GLOBALIZATION, THE VOLATILITY OF INTERMEDIATE GOODS PRICES, AND ECONOMIC GROWTH

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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 to capital invested in modern firms. The induced portfolio decisions of households lead to a reallocation of capital from traditional to modern firms. Despite the presence of a reverse precautionary saving channel, the growth rate unambiguously increases because of the reallocation of capital. Empirical estimates for OECD countries support the theoretical results.

Keywords: Globalization, Trade in Intermediate Goods, Portfolio Decisions, Economic Growth

1. INTRODUCTION

The question of whether and how globalization affects economic growth is one of the most fundamental questions in economics. Rodríguez and Rodrik (2000) have argued forcefully that the openness growth nexus is quite complex and, therefore, in-depth research aimed at the identification of specific channels is called for. In this paper, we follow their suggestion. At the level of theoretical research, a specific channel that highlights the general importance of intermediate goods as a chain link in the globalization growth nexus is investigated. Moreover, we provide some empirical evidence on the relationship between intermediate goods price volatility 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 better understand the relationship between goods market integration and economic 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.[1]

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Furthermore, trade in intermediate goods is quantitatively substantial. The average share of overall goods trade in intermediate goods 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).[2]

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%.[3] 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 (the intermediate goods–intensive sector) and traditional–final output firms (which use the second input factor, capital, intensively).

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-Bawerk (1921)], which might increase the productivity of the complementary factors.[4]

We set up a model of a stylized economy, which allows us to investigate the nexus between trade in intermediate goods and economic growth. The model comprises two sectors, namely a final output sector and an intermediate goods sector. Production in the intermediate goods sector is subject to random shocks. 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 with capital.

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.[5] As a result, the volatility of the rate of return (ROR) to capital allocated to modern firms decreases. The induced portfolio decisions of households then lead 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, this paper is probably closest to Obstfeld (1994), who studies the consequences of international financial market integration for risk taking and long-run growth. There are, however, a number of important differences:[6] First, this paper investigates the consequences of goods market integration and hence is devoted to the real side of the economy. Second, we set up a general equilibrium model where 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. In contrast, Obstfeld (1994) assumes that there are two linear investment projects, one safe low-yield and one risky high-yield project.[7]

It should also be noticed that there is a branch of literature that argues that market integration should spur output volatility. For instance, rising financial integration could also lead to increasing specialization such that economies become more vulnerable to industry-specific shocks [Kalemli-Ozcan et al. (2003)]. In addition, sudden changes in the direction of capital flows could induce boom–bust cycles in developing countries, most of which do not have deep enough financial sectors to cope with volatile capital flows [Aghion et al. (1999)].

We do not model the causes of persistent patterns of specialization and trade in intermediate goods. The economies under consideration are identical ex ante, i.e., before technology shocks have materialized. They possess the same constant– returns to scale technologies and the same factor endowments. Hence, there is no reason for persistent international specialization.[8] Kleinert (2003) has investigated three possible explanations for growing trade in intermediate goods, namely the outsourcing hypothesis, the multinational enterprise (MNE) hypothesis, and the global sourcing hypothesis. Increasing importance of MNE networks is found to be the most important reason for growing trade in intermediate goods.

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 empirical literature has developed that investigates the volatility–growth nexus more deeply. For instance, Kose et al. (2006) 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. (2006, p. 180)]. This paper contributes to this strand of literature by showing that goods market integration generates 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.[9]

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 channel derived in this paper and the international portfolio diversification mechanism. Section 7 provides empirical evidence on the channel under study. Finally, Section 8 summarizes and concludes. All derivations and proofs have been relegated to an Appendix.

2. THE DETERMINISTIC ECONOMY

2.1. Firms

There are two types of firms in the final output sector. The output of the representative traditional firm is denoted as y_T, whereas the output of the representative modern firm is labelled y_M. The production technologies of the two types of firms are 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), $0 < \alpha < 1$ is 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 later.

There are 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 $p_x^S = \eta$. Profit maximization of y_M-producers implies an inverse demand schedule for intermediate goods, $p_x^D = (1 - \alpha)A(\theta k)^\alpha x^{-\alpha}$. From equilibrium in the x-market, i.e., $p_x^S = p_x^D$, the equilibrium amount of x is given by

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

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

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

Provided that $A^{1/\alpha}(\frac{\eta}{1-\alpha})^{(\alpha-1)/\alpha} > A$, roundabout production is efficient. Roundabout production, in the model under study, means that there is the possibility of using Y-goods to produce x-goods that are, in turn, used as an input in the production of Y-goods. The technology $y_T = A(1 - \theta)k$ involves one roundabout production process, namely converting Y-goods into physical capital, which can be used to produce Y-goods. The technology $y_M = A(\theta k)^\alpha x^{1-\alpha}$ involves a second roundabout production process. Now, if this second roundabout production process is sufficiently productive, the capital productivity of the y_M technology exceeds the productivity of the y_T technology.[11] An alternative, and complementary, argument for the assumption according to which the production technology that employs intermediate goods is more productive than the production technology that does

not employ intermediate goods is based on economies of specialization [e.g., Romer (1990)]. The availability of an increasing number of intermediate goods captures the idea that production can be organized more efficiently so that total factor productivity in the final output sector rises. A model that captures this mechanism explicitly requires a range of intermediate goods that are imperfect substitutes in Y-production. The formulation employed in this paper can be viewed as a tractable shortcut for such a more complicated modeling strategy.

It will be shown that for $A^{1/\alpha}(\frac{\eta}{1-\alpha})^{(\alpha-1)/\alpha} > A$, the representative household sets θ equal to unity. In contrast, for $A^{1/\alpha}(\frac{\eta}{1-\alpha})^{(\alpha-1)/\alpha} < A$, 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.[12]

Noting (4) and $p_x^S = \eta$, one gets the following *indirect production function*:

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

This formulation shows that changes in the price of intermediate goods affect the productivity of capital, employed by modern firms, in a way similar 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. Because, at equilibrium, physical capital is combined with a larger amount of x, the productivity of capital increases.

2.2. Households

The representative household is assumed to maximize the present value of utility, given by

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

where $\rho > 0$ denotes the time preference rate and $t \in \mathbf{R}_+$ the time index. The instantaneous utility function reads as follows:

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

where $\sigma > 0$ and c denotes per capita consumption. 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 being consumed, respectively.[13] Hence, the relative price of y_T in terms of y_M is fixed 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. 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 $r_T = A$, whereas ownership claims on modern firms pay a ROR of $r_M = A^{1/\alpha}(\frac{\eta}{1-\alpha})^{(\alpha-1)/\alpha}$. The household's flow budget constraint reads

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

where $\dot{a} := da/dt$. The solution to this 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 $A^{1/\alpha}(\frac{\eta}{1-\alpha})^{(\alpha-1)/\alpha} < A$ and $r = r_M = A^{1/\alpha}(\frac{\eta}{1-\alpha})^{(\alpha-1)/\alpha}$ for $A^{1/\alpha}(\frac{\eta}{1-\alpha})^{(\alpha-1)/\alpha} > A$.[15]

3. MARKET INTEGRATION

Consider two economies that are perfectly identical except for the input coefficients in intermediate goods production η. The equilibrium price of intermediate goods in the integrated economy p_x^i is given (we assume that the conditions for interior solutions hold) by

$$p_x^i = \min(\eta_1, \eta_2), \tag{8}$$

where η_1 and η_2 denote the input coefficients in intermediate goods production in countries 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*:

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

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 $[\min(\eta_1, \eta_2)]^{(\alpha-1)/\alpha}$ is smaller than the volatility of $\eta^{(\alpha-1)/\alpha}$.

