its price is set equal to unity. Hence, the supply price of x is given by $p_x^S = \eta$. From equilibrium in the x -market (i.e. $p_x^S = p_x^D$) and the demand price $p_x^D = (1 - \alpha)A(\theta k)^\alpha x^{-\alpha}$, the equilibrium amount of x can be readily derived to read as follows:

$$x = \left(\frac{A(1 - \alpha)}{\eta} \right)^{\frac{1}{\alpha}} \theta k. \quad (3)$$

From (2) and (3) one obtains the *reduced form production function* for y_M :¹⁰

$$y_M = A^{\frac{1}{\alpha}} \left(\frac{\eta}{1 - \alpha} \right)^{\frac{\alpha - 1}{\alpha}} \theta k. \quad (4)$$

Provided that $A^{\frac{1}{\alpha}} \left(\frac{\eta}{1 - \alpha} \right)^{\frac{\alpha - 1}{\alpha}} > A$, roundabout production is efficient. It will turn out below that, in this case, the representative household sets θ equal to unity. In contrast, for $A^{\frac{1}{\alpha}} \left(\frac{\eta}{1 - \alpha} \right)^{\frac{\alpha - 1}{\alpha}} < A$, roundabout production is inefficient and optimal θ is set equal to zero. It is clear that in this deterministic economy only one type of production process is active.¹¹

For future use it is instructive to consider the *indirect production function*:¹²

$$y_M = A^{1/\alpha} (1 - \alpha)^{\frac{1 - \alpha}{\alpha}} p_x^{\frac{\alpha - 1}{\alpha}} \theta k. \quad (5)$$

This formulation shows that changes in the price of intermediate goods affect the productivity of capital (employed by modern firms) in a similar way to (multiplicative) technology shocks. The economic intuition behind this implication is straightforward: For instance, a drop in p_x increases the final output producer's demand for x . Since, in equilibrium, physical capital is combined with a larger amount of x , the productivity of capital increases.

2.2 Households

As usual, the representative household is assumed to maximize the present value of utility given by:

$$U = \int_0^{\infty} u(c) e^{-\rho t} dt, \quad (6)$$

¹⁰This production function is structurally similar to the one employed in Barro (1990).

¹¹This is due to the simplifying assumption according to which y_T and y_M are perfect substitutes in consumption, as explained in the next section.

¹²Solve the first order condition $p_x^D = (1 - \alpha)A(\theta k)^\alpha x^{-\alpha}$ for x and substitute into (2).

where $\rho > 0$ denotes the time preference rate and t the time index. The instantaneous utility function reads as follows:

$$u(c) = \frac{c^{1-\sigma} - 1}{1-\sigma}, \quad (7)$$

where $\sigma > 0$. Output of the traditional firm (y_T) and output of the modern firm (y_M) are perfect substitutes in consumption c , i.e. $c = y_T^c + y_M^c$ with y_T^c and y_M^c denoting the amounts of y_T and y_M consumed, respectively.¹³ This assumption fixes the relative price of y_T in terms of y_M to unity. The economy's resource constraint can be expressed as $y_T + y_M = c + \eta x + \dot{k}$, where $\dot{k} := dk/dt$.

The representative household can, in principle, hold assets in one of three forms: (i) ownership claims on traditional firms; (ii) ownership claims on modern firms; or (iii) consumption loans. Both ownership claims and loans are perfect substitutes as stores of value and hence must pay the same ROR. A household's net asset holding is denoted by a .¹⁴ Due to perfect competition in the capital market and the production technologies (1) and (2), ownership claims on traditional firms pay a ROR of $r_T = A$, while ownership claims on modern firms pay a ROR of $r_M = A^{\frac{1}{\alpha}} \left(\frac{\eta}{1-\alpha}\right)^{\frac{\alpha-1}{\alpha}}$.¹⁵ The flow budget constraint for the household is:

$$\dot{a} = r_T(1-\theta)a + r_M\theta a - c,$$

where $\dot{a} := da/dt$. The solution to the above-sketched optimization problem leads to the familiar Keynes-Ramsey rule of optimal consumption:

$$\frac{\dot{c}}{c} = \frac{r - \rho}{\sigma},$$

where $r = r_T = A$ for $A^{\frac{1}{\alpha}} \left(\frac{\eta}{1-\alpha}\right)^{\frac{\alpha-1}{\alpha}} < A$ and $r = r_M = A^{\frac{1}{\alpha}} \left(\frac{\eta}{1-\alpha}\right)^{\frac{\alpha-1}{\alpha}}$ for $A^{\frac{1}{\alpha}} \left(\frac{\eta}{1-\alpha}\right)^{\frac{\alpha-1}{\alpha}} > A$.

3 Market integration

Consider two economies which are perfectly identical except for the input coefficients in intermediate goods production η . The equilibrium price of intermediate goods in

¹³The simplifying assumption according to which y_T and y_M are perfect substitutes in consumption is not critical for the basic results derived below but greatly simplifies the analysis.

¹⁴Since households are identical there will be no loans in equilibrium and thus $k = a$.

