SAVING, GROWTH, AND LIQUIDITY CONSTRAINTS*

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In the context of an overlapping-generations model, we show that liquidity constraints on households (i) raise the saving rate, (ii) strengthen the effect of growth on saving, (iii) increase the growth rate if productivity growth is endogenous, and (iv) may increase welfare. The first three positions are supported by cross-country regressions of saving and growth rates on indicators of liquidity contraints on households. The results suggest that financial deregulation in the 1980s has contributed to the decline in national saving and growth rates in the OECD countries.

I. INTRODUCTION

The role of capital market imperfections has received increasing attention in the recent literature on consumer behavior. Liquidity constraints have been said to explain the excess sensitivity of consumption to anticipated income fluctuations [Hayashi 1987] and cited in arguing the effectiveness of public financial policies and transitory taxes [Hubbard and Judd 1986]. Much less attention has been devoted to the effect of liquidity constraints on the aggregate saving rate. If households cannot borrow the desired amount, aggregate saving will be higher than in the presence of perfect credit markets. Although this relation has been investigated in a few individual country studies,[1] it has been overlooked in the explanation of the international differences in saving rates. Previous literature on these differences has focused instead on the

*This paper is part of a research program on "Financial and Monetary Integration in Europe" supported by a grant from the Commission of the European Communities under its SPES Programme (No. E89300105/RES). It has also been supported by grants from the Italian National Research Council (CNR) and by the Italian Ministry of Universities and Scientific Research (MURST). A number of academics and businessmen have provided us with information on national mortgage markets; their contribution is gratefully acknowledged. We also thank Ben Bernanke, Olivier Blanchard, Sergio Rebelo, Nouriel Roubini, Bruce Smith, and Stephen Zeldes for useful comments; Robert Barro and Holger Wolf for supplying their data set; and seminar participants in Bologna, Dublin, Jerusalem, Lisbon, Naples, Pavia, and Rome.

1. Hayashi, Ito, and Slemrod [1988] show, by means of simulations, that a reduction of 20 percent in the down payment required to purchase a house in Japan can lead to a reduction in private saving of 2 percent of national income. Guiso, Jappelli, and Terlizzese [1994] argue that the high Italian saving rate is mainly due to its relatively underdeveloped consumer credit and mortgage markets. Muellbauer and Murphy [1990], Bayoumi [1991], and Miles [1992] show that financial deregulation has been a key determinant of the sharp decline of the U.K. saving rate in the 1980s.

The Quarterly Journal of Economics, February 1994

role of demographic variables [Modigliani 1970], social security [Feldstein 1980], and fiscal policy [Modigliani 1990].

If liquidity constraints lead to higher saving rates, the implications may be far-reaching. One implication considered in this paper is that by inducing capital accumulation, liquidity constraints on households may favor a higher growth rate. Endogenous growth models highlight that steady-state growth is an increasing function of the saving rate: in these models, other things equal, factors that stimulate saving promote growth.

This positive relation between liquidity constraints and growth may appear surprising, considering that the models that have so far analyzed the relation between financial development and growth have generally concluded that capital market imperfections tend to inhibit growth, in accordance with the McKinnon-Shaw view of economic development [Bencivenga and Smith 1991; Greenwood and Jovanovic 1990]. In these models financial intermediation promotes growth because it increases the rate of return on capital via a more efficient allocation of credit to investment.

In this paper, however, rather than focusing on credit to firms, we consider the role of the supply of credit to households. If banks ration credit to households while making it available to firms efficiently, capital accumulation and growth will be enhanced. As we shall see, the idea that credit rationing may be selectively directed to households but not to firms is not unwarranted as a description of financial intermediation in several OECD economies in the postwar period. It can also be rationalized in view of the differences in regulations and in the intrinsic nature of lending to households and firms, which differs with respect to the average loan size, the pervasiveness of informational asymmetries, and the costs of contract enforcement.

The plan of the paper is the following. Section II presents a simple overlapping-generations model to illustrate the link between liquidity constraints, saving, and growth. Section III describes some indicators of liquidity constraints that will be used in the empirical tests. Section IV presents evidence that these indicators help to explain the international differences in saving rates in the international panel of countries constructed by Modigliani [1990]. Section V offers evidence that the growth rate too is positively affected by liquidity constraints; here we use the international data sets constructed by De Long and Summers [1991] and Barro and Wolf [1989]. The implications of our results for current policy issues are discussed in Section VI.

II. A Simple Model

To illustrate the relationships between liquidity constraints, saving, and growth, we resort to a simple overlapping-generations model where individuals live for three periods. We assume that they earn labor income only in the second period of their life. This provides an incentive for intergenerational borrowing. When young, individuals borrow to finance current consumption. When middle-aged, they repay the loan taken out in the first period and save for retirement. When old, they consume the savings accumulated in the second period of their life. When markets are perfect, the young borrow the desired amount; but with liquidity constraints, they can borrow at most a proportion ϕ of the present value of their lifetime income, for reasons that we do not model explicitly. For simplicity, population is assumed to be stationary, the size of each generation being normalized to one. Preferences are given by

$$u(c_{t,t},c_{t,t+1},c_{t,t+2}) = \ln c_{t,t} + \beta \ln c_{t,t+1} + \beta^2 \ln c_{t,t+2}, \tag{1}$$

where β is the discount factor and the first subscript indicates the generation, while the second refers to the timing of consumption.

Households maximize utility subject to

$$c_{t,t} + \frac{c_{t,t+1}}{R_{t+1}} + \frac{c_{t,t+2}}{R_{t+1}R_{t+2}} \leq \frac{e_{t+1}}{R_{t+1}}, \tag{2a}$$

$$c_{t,t} \leq \phi \frac{e_{t+1}}{R_{t+1}}, \tag{2b}$$

where e_{t+1} is real labor earnings at time $t+1$, and R_{t+1} is the real interest factor between time t and $t+1$. Equation (2a) is the intertemporal budget constraint. Equation (2b) is a liquidity constraint: the young can borrow at most a fraction ϕ of their discounted lifetime income. If the liquidity constraint (2b) is not binding, the consumption of the young is

$$c_{t,t} = \gamma e_{t+1}/R_{t+1}, \tag{3}$$

where $\gamma = 1/(1 + \beta + \beta^2)$. If $\phi < \gamma$, instead, the borrowing constraint is binding, and first-period consumption is equal to the borrowing limit (the right-hand side of (2b)). Aggregate net wealth is given by the sum of the wealth of the middle-aged and the debt of the young:

$$W_t = \frac{\beta(1-\phi)}{1+\beta} e_t L - \phi \frac{e_{t+1}}{R_{t+1}} L, \tag{4}$$

where $\phi = \gamma$ when liquidity constraints are not binding. Wealth is greater when liquidity constraints are more severe; i.e., when ϕ is lower.

Technology is summarized by the following aggregate production function:

$$Y_t = A_t K_t^{\alpha} L^{1-\alpha}. \tag{5}$$

where Y_t is aggregate output, K_t is the aggregate capital stock, and L is the labor force, which will be set equal to one hereafter. Capital depreciates completely within one period. Depending on how technical progress (A_t) is modeled, one can obtain as special cases the Solow exogenous growth model and the Romer [1989] endogenous growth model.