4. THE STOCHASTIC ECONOMY

We now introduce uncertainty into the model. As the analysis proceeds, we distinguish between autarky and integration to reveal the consequences of market integration in the stochastic environment.

4.1. The Return on Capital Employed by Modern Firms

It is now assumed that the production of intermediate inputs is subject to random shocks. Specifically, the input coefficients η_i for $i \in \{1, 2\}$ fluctuate randomly in a stationary fashion and are described by the following simple probability distribution:[17]

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

where $\varepsilon_i > 0$. The expected value of η_i is $E(\eta_i) = \bar{\eta}$.[18]

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

$$r_M^a = b\eta^{\frac{\alpha-1}{\alpha}}, \tag{11}$$

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

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

PROPOSITION 1. *Provided that two identical economies with a production structure as described in Section 2.1 and idiosyncratic shocks in intermediate goods production according to (10) join a goods market integration, the variance of the ROR of capital employed by modern firms under integration is given by* $V(r_M^i) = 0.75 V(r_M^a)$.

Proof. See the Appendix. ∎

It should be observed that the reduction in the volatility of the ROR is due to goods market integration and not, as in Obstfeld (1994), the result of portfolio diversification in an integrated financial market.

The ROR on 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 $V(r_M^i) = 0.75 V(r_M^a)$. In the Appendix it is shown that the ROR (per period dt) can be expressed as follows:[20]

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

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

where $\bar{r}_M := bE[\eta^{(\alpha-1)/\alpha}]$ and $\lambda > 0$. Several aspects should be noted: First, to simplify matters, we hold the expected ROR in the modern sector $\bar{r}_M$ fixed. The model under study does indeed imply that the expected ROR increases in response to market integration. Taking this effect into account would even strengthen

the results derived later.[21] Second, 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 $(1 - \gamma)dt$, where $0 < \gamma < 1$.[22] This type of uncertainty is compatible with the binary shock scheme given by (10). It should be noted that the choice of the type of uncertainty, i.e., Wiener versus Poisson uncertainty, is largely a matter of taste, because the results are qualitatively identical [Steger (2005)]. Third, 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 easily be satisfied by choosing the parameters λ and γ such that $V[\lambda(dn_1 - dn_2)] = b^2 V[\eta^{(\alpha-1)/\alpha}]$.[23]

Regarding the interpretation of the equilibrium in the two-country stochastic economy under integration, the following aspect should be noticed. In the real world, there are frictions associated with the reallocation of input factors. Hence, only persistent shocks may induce a shift in intermediate goods production from one country to another. Nonetheless, we think that it is quite reasonable to believe that the equilibrium price of intermediate goods in a world with just one intermediate goods producer (and stochastic technology shocks) is more volatile than in a world with many intermediate goods producers (assuming that technology shocks are uncorrelated). This aspect is captured by the model.

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 sequences 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 on 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:

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

where $\bar{r}_M, r_T, dn_1$, and dn_2 are defined as before. The first term on the RHS shows the continuous evolution of a, which is given by the difference between capital income, i.e., an average ROR times the stock of net assets, and consumption.

The second term on the RHS gives the discontinuous jump in net assets due to stochastic increments in the ROR, as described previously.

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.[24]

The general formulation of the flow budget constraint in (15) has the advantage that the intertemporal problem needs to be solved only once. The implications of economic integration for the household's portfolio decision 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.

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

$$\max_{\{c,\theta\}} E_0 \int_0^\infty u(c)\, e^{-\rho t}\, dt,$$

$$\text{s.t. (15)}; \ a(0) = a_0 > 0; \ 0 \le c \le y; \ 0 \le \theta \le 1, \tag{16}$$

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

5. MAIN IMPLICATIONS

The solution to the dynamic problem (16) determines the asset allocation share θ and the consumption–wealth ratio $\Psi := c/a$. Both θ and Ψ then pin down the expected growth rate of consumption $E(dc/cdt)$.[25]

5.1. 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 (see the Appendix for the derivation):

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

The LHS of (17) gives the differential between the (expected) ROR on capital allocated to modern firms and the ROR on capital allocated to traditional firms. The RHS can be expressed as $\gamma\phi\lambda\frac{u'(\widetilde{\widetilde{c}})}{u'(c)} - \gamma\phi\lambda\frac{u'(\widetilde{c})}{u'(c)} > 0$, where $\widetilde{\widetilde{c}}$ denotes the level of consumption after a downward jump in a and $\widetilde{c}$ denotes consumption after an upward jump in a, respectively.[26] This term gives the difference between the expected proportional change in marginal utility in response to a downward jump

in a, i.e., $\gamma\phi\lambda\frac{u'(\widetilde{\widetilde{c}})}{u'(c)}$, and the expected proportional change in marginal utility in response to an upward jump in a, i.e., $\gamma\phi\lambda\frac{u'(\widetilde{c})}{u'(c)}$.[27] Because the utility function is concave, there is a desire for consumption smoothing and hence the expression on the RHS 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 LHS of (17), equals the marginal cost of increasing θ, given by the RHS 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., $\partial\theta/\partial\phi < 0$. 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 on ownership claims on modern firms. Thus $\partial\theta/\partial\phi < 0$ simply states that risk-averse households invest more in risky assets in response to declining riskiness.

We are now in a 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 than in 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 smaller volatility in the ROR, the costs of changes in marginal utility, as given by the RHS of (17), fall. As a result, the household increases θ to reestablish the optimality condition (17).

Figure 1 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 on 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 downward at the origin. The dashed upward-sloping curve (RHS—Integration) shows the marginal costs under integration. Accordingly, the representative household increases θ until marginal benefits equal marginal costs.

This portfolio shift is mirrored by a reallocation of physical capital from traditional firms to modern firms.[28]
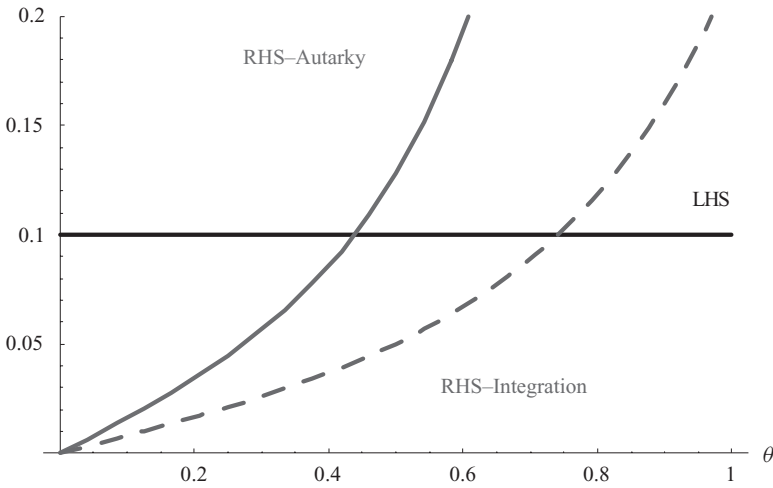
FIGURE 1. Market integration and optimal asset allocation; LHS and RHS refer to equation (17).