¹⁵It is clear that only one type of ownership claims is actually held in equilibrium. For $A^{\frac{1}{\alpha}} \left(\frac{\eta}{1-\alpha}\right)^{\frac{\alpha-1}{\alpha}} < A$, $r_T = A$ and $r_M = 0$, while for $A^{\frac{1}{\alpha}} \left(\frac{\eta}{1-\alpha}\right)^{\frac{\alpha-1}{\alpha}} > A$, $r_M = A^{\frac{1}{\alpha}} \left(\frac{\eta}{1-\alpha}\right)^{\frac{\alpha-1}{\alpha}}$ and $r_T = 0$. The decision on θ is trivial in the deterministic setup.

the integrated economy p_x^i is given by (we assume that the conditions for interior solutions hold):

$$p_x^i = \min(\eta_1, \eta_2), \quad (8)$$

where η_1 and η_2 denote the input coefficients in intermediate goods production in country 1 and 2, respectively. Provided that $\eta_1 = \eta_2$, the world market price is identical to the autarky price. In this case, the world economy replicates the economies under autarky. Integrating two perfectly identical economies has no consequences within this deterministic setup. This changes provided that (i) one allows the technology parameters η_1 and η_2 to become stochastic and (ii) one assumes (realistically) that the national shocks are not perfectly correlated.¹⁶

Inserting the intermediate goods price under integration (8) into the indirect production function (5) gives the *reduced form production function under integration*:

$$y_M = A^{1/\alpha}(1 - \alpha)^{\frac{1-\alpha}{\alpha}} [\min(\eta_1, \eta_2)]^{\frac{\alpha-1}{\alpha}} \theta k. \quad (9)$$

This formulation immediately points to the fact that the volatility of the marginal product of capital allocated to the modern sector decreases in response to economic integration whenever the volatility of the expression $[\min(\eta_1, \eta_2)]^{\frac{\alpha-1}{\alpha}}$ is smaller than the volatility of $\eta^{\frac{\alpha-1}{\alpha}}$.

4 The stochastic economy

In this section, we introduce uncertainty into the model set up above. As the analysis proceeds we distinguish between autarky and integration to reveal the consequences of market integration in the stochastic environment.

4.1 The ROR of capital employed by modern firms

It is now assumed that the production of intermediate inputs is subject to random shocks. Specifically, the input coefficient η fluctuates randomly in a stationary fashion and is described by the following simple probability distribution:¹⁷

$$\eta = \begin{cases} \bar{\eta} + \varepsilon & \text{with } P(\bar{\eta} + \varepsilon) = 0.5 \\ \bar{\eta} - \varepsilon & \text{with } P(\bar{\eta} - \varepsilon) = 0.5, \end{cases} \quad (10)$$

¹⁶The two shocks will be assumed to follow the same probability distribution but they represent independent realizations (idiosyncratic shocks).

¹⁷This modeling is similar to Bertola (1994), who sets up a continuous time growth model with intermediate goods assuming that productivity of the intermediate goods producer follows a stochastic binary scheme (cf. Bertola, 1994, p. 219).

where $\varepsilon > 0$. The expected value of η is $E(\eta) = \bar{\eta}$.¹⁸

Considering the reduced form production functions under autarky (4) and integration (9) shows that the ROR per period of time dt of capital allocated to modern firms under autarky (r_M^a) and integration (r_M^i) is:

$$r_M^a = b\eta^{\frac{\alpha-1}{\alpha}} \quad (11)$$

$$r_M^i = b[\min(\eta_1\eta_2)]^{\frac{\alpha-1}{\alpha}}, \quad (12)$$

where $b := A^{1/\alpha}(1-\alpha)^{\frac{1-\alpha}{\alpha}}$. Using $V(u)$ to denote the variance of some variable u , the variance of r_M^a is $b^2V(\eta^{\frac{\alpha-1}{\alpha}})$, while the variance of r_M^i is $b^2V[(\min(\eta_1\eta_2))^{\frac{\alpha-1}{\alpha}}]$. The relation between the volatility of the ROR of capital allocated to modern firms under autarky and integration is described by

Proposition 1:

Provided that two identical economies which are characterized by a production structure as described in Section 2.1 and idiosyncratic shocks in intermediate goods production join a goods market integration, the variance of the ROR of capital employed by modern firms under integration is given by $V(r_M^i) = 0.75V(r_M^a)$.

Proof: *This immediately follows from $V[(\min(\eta_1\eta_2))^{\frac{\alpha-1}{\alpha}}] = 0.75V(\eta^{\frac{\alpha-1}{\alpha}})$, which is shown in the appendix.*

It should be noticed that the reduction in the volatility of the ROR is due to goods market integration and not the result of portfolio diversification in an integrated financial market.