II.1. Exogenous Growth

The standard way of modeling growth is to assume Hicks-neutral technical progress, making total factor productivity A_t an increasing function of time:

$$A_t = A(1 + \rho)^t, \tag{6}$$

where ρ denotes the productivity growth rate. As shown in the Appendix, using the first-order conditions for profit maximization and substituting the expression for wealth (4) into the capital market equilibrium condition $W_t = K_{t+1}$, one obtains

$$(1 + \beta)[\alpha + \phi(1 - \alpha)]K_{t+1} = \beta(1 - \phi)\alpha(1 - \alpha)A(1 + \rho)^t K_t^{\alpha}. \tag{7}$$

Equation (7) implies that in steady state the capital stock grows according to

$$K_t = K_0(1 + \rho)^{t/(1-\alpha)}, \tag{8}$$

where

$$K_0 = \left[\frac{\beta(1 - \phi)\alpha(1 - \alpha)A(1 + \rho)^{-1/(1-\alpha)}}{(1 + \beta)[\alpha + \phi(1 - \alpha)]}\right]^{1/(1-\alpha)}.$$

Thus, in steady state capital and output grow at the common rate $(1 + \rho)^{1/(1-\alpha)} - 1$. The steady-state net saving rate, $(K_{t+1} - K_t)/Y_t$, is equal to the growth rate, $\hat{K}_{t+1} = (K_{t+1} - K_t)/K_t$, multiplied by the (constant) capital-output ratio:

$$\frac{S_t}{Y_t} = \hat{K}_{t+1}\frac{K_t}{Y_t} = [(1 + \rho)^{1/(1-\alpha)} - 1]\frac{K_0}{Y_0} \tag{9}$$
$$= [(1 + \rho)^{1/(1-\alpha)} - 1]\left[\frac{\beta(1 - \phi)\alpha(1 - \alpha)(1 + \rho)^{-1/(1-\alpha)}}{(1 + \beta)[\alpha + \phi(1 - \alpha)]}\right].$$

The above expression indicates that a rise in steady-state growth increases saving, since

$$\frac{\partial(S_t/Y_t)}{\partial(K_{t+1}/K_t)} = (1 + \rho)^{-1/(1-\alpha)} \frac{K_0}{Y_0}. \tag{10}$$

The steady-state growth rate is independent of ϕ: growth does not depend on the availability of credit to households. However, the saving rate in an economy with liquidity constraints ($\phi < \gamma$) is higher than in an economy with perfect markets ($\phi \geq \gamma$); and if in the former case borrowing constraints are relaxed (ϕ increases), saving falls. Moreover, the effect of growth on saving is stronger when there are liquidity constraints, to an extent that varies inversely with the magnitude of the parameter ϕ.

This proposition also holds between steady states. Suppose that at time t an economy in steady state is hit by a permanent discrete shock in total factor productivity A, and denote the percentage increase in A by $\hat{A}$. As shown in the Appendix, n periods after the shock the transitional growth rate is

$$\hat{K}_{t+n} = \hat{Y}_{t+n} = (1 + \rho)^{1/(1-\alpha)}(1 + \hat{A})^{\alpha^{n-1}} - 1. \tag{11}$$

The first term in the product is the steady-state growth factor; the second reflects the transient contribution to growth of the productivity shock $\hat{A}$. Although the new steady-state capital stock is higher, the capital-output ratio remains constant not only in the new steady state, but also in the transition. The transitional saving rate,

$$\frac{S_{t+n}}{Y_{t+n}} = [(1 + \rho)^{1/(1-\alpha)}(1 + \hat{A})^{\alpha^{n-1}} - 1] \frac{K_0}{Y_0}, \tag{12}$$

is higher when liquidity constraints are more severe, because the capital-output ratio K_0/Y_0 is higher. Note that liquidity constraints affect saving only by interacting with growth: in the absence of growth, saving is zero independent of liquidity constraints. It is only when there is growth, either in steady state or in the transition, that liquidity constraints raise saving.

To summarize, the model yields two empirical predictions: (i) liquidity constraints raise savings, and (ii) the effect of growth on saving is stronger in economies with liquidity constraints. These two predictions also hold in a small open economy with perfect capital mobility, where the interest rate is determined exogenously by international capital markets. The main difference relative to the closed economy model considered so far is that the effect of growth on saving is no longer unambiguously positive. As shown in the Appendix, in an open economy the growth rate is the same as in a closed economy, while the saving rate is

$$\frac{S_t}{Y_t} = (1-\alpha)\left[\frac{\beta(1-\phi)}{1+\beta} - \frac{\phi(1+\rho)^{1/(1-\alpha)}}{R}\right][1-(1+\rho)^{-1/(1-\alpha)}]. \tag{13}$$

Again, saving increases with the severity of liquidity constraints (it decreases with ϕ). But in an open economy the effect of growth on saving is no longer necessarily positive:

$$\frac{\partial(S_t/Y_t)}{\partial(Y_{t+1}/Y_t)} = (1-\alpha)\left[\frac{\beta(1-\phi)}{1+\beta}(1+\rho)^{-2/(1-\alpha)} - \frac{\phi}{R}\right]. \tag{14}$$

This ambiguity derives from the fact that in an open economy growth has two opposite effects on saving. On the one hand, it increases the current income of the middle-aged and their desired wealth. On the other, it also increases the future income of the young, thereby enabling them to borrow more.[2] This second effect is attenuated by the presence of liquidity constraints and disappears entirely if the young have no access to credit markets ($\phi = 0$).[3] Thus, the proposition that liquidity constraints reinforce the effect of growth on saving still holds.

II.2. Endogenous Growth

In the previous model saving does not affect growth, regardless of the presence of liquidity constraints. This no longer holds if productivity growth is endogenous. Suppose that A_t, rather than being an exogenous process $A(1+\rho)^t$, is given by

$$A_t = AK_t^{\eta}, \tag{15}$$

where K_t is the aggregate level of capital. Thus, the state of technology evolves not as a function of time (as in the previous model), but rather as a function of the aggregate level of capital.[4] A

2. These two effects are present also in the closed economy model. But in that case growth also has an additional positive effect on saving: there the interest rate responds positively to an increase in growth, which reduces the discounted lifetime income of the young, and thereby their desired borrowing. Conversely, in an open economy the interest rate is fixed and this wealth effect is absent.

3. In this case the effect of growth on saving is the same as in the closed economy, as can be seen by differentiating equation (9) with $\phi = 0$.