5.2. Consumption–Wealth Ratio Ψ

The optimal consumption–asset ratio $\Psi := c/a$ turns out to read as follows (see the Appendix for the derivation):

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

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. A natural 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.[29] 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., $\partial\Psi/\partial\phi < 0$.*
 (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., $\partial\Psi/\partial\phi > 0$.*

Proof. See the Appendix. ∎

The economic intuition is best described by employing the concept of certainty-equivalent ROR [Weil (1990)]. A reduction in ϕ, which is equivalent to a reduction in the volatility of the ROR on capital employed by modern firms, increases the certainty-equivalent ROR on capital allocated to modern firms. This unfolds an

intertemporal substitution effect, i.e., less contemporaneous consumption, and an intertemporal income effect, i.e., more contemporaneous consumption. For $\sigma > 1$, the income effect dominates the substitution effect, so that Ψ rises. This is the well-known precautionary saving mechanism.[30] 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.

5.3. 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.

The expected growth rate of consumption (per period of time) can be shown to read as follows (see the Appendix for the derivation):

$$E\left(\frac{dc}{cdt}\right) = \frac{r-\rho}{\sigma} - \frac{\gamma}{\sigma}[2 - (1 + \phi\lambda\theta)^{1-\sigma} - (1 - \phi\lambda\theta)^{1-\sigma}]. \qquad (19)$$

Again, the benchmark case is $\sigma = 1$, which implies that $E(\frac{dc}{cdt}) = r - \rho$. On account of Proposition 2, market integration would unambiguously foster growth, because of 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., $\partial E(dc/cdt)/\partial\phi < 0$.*

Proof. See the Appendix.   ■

This proposition implies that, even in the case of $\sigma > 1$, the reallocation effect always dominates the precautionary saving effect. As a consequence, market integration has been shown, in the model under study, to unambiguously foster growth. Notice that because the (expected) saving rate is constant in this AK-type growth model, equation (19) also gives the growth rate of output.

6. RELATION BETWEEN REAL AND FINANCIAL CHANNELS

The model under study describes the following channel: Integration of the (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 on financial capital invested in modern firms. This channel is labeled the *real channel of risk reduction*.[31]

The preceding mechanism is reminiscent of the *international portfolio diversification mechanism* familiar from the literature on international macroeconomics [Obstfeld (1994)]. Provided that the ROR on national investments are not perfectly correlated across countries, financial market integration enables an international portfolio diversification. The volatility of the ROR on an internationally diversified portfolio is smaller than that of the national portfolio. This reduction in volatility is welfare-enhancing. Moreover, Obstfeld (1994) has shown that financial market integration leads to a reallocation of capital in favor of the risky, high-yield investment, thereby fostering 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 market integration leads to a reduction in the volatility of the ROR on the portfolio held by the representative household. However, the volatility of the ROR on 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 on the risky national investment itself drops in response to international goods market integration. Third, the real channel requires that households have to revise their allocation of wealth on domestic firms. In contrast, according to Obstfeld (1994), households revise their wealth allocation between domestic and foreign firms. The literature on the home bias puzzle in equity investment has stressed that the acquisition of foreign stocks is connected with relatively high costs [Obstfeld and Rogoff (1996, Chapter 5.3)]. This may imply that the wealth reallocation induced in response to market integration may be weaker in the case of financial globalization than for the real channel.

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 described previously, 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 in exactly the same way as described previously. 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 on 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 in the preceding sections implies two key empirical relationships: First, an economy's trade openness should affect the volatility of intermediate goods prices negatively. Second, the volatility of intermediate goods prices should exert a negative impact on the growth rate of output. We now test these two hypotheses, employing panel data estimations. Five-year average data from 1960 to 2000 on the 9 OECD countries providing adequate statistics for intermediate goods prices are used.[32] In this sample, the number of cross-sectional units is small, so the standard errors of a GLS-random effects estimator become unreliable. Consequently, we first adopt the estimation procedure of panel-corrected standard errors (PCSE), which is designed exactly for this kind of data. In a next step, the PCSE results are compared with a fixed effects (FE) model. To test for the relationship between the two equations implied by the model, we present two variants. In the single-equation estimation for growth we introduce an interaction term to capture the link between price volatility and openness. We then proceed with simultaneous-equation estimates. By adoption of the three-stage least-squares (3SLS) procedure, consistency and efficiency are achieved by instrumentation and appropriate weighting, respectively. Finally, the equations are alternatively tested using the seemingly unrelated regression (SUR) technique.

The endogenous variables are real per capita growth of GDP, *growth*, and the average standard deviation of monthly intermediate goods prices, *igpvol*, which measures intermediate goods price volatility. The macroeconomic data are taken from the Penn World Table, Version 6.1, [see Heston et al. (2002)], and from Barro and Lee (2000), whereas the price series are provided by the OECD (2005) and the IMF; see the Appendix for a detailed description of the underlying data set. We control for standard growth correlates such as (the logarithm of) initial GDP per capita, *logingdp*, initial human capital, *inhcap*, the average investment share, *invshare*, and average population growth, *popgrowth*. Moreover, we test whether inflation and inflation volatility affect our growth relation. The price volatility estimates show the impact of the openness measure, *open,* reflecting trade openness, on intermediate goods price volatility. They control for, first, the impact of the (average) standard deviation of monthly oil prices, *opvol*, and, second, additional measures of financial openness and de jure trade. Oil is a primary input and not an intermediate good with different price volatilities in the different countries, as treated in the model. However, it has a high volatility, which also affects intermediate goods prices; the correlation between the two price volatilities is 0.39. Regarding the time-specific effects, different dummies for time periods are introduced. Because the dummy variable for the period 1990–1995 is always significant in the regressions, we include it in all the estimates. The German reunification and its impact on the EU and, to a lesser extent, the first Iraq war are the reasons that the growth process appears to be special during that time period.

Table 1 reports the results of the different regressions. In columns (1)–(6), the system is estimated separately for the growth equation, with the results provided in the upper half of the table, and the price volatility relation, with the results shown in the lower part. Columns (7) and (8) represent simultaneous-equation estimates, so that the whole column belongs to the same estimate.

Let us first discuss (1)–(6). In the growth estimates, we observe that the variable of main interest, *igpvol*, appears negative and significant throughout the different specifications. Equation (1) uses the initial conditions in addition to the price volatility as explanatory variables. The initial GDP per capita has a negative sign, which is well known from the literature, showing (conditional) β-convergence in income levels. In (2), the investment share and the population growth have no significant impact on growth, which is plausible for the case of OECD countries with little variation in these respects. In equation (3), the impact of the inflation of consumer prices is added but has no effect on growth. To compare the PCSE procedure with a FE model, results of the specification in (3) obtained by FE are reported in equation (4), which shows a robust impact of *igpvol* with a somewhat weaker effect of the other exogenous variables, except *inflation*, which appears negative and significant at the 10% level. In (5) we additionally control for inflation volatility by using *inflatvol*, but there is no significant effect. The impact of trade is introduced in equation (6) through the interaction term *open*igpvol*, which multiplies openness and price volatility. The negative and significant interaction term shows 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.