The ROR of capital in modern firms is now decomposed into a deterministic and a stochastic component.¹⁹ On this occasion, we distinguish between autarky and integration employing the result that $V(r_M^i) = 0.75V(r_M^a)$. In the appendix it is shown that the ROR (per period dt) can be expressed as follows:²⁰

$$r_M^a = \bar{r}_M dt + \lambda(dn_1 - dn_2) \quad (13)$$

$$r_M^i = \bar{r}_M dt + \sqrt{0.75}\lambda(dn_1 - dn_2) \quad (14)$$

¹⁸Moreover, we assume that roundabout production is always efficient, i.e. $A^{\frac{1}{\alpha}}\left(\frac{\eta}{1-\alpha}\right)^{\frac{\alpha-1}{\alpha}} > A$ holds. Otherwise, the solution to the stochastic optimization problem would be trivial with $\theta = 0$.

¹⁹This enables the application of standard methods for stochastic dynamic optimization under Poisson uncertainty when solving the household's problem. For dynamic optimization under Poisson uncertainty see Wälde (1999).

²⁰This formulation of the stochastic ROR is standard in the literature on stochastic growth models; for instance, see Eaton [1981, equation (10) and (11)].

where $\bar{r}_M := bE(\eta^{\frac{\alpha-1}{\alpha}})$ and $\lambda > 0$. To keep things as simple as possible, we hold the expected ROR in the modern sector \bar{r}_M fixed. In fact the model under study implies that this expected ROR increases in response to market integration. Taking this effect into account would even strengthen the results derived below.²¹ The stochastic component is represented by a composite and symmetric Poisson increment $\lambda(dn_1 - dn_2)$, where $dn_1 = 1$ with probability γdt and $dn_1 = 0$ with $(1-\gamma)dt$ and, analogously, $dn_2 = 1$ with γdt and $dn_2 = 0$ with $(1-\gamma)dt$. This type of uncertainty is compatible with the binary shock scheme given by (10). The expected value and variance of the stochastic component $\lambda(dn_1 - dn_2)$ is $E[\lambda(dn_1 - dn_2)] = 0$ and $V[\lambda(dn_1 - dn_2)] = 2\lambda^2\gamma dt - 2\lambda^2\gamma^2 dt^2$. The representation of the ROR shown in (13) is equivalent to (11) in the sense that both expected value and variance are identical. The first requirement is satisfied by construction (symmetry). The second requirement can be easily satisfied by choosing the parameters λ and γ such that $V[\lambda(dn_1 - dn_2)] = b^2V(\eta^{\frac{\alpha-1}{\alpha}})$.²²

Finally, we assume the following timing of events: x -producers decide on the supply of x and y_M -producers decide on the demand for x after the shocks have materialized. Hence, both types of firm solve a sequence of deterministic problems. However, the equilibrium amount of x is stochastic and, according to (4), the productivity of capital employed by modern firms is also stochastic. Moreover, we assume that households decide on their portfolio allocation before the productivity shock occurs. The ROR of ownership claims on modern firms is stochastic and portfolio decisions are made under uncertainty.

4.2 Households

The intertemporal stochastic decision problem of the representative household is described and subsequently its solution is discussed. Again, we distinguish between the case of autarky and integration.

Considering the ROR of capital allocated to modern firms [(13) and (14)], the flow budget constraint of the representative household is described by a stochastic differential equation in net assets a :

$$da = [\bar{r}_M\theta a + r_T(1-\theta)a - c]dt + \theta a\phi\lambda(dn_1 - dn_2), \quad (15)$$

where \bar{r}_M , r_T , dn_1 , and dn_2 are defined as above. The first term on the right hand side shows the continuous evolution of a , which is basically given by the difference between

²¹Another reason for ignoring the consequences on the expected ROR lies in the fact that this effect becomes very small when the supply curve for intermediate goods is upward sloping.

²²A similar statement applies to (14) and (12). In this case one must, however, take the qualification that the expected ROR in the modern sector \bar{r}_M is held fixed into account.

capital income (an average ROR times the stock of net assets) minus consumption. The second term on the right hand side gives the discontinuous jump in net assets due to stochastic increments in the ROR (as described above).

Recalling (13) and (14) indicates that for $\phi = 1$ equation (15) gives the flow budget constraint of the representative household under autarky. On the other hand, for $\phi = \sqrt{0.75}$ equation (15) describes the flow budget constraint under integration.²³

The general formulation of the flow budget constraint in (15) has the advantage that the stochastic dynamic problem needs to be solved only once. The implications of economic integration for the household's portfolio decisions (and the consequences for intersectoral capital allocation) can then be found by comparative static analysis with respect to ϕ . This simplification is made possible by the fact that the household's decisions under uncertainty are predominantly determined by the expected value and the variance of the ROR.

As usual, the household is assumed to maximize the expected present value of utility. The underlying dynamic problem comprises one state variable a and two control variables, namely c and θ :

$$\begin{aligned} \max_{\{c, \theta\}} E_0 \int_0^{\infty} u(c) e^{-\rho t} dt \\ \text{s.t. (15); } a(0) = a_0; \quad 0 \leq c \leq y; \quad 0 \leq \theta \leq 1, \end{aligned} \quad (16)$$

where E_0 denotes the expectation operator (conditional on information at $t = 0$).