4. See Jones and Manuelli [1990] for a survey of models of endogenous growth with finite horizons.

standard way of motivating equation (15) is to assume that technology displays increasing returns to scale owing to externalities or spillovers, as in Romer [1989]. Individual firms behave competitively and maximize profits taking A_t as given. This leads to the aggregate production function,

$$Y_t = AK_t^{\alpha+\eta}. \tag{16}$$

The degree of increasing returns depends on the value of η. If $\eta = 0$, returns to scale are constant at the aggregate level; while if $\eta > 0$, they are increasing. If $\alpha + \eta = 1$, production is a linear function of capital. On these assumptions, the law of motion of capital is

$$(1 + \beta)[\alpha + \phi(1 - \alpha)]K_{t+1} = \beta(1 - \phi)\alpha(1 - \alpha)AK_t^{\alpha+\eta}, \tag{17}$$

which is comparable to equation (7) except for the presence of the externality and the absence of exogenous productivity growth. Taking logarithms, equation (17) becomes

$$\ln K_{t+1} - \ln K_t = \ln g - (1 - \alpha - \eta) \ln K_t, \tag{18}$$

where

$$g = \left[\frac{\beta(1 - \phi)\alpha(1 - \alpha)A}{(1 + \beta)[\alpha + \phi(1 - \alpha)]}\right].$$

This equation shows that when $\alpha + \eta < 1$, positive growth occurs only if the economy starts with a capital stock below the steady-state level, $K_t = g^{1/(1-\alpha-\eta)}$, while in steady state the growth rate of capital is zero (when $\eta = 0$, the model reduces to the case of subsection II.1 with $\rho = 0$). If $\alpha + \eta > 1$, the economy exhibits explosive growth. When $\alpha + \eta = 1$ the steady-state growth rate is $g - 1$ (the solution of equation (18) is given in the Appendix).

An economy with liquidity constraints grows faster because the constant term g in equation (18) is inversely related to ϕ. In particular, if $\alpha + \eta = 1$, the growth rate of an economy with liquidity constraints is *permanently* higher that that of an economy with perfect credit markets. The same applies to the saving rate, which in this case is simply equal to $(g - 1)/A$.

We can now summarize the empirical predictions of the two models presented in this section. In the exogenous growth model liquidity constraints raise aggregate saving and strengthen the effect of growth on saving. In the endogenous growth model the higher saving rate induced by liquidity constraints also translates into faster growth.[5]

II.3. Welfare[6]

Since liquidity constraints raise saving and growth, one may wonder if they also raise welfare. Liquidity constraints have two opposite effects on welfare: they force the consumption of the young to be lower than the unconstrained level, but they also raise their permanent income by fostering capital accumulation. When productivity growth is exogenous, the trade-off appears only if the economy would be dynamically efficient in the absence of liquidity constraints. If under perfect markets the interest rate exceeds the growth rate, the forced saving induced by liquidity constraints brings the economy closer to the golden rule, although at the cost of distorting the consumption path of each generation. It can be shown that in this case there is an optimal degree of financial repression of households, i.e., a value of ϕ that maximizes steady state welfare.[7]

The trade-off between the loss from distorting intertemporal choices and the gain from raising capital accumulation also appears when productivity growth is endogenous. However, in this case the trade-off is nonstationary. While the distortionary loss associated with the borrowing constraint is the same for all generations, the welfare gain of each generation increases over time, because tighter liquidity constraints raise steady state growth. This insight applies to the steady state comparison of two economies with different values of ϕ, as well as to a policy experiment where ϕ is permanently and unexpectedly reduced. In the latter case simulations show that for reasonable parameter values, financial repression hurts at most the current generation, and benefits all the subsequent ones.

Consider, for instance, the case where $\alpha = 0.3$ and $\beta = 0.9$. Under perfect markets the young would like to borrow 36.9 percent of their permanent income. If ϕ is permanently and unexpectedly

5. Liquidity constraints may also have a negative effect on productivity growth if they reduce human capital formation [Buiter and Kletzer 1992]. This effect is absent in our model. De Gregorio [1992] proposes a model where liquidity constraints raise saving but lower human capital accumulation, so that their overall effect on growth is ambiguous.

6. The results summarized in this section are discussed and proved in Jappelli and Pagano [1994].

7. If instead the economy is dynamically inefficient with perfect markets, tighter liquidity constraints are unambiguously associated with lower steady state welfare.

reduced to any value above 16.8 percent, the welfare of all generations, including the present one, increases: in this parameter region a moderate financial repression is a Pareto improvement. If ϕ is further reduced to any value between 16.8 and 1 percent, the current generation is hurt, and the welfare of all the others increases.

III. International Differences in Household Credit and Mortgage Markets

The volume of credit available to households and their access to credit markets differ substantially between countries, even within the group of OECD countries. This is illustrated in Table I. Columns (4), (5), and (6) show the ratio of consumer credit to national income in 1980, where consumer credit is defined as the amount of household indebtedness that finances current consumption and the purchase of durable goods.[8]

The differences that emerge from Table I are striking. In 1980 Canada, the United States, and the Scandinavian countries, consumer credit exceeds 10 percent of national income. France, Greece, Italy, and Portugal are at the low end of the spectrum with consumer credit under 3 percent of national income. A similar ranking emerges also if one considers the volume of outstanding mortgage home purchase loans, as shown by Jappelli and Pagano [1989] for a smaller sample of countries.

Household debt may reflect not only credit market imperfections, but also differences in the demand for loans, induced by factors as disparate as tax incentives, demographics, and preferences. The maximum LTV ratio for the purchase of a house does not suffer from this identification problem, since it is an indicator of the availability of credit to households. To obtain the mortgage, the household must meet the down payment, irrespective of its future ability to repay. This results in forced savings unless the household chooses to postpone or forgo the purchase of the house.[9] This choice depends on the shadow value of owning relative to renting, i.e, by the tax incentives to owning, the risk of rent termination or increase, the availability of rental housing (often limited by rent controls), and the "pride of ownership." In column

8. Sources and definitions are reported in an Appendix available upon request.
9. Another condition for forced saving is that the household cannot circumvent the down payment constraint by borrowing in the market for personal loans. Thus, it must be credit constrained in the consumer credit market also.

TABLE I
CREDIT TO HOUSEHOLDS AND TO THE PRIVATE SECTOR: AN INTERNATIONAL COMPARISON[a]

OECD countries	Maximum loan-to-value ratio 1961–1970 (1)	Maximum loan-to-value ratio 1971–1980 (2)	Maximum loan-to-value ratio 1981–1987 (3)	Consumer credit as a percentage of net national product 1960 (4)	Consumer credit as a percentage of net national product 1970[b] (5)	Consumer credit as a percentage of net national product 1980[b] (6)	Credit to the private sector in 1975 as a percentage of GDP[c] (7)
Canada	75	75	80	8.9	12.9	14.4	33.9
United States	80	80	89	14.1	15.8	16.1	37.5
Japan	—	—	60	—	5.9	7.4	90.6
Australia	75	75	80	—	—	7.7	27.5
New Zealand	66	66	80		—	—	26.3
Austria	—	—	60	—	—	—	55.0
Belgium	65	65	75	—	3.5	4.6	22.0
Denmark	70	85	95	—	16.1	14.9	50.9
Finland	80	80	85	18.3	17.4	15.0	47.5
France	80	80	80	—	1.7	2.4	43.3
Germany	65	65	80	—	4.1	7.9	68.4
Greece	—	—	50	—	0.0	0.1	47.6
Ireland	80	80	90	—	6.1	8.6	27.6
Italy	50	50	56	—	2.4	2.5	52.0
Luxembourg	—	60	60		—	—	—
Netherlands	75	75	75	1.7	2.1	4.1	39.2
Norway	75	75	80	—	13.3	13.7	39.6
Portugal	60	60	60	—	—	1.5	106.6
Spain	60	60	80	—	—	4.9	77.7
Sweden	90	90	95	—	—	31.6	43.0
Turkey	—	50	50	—	—	—	25.4
United Kingdom	—	81	87	—	—	5.7	26.0
Non-OECD countries							
Indonesia		75					21.2
Israel		50					38.3
Korea		30					35.4
Malaysia		65					27.2
Mexico		60					5.4
Philippines		75					23.5
Taiwan		40					—
Thailand		65					26.9

a. An Appendix available upon request reports data sources and definitions for consumer credit and the maximum LTV ratio.

b. Data for Australia, Portugal, and Spain refer to 1981, 1986, and 1982, respectively. Data for Japan, Belgium, Denmark, Ireland, and Norway refer to 1978, 1977, 1978, 1971, and 1978, respectively.

c. *Source:* International Financial Statistics, IMF line 32d (claims on private sector), and line 99b (GDP).