In the single-equation estimates (1)–(6) of the price volatility, shown in the lower part of Table 1, we see that the openness variable *open* has a highly significant negative impact on intermediates price volatility *igpvol*, once the variation of oil prices is controlled for. This holds true for all specifications. Country-specific effects of price adjustments, which are, for instance, determined by market forms, institutions, and macroeconomic stability, are captured by dummy variables for all countries (except for the United States, to avoid perfect collinearity, and (4), which includes fixed effects); these results are not included in the table. The volatility of oil prices *opvol* has a positive impact on the intermediates price variation, which is significant. The dummy for the period 1990–1995 is again included in all the equations. The estimated coefficient for capital openness *capopen,* a recent index from Chinn and Ito (2008), is not significant. In (4), the FE estimator does not alter the outcome; it is in fact similar to using country dummy variables. Columns (5) and (6) additionally control for capital account transactions, an index from Quinn (1997), and taxes on international trade as a percentage of GDP; neither has a significant impact on the results. The effect of trade openness is fully preserved. These additional results confirm that the effect of goods trade rather than financial openness is most relevant for the analyzed type of openness-growth nexus.

In (7), we use the three-stage least squares procedure to estimate the two relationships simultaneously. It is most interesting to see that the results do not

TABLE 1. Estimation results (different estimation methods and control variables)

Variable	(1) PCSE	(2) PCSE	(3) PCSE	(4) FE	(5) PCSE	(6) PCSE	(7) 3SLS	(8) SUR
growth								
igpvol	−0.153***	−0.151**	−0.198***	−0.273***	−0.161**		−0.144**	−0.118**
	(0.0560)	(0.0597)	(0.0717)	(0.0924)	(0.0811)		(0.0603)	(0.0529)
logingdp	−0.0335*	−0.0338*	−0.0930***	−0.0951*	−0.0978***	−0.0437**	−0.0330	−0.0342
	(0.0192)	(0.0191)	(0.0319)	(0.0553)	(0.0341)	(0.0193)	(0.0213)	(0.0212)
inhcap	0.173	0.186	0.365**	−0.234	0.401**	0.246*	0.173	0.187
	(0.137)	(0.142)	(0.148)	(0.528)	(0.160)	(0.140)	(0.141)	(0.140)
dum9095	−0.022***	−0.022***	−0.022***	−0.022***	−0.0218***	−0.021***	−0.022***	−0.021***
	(0.005)	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.004)
invshare		0.0117						
		(0.0610)						
popgr		0.0321						
		(0.230)						
inflation			−0.0675	−0.135*	−0.0492	−0.0410		
			(0.0586)	(0.0751)	(0.0539)	(0.0487)		
inflatvol					−0.131	−0.143		
					(0.106)	(0.107)		
open* igpvol						−0.0022**		
						(0.0009)		
constant	0.159**	0.156**	0.401***	0.467**	0.418***	0.441***	0.156*	0.159**
	(0.0697)	(0.0697)	(0.128)	(0.205)	(0.136)	(0.146)	(0.0802)	(0.0800)

igpvol

open	−0.132**	−0.115***	−0.131***	−0.131**	−0.135***	−0.129***	−0.113***	−0.112***
	(0.0553)	(0.0405)	(0.0447)	(0.0484)	(0.0449)	(0.0469)	(0.0306)	(0.0305)
opvol	1.087***	1.131***	1.121***	1.121***	1.132***	1.155***	1.174***	1.176***
	(0.335)	(0.236)	(0.239)	(0.258)	(0.239)	(0.224)	(0.222)	(0.222)
dum9095		−2.43**	−2.51**	−2.51***	−2.53**	−2.39**	−2.446***	−2.451***
		(1.03)	(1.06)	(0.90)	(1.08)	(1.02)	(0.764)	(0.764)
capopen			0.266	0.266	0.209	0.479		
			(0.466)	(0.538)	(0.467)	(0.506)		
tradetax					−0.605	−0.775		
					(1.165)	(1.119)		
captransa						−0.751		
						(0.876)		
constant	1.426	1.338*	0.944	6.320***	1.289	3.363	3.472**	3.405**
	(1.067)	(0.773)	(1.110)	(1.910)	(1.243)	(2.917)	(1.446)	(1.444)
# of obs.	51	51	45	45	45	45	51	51
R^2 growth	.45	.45	.48	.58	.50	.51	.45	.44
R^2 igvpol	.45	.54	.54	.47	.54	.55	.54	.54

Note: Standard errors in parentheses. ***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level. Endogenous variables: per capita growth (*growth*) and intermed. goods price volatility (*igpvol*).
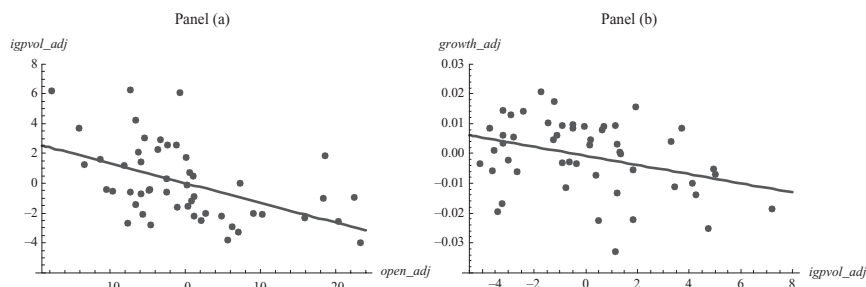
FIGURE 2. Link between openness, intermediate goods price volatility, and economic growth. Panel (a) corresponds to estimate (1), shown in Table 1 (lower part), where *open* is the residual from regressing *open* on all other RHS variables. The variable *igpvol* is the residual from regressing *igpvol* on all RHS variables except *open*. Panel (b) corresponds to estimate (1) shown in Table 1 (upper part), where *igpvol* is the residual from regressing *igpvol* on all other RHS variables. The variable *growth* is the residual from regressing *growth* on all RHS variables except *igpvol*.

deviate much from the outcomes in columns (1)–(6). In particular, the impact of price volatility on growth and the effect of trade openness on price volatility are fully corroborated by the simultaneous estimation. In (7), the period and country dummies are used as exogenous instruments in the first stage, so that they do not appear in the table. The introduction of these instruments is useful to reduce the scope for omitted variable bias. Finally, in (8), we use the alternative estimation technique of SUR, which amounts to running the simultaneous model without instrumenting for the endogenous variables. Once more, we find a very similar result, which provides evidence for trade having a positive impact on growth via the volatility of intermediate goods prices. In summary, the empirical investigation supports the conclusion that the theoretical analysis has indeed derived an important channel in the globalization growth nexus.