5 Main implications

5.1 Basic results

The solution to the dynamic problem (16) determines the asset allocation share θ as well as the consumption wealth ratio $\Psi := c/a$. Both θ and Ψ then pin down the expected growth rate of consumption $E(dc)/(c dt)$.²⁴

Asset allocation share θ The optimal share of assets invested in ownership claims issued by modern firms θ is implicitly determined by the following first order condition for θ :

$$\bar{r}_M - r_T = \phi \lambda \gamma [(1 - \phi \lambda \theta)^{-\sigma} - (1 + \phi \lambda \theta)^{-\sigma}]. \quad (17)$$

²³In a more general model with asymmetric economies and a large number of economies, ϕ could be considered as continuous variable on $(0, 1]$.

²⁴Nearly all derivations have been relegated to an appendix, which is available upon request.

The left hand side of (17) gives the differential between the (expected) ROR of capital allocated to modern firms and the ROR of capital allocated to traditional firms. The right hand side can be expressed as $\gamma\phi\lambda\frac{u'(\tilde{c})}{u'(c)} - \gamma\phi\lambda\frac{u'(c)}{u'(c)} > 0$, where \tilde{c} denotes the level of consumption after a downward jump in a and \tilde{c} denotes consumption after an upward jump in a , respectively.²⁵ This term gives the difference between the expected proportional change in marginal utility in response to a downward jump in a (i.e. $\gamma\phi\lambda\frac{u'(\tilde{c})}{u'(c)}$) and the expected proportional change in marginal utility in response to an upward jump in a (i.e. $\gamma\phi\lambda\frac{u'(c)}{u'(c)}$).²⁶ Since the utility function is concave, there is a desire for consumption smoothing and hence the expression on the right hand side of (17) can be considered as a measure of the costs of (discontinuous) changes in $u'(c)$. By choosing θ the household can control this expression. The first order condition (17) thus says that the household chooses θ such that the marginal benefit of increasing θ [given by the left hand side of (17)] equals the marginal cost of increasing θ [given by the right hand side of (17)].

By applying the implicit function theorem to (17), one can determine the consequences of market integration with respect to the optimal portfolio choice, which is summarized by

Proposition 2:

Market integration (which is captured by a drop in ϕ from 1 to $\sqrt{0.75}$) leads to an increase in the share of assets invested in modern firms, i.e. $\frac{\partial\theta}{\partial\phi} < 0$. As a result, the average ROR earned by the representative household $r := r_T(1 - \theta) + \bar{r}_M\theta$ increases.

Proof: see the appendix.

The intuition behind this proposition is straightforward. Market integration leads to a reduction in the volatility of intermediate goods prices and in turn to a reduction in the volatility of the ROR of ownership claims on modern firms. Thus $\frac{\partial\theta}{\partial\phi} < 0$ simply states that risk averse households invest more in risky assets in response to a declining riskiness.

We are now in the position to describe the consequences of market integration with respect to the household's portfolio decision. In an integrated economy the volatility of intermediate goods prices and hence the volatility of the ROR of the risky asset are smaller compared to the autarky case. This is captured by the parameter ϕ in (17), which is $\phi = 1$ under autarky and $\phi = \sqrt{0.75}$ under integration. With a

²⁵Since $\Psi = c/a$ will turn out to be constant in equilibrium any jump in a (due to a shock in the ROR according to (15)) induces an equi-proportionate jump in c .

²⁶For instance, γ is the probability of a downward jump, $\phi\lambda$ gives the proportional rate of change in a (equal to the rate of change of c) and $\frac{u'(\tilde{c})}{u'(c)}$ is the proportional change in marginal utility.

smaller volatility in the ROR, the costs of changes in marginal utility [as given by the right hand side of (17)] fall. As a result, the household increases θ to reestablish the optimality condition (17).

Figure 2 illustrates this reasoning. The horizontal axis shows the asset allocation share θ . The horizontal solid line gives $\bar{r}_M - r_T$ (labeled LHS). The solid upward sloping curve (RHS - Autarky) shows the marginal costs of increasing θ , valid under autarky. The optimal choice of θ is determined by the intersection between these two curves. In response to market integration, the volatility of the ROR of the risky asset drops and, for fixed θ , the marginal costs of increasing θ decrease. This means that the upward sloping "marginal cost curve" is rotated downwards at the origin. The dashed upward sloping curve (LHS - Integration) shows the marginal costs under integration. Accordingly, the representative household increases θ until marginal benefits equal marginal costs.