(2) of Table I we report the maximum LTV ratio for twenty-two OECD and eight non-OECD countries in the 1970s, which is the midsample decade in the data set to be used in the rest of the paper. The LTV ratio refers to conventional housing loans extended to first-time buyers.[10]

There is a strong positive correlation between the data of columns (2) and (6). The countries where consumer credit exceeds 10 percent of national income also feature large maximum LTV ratios (at or above 75 percent). Conversely, where the maximum LTV ratio in the 1970s was 50 percent (Greece and Italy), consumer credit in 1980 did not exceed 3 percent of national income. There are also large differences between the developing economies for which we have data: the maximum LTV ratio was 30 percent in Korea, 40 percent in Taiwan, and 75 percent in Indonesia and the Philippines.

The main reasons why liquidity constraints differ between countries and may change over time involve (i) regulation, (ii) the cost of enforcing loan contracts, and (iii) the information on borrower's creditworthiness available to lenders. All three may lead to rationing or to differences between borrowing and lending rates [Jaffee and Stiglitz 1990].

Regulation often imposes maximum LTV ratios for mortgage loans. These vary considerably between countries: in the 1970s the limit was as low as 50 percent in Italy, 60 percent in Spain, and 66 percent in New Zealand, and as high as 75 percent in Canada and 80 percent in France. In addition, in some countries selective credit ceilings have been placed on consumer credit (e.g., in France until early 1987) or mortgages (e.g., in Korea), often with the explicit aim of fostering industrial investment.[11] Regulation has also limited credit to households by subjecting mortgages to interest rate ceilings and restricting entry into this market to a select group

10. The maximum LTV ratio is difficult to measure for a variety of reasons. In the course of a decade it may change (in this case we take the average of the maximum LTV ratio during the decade. Regulatory ceilings differ across classes of mortgages (we refer to conventional loans without mortgage insurance, government guarantees or subsidies). In some countries there is no statutory maximum LTV ratio and payments arrangements are at the discretion of the individual lender (in this case we assume that the maximum LTV ratio equals the maximum observed average LTV ratio in the decade). An Appendix available upon request reports sources and definitions for the LTV ratio in each country.

11. This is witnessed by country studies on South Korea and Taiwan. For instance, Park [1993, p. 145] argues: "One advantage of the repressive financial system in Korea, and to a lesser degree in Taiwan, may have been its ability to supply long-term finance. . . . Without government intervention the profit-oriented behavior of the commercial banks and non-bank financial intermediaries would have resulted in a dearth of long-term finance."

of financial intermediaries: saving banks in Spain; building societies in the United Kingdom, Australia, New Zealand, and Ireland; Bausparkassen in Austria and Germany; and special credit institutions in Italy.[12] Governments also limit private contracting, especially by forbidding loans with maturities above specified limits [Lomax 1991].[13]

In some countries there are substantial *costs of enforcing contracts and of disposing of collateral.* The EC Mortgage Federation [1990] reports that, on average, the costs of a mortgage foreclosure exceed 10 percent of the selling price in Belgium, Greece, Spain, France, Italy, and Portugal, while in the rest of the EC it is around 5 percent. The main reason why these costs differ is the length of the judicial process, which largely determines the legal expenses and the amount of forgone interest. In Italy it takes an average of four years to repossess a house in case of mortgage foreclosure; the time required is also substantial in Belgium (two years), Germany (fifteen months), Portugal (eighteen months), and Spain (three years). In the other EC countries and in the United States the judicial process takes under a year, with lows of five months in Denmark and three months in the Netherlands. Quick comparison with the figures of Table I reveals that where enforcement is costly and lengthy, consumer credit markets are less developed and maximum LTV ratios are smaller.

Finally, the *information available to lenders* varies substantially between countries and may help account for some of the differences reported in Table I. In the United States, Canada, and the Scandinavian countries, lenders share information about borrowers. Specialized credit reference agencies provide fast and reliable information on the credit history of loan applicants. In other countries, where the consumer credit market is thin, information sharing is absent or operates on a limited scale. Pagano and Jappelli [1993] show that information sharing reduces lending risk and may expand the market.

The data in Table I also show that there is no necessary connection between the degree to which credit is available to firms and the degree to which it is available to households. Column (3)

12. In most of these countries, regulation eased considerably in the 1980s. The key elements of liberalization have generally been allowing banks to compete with the credit institutions specialized in mortgage lending, and raising the maximum LTV ratio.

13. Limiting the maximum maturity is equivalent to imposing a low LTV ratio, since it raises monthly installments and the burden debt servicing. Thus, other things being equal, where mortgage maturities are shorter, households must take smaller loans.

reports credit to the private sector as a fraction of GDP, which is an index of financial intermediation for the economy as a whole. Countries with high ratios, such as Italy, Portugal, and Spain, feature low consumer credit, while the United States and Canada, where consumer credit and mortgage markets are very developed, exhibit comparatively low total private credit. This point is quite important because it indicates that no single summary measure of financial repression can be appropriately used in studies of saving and growth. Financial development is often lopsided: lending to the business sector may be abundant even while households have virtually no access to credit.

IV. Saving and Liquidity Constraints

In this section we test whether the measures of liquidity constraints presented in the previous section help to explain the international differences in national saving rates, as predicted by our model. We also test a corollary of that model, namely that the effect of growth on saving is greater where liquidity constraints are more pervasive. The data cover a panel of nineteen countries (all the main OECD countries are included) and are drawn from Modigliani [1990]. Observations are averages of annual data for three periods: 1960–1970, 1971–1980, and 1981–1987). Figure I plots the national saving rate against the LTV ratio in the 1970s and shows that the two variables are negatively correlated (the correlation coefficient for the entire sample is −0.55).