The empirical evidence for a negative partial correlation between openness and the volatility of intermediate goods prices is illustrated by the scatterplot shown in Figure 2a. The respective points show combinations of (adjusted) openness (*open_adj*) and the (adjusted) volatility of intermediate goods prices (*igpvol_adj*), resulting from the estimates in Table 1. Panel (a) corresponds to estimate (1) (lower part), where *open_adj* is the residual from regressing *open* on all other RHS variables. The variable *igpvol_adj* is the residual from regressing *igpvol* on all RHS variables except *open*. The empirical evidence for a negative partial correlation between the volatility of intermediate goods prices and economic growth is illustrated by the scatterplot in Figure 2b. The respective points show combinations of the (adjusted) standard deviation of intermediate goods prices (*igpvol_adj*) and the (adjusted) growth rates (*growth_adj*), as resulting from a basic growth regression controlling for standard growth correlates. Panel (b) corresponds to estimate (1) (upper part), where *igpvol_adj* is the residual from regressing *igpvol*

on all other RHS variables. The variable *growth_adj* is the residual from regressing *growth* on all RHS variables except *igpvol*.

In both panels, the estimated coefficients equal the slopes of the regression lines. The negative and statistically significant regression lines exhibit that an increase in trade openness indeed reduces the volatility of intermediate goods prices, which tends to speed up growth.

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 on the ROR on capital employed by firms using intermediate goods intensively. The induced portfolio adjustment of households then leads to a reallocation of capital from traditional firms to modern firms. Because modern firms are more productive, due to a higher degree of specialization and additional roundaboutness in production, economic growth increases.

(2) This result is interesting because 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 one, 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 results obtained by Ramey and Ramey (1995), who find a negative correlation between output volatility and economic growth. Moreover, the model provides one candidate explanation for this observed negative correlation. Such theoretical clarifications have recently been demanded by authors who have investigated this aspect empirically [Kose et al. (2006)].

(4) Empirical evidence supports the view that the growth rate of per capita income is indeed negatively correlated, after controlling for standard growth correlates, with the volatility of intermediate goods prices. This relationship is statistically significant and robust across different empirical specifications. Moreover, the negative impact of intermediate goods price volatility on growth increases with the openness of an economy, which is 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 to investigate whether the results remain valid in a second-best setup.

NOTES

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

2. Campa and Goldberg focus on major industrialized economies.

3. The numbers refer to averages over the six major OECD countries in 1995.

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

5. This assumption is critical. However, it is also fairly reasonable and empirically valid.

6. We will return to a comparison between the real channel, developed in this paper, and the financial channel analyzed in Obstfeld (1994) in Section 6.

7. Devereux and Smith (1994) 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.

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

9. In a recent study Imbs (2007) has confirmed that the link between volatility and growth is significantly negative across countries. However, the relation is shown to be positive across sectors.

10. Equations (1) and (3) demonstrate that the model is basically an AK-type growth model in the spirit of Barro (1990) and Rebelo (1991).

11. von Böhm-Bawerk (1921) reasoned that the net return to capital is, among other things, the result of the greater value produced by roundaboutness.

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

13. This assumption is not critical for the results derived later but greatly simplifies the analysis.

14. Because households are identical, there will be no loans at equilibrium, and thus $k = a$.

15. At equilibrium, only one type of ownership claims are actually held by private households. The decision on θ is trivial in the deterministic setup.

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

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

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

19. This enables the application of standard methods for stochastic dynamic optimization under Poisson uncertainty. For dynamic optimization under Poisson uncertainty see Wälde (1999) and Sennewald and Wälde (2005).

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

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

22. Expected value and variance are given by $E[\lambda(dn_1 - dn_2)] = 0$ and $V[\lambda(dn_1 - dn_2)] = 2\lambda^2\gamma\,dt - 2\lambda^2\gamma^2 dt^2$.

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

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

25. Nearly all derivations have been relegated to the Appendix.

26. Because $\Psi = c/a$ will turn out to be constant at equilibrium, any jump in a due to a shock in the ROR according to (15) induces an equiproportionate jump in c

27. For 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 $u'(\widetilde{\widetilde{c}})/u'(c)$ is the proportional change in marginal utility.

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

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

30. For a discussion of precautionary saving in response to interest rate uncertainty, see Sandmo (1970).

31. With 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.

32. The sample covers Belgium, Denmark, Spain, Finland, France, the United Kingdom, Germany, the Netherlands, and the United States. 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 comparable.

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APPENDIX

A.1. DATA AND DESCRIPTIVE STATISTICS

Table A.1 gives the sources, together with some descriptive statistics, for the data set employed in Section 7.

TABLE A.1. Data sources and test statistics

Variable	Description	Source	Mean	St.dev.
growth	Real per capita GDP growth, constant prices, ref. 1996 (Laspeyres)	PWT 6.1	0.0267	0.0164
igpvol	St.dev. of monthly intermed. goods prices[a]	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[a]	Barro/Lee (2000)	7.93	1.80
invshare	Average investment share[a]	PWT 6.1	25.06	4.21
popgrowth	Population growth	PWT 6.1	0.0054	0.0037
inflation	Annual inflation rates, consumer prices[a]	IMF WEO	5.98	4.02
inflatvol	St.dev. of annual inflation rates[a]	IMF WEO	2.04	1.71
open	(Exports+imports)/GDP	PWT 6.1	47.86	28.84
opvol	St.dev. of monthly oil prices	Dow Jones Energy Service	3.00	1.82
capopen	Capital openness	Chinn/Ito (2008)	1.23	1.26
tradetax	Taxes on international trade (%of GDP)	IMF GFS	0.298	0.48
captransa	Capital account transactions	Quinn (1997)	3.19	0.73

[a]Data multiplied by 100 to increase readability of coefficients and standard errors reported in Table 1 (upper part).

A.2. PROOFS

Proof of Proposition 1: Volatility of ROR under Autarky and Integration.   From the reduced form production function $y_M = b\eta^{(\alpha-1)/\alpha}\theta k$, we get the ROR on capital in the modern sector under autarky, $r_M^a = b\eta^{(\alpha-1)/\alpha}$, where η is described by

$$\eta = \begin{cases} \bar{\eta} + \varepsilon & \text{with } P = 0.5 \\ \bar{\eta} - \varepsilon & \text{with } P = 0.5. \end{cases}$$

Turning to integration, the set of possible realizations, given the binary shock scheme in both countries (as displayed earlier), reads

$$(\bar{\eta} + \varepsilon_1, \bar{\eta} + \varepsilon_2) \quad \text{with } P = 0.25,$$
$$(\bar{\eta} + \varepsilon_1, \bar{\eta} - \varepsilon_2) \quad \text{with } P = 0.25,$$
$$(\bar{\eta} - \varepsilon_1, \bar{\eta} + \varepsilon_2) \quad \text{with } P = 0.25,$$
$$(\bar{\eta} - \varepsilon_1, \bar{\eta} - \varepsilon_2) \quad \text{with } P = 0.25,$$

where ε_1 and ε_2 denote shock realizations in countries 1 and 2, respectively. Because, in the integrated world, final output producers purchase the intermediate goods from the producers offering the lowest price, $p_x^S = \eta$, the ROR is $r_M^i = b\eta^{(\alpha-1)/\alpha}$ with $\eta = \min(\eta_1, \eta_2)$. This implies that the ROR under integration can be equivalently described by $r_M^i = b\eta^{(\alpha-1)/\alpha}$

with

$$\eta = \begin{cases} \bar{\eta} + \varepsilon & \text{with probability } P = 0.25 \\ \bar{\eta} - \varepsilon & \text{with probability } 1 - P = 0.75. \end{cases}$$