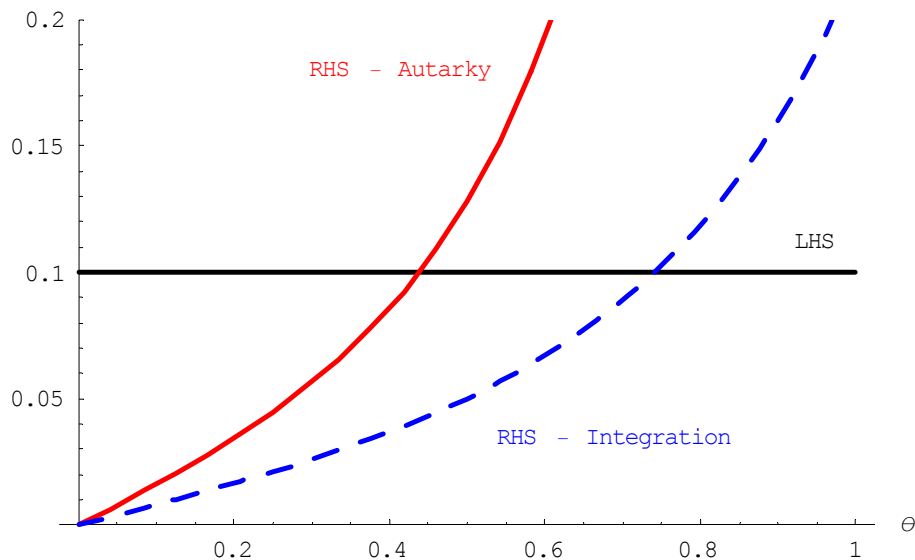


Figure 2: Market integration and optimal asset allocation; LHS and RHS refer to equation (17)

This portfolio shift is mirrored by a reallocation of physical capital from traditional firms to modern firms.²⁷

²⁷In the model, this reallocation occurs instantaneously. In the real world this process is distributed over time due to capital reallocation costs.

Consumption wealth ratio Ψ The optimal consumption asset ratio $\Psi := c/a$ turns out to read as follows:

$$\Psi = \frac{(\sigma - 1)r + \rho}{\sigma} + \frac{\gamma}{\sigma}[2 - (1 + \phi\lambda\theta)^{1-\sigma} - (1 - \phi\lambda\theta)^{1-\sigma}], \quad (18)$$

where $r := r_T(1 - \theta) + \bar{r}_M \theta$. The question of how Ψ varies with a change in ϕ is all but trivial. An important benchmark case is $\sigma = 1$ (logarithmic utility), which implies $\Psi = \rho$. The consumption wealth ratio is a constant and not affected by a change in the volatility of the risky asset.²⁸ The more general case $\sigma \neq 1$ is described by

Proposition 3:

(i) *Provided that $\sigma > 1$, the optimal consumption wealth ratio increases in response to market integration (a drop in ϕ from 1 to $\sqrt{0.75}$), i.e. $\frac{\partial \Psi}{\partial \phi} < 0$.*

(ii) *For $\sigma < 1$, the optimal consumption wealth ratio decreases in response to market integration (a drop in ϕ from 1 to $\sqrt{0.75}$), i.e. $\frac{\partial \Psi}{\partial \phi} > 0$.*

Proof: *see the appendix.*

The economic intuition is best described by employing the concept of certainty equivalent ROR (Weil, 1990). A reduction in ϕ (equivalent to a reduction in the volatility of the ROR of capital employed by modern firms) increases the certainty equivalent ROR of capital allocated to modern firms. This unfolds an intertemporal substitution effect (less contemporaneous consumption) and an intertemporal income effect (more contemporaneous consumption). For $\sigma > 1$, the income effect dominates the substitution effect such that Ψ rises. This is the well known precautionary saving mechanism. It is important to notice that the empirically relevant case is $\sigma > 1$. Hence, market integration should increase Ψ (i.e. reduce the saving rate) and depress growth.

Expected growth rate $E(dc)/cdt$ The analysis conducted so far has revealed that (i) market integration increases θ and thereby raises r ; this reallocation effect fosters growth. (ii) For $\sigma > 1$ (which is empirically relevant) market integration increases Ψ , which depresses growth. It is, therefore, interesting to see whether any clear-cut proposition can be made with respect to the consequences of market integration for the expected growth rate.

²⁸This is, of course, due to the fact that the intertemporal substitution and income effect exactly cancel.

The expected growth rate of consumption (per period of time) can be shown to read as follows:

$$\frac{E(dc)}{c dt} = \frac{r - \rho}{\sigma} - \frac{\gamma}{\sigma} [2 - (1 + \phi\lambda\theta)^{1-\sigma} - (1 - \phi\lambda\theta)^{1-\sigma}]. \quad (19)$$

Again, an interesting benchmark case is $\sigma = 1$, which implies $E(dc)/cdt = r - \rho$. On account of Proposition 2, market integration would unambiguously foster growth (due to reallocation of capital at constant Ψ). The remaining cases ($\sigma \neq 1$) are described by

Proposition 4:

The expected growth rate of consumption $E(dc)/cdt$ unambiguously increases in response to market integration (a drop in ϕ from 1 to $\sqrt{0.75}$), i.e. $\frac{\partial E(dc)/cdt}{\partial \phi} < 0$.

Proof: see the appendix.

This proposition simply states that (even in the case of $\sigma > 1$) the reallocation effect dominates the precautionary saving effect. As a consequence, market integration has been shown, in the model setup under study, to unambiguously foster growth.

