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The Long-Run Savings Function in Cross-Section and Time-Series Perspective

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This paper analyzes the fundamental long-run relationship between the savings rate and the income level in developing and industrialized countries. For both country groups Kuznets' hypothesis of a constant average propensity to save is rejected, as our empirical results show an S-shaped movement of the savings rate when income increases. Successful industrial newcomers are characterized by rapidly rising rates of capital formation at low and moderate income levels. Thus, world-wide economic leadership of a country seems to depend crucially on its savings behaviour during the development process.

I. Introduction

There is widespread consensus in the literature on problems of capital formation and savings in developing countries that a country's per capita income (PCI) is one of the most important exogenous variables determining the domestic saving rate. Numerous empirical studies have applied this variable to cover the Keynesian absolute income hypothesis both using cross-section as well as time-series analysis. However, the saving-income relationship is far from clear-cut. Whereas in most cross-section studies a positive relationship between the savings rate and the income level (PCI) comes out clearly, individual country studies often show quite different results. For example, Leff (1968, pp. 610) finds no increase in the marginal propensity to save during the industrialization process of Brazil. This corresponds to the well-known findings of Kuzenets

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(1965, pp. 30), who examined savings behaviour in developed countries. He stressed the view that no upward movement of the savings rate could be detected. The contradiction between long term time-series results and household panel data (exhibiting a positive savings-income correlation) was obvious and gave rise to the development of several theories and hypotheses to harmonize the conflicting observations. The theories of Duesenberry (relative income hypothesis), Friedman (permanent income hypothesis), and Ando and Modigliani (life cycle theory) have become well known. Contrary to the Keynesian argument of the dominating income level effect, the above mentioned theories regard the growth of income as decisive.

Despite the empirical significance of the income growth effect (Singh, 1975, pp. 121), it is still unclear whether the long term savings function is linear with a constant average propensity to save (APS), i.e., whether Kuznets' theory can be maintained. Therefore, this paper comprehensively analyzes the fundamental long-run relation between the savings rate and the income level both using cross-section and time-series studies. It is organized in five sections. The following section briefly summarizes the empirical evidence on savings behaviour in several industrial and developing countries and introduces a saving function that may describe the long term savings-income relationship in both country groups. Section Ⅲ outlines and discusses several savings functions frequently used in empirical analysis. An econometrics comparison based on a large cross-section sample consisting of LDCs is then carried out in section Ⅳ. The results are confronted with the historical savings record of four major industrial countries in section Ⅴ. The analysis is completed in section Ⅵ, where we evaluate the savings performance of three industrial newcomers, Japan, Taiwan, and Korea. The results indicate that the economic success of a particular country crucially depends on its savings performance during the period of development.

Ⅱ. Kuznets Versus Keynes and Rostow

Those authors, who found a significantly positive correlation between the savings rate and the level of per capita income within a cross-country framework, frequently used samples showing a great variance of income levels. This reflects different stages of development comprising pre-industrial, agriculture-dominated subsistence economies (poor African countries) as well as high income countries (newly industrializing countries). Contrary to the above mentioned cross- country results, the individual country experience is mixed. Whereas Krishna/Raychaudhuri (1980,(India)) and Quian (1988,(China)) confirm the positives savings rate-income correlation, Leff (1968,(Brazil)) rejects it. All those studies have in common that they were based on relatively short time series (20-30 years).

But what do we know about the savings behaviour of a country in the very long run? Relatively little, since reliable estimates for savings and national income in developing countries are available merely for the three previous decades. Fortunately, the data situation is more favourable in industrialized countries. Clark has compiled savings data for this group from a variety of sources. All countries listed have experienced a substantial increase of their PCI in the past. Though Clark does not present individual country time-series, it is obvious that all countries except France, the United Kingdom and the United States show an upward movement of the net national savings rate (Clark, 1977, pp. 269). With regard to Germany there is additional confirmation for a rapidly rising savings rate during the period 1850-1913, the era of industrialization (v. Knorring, 1970, pp. 77). This gives overwhelming support to a secular rise of the savings rate during the development process and is fully in accordance with Rostow's stage theory of long term growth, implying rapid increases of the investment rate particularly during the "take-off" period. On the other hand, Kuznets seems to have generalized the US experience. Although he takes due account of the upward movement in Britain's, Germany's and Sweden's net savings rate in the 19th and early 20th century, he designates the positive trend as a relatively weak one (Kuznets, 1962, pp. 221).