This description immediately implies that the ROR under autarky, r_M^a, equals $b(\bar{\eta}+\varepsilon)^{(\alpha-1)/\alpha}$ with $P = 0.5$ and $b(\bar{\eta} - \varepsilon)^{(\alpha-1)/\alpha}$ with $P = 0.5$. On the other hand, the ROR under integration, r_M^i, is $b(\bar{\eta} + \varepsilon)^{(\alpha-1)/\alpha}$ with $P = 0.25$ and $b(\bar{\eta} - \varepsilon)^{(\alpha-1)/\alpha}$ with $P = 0.75$. Moreover, r_M^a and r_M^i are binomial stochastic variables with a variance (per unit of time) given by $V(u) = P(1 - P)$, and hence

$$\frac{V(r_M^i)}{V(r_M^a)} = \frac{0.25 \cdot 0.75}{0.5 \cdot 0.5} = 0.75.$$

This completes the proof of Proposition 1.

Proof of Proposition 2: Comparative Statics for θ.   The asset allocation share is determined by

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

To derive $\partial\theta/\partial\phi$, we apply the implicit function theorem. First, notice that the stated first-order condition can be expressed as $F(\theta; \phi) = 0$, which implies $\theta^* = \theta^*(\phi)$, where θ^* denotes the optimal choice of θ. Substituting this relation into the first-order condition gives $F[\theta^*(\phi); \phi] = 0$. Differentiation w.r.t. ϕ gives

$$F_\theta \frac{\partial\theta^*}{\partial\phi} + F_\phi = 0,$$

$$\frac{\partial\theta^*}{\partial\phi} = \frac{-F_\phi}{F_\theta}.$$

The partial derivative F_θ is given by

$$F_\theta = \gamma\lambda^2\sigma\phi^2(1 - \phi\lambda\theta)^{-1-\sigma} + \gamma\lambda^2\sigma\phi^2(1 + \phi\lambda\theta)^{-1-\sigma},$$

and F_ϕ reads

$$F_\phi = \gamma\theta\lambda^2\sigma\phi(1-\phi\lambda\theta)^{-1-\sigma}+\gamma\lambda(1-\phi\lambda\theta)^{-\sigma}+\gamma\theta\lambda^2\sigma\phi(1+\phi\lambda\theta)^{-1-\sigma}-\gamma\lambda(1+\phi\lambda\theta)^{-\sigma}.$$

The ratio $-F_\phi/F_\theta$ can accordingly be expressed as follows:

$$\frac{-F_\phi}{F_\theta} = -\frac{(1 - \phi\lambda\theta)^{-\sigma} - (1 + \phi\lambda\theta)^{-\sigma}}{\lambda\sigma\phi^2[(1 - \phi\lambda\theta)^{-1-\sigma} + (1 + \phi\lambda\theta)^{-1-\sigma}]} - \frac{\theta}{\phi}.$$

Because the numerator of the first ratio on the RHS is positive (from the first-order condition for θ it equals $(\bar{r}_M - r_T)/\phi\lambda\gamma$), and the denominator is positive as well, we have established that

$$\frac{\partial\theta^*}{\partial\phi} = \frac{-F_\phi}{F_\theta} < 0.$$

This proves Proposition 2 in the main text.

Proof of Proposition 3: Comparative Statics for Ψ.   The consumption–wealth ratio is

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

with $r := \bar{r}_M\theta + r_T(1 - \theta)$. The partial derivative of the first term on the RHS, denoting $r = \bar{r}_M\theta + r_T(1 - \theta)$, reads

$$\frac{\partial}{\partial\phi}\frac{(\sigma - 1)r\,[\theta(\phi)] + \rho}{\sigma} = \frac{\sigma - 1}{\sigma}\theta'(\phi)\underbrace{(\bar{r}_M - r_T)}_{=r'(\theta)}.$$

Moreover, the partial derivative of the second term on the RHS, denoting the first-order condition for θ, can be expressed as

$$\frac{\partial}{\partial\phi}\frac{\gamma[2 - (1 + \phi\lambda\theta)^{1-\sigma} - (1 - \phi\lambda\theta)^{1-\sigma}]}{\sigma} = \frac{1 - \sigma}{\sigma}[\theta + \phi\theta'(\phi)]\frac{\bar{r}_M - r_T}{\phi}.$$

Taken together, these yield

$$\frac{\partial\Psi}{\partial\phi} = \frac{\sigma - 1}{\sigma}\theta'(\phi)\,(\bar{r}_M - r_T) + \frac{1 - \sigma}{\sigma}\frac{\theta + \phi\theta'(\phi)}{\phi}\,(\bar{r}_M - r_T),$$

and, hence, one gets

$$\frac{\partial\Psi}{\partial\phi} = \frac{1 - \sigma}{\sigma}\underbrace{\frac{\theta}{\phi}}_{>0}\underbrace{(\bar{r}_M - r_T)}_{>0} = \begin{cases} < 0 & \text{for } \sigma > 1 \\ > 0 & \text{for } \sigma < 1. \end{cases}$$

This proves Proposition 3 in the main text.

Proof of Proposition 4: Comparative Statics for $E(dc/cdt)$.   The expected growth rate of consumption is given by

$$E\left(\frac{dc}{cdt}\right) = \frac{r - \rho}{\sigma} - \frac{\gamma}{\sigma}[2 - (1 + \phi\lambda\theta)^{1-\sigma} - (1 - \phi\lambda\theta)^{1-\sigma}].$$

We want to show that market integration speeds up growth. Let us consider the transition from market integration ($\phi = \sqrt{0.75}$) to autarky ($\phi = 1$), such that, formally, we are considering the consequences of increasing ϕ. The growth rate falls in response to a rise in ϕ, provided that

$$\frac{\partial}{\partial\phi}E\left(\frac{dc}{cdt}\right) = \frac{\partial}{\partial\phi}\frac{r - \rho}{\sigma} - \frac{\partial}{\partial\phi}\frac{\gamma[2 - (1 + \phi\lambda\theta)^{1-\sigma} - (1 - \phi\lambda\theta)^{1-\sigma}]}{\sigma} < 0$$

$$\Longleftrightarrow \frac{\partial}{\partial\phi}\frac{r - \rho}{\sigma} < \frac{\partial}{\partial\phi}\frac{\gamma[2 - (1 + \phi\lambda\theta)^{1-\sigma} - (1 - \phi\lambda\theta)^{1-\sigma}]}{\sigma}.$$

The term $\frac{\partial}{\partial\phi}\frac{r-\rho}{\sigma}$ is unambiguously negative (due to a drop in θ). From the previous discussion, we know that for $\sigma < 1$ it holds true that

$$\frac{\partial}{\partial\phi}\frac{\gamma[2 - (1 + \phi\lambda\theta)^{1-\sigma} - (1 - \phi\lambda\theta)^{1-\sigma}]}{\sigma} > 0.$$

Hence, in this case, $\frac{\partial}{\partial\phi}E(dc/cdt) < 0$ is automatically satisfied.