6 Relation between real and financial channels

The model under study describes the following channel: Integration of (intermediate) goods market leads to (i) a drop in the volatility of intermediate goods prices; (ii) a reduction in the volatility of intermediate goods employed by modern firms; (iii) a fall in the volatility of the marginal product of physical capital allocated to modern firms; and (iv) a lower riskiness of the ROR of financial capital invested in modern firms. This channel is labeled the *real channel of risk reduction*.²⁹

The preceding mechanism is reminiscent of the *international portfolio diversification mechanism* familiar from the literature on international macroeconomics (e.g. Obstfeld, 1994). Provided that the ROR of national investments are not perfectly correlated across countries, financial market integration enables an international portfolio diversification. The volatility of the ROR of an internationally diversified portfolio is smaller compared to the national portfolio. This reduction in volatility is welfare enhancing. Moreover, using a partial equilibrium framework, Obstfeld (1994) has shown that financial market integration leads to a reallocation of capital in favour of the risky, high-yield investment, thereby fostering growth.

²⁹With risk averse households, this effect itself is welfare improving. Moreover, there is a reallocation of capital from traditional firms (less risky, lower yield) to modern firms (more risky, higher yield). This second effect boosts growth.

The two mechanisms share some similarities, but are also different in important respects. First, and most obvious, the real channel of risk reduction is related to goods market integration, whereas the international portfolio diversification mechanism is related to financial market integration. Second, in both cases international integration leads to a reduction in the volatility of the ROR of the portfolio held by the representative household. However, the volatility of the ROR of the risky national investment(s) is not affected by financial market integration and international portfolio diversification. In contrast, the real channel of risk reduction implies that the volatility of the ROR of the risky national investment itself drops in response to international goods market integration. Third, there is also an important difference concerning the action taken by the representative household: in the case of international portfolio diversification, the household reshuffles its portfolio by actively buying foreign assets. The real channel requires less conscious actions to be taken by economic agents. All that is needed here is the functioning of an integrated intermediate goods market in the sense of "one good one price".

At this stage, the question arises of whether the real channel of risk reduction and the portfolio diversification channel are substitutes or complements. To clarify this aspect, consider the following situation: Two economies (characterized by the structure as described above) integrate their financial markets. Without further restrictions, this leads to international portfolio diversification à la Obstfeld. Next, the economies under consideration integrate their (intermediate) goods market. Does this mean that the real channel of risk reduction becomes obsolete? The answer is no. The mechanism works exactly in the same way as described above. In response to intermediate goods market integration, the volatility (i) of intermediate goods prices, (ii) of the amount of intermediate goods employed by modern firms, (iii) of the marginal product of physical capital and (iv) of the ROR of financial capital allocated to modern firms drops in the same way as under financial autarky.

7 Empirical evidence for OECD countries

The model set up above implies that the growth rate of output should be negatively correlated with the volatility of intermediate goods prices. This empirical hypothesis is now tested econometrically. We use five-year average data from 1960 to 2000 of the 9 OECD countries providing adequate statistics for intermediate goods prices.³⁰ In

³⁰The sample covers Belgium, Denmark, Spain, Finland, France, UK, Germany, the Netherlands, and the USA. Data are taken from OECD (2005), see appendix. As certain countries report shorter price series the panel is unbalanced. For three countries the definition of intermediate goods deviates marginally from the others (energy, food), which has been corrected so that the prices become

this sample, the number of cross sectional units appears to be too small to produce appropriate standard errors for a GLS random effects estimator. Consequently, we adopt a procedure which is designed exactly for this kind of data, the estimation with panel corrected standard errors (PCSE). The PCSE results are obtained by the corresponding option in the Stata software package and compared with a fixed effects (FE) model. The endogenous variable is real per capita growth of GDP. As explanatory variables we use the data series which have proven to be robust in recent empirical growth literature, specifically (the logarithm of) initial GDP per capita *logingdp*, initial human capital *inhcap*, the average investment share *invshare*, and average population growth *popgrowth*; see the appendix for a description of the underlying data set. The macroeconomic data are taken from the Penn World Table, version 6.1, see Heston et al. (2002), and from Barro and Lee (2000). The new exogenous variable we add is our measure of the price volatility *igppvol* which is the standard deviation of monthly intermediate goods prices. Regarding the time specific effects, different dummies for time periods are introduced. Because the dummy variable for the period 1990-95 is always significant we include it in all estimations; the German reunification and its impact on the EU and, to a lesser extent, the first Iraq war are the reasons why the growth process is specific during that time period. To test the causal chain from trade to price volatility to growth we use an interaction term multiplying openness, measured by the trade share *open*, with *igppvol* and introduce *open* as a separate variable on the right hand side.

Table 3 reports the results of the different regressions. Most importantly, we observe that the variable of main interest *igppvol* appears negative and significant throughout the different specifications and estimations. In specification (1), besides price volatility, only the initial conditions are used as explanatory variables. The initial GDP per capita has the negative sign which is well-known from the literature showing (conditional) β -convergence in income levels.