How can this upward movement be justified? In the context of standard neoclassical growth theory, the savings rate is mostly considered exogenous and is not systematically related to the income level. If we focus on the savings behaviour of a low income country with an actual capital-labour ratio far below its steady-state value, it is obvious that the capital's marginal product, the real interest rate, is relatively high, thus giving incentives for increased saving. As the real interest rate gradually decreases when the economy grows over time, the savings rate is expected to decrease as well. On the other hand, as per capita income is far below its steady-state value and consequently a large gap between actual income and future target income exists, households may be forced to save relatively little in order to rapidly adopt high consumption standards. Thus, the net effect of a rising per capita income on the savings rate remains ambiguous.

A generally positive relationship between the savings rate and the income level can be derived from Keynes' "General Theory" (Keynes, 1936, pp. 96). According to his "fundamental psychological law" (which had already been formulated by Lujo Brentano in 1908!) (Zinn, 1993, pp. 447), the average savings rate (APS) as well as the marginal savings rate (MPS) increase as income grows. However, it is obvious that this increase cannot go on permanently. There must be an upper limit of the savings rate, as it is impossible that APS exceeds 100%. Long-term convergence towards an APS of 100% is equally implausible as well as empirically irrelevant. This implies an S-shaped functional relationship between the average savings rate and the level of per capita income.

Landau (1971, pp. 300) and Bhalla (1980, pp. 738) argue in favour of a non-linear savings function as follows. At a low income (subsistence) level, there are only very little savings from households and subsistence peasants. During the subsequent industrialization process the amount of savings rise, as income and wealth distribution both become increasingly unequal. This will occur in the corporate sector first, particularly if industrial development is driven by initial exploitation of natural resources. As mass income begins to rise, and the process of increased income inequality is reverse, the household sector will also exhibit rising savings rates. It is plausible to assume a significant upswing of the savings rate when the economy moves from a low income level around 500 US$ to an intermediate level (around 2,000 US$). A high income level presumably exhibits a constant savings rate. Figure 1 shows the stylized relationship.

As there is no prescription of the particular mathematical form of the savings function, we have to assess different types of functional forms. Figure 1 indicates that the functional form of the S-Y-relation, respectively the S/Y-PCI-relation, implies great flexibility. In any case, it is nonlinear and it is left to empirical investigation to find a generally applicable form. Therefore, the following outlines the different types of nonlinear function frequently used in empirical analysis and to assess their suitability to represent the characteristics of the development process.

III. Nonlinear Savings Functions

We begin with the basic Keynesian textbook specification, which is a linear approximation to Keynes' general model.

$$S = -\alpha_0 + \beta_0 Y, \tag{1}$$

where S = aggregate savings, Y = domestic income,
α_0, β_0 = coefficients.

Division through by N(=population) gives

$$\frac{S}{N} = -\frac{\alpha_0}{N} + \beta_0\left(\frac{Y}{N}\right) = -\alpha_1 + \beta_1\left(\frac{Y}{N}\right). \tag{2}$$

The average propensity to save (APS) can be calculated by multiplying (2) with N/Y, which gives

$$\frac{S}{Y} = -\alpha_1\left(\frac{N}{Y}\right)+\beta_1=\beta_1-\alpha_1\left(\frac{Y}{N}\right)^{-1} = \beta_1-\alpha_1/\mathrm{PCI}. \tag{3}$$

From (3) the marginal propensity to save (MPS) can be derived as $\frac{dS}{dY} = \beta_1$. Since $d(dS/dY)/dPCI = 0$, MPS is constant over time (when income rises), whereas APS converges towards MPS.

A modification of the Keynesian type (3) is the following reciprocal power function

$$\frac{S}{Y} = \alpha_1 - \frac{\alpha_2}{PCI^c} \tag{4}$$

based on the savings function

$$S = \alpha_1 Y - \alpha_2 \frac{YN^c}{Y^c} \tag{5}$$

MPS is given as (6)

$$dS/dY = \alpha_1 - \frac{\alpha_2(1-c)}{PCI^c}. \tag{6}$$

In this case, APS and MPS rise over time when income increases, as

$$\frac{d(S/Y)}{dPCI} = \alpha_2 cPCI^{-c-1} \text{ and } \frac{d(dS/dY)}{dPCI} = (c-c^2)\alpha_2 PCI^{-c-1}, \ (0<c<1).$$

APS and MPS both converge to a saturation level (α_1), whereby the movement of APS is similar to the simple Keynesian function.