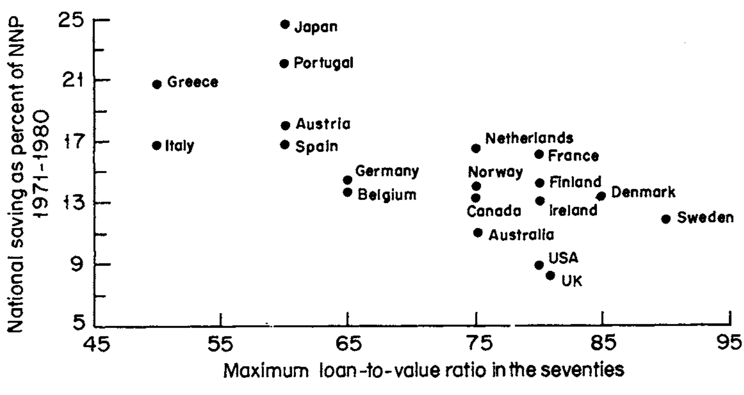

FIGURE I
Net National Saving Rate and Maximum Loan-to-Value Ratio

We estimate a pooled regression over nineteen countries and three time periods; due to seven missing observations for the LTV ratio, the sample size is fifty observations. The dependent variable is net national saving divided by net national product. Unlike private saving, national saving is invariant with respect to inflation-induced transfers between the private and the public sector. Our benchmark is Modigliani's [1990] baseline specification, where the regressors are the GDP growth rate,[14] the ratio of inflation-adjusted government saving to net national product, and the dependency ratio.[15]

While theory suggests that each of these variables should explain national saving, the predicted sign of each is ambiguous a priori. As is shown in Section II, in a closed economy the effect of growth on saving is positive, but in a small open economy it becomes ambiguous; faster growth may actually reduce the saving rate by stimulating the consumption of the young. The effect of public saving on national saving is also ambiguous, since it depends on the degree of intergenerational altruism of households. Finally, the dependency ratio has two potential effects on saving: an increase in the ratio of the population under fifteen to the total population increases family needs and reduces saving; but a permanently higher dependence ratio also implies a higher ratio of workers to retirees, thereby increasing saving.

The regressions in rows 1 to 6 in Table II add the maximum LTV ratio to Modigliani's baseline specification. Each regression also includes country and time dummies (for brevity, their coefficients are not reported). Regression II.1 reveals a positive relation between growth and saving, in line with Modigliani's findings. The coefficient of government saving is positive and significant, in contrast to Barro's [1974] with altruism. The coefficient of the dependency ratio is small and not significantly different from zero. The coefficient of the LTV ratio is negative and precisely estimated, supporting the main prediction of the model in subsection II.1: a 10 percent increase in the LTV ratio reduces the national saving rate by almost two percentage points.

The coefficients may be biased if growth is itself endogenous and positively correlated with the error of the saving equation, as

14. In Section II the population is assumed constant, and growth can occur only if there is productivity growth. But in our simple model productivity and population growth have the same effect on saving, so that the appropriate measure of growth to be used as a regressor is the total growth rate of GDP.

15. The inflation adjustment adds the inflation tax on nominal government liabilities to the conventional measure of government saving.

TABLE II
SAVING AND LIQUIDITY CONSTRAINTS: DATA FROM MODIGLIANI
(DEPENDENT VARIABLE: RATIO OF NET NATIONAL SAVING TO NNP)[a]

Regression (estimation method)	Constant (1)	GDP growth (2)	Government surplus relative to NNP (3)	Dependency ratio (4)	Maximum LTV ratio in rows 1 to 6; ratio of consumer credit to NNP in rows 7 to 9 (5)	Adj. R^2 (6)
II.1	0.242	1.907	0.654	−0.095	−0.195	0.809
(OLS)	(5.43)	(2.50)	(4.38)	(−0.94)	(−4.03)	
II.2[b]	0.208	2.825	0.619	−0.096	−0.200	0.703
(IV)	(2.94)	(1.23)	(3.23)	(−0.77)	(−3.29)	
II.3[c]	0.218	0.416	0.565	−0.057	−0.174	—
(Robust)	(5.16)	(1.00)	(3.98)	(−0.59)	(−3.77)	
II.4[d]	0.122	4.703	0.746	−0.120	−5.464	0.790
(OLS)	(3.31)	(4.12)	(4.83)	(−1.15)	(−3.49)	
II.5[b,d]	0.124	5.561	0.748	−0.102	−7.091	0.780
(IV)	(2.24)	(2.56)	(4.61)	(−0.95)	(−3.71)	
II.6[c,d]	0.073	7.075	0.629	0.017	−8.398	—
(Robust)	(3.13)	(9.72)	(6.40)	(0.26)	(−8.42)	
II.7	0.122	0.953	0.599	−0.079	−0.308	0.538
(OLS)	(3.44)	(1.05)	(2.60)	(−0.80)	(−3.41)	
II.8[b]	0.105	2.528	0.390	−0.131	−0.345	0.488
(IV)	(2.74)	(1.96)	(1.45)	(−1.22)	(−3.54)	
II.9[c]	0.122	0.710	0.525	−0.078	−0.269	—
(Robust)	(3.46)	(0.79)	(2.29)	(−0.80)	(−2.99)	

a. All regressions include two time dummies (sixties and seventies). The regressions in rows 1 to 6 also include country dummies. In rows 1 to 6 the mean of the dependent variable is 0.132, and the sample includes 50 observations on the following countries: Canada, United States, Australia, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Portugal, Spain, and Sweden in the sixties, seventies, and eighties; the United Kingdom in the seventies and eighties; Japan, Austria, and Greece in the eighties. In rows 7 to 9 the mean of the dependent variable is 0.127, and the sample includes 35 observations on the following countries: Canada, United States, Finland, and Netherlands in the sixties, seventies, and eighties; Japan, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, and Norway in the seventies and eighties; Australia, Portugal, Spain, Sweden, and United Kingdom in the eighties. Data definitions and sources for the LTV ratio and for consumer credit are reported in an Appendix available upon request. t-statistics are in parentheses.

b. The instruments for growth are beginning-of-period per capita GDP, beginning, of-period primary and secondary enrollment rates, lagged growth, and time and country dummies.

c. The robust estimation method performs an initial OLS regression, calculates the Cook's distance, eliminates the gross outliers for which the Cook's distance exceeds 1, and then performs iterations based on Huber weights followed by iterations based on a biweight function (a routine programmed in the STATA econometric software).

d. In regressions 4, 5, and 6 the LTV ratio in column (5) is multipled by the growth rate.

implied by the endogenous growth model of subsection II.2. To take this potential bias into account, in row II.2 we perform instrumental variables estimation.[16] The estimated coefficient of growth rises relative to regression II.1, a pattern that is consistent with the hypothesis of endogenous growth. The coefficient of the LTV ratio is virtually unaffected. In row II.3 we repeat the estimation using a robust method to control for the effect of influential values. Also in this case the coefficient of the LTV ratio is negative and highly significant.

In rows II.4 to II.6 we test the second prediction of the model, namely that the effect of growth on savings depend on the severity of liquidity constraints. We replace the maximum LTV ratio with the product of the latter and the growth rate. The coefficient of this variable is negative and significantly different from zero (irrespective of the estimation method), consistent with the model's prediction. Thus, the effect of growth on saving is smaller in countries where households have easier access to credit. For instance, the coefficients in row II.4 indicate that in the United States a 1 percent increase in growth raised savings by only one-third of a percentage point in the 1970s. In Italy, instead, the same increase in growth induced an increase in saving by almost two percentage points.