In equation (2), the investment share and the population growth have no significant impact on growth. This is plausible for the case of OECD countries, which show little variation in these variables. The investment share is the variable which could cause a simultaneity bias; as it has no explanatory power here, specific instrumental variable methods are not adopted. In model (3) we have included all the period dummies, except *dum95-2000* to avoid perfect collinearity, without reporting their specific impact. Only *dum80-85* is significant besides the reported *dum90-95*. It turns out that the impact of intermediate goods prices remains robust and initial human capital becomes significant at the 10% level as well. To compare the PCSE procedure

comparable.

with an FE model, results of the specification in (1) obtained by FE are reported in equation (4), which exhibits a robust impact of *igpvol* with a somewhat weaker effect of the other exogenous variables. The impact of trade is introduced in specification (5), with the interaction term *open*igpvol*. The negative and significant interaction term indicates that the more open the economy is, the larger becomes the negative impact of intermediate goods price volatility on growth, which is in accordance with our model. Taken alone, openness has no effect on growth. In equation (6), we test additionally for the impact of consumer price volatility *conspvol* on growth; the sign is negative as expected, but the standard error is too large for the variable to have a significant impact.

Table 3: Estimation results

Endogenous variable: per capita growth; estimation method: PCSE							
Variable	(1)	(2)	(3, dum)	(4, FE)	(5)	(6)	(7)
const	0.16** (0.07)	0.16** (0.07)	0.29* (0.16)	0.13 (0.13)	0.19*** (0.07)	0.14 (0.09)	0.23*** (0.07)
igpvol	- 0.153*** (0.056)	- 0.151** (0.060)	- 0.112** (0.054)	- 0.154** (0.065)			-0.172** (0.069)
open*igpvol					- 0.0022** (0.0009)	- 0.0016** (0.0007)	
logingdp	- 0.033* (0.019)	- 0.034* (0.019)	- 0.068* (0.040)	- 0.025 (0.037)	- 0.044*** (0.019)	- 0.030 (0.024)	- 0.056*** (0.018)
inhcap	0.173 (0.137)	0.186 (0.142)	0.317* (0.175)	0.069 (0.427)	0.246* (0.140)	0.162 (0.158)	0.303** (0.124)
invshare		0.012 (0.061)					
popgrowth		0.032 (0.23)					
open					0.009 (0.006)	0.005 (0.005)	0.003 (0.003)
conspvol						-0.112 (0.119)	
dum90-95	-0.022*** (0.005)	-0.022*** (0.005)	-0.021*** (0.0006)	-0.022*** (0.005)	-0.021*** (0.005)	-0.022*** (0.005)	-0.022*** (0.005)
# of obs.	51	51	51	51	51	51	51
R ²	0.45	0.45	0.57	0.44	0.43	0.44	0.42
Wald χ^2	46.30	48.11	985.46	-	37.66	42.62	40.62

Notice: Standard errors in parentheses; * significant at the 10 % level; ** significant at the 5 % level; *** significant at the 1 % level.

Finally, a two step procedure has been adopted to specification (7) to get another view on price volatilities. In a first step, we have regressed *igpvol* on *conspvol* and the standard deviation of monthly oil prices and then taken the residuals as explanatory variable for intermediate goods price volatility in the regression. By doing so, we get the specific volatility of intermediate goods prices relative to other prices. As can be seen from the table, also in this respect the *igpvol* variable performs well; it is negative, significant and of similar size as in the other specifications.

Overall, the empirical results are fairly encouraging. These findings support the view that the theoretical model identifies an important channel in the globalization growth nexus. Of course, further empirical work will be helpful to corroborate our results under different conditions.

8 Summary and conclusion

We have set up a dynamic general equilibrium growth model with productivity shocks in intermediate goods production to investigate a specific channel through which globalization affects economic growth. The model implies that the growth rate of output should be negatively correlated with the volatility of intermediate goods prices. This empirical hypothesis has been tested econometrically. The main results can be summarized as follows:

(1) Provided that productivity shocks in intermediate goods production are not perfectly correlated across countries, the long run growth rate increases in response to market integration. This is due to the fact that goods market integration reduces the volatility of intermediate goods prices which leads to a decrease in the volatility of the ROR of capital employed by those firms using intermediate goods intensively (which have been labelled modern firms). The induced portfolio adjustment of households then leads to a reallocation of capital from traditional firms to modern firms. Since modern firms are more productive (due to a higher degree of specialization and additional roundaboutness in production) economic growth increases.

(2) The result stated above is interesting since a reduction in the volatility of the (uncertain) ROR additionally unfolds a precautionary saving effect. Empirically plausible values for the coefficient of relative risk aversion (larger than 1) imply that this mechanism tends to reduce household savings, capital investment, and therefore growth. Nonetheless, it has been shown analytically that the reallocation mechanism always dominates the precautionary saving mechanism.

(3) The model is consistent with the finding of Ramey and Ramey (1995) according to which there is a negative relation between volatility and growth. Moreover,

the model describes an important mechanism through which globalization affects the volatility growth nexus. Goods market integration should strengthen this negative relationship. Such theoretical clarifications have recently been demanded by authors who have investigated this aspect empirically (Kose et al., 2004).

(4) Empirical investigations have shown that the growth rate of per capita income is indeed negatively correlated (after controlling for the usual variables) with the standard deviation of intermediate goods prices. This relationship is significant across different empirical specifications. Moreover, it has been shown empirically that the negative impact of intermediate goods price volatility on growth increases with the openness of an economy, which is perfectly in line with the logic of the model.