Let us turn to $\sigma > 1$, such that

$$\frac{\partial}{\partial \phi} \frac{\gamma[2 - (1 + \phi\lambda\theta)^{1-\sigma} - (1 - \phi\lambda\theta)^{1-\sigma}]}{\sigma} < 0.$$

Consider $\frac{\partial}{\partial \phi} \frac{r - \rho}{\sigma}$, which is given by

$$\frac{\partial}{\partial \phi} \frac{r[\theta(\phi)] - \rho}{\sigma} = \frac{\theta'(\phi)(\bar{r}_M - r_T)}{\sigma}.$$

Next, consider the partial derivative of the second term:

$$\frac{\partial}{\partial \phi} \frac{\gamma[2 - (1 + \phi\lambda\theta)^{1-\sigma} - (1 - \phi\lambda\theta)^{1-\sigma}]}{\sigma} = \frac{1 - \sigma}{\sigma}[\theta + \phi\theta'(\phi)]\frac{\bar{r}_M - r_T}{\phi\lambda\gamma}.$$

Putting the two together yields

$$\frac{\theta'(\phi)(\bar{r}_M - r_T)}{\sigma} < \frac{1 - \sigma}{\sigma}[\theta + \phi\theta'(\phi)]\frac{\bar{r}_M - r_T}{\phi\lambda\gamma},$$

which can be simplified to read

$$\theta'(\phi) < \frac{1 - \sigma}{\sigma}\frac{\theta}{\phi}.$$

Now insert the expression for $\theta'(\phi)$ derived earlier. This gives

$$-\frac{(1 - \phi\lambda\theta)^{-\sigma} - (1 + \phi\lambda\theta)^{-\sigma}}{\lambda\sigma\phi^2[(1 - \phi\lambda\theta)^{-1-\sigma} + (1 + \phi\lambda\theta)^{-1-\sigma}]} - \frac{\theta}{\phi} < \frac{1 - \sigma}{\sigma}\frac{\theta}{\phi}$$

$$-\frac{(1 - \phi\lambda\theta)^{-\sigma} - (1 + \phi\lambda\theta)^{-\sigma}}{\lambda\sigma\phi^2[(1 - \phi\lambda\theta)^{-1-\sigma} + (1 + \phi\lambda\theta)^{-1-\sigma}]} < \frac{1}{\sigma}\frac{\theta}{\phi}.$$

Because we know that the LHS is negative, as shown in the proof of Proposition 2, and the RHS is positive, the preceding inequality is unambiguously satisfied. This proves Proposition 4 in the main text.

A.3. DERIVATIONS

Decomposition of ROR into deterministic and stochastic component, (13) *and* (14). The ROR on capital invested in the modern sector under autarky r_M^a and under integration r_M^i is given by

$$r_M^a = b\eta^{\frac{\alpha-1}{\alpha}},$$

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

with variances $V(r_M^a) = b^2 V[\eta^{(\alpha-1)/\alpha}]$ and $V(r_M^i) = b^2 V\{[\min(\eta_1, \eta_2)]^{(\alpha-1)/\alpha}\}$. Because optimal decisions under uncertainty are predominantly determined by the expected value and variance of the stochastic variables involved, one can equivalently represent this ROR as the sum of a deterministic and a stochastic component with the same expected value and the same variance. Specifically, $r_M^a = b\eta^{(\alpha-1)/\alpha}$ (with $\eta = \bar{\eta} + \varepsilon$ or $\eta = \bar{\eta} - \varepsilon$) can be represented as $r_M^a = bE[\eta^{(\alpha-1)/\alpha}]dt + \lambda dz$, where dz is a stochastic increment,

either $dz = \varepsilon$ with $P = 0.5dt$ or $dz = -\varepsilon$ with $P = 0.5dt$. For instance, the realization $dz = \varepsilon$ corresponds to $\eta = \bar{\eta} + \varepsilon$. Notice that, by construction, the expected values of both representations are identical. Moreover, the parameter λ can be chosen such that the variance of $b\eta^{(\alpha-1)/\alpha}$ is identical to the variance of $bE[\eta^{(\alpha-1)/\alpha}]dt + \lambda dz$.

To apply standard methods of dynamic optimization under (Poisson) uncertainty, the stochastic component of the ROR per period of time is now represented as a composite and symmetric Poisson increment; i.e., we set $dz = dn_1 - dn_2$, where dn_1 and dn_2 are described by

$$dn_1 = \begin{cases} 1 & \text{with probability } \gamma dt \\ 0 & \text{with probability } (1 - \gamma)dt \end{cases}$$

and

$$dn_2 = \begin{cases} 1 & \text{with probability } \gamma dt \\ 0 & \text{with probability } (1 - \gamma)dt. \end{cases}$$

The variance of $V[\lambda(dn_1 - dn_2)]$ is equal to $2\lambda^2\gamma dt - 2\lambda^2\gamma^2 dt^2$ and, hence, λ and γ must be chosen such that $b^2 V[\eta^{(\alpha-1)/\alpha}] = 2\lambda^2\gamma dt - 2\lambda^2\gamma^2 dt^2$.

The household's flow budget constraint, (15).   The ROR (modern sector) per period of time under autarky can be expressed as $r_M^a = \bar{r}_M dt + \lambda(dn_1 - dn_2)$ with $\bar{r}_M := bE[\eta^{(\alpha-1)/\alpha}]$. Moreover, letting $V(r_M^i) = 0.75V(r_M^a)$, the ROR (modern sector) per period of time under integration can be expressed as $r_M^i = \bar{r}_M dt + \sqrt{0.75}\lambda(dn_1 - dn_2)$. Therefore, the household's flow budget constraint in general form (valid for both autarky and integration) can be expressed as follows:

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

For $\phi = 1$ this is the flow budget constraint under autarky, whereas for $\phi = \sqrt{0.75}$ this is the flow budget constraint under integration. To be precise, this formulation uses the simplifying assumption $E(r_M^a) = E(r_M^i) = \bar{r}_M = E[\eta^{(\alpha-1)/\alpha}]$. The exact relation, however, reads $E(r_M^i) = E\{[\min(\eta_1, \eta_2)]^{(\alpha-1)/\alpha}\}$. This assumption is noncritical for the results derived, as explained in the main text.