In rows II.7 to II.9 we replace the LTV ratio with the beginning-of-period stock of consumer credit (divided by net national product).[17] To the extent that a high value of consumer credit proxies for households' ability to borrow, we expect it to be associated with below-average saving. The coefficient of consumer credit is indeed negative and significant (irrespective of the estimation method.)[18] The coefficients imply that a 1 percent increase in consumer credit as a share of NNP lowers saving by about one-third of a percentage point. The similarity between these results and those obtained using the LTV ratio reflects the high correlation (0.67) between the two proxies for households' access to credit markets.

16. The instruments for growth are beginning-of-period per capita GDP, lagged growth, beginning-of-period primary and secondary enrollment rates, and country dummies. An alternative way to correct for endogeneity of growth is to replace the contemporaneous growth rate with the growth rate of GDP in the previous decade: this specification yields results which are very similar to the instrumental variables estimates.

17. We use beginning-of-period data for consumer credit to overcome the objection that in a saving regression the stock of consumer debt is endogenous. Due to the small number of observations on consumer credit (see Table I), in rows II.7 to II.9 country dummies are not included in the regressions.

18. Because of the different size and composition of the sample, the regressions with consumer credit are not directly comparable with those that use the LTV ratio as a regressor.

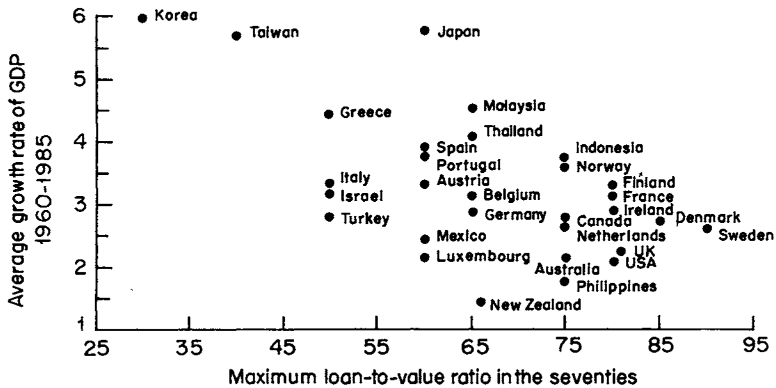

FIGURE II
Growth Rate and Maximum Loan-to-Value Ratio

V. Growth and Liquidity Constraints

In endogenous growth models, what stimulates saving also promotes growth. Having found that liquidity constraints are an important determinant of the international differences in saving rates, we now explore whether they also have some explanatory power in reduced-form regressions for growth. To test this conjecture, we use two international data sets, one by De Long and Summers [1991] and another by Barro and Wolf [1989], both of which are based on the seminal work of Summers and Heston [1991]. Data on maximum LTV ratios are available for only 25 of the 61 countries covered by De Long and Summers and for 30 of the 118 countries covered by Barro and Wolf. Figure II points to the presence of a negative correlation between the average GDP growth rate in 1960–1985 and the LTV ratio in the 1970s (their correlation is −0.60).

The results for the two data sets are given in Table III. Regression III.1 adds the LTV ratio to the baseline specification proposed by De Long and Summers [Table XIII, p. 454]. We regress the average growth rate of GDP per employee in 1960–1985 on the labor force growth, the share of equipment and non-equipment investment, the labor productivity gap relative to the United States, and the LTV ratio.[19] Even though our sample is smaller

19. The dependent variable in these regressions is productivity growth, not the total growth rate used in the saving regressions of the previous section. Endogenous growth models predict that saving correlates with productivity growth, not with population growth.

TABLE III
GROWTH AND LIQUIDITY CONSTRAINTS

Data from De Long and Summers[a]

Regression (estimation method)	Constant	GDP gap relative to the U. S.	Labor force growth	Equipment share	Nonequipment share	LTV ratio in the seventies[b]	Adj. R^2
III.1	0.024	0.025	−0.084	0.113	0.051	−0.036	0.784
(OLS)	(2.42)	(5.12)	(−0.80)	(2.23)	(1.64)	(−4.11)	
III.2[b]	0.024	0.026	−0.034	0.116	0.034	−0.033	—
(Robust)	(2.14)	(4.85)	(−0.29)	(2.06)	(0.97)	−3.40)	

Data from Barro and Wolf[c]

	Constant	GDP per capita in 1960	Number of revolutions and coups per year	Number of assassinations per million population	1960 PPP value for the investment deflator	Government consumption to real GDP (1970–1985)	Primary school enrollment rate in 1960	Secondary school enrollment rate in 1960	LTV ratio in the seventies[b]	Adj. R^2
III.3	0.049	−0.005	−0.011	−0.003	−0.004	−0.035	0.013	0.022	−0.026	0.510
(OLS)	(3.51)	(−3.72)	(−0.78)	(−0.82)	(−0.37)	(−0.81)	(1.26)	(2.01)	(−1.86)	
III.4	0.057	−0.004						0.023	−0.031	0.506
(OLS)	(7.74)	(−3.43)						(2.25)	(−2.45)	
III.5[b]	0.056	−0.005						0.023	−0.025	—
(Robust)	(7.42)	(−3.83)						(2.22)	(−1.93)	

a. In rows III.1 and III.2 the sample includes eighteen OECD and seven non-OECD countries: Canada, United States, Japan, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, United Kingdom, Indonesia, Israel, Korea, Malaysia, Mexico, the Philippines, and Thailand. The mean of the dependent variable is 0.03. We proxy the missing values for the LTV ratios in Japan, Austria, and Greece with the respective values in the eighties (see Table I). Data, sources, and definitions for the LTV ratio are available upon request. t-statistics are in parentheses.

b. See footnote c in Table II.

c. In rows III.3 to III.5, in addition to the 25 countries listed above, the sample includes Australia, New Zealand, Sweden, Taiwan, and Turkey. The mean of the dependent variable is 0.033.

than that used by De Long and Summers, our results are qualitatively similar.[20]

The coefficient of the initial productivity gap is positive and significant, indicating that countries with a lower initial productivity relative to the United States exhibited fast growth in subsequent periods, controlling for other variables. Since our sample consists mainly of OECD countries, this result agrees with many other empirical studies of growth in developed economies. The coefficient of equipment investment is larger and more precisely estimated than that of nonequipment investment, as found by De Long and Summers. The coefficient of the LTV ratio is negative and significantly different from zero, supporting the hypothesis that liquidity constraints promote growth. The magnitude of the coefficient indicates that an increase of 10 percent in the LTV ratio reduces growth by 0.36 percentage points. As shown in row III.2, this result is robust to the presence of outliers. It is also unaffected when we restrict the estimation to the eighteen OECD countries of the sample.

It should be noted that in this case a test of the significance of the LTV coefficient is a joint test of endogenous growth and imperfect capital mobility. With perfect capital mobility, investment and growth should not be affected by national saving rates, and therefore by the determinants of saving, including proxies for liquidity constraints. A zero coefficient of the LTV ratio may indicate either that growth does not depend on liquidity constraints, or that capital flows freely across national boundaries. A positive coefficient, however, is consistent only with a model of endogenous growth and imperfect capital mobility. Our result thus accords with the evidence offered by Feldstein and Bacchetta [1991] that in the 1960s and 1970s capital did not move freely across countries.