The paper points to a number of interesting issues for future research. For instance, there is an extensive literature investigating the welfare implications of financial market integration (e.g. Asdrubali et al., 1996; Gourinchas and Jeanne, 2003). Similarly, it would be interesting to assess the welfare consequences of the real channel of risk reduction in response to goods market integration. On this occasion, a sensible distinction could be made between perfect and imperfect competition in the intermediate goods sector.

9 Data appendix

This appendix gives the sources together with some descriptive statistics of the data set employed in Section 7.

Table 4: Data

Sources and descriptive statistics

Variable	Description	Source	Mean	St.Dev.
growth	real per capita GDP growth, constant prices, ref. 1996	PWT 6.1	0.0267	0.0164
igpvol	St.dev. of monthly intermed. goods prices*	OECD MEI	3.934	3.001
logingdp	log of initial GDP per capita	PWT 6.1	4.162	0.149
inhcap	initial years of average schooling*	Barro/Lee	7.93	1.80
invshare	average investment share	PWT 6.1	25.06	4.21
popgrowth	population growth	PWT 6.1	0.0054	0.0037
open	(Exports+Imports)/GDP	PWT 6.1	47.86	28.84
conspvol	St.dev. of monthly consumer goods prices	OECD MEI	3.001	1.839

*Data multiplied by 100 to increase readability of coefficients and standard errors reported in Table 3.

References

- [1] Asdrubali, P., B.E. Sorensen, and O. Yosha, Channels of Interest Risk Sharing: United States 1963-1990, *Quarterly Journal of Economics*, 1996, 1081-1110.
- [2] Barro, R.J., Government Spending in a Simple Model of Endogenous Growth, *Journal of Political Economy*, 1990, Vol. 98, No. 2, S103-S125.
- [3] Barro, R.E. and J-W.Lee (2000): International Data on Educational Attainment: Updates and Implications, April 2000, <http://www.cid.harvard.edu/ciddata/ciddata.html>.
- [4] Bertola, G., Flexibility, investment and growth, *Journal of Monetary Economics*, 1994, 34, 215-238.
- [5] von Böhm-Barwerk, E., *Kapital und Kapitalzins*, Jena, 1921.
- [6] Campa, J. and L. Goldberg, The Evolving External Orientation of Manufacturing: A Profile of Four Countries, *FRBNY Economic Policy Review*, July, 1997, 53-81.
- [7] Devereux, M.B. and G.W. Smith, International Risk Sharing and Economic Growth, *International Economic Review*, 1994, Vol. 35, No. 3, 535-550.
- [8] Dollar, D., Outward-Oriented Developing Economies Really Do Grow More Rapidly: Evidence from 95 LDCs, 1976-1985, *Economic Development and Cultural Change*, 1992, 40(3), 523-544.
- [9] Eaton, J., Fiscal Policy, Inflation and the Accumulation of Risky Capital, *Review of Economic Studies*, 1981, XLVIII, 435-445.
- [10] Edwards, S. (1998). Openness, productivity and growth: what do we really know? *Economic Journal*, 108, March, 383-398.
- [11] Gourinchas, P.-O. and O. Jeanne, The Elusive Gains from Financial Integration, *NBER Working Paper Series*, #9684, May 2003.
- [12] Grossman, G. and E. Helpman, *Innovation and Growth in the Global Economy*, Cambridge, MIT Press, 1991.
- [13] Heston, A., R. Summers and B. Aten (2002): Penn World Table Version 6.1, Center for International Comparisons at the University of Pennsylvania (CICUP), October 2002.
- [14] Kleinert, J., Growing Trade in Intermediate Goods: Outsourcing, Global Sourcing, or Increasing Importance of MNE Networks? *Review of International Economics*, 11, 3, 2003.
- [15] Kose, A.M., E.S. Prasad and M.E. Terrones, How do trade and financial integration affect the relationship between growth and volatility?, *IMF Working Paper*, May, 2003.
- [16] Obstfeld, M., Risk-Taking, Global Diversification, and Growth, *American Economic Review*, 1994, Vol. 85, No. 5, 1310-1329.
- [17] *OECD Main Economic Indicators*, Vol. 2005, No. 2, Paris, 2005.
- [18] *OECD, Structural Analysis (STAN) database*, 2004, Paris.

- [19] Ramey, G. and V.A. Ramey, Cross Country Evidence on the Link Between Volatility and Growth, *American Economic Review*, 1995, Vol. 85, No. 5, 1138-1151.
- [20] Rodríguez, F. and D. Rodrik, Trade Policy and Economic Growth: a Skeptic's Guide to the Cross-National Evidence, in: Ben S. Bernanke and Kenneth Rogoff (eds.), *NBER Macroeconomics Annual 2000*, Volume 15, Cambridge and London: MIT Press.
- [21] Weil, P., 1990, Nonexpected Utility in Macroeconomics, *Quarterly Journal of Economics*, 105, 29-42.
- [22] Wälde, K., Optimal Saving under Poisson Uncertainty, *Journal of Economic Theory*, 1999, 87, 194-217.
- [23] Warnock, F. E., Home Bias and High Turnover Reconsidered, *Journal of International Money and Finance*, 2002, 21, 795-805.