The household's asset allocation decision (17).   The Bellman equation for the stochastic dynamic problem under study is [e.g., Eaton (1981)]

$$\rho V(a) = \max_{\{c,\theta\}} [u(c) + EdV(a)/dt].$$

Denoting the general flow budget constraint, capturing both the autarky and the integration case, $EdV(a)/dt$ is given by [Wälde (1999, p. 211)]

$$EdV(a)/dt = V'(a)[\bar{r}_M\theta a + r_T(1-\theta)a - c] + [V(\tilde{a}) - V(a)]\gamma + [V(\tilde{\tilde{a}}) - V(a)]\gamma,$$

where $\tilde{a} := a + \theta a\phi\lambda$ after $dn_1 = 1$ and $\tilde{\tilde{a}} := a - \theta a\phi\lambda$ after $dn_2 = 1$. Hence the Bellman equation can be written

$$\rho V(a) = \max_{\{c,\theta\}} \big\{ u(c) + V'(a)[\bar{r}_M\theta a + r_T(1-\theta)a - c]$$

$$+ [V(\tilde{a}) - V(a)]\gamma + [V(\tilde{\tilde{a}}) - V(a)]\gamma \big\}.$$

The necessary first-order condition for optimal consumption is

$$u'(c) = V'(a).$$

The first-order condition for the optimal portfolio choice reads

$$(\bar{r}_M a - r_T a) V'(a) - a\lambda\gamma\phi V'(\widetilde{a}) + a\lambda\gamma\phi V'(\widetilde{\widetilde{a}}) = 0,$$

and hence one gets

$$\bar{r}_M - r_T = \frac{a\lambda\gamma\phi V'(\widetilde{\widetilde{a}}) - a\lambda\gamma\phi V'(\widetilde{a})}{V'(a)}.$$

The linear policy rule, i.e., $c = \Psi a$ (to be shown hereafter), implies $u'(\widetilde{c})/u'(c) = (1 + \phi\lambda\theta)^{-\sigma}$ and $u'(\widetilde{\widetilde{c}})/u'(c) = (1 - \phi\lambda\theta)^{-\sigma}$. Hence, optimal θ is implicitly defined by

$$\bar{r}_M - r_T = \frac{\lambda\gamma\phi u'(\widetilde{\widetilde{c}}) - \lambda\gamma\phi u'(\widetilde{c})}{u'(c)} = \phi\lambda\gamma[(1 - \phi\lambda\theta)^{-\sigma} - (1 + \phi\lambda\theta)^{-\sigma}].$$

This is equation (17) in the main text.

The growth rate of c and Ψ, (18) *and* (19).   The optimal growth rate of c is determined. Subsequently, the constant consumption–wealth ratio is derived. Consider the maximized Bellman equation:

$$\rho V(a) = u[c(a)] + V'(a)[\bar{r}_M\theta a + r_T(1 - \theta)a - c(a)]$$
$$+ [V(\widetilde{a}) - V(a)]\gamma + [V(\widetilde{\widetilde{a}}) - V(a)]\gamma.$$

First, we compute the partial derivative of the Bellman equation w.r.t. to a:

$$\rho V'(a) = c'(a)u'(c(a)) + [r_T(1 - \theta) + \bar{r}_M\theta - c'(a)]V'(a)$$
$$+\gamma[(1 - \phi\lambda\theta)V'(a(1 - \phi\lambda\theta)) - V'(a)] + \gamma[(1 + \phi\lambda\theta)V'(a(1 + \phi\lambda\theta)) - V'(a)]$$
$$+[\bar{r}_M\theta a + r_T(1 - \theta)a - c(a)]V''(a).$$

Solving for $V''(a)[\bar{r}_M\theta a + r_T(1 - \theta)a - c(a)]dt$ gives

$$V''(a)[\bar{r}_M\theta a + r_T(1 - \theta)a - c(a)]dt$$
$$= \{\rho - [\bar{r}_M\theta + r_T(1 - \theta)]\}V'(a)dt - \gamma\{(1 - \phi\lambda\theta)V'[a(1 - \phi\lambda\theta)] - V'(a)\}dt$$
$$- \gamma\{(1 + \phi\lambda\theta)V'[a(1 + \phi\lambda\theta)] - V'(a)\}dt.$$

Next, the differential $dV'(a)$ is derived by applying Itô's lemma for Poisson processes [Sennewald and Wälde (2005)]:

$$dV'(a) = V''(a)[\bar{r}_M\theta a + r_T(1 - \theta)a - c]dt + [V'(\widetilde{a}) - V'(a)]dn_1 + [V'(\widetilde{\widetilde{a}}) - V'(a)]dn_2.$$

Replacing the first term on the RHS with the derived expression yields

$$dV'(a) = \{\rho - [\bar{r}_M\theta + r_T(1 - \theta)]\}V'(a)dt - \gamma\{(1 - \phi\lambda\theta)V'[a(1 - \phi\lambda\theta)]$$
$$- V'(a)\}dt - \gamma\{(1 + \phi\lambda\theta)V'[a(1 + \phi\lambda\theta)] - V'(a)\}dt + [V'(\widetilde{a}) - V'(a)]dn_1$$
$$+ [V'(\widetilde{\widetilde{a}}) - V'(a)]dn_2.$$

Replacing $V'(a)$ by $u'(c)$, $V'(\tilde{a})$ by $u'(\tilde{c})$, and $V'(\tilde{\tilde{a}})$ by $u'(\tilde{\tilde{c}})$, and taking into account that, for CRRA utility, $u'(\tilde{c})(1+\phi\lambda\theta)/u'(\tilde{c}) = (1+\phi\lambda\theta)^{1-\sigma}$ and $u'(\tilde{\tilde{c}})(1-\phi\lambda\theta)/u'(\tilde{c}) = (1-\phi\lambda\theta)^{1-\sigma}$ finally leads to

$$du'(c) = u'(c)\left\{\rho - [\bar{r}_M\theta + r_T(1-\theta)] + \gamma[2 - (1-\phi\lambda\theta)^{1-\sigma} - (1+\phi\lambda\theta)^{1-\sigma}]\right\}dt$$
$$+ [u'(\tilde{c}) - u'(c)]dn_1 + [u'(\tilde{\tilde{c}}) - u'(c)]dn_2.$$

Next determine dc. First, note that the preceding function is a SDE in $u'(c)$ and, second, define a function $f[u'(c)] = c$ and then determine (using Itô's lemma for Poisson processes) $df(.) = dc$. In addition, observe that

$$\frac{df[u'(c)]}{du'(c)} = \frac{dc}{du'(c)} = \frac{1}{u''(c)}.$$

Assuming that preferences are CRRA, implying $\sigma = -u''(c)c/u'(c)$, leads to

$$dc = \frac{c}{\sigma}\{[\bar{r}_M\theta + r_T(1-\theta)] - \rho - \gamma[2 - (1-\phi\lambda\theta)^{1-\sigma} - (1+\phi\lambda\theta)^{1-\sigma}]\}dt$$
$$+ (\tilde{c} - c)dn_1 + (\tilde{\tilde{c}} - c)dn_2.$$

Taking $(\tilde{c} - c)\gamma = (\tilde{\tilde{c}} - c)\gamma$ into account, the expected growth rate may be expressed as

$$E\left(\frac{dc}{cdt}\right) = \frac{r-\rho}{\sigma} - \frac{\gamma}{\sigma}[2 - (1+\phi\lambda\theta)^{1-\sigma} - (1-\phi\lambda\theta)^{1-\sigma}].$$

This is equation (19) in the main text.

Next we turn to the expected growth rate of assets, which results from

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

and can hence be expressed as

$$E\left(\frac{da}{adt}\right) = \bar{r}_M\theta + r_T(1-\theta) - \Psi,$$

where $\Psi = c/a$. Because, in a steady state, θ is constant, Ψ must be constant as well. The consumption–wealth ratio then follows from $E(dc/c\,dt) = E(da/a\,dt)$, which yields

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

This is equation (18) in the main text.