In rows III.3 to III.5 we add the LTV ratio to the specification used by Barro [1991, Table I, pp. 410–11], which differs in many respects from that of rows III.1 and III.2. First, the dependent variable is the rate of growth of per capita GDP, rather than the rate of growth of GDP per employee. Second, per capita GDP replaces the productivity gap as a proxy for the level of the capital

20. In rows III.1 and III.2 of Table III, we omit the variables, assassinations, revolutions, government consumption, and primary and secondary enrollment rates in 1960. If included, they are not significantly different from zero, as in De Long and Summers [1991].

stock.[21] Third, two variables proxy for political instability (number of assassinations per million population per year and number of revolutions and coups per year) and one for trade distortions (the 1960 purchasing power parity value for the investment deflator). Fourth, government consumption, net of defense expenditures, captures the distortionary effect of taxation. Fifth, the primary and secondary school enrollment rates proxy for the initial level of the stock of human capital.

The main determinants of growth are the initial level of per capita GDP, the secondary school enrollment rate, and the LTV ratio. The coefficient of the latter is comparable to that estimated in the previous two regressions. In row III.4 we drop the variables with insignificant coefficients, and in row III.5 we perform robust estimation. The importance of the LTV ratio as a determinant of growth is confirmed by these regressions (these results are confirmed if we restrict the sample to the OECD countries).

The results of this section may appear surprising in view of the empirical evidence recently produced in Roubini and Sala-i-Martin [1991], which finds that proxies for financial market distortions are negatively correlated with growth.[22] However, the finding that financial development tends to promote rather than to inhibit growth does not contradict the results of this section, because the link between capital markets and growth underscored in this paper refers to the effect of imperfections in the mortgage and consumer credit markets, which have no necessary correlation with the development of lending to firms. Our results complement, rather than contradict, the claim that financial repression in the market for business loans reduces productive investment and growth.

VI. Conclusions and Policy Implications

We have empirically assessed the validity of three propositions, namely that liquidity constraints on households raise the saving rate, strengthen the effect of growth on saving, and foster productivity growth in models in which growth is endogenous. The

21. Thus, here conditional convergence requires a negative coefficient of initial GDP.

22. This work proxies financial distortions with dummies based on the ex post real interest rate (on the ground that financial repression tends to keep real interest rates artificially low) and financial development with the reserve ratio of the banking system (on the ground that a high reserve ratio is a symptom of financial underdevelopment).

evidence reported in Sections IV and V does not reject any of these propositions.

To assess the effects of liquidity constraints implied by our estimates, we compute the contribution of the maximum loan-to-value (LTV) ratio to national saving and growth. In columns (3) and (4) of Table IV, we report the product of the deviations of the LTV ratio from its mean and the coefficient of the LTV ratio in the saving regression II.2 (−0.20). Countries with lower than average LTV ratios exhibit higher than average saving, other things equal. For instance, if in the 1980s Italy featured the sample average LTV ratio of 74.3 percent (rather than its actual value of 56), the Italian saving rate would have been 3.6 percentage points lower (the corresponding calculation for the United States predicts that its saving rate would have been 2.9 points higher than its actual value).

In column (6) we perform the corresponding calculation to measure the impact of the LTV ratio on growth. We report the product of the deviation of the LTV ratio from its mean and its estimated coefficient in the growth regression III.3 (−0.026). Where credit is more easily available, as in the United States, the United Kingdom, and Scandinavian countries, the contribution to growth is negative. Where credit is more tightly rationed, as in Japan, Greece, Italy, and Turkey, the contribution is positive. Outside the OECD, liquidity constraints have a remarkable effect on the growth performance of Taiwan and Korea.

The estimates can be used to assess the impact of financial deregulation on national saving rates in the 1980s. In our sample of OECD countries, the (unweighted) average national saving rate declined by 5.1 percentage points, from 15.1 percent in the 1970s to 10 percent in the 1980s. The increase in the maximum LTV ratio (from a sample average of 70.8 in the 1970s to 76.7 in the 1980s) accounts for 1.2 percentage points, or 23 percent of this decline. This effect is largest in the countries that deregulated their mortgage markets in the early 1980s. For instance, in Spain national saving declined from 16.7 percent in 1971–1980 to 9.6 percent in 1981–1987; financial deregulation explains 3.9 percentage points, over a half of this decline. In Belgium, Denmark, and Ireland the increase in the LTV ratio accounts for two points of the decline in saving. In the United Kingdom deregulation explains 60 percent of the two points reduction in the national saving rate.

The policy implications for the process of financial integration

TABLE IV
THE EFFECT OF LIQUIDITY CONSTRAINTS ON SAVING AND GROWTH

	Net national saving as a % of NNP[a]		Contribution of the LTV ratio to national saving[b]		Average rate of growth of GDP[c]	Contribution of the LTV ratio to growth[d]
	1971–1980	1981–1987	1971–1980	1981–1987	(1960–1985)	
	(1)	(2)	(3)	(4)	(5)	(6)
OECD countries						
Canada	13.3	9.4	−0.1	−1.1	2.8	−0.2
United States	8.9	3.9	−1.1	−2.9	2.1	−0.4
Japan	24.6	20.2	—	2.8	5.8	0.2
Australia	11.0	3.4	−0.1	−1.1	2.1	−0.2
New Zealand	—	—	—	—	1.5	0.0
Austria	18.0	13.0	—	2.8	3.3	0.2
Belgium	13.9	6.5	1.8	−0.1	3.2	0.0
Denmark	13.3	6.0	−2.1	−4.1	2.7	−0.5
Finland	14.2	10.7	−1.1	−2.1	3.3	−0.4
France	16.3	8.0	−1.1	−1.1	3.2	−0.4
Germany	14.3	10.7	1.8	−1.1	2.9	0.0
Greece	20.7	8.5	—	4.8	4.4	0.4
Ireland	13.1	8.3	−1.1	−3.1	2.9	−0.4
Italy	16.7	10.9	4.8	3.6	3.3	0.4
Luxembourg	—	—	—	—	2.2	0.2
Netherlands	16.4	13.3	−0.1	−0.1	2.7	−0.2
Norway	14.0	15.8	−0.1	−1.1	3.7	−0.2
Portugal	22.0	19.8	2.8	2.8	3.8	0.1
Spain	16.7	9.6	2.8	−1.1	3.9	0.1
Sweden	11.8	6.0	−3.1	−4.1	2.6	−0.6
Turkey	—	—	—	—	2.8	0.4
United Kingdom	8.2	6.2	−1.3	−2.5	2.2	−0.4
Non-OECD countries						
Indonesia					3.7	−0.2
Israel					3.2	0.4
Korea					6.0	0.9
Malaysia					4.5	0.0
Mexico					2.5	0.2
Philippines					1.8	−0.2
Taiwan					5.7	0.7
Thailand					4.1	0.0
Average[e]	15.1	10.0	0.0	0.0	3.3	0.0

a. Source: Modigliani [1990].
b. Product of the deviation of the LTV ratio from its mean and its coefficient in regression II.2.
c. Source: Barro and Wolf [1989].
d. Product of the deviation of the LTV ratio from its mean and its coefficient in regression III.3.
e. Unweighted average of all countries.

and liberalization in the European Community are important. This process may lead to further easing of liquidity constraints in the countries where the mortgage and consumer credit markets are still relatively underdeveloped. Our estimates suggest that the development of these markets will lead to a deterioration in the Community's overall saving and growth performance, and our model indicates that it may also reduce the welfare of current and future generations.

APPENDIX

Derivation of Equations (7) and (8)

The first-order conditions for profit maximization are given by

$$e_t = (1 - \alpha)A_t K_t^{\alpha}, \tag{A1}$$

$$R_t = \alpha A_t K_t^{\alpha - 1}, \tag{A2}$$

where $A_t = A(1 + \rho)^t$. Substituting (A1) and (A2) into the equilibrium condition $W_t = K_{t+1}$, one obtains equation (7) in the text. Rearranging and taking logs of equation (7),

$$\ln K_{t+1} = \ln g + t \ln (1 + \rho) + \alpha \ln K_t, \tag{A3}$$

where $g = \beta(1 - \phi)\alpha(1 - \alpha)A/(1 + \beta)[\alpha + \phi(1 - \alpha)]$. The solution to this difference equation is

$$\ln K_t = \left[\ln K_0 - \frac{\ln g}{1 - \alpha} + \frac{\ln (1 + \rho)}{(1 - \alpha)^2}\right]\alpha^t + \frac{\ln g}{1 - \alpha} - \frac{\ln (1 + \rho)}{(1 - \alpha)^2} + \frac{\ln (1 + \rho)}{1 - \alpha} t. \tag{A4}$$

Along a steady state growth path the initial capital stock K_0 is given by

$$\ln K_0 = \frac{\ln g}{1 - \alpha} - \frac{\ln (1 + \rho)}{(1 - \alpha)^2}. \tag{A5}$$

Substituting (A5) into (A4), one obtains the law of motion of the capital stock along the steady state path:

$$\ln K_t = \frac{\ln g}{1 - \alpha} - \frac{\ln (1 + \rho)}{(1 - \alpha)^2} + \frac{\ln (1 + \rho)}{1 - \alpha} t. \tag{A6}$$

Taking the antilogarithm of (A6) and substituting for g, one obtains equation (8) in the text.

Derivation of Equation (11)

At time t, when the productivity shock occurs, the capital stock is a predetermined variable, resulting from the capital market equilibrium condition,

$$(1 + \beta)[\alpha + \phi(1 - \alpha)]K_t = \beta(1 - \phi)\alpha(1 - \alpha)A(1 + \rho)^{t-1}K_{t-1}^{\alpha}. \tag{A7}$$

At time $t + 1$, the capital stock starts adjusting according to the new equilibrium condition:

$$(1 + \beta)[\alpha + \phi(1 - \alpha)]K_{t+1} = \beta(1 - \phi)\alpha(1 - \alpha)A(1 + \hat{A})(1 + \rho)^{t}K_{t}^{\alpha}. \tag{A8}$$

Taking logs in (A7) and (A8), and subtracting one from the other, one obtains

$$\ln K_{t+1} - \ln K_t = \ln [(1 + \hat{A})(1 + \rho)] + \alpha(\ln K_t - \ln K_{t-1}). \tag{A9}$$

From (A6) one obtains that $[\ln K_t - \ln K_{t-1} = [\ln (1 + \rho)]/(1 - \alpha)$; substituting this in (A9) and taking the antilogarithm, one finds the capital stock in the period following the shock:

$$K_{t+1} = K_t(1 + \rho)^{1/(1-\alpha)}(1 + \hat{A}). \tag{A10}$$

In subsequent periods the capital market equilibrium condition is the same as (A8) except for the timing of variables. Repeating the above procedure, one obtains

$$K_{t+n} = K_{t+n-1}(1 + \rho)^{1/(1-\alpha)}(1 + \hat{A})^{\alpha^{n-1}}, \tag{A11}$$

which immediately leads to equation (11) in the text. The same expression also holds for the rate of growth of output, so that the capital-output ratio is constant in the transition.

Derivation of Equation (13)

In a small open economy the interest rate is an exogenous R, and the first-order condition for profit maximization becomes

$$R = \alpha A_t K_t^{\alpha-1}. \tag{A12}$$

Equation (A12) implies that the capital stock is

$$K_t = (\alpha A_t/R)^{1/1-\alpha}. \tag{A13}$$

Substituting the first-order conditions for profit maximization (A1) and (A12) into equation (4) in the text, using the expression (A13) for the capital stock, and noticing that $A_{t+1} = A_t(1 + \rho)$, one obtains an expression for aggregate wealth:

$$(A14)\quad W_t = \frac{\beta(1-\phi)}{1+\beta}(1-\alpha)A_tK_t^{\alpha} - \frac{\phi}{R}(1-\alpha)A_{t+1}K_{t+1}^{\alpha}$$
$$= \frac{\beta(1-\phi)}{1+\beta}(1-\alpha)\,A_t\left(\frac{\alpha A_t}{R}\right)^{\alpha/(1-\alpha)}$$
$$- \frac{\phi}{R}(1-\alpha)\,A_{t+1}\left(\frac{\alpha A_{t+1}}{R}\right)^{\alpha/(1-\alpha)}$$
$$= \left[\frac{\beta(1-\phi)}{1+\beta} - \frac{\phi}{R}(1+\rho)^{1/(1-\alpha)}\right]A_t^{1/(1-\alpha)}\left(\frac{\alpha}{R}\right)^{\alpha/(1-\alpha)}(1-\alpha).$$

Saving is no longer equal to the change in the capital stock, because the latter is equal to the sum of national saving and the external deficit. National saving is the change in domestic assets, $S_t \equiv W_t - W_{t-1}$:

$$(A15)\quad S_t = \left[\frac{\beta(1-\phi)}{1+\beta} - \frac{\phi}{R}(1+\rho)^{1/(1-\alpha)}\right]$$
$$\times\,[1-(1+\rho)^{-1/(1-\alpha)}]A_t^{1/(1-\alpha)}\left(\frac{\alpha}{R}\right)^{\alpha/(1-\alpha)}(1-\alpha).$$

To obtain equation (13) in the text, one divides equation (A15) by national income

$$(A16)\quad Y_t = A_t^{1/(1-\alpha)}(\alpha/R)^{\alpha/1-\alpha}.$$

Solution of Equation (18)

If $\alpha + \eta < 1$, the solution is

$$(A17)\quad \ln K_t = \left[\ln K_0 - \frac{\ln g}{1-\alpha-\eta}\right](\alpha+\eta)^t + \frac{\ln g}{1-\alpha-\eta},$$

so that the growth rate of capital is $\hat{K}_{t+1} = (g/K_0^{1-\alpha-\eta})^{(\alpha+\eta)^{t-1}} - 1$. If instead $\alpha + \eta = 1$, the solution is

$$(A18)\quad \ln K_t = \ln K_0 + t\ln g,$$

and the growth rate of capital is $\hat{K}_{t+1} = g - 1$.

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[Footnotes]

[20] **Equipment Investment and Economic Growth**
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