Alternatively, consider the frequently used semi-logarithmic function (Fry, 1978, pp.468).

$$\frac{S}{Y} = \alpha_1 + \alpha_2 \ln(PCI). \tag{7}$$

Then MPS is given as

$$\frac{dS}{dY} = (\alpha_1 + \alpha_2) + \alpha_2 \ln(PCI). \tag{8}$$

Both ratios rise over time, as $d(S/Y)/dPCI = d(dS/dY)/dPCI = \alpha_2 PCI$. There is no saturation level, the difference between MPS and APS being constant (α_2).

Although several researchers (Krishna/Raychaudhuri, 1980, pp. 14;

Fry, 1980, pp. 468) have applied the functions (3), (4), (7) in empirical model building, the mathematical exposition clearly shows that none of these is capable of replicating the S-shaped behaviour of the average propensity to save as illustrated in figure 1. Consequently, these functions must be rejected, whatever their empirical properties may be.

An interesting nonlinear approach, which has been sporadically used in empirical estimation (Fry, 1978, pp.466 ; Giovannini, 1985, pp.200), was proposed by Singh (1975, pp. 260). It is a modified logarithmic function based on the following savings-income relationship:

$$S = \alpha_1 Y + \frac{\alpha_2 Y}{(\ln PCI)^2} + \frac{\alpha_3 Y}{(\ln PCI)^4} \quad (\alpha_2 < 0, \alpha_3 > 0). \tag{9}$$

Consequently, APS and MPS are given as

$$\frac{S}{Y} = \alpha_1 + \frac{\alpha_2}{(\ln PCI)^2} + \frac{\alpha_3}{(\ln PCI)^4}. \tag{10}$$

$$\frac{dS}{dY} = \alpha_1 + \alpha_2[(-2)(\ln PCI)^{-3} + (\ln PCI)^{-2}]$$
$$+ \alpha_3[(-4)(\ln PCI)^{-5} + (\ln PCI)^{-4}]. \tag{11}$$

This function exhibits an S-shaped behaviour of both savings rates with a first increasing, but later decreasing difference between MPS and APS. Both ratios converge towards a saturation level (α_1). Although Singh's specification succeeds in modelling the S-shaped increase of the APS, it has serious disadvantages. The first problem is a high degree of multicollinearity between $1/(\ln PCI)^2$ and $1(\ln PCI)^4$. This will cause rather poor estimates of the regression coefficients, so that a reliable estimation of the savings function can hardly be performed. Typical consequences of collinearity are implausible signs of the coefficients and low t-statistics. Even small alterations of the underlying samples will affect the estimated coefficients substantially. As the author's own numerous simulations with different cross-section and time-series samples indicated, the correlation coefficient between $1/(\ln PCI)^2$ and

$1(\ln \text{PCI})^4$ is around, 0.98 - 0.99, so that this problem cannot be neglected. Secondly, Singh's function fails to generate meaningful savings rates at very low income levels. A priori, one would desire that APS and MPS decrease monotonically when PCI becomes lower. Singh's logarithmic approach, however, shows quite different results. APS and MPS both have a pole at PCI = 1 and within an approximate range of $0 < \text{PCI} < 100$, their values are economically meaningless. As a consequence of these points, it is obvious that the coefficients α_2 and α_3 are difficult to interpret. Thirdly, as Bhalla (1980, pp. 740) has argued, the estimated implicit saturation levels of the Singh's function are unrealistically high.

A nonlinear-in-the-parameters function, which avoids the above disadvantages of Singh's logarithmic approach, is the logistic function, a special case of an S-shaped exponential function (50% symmetry). A logistic movement of the APS is described by the following formula

$$\frac{S}{Y} = \frac{\alpha_1}{1+\alpha_2 e^{-\alpha_3 \text{PCI}}}. \tag{12}$$

and MPS is given as

$$\frac{dS}{dY} = \frac{\alpha_1(e^{\alpha_3\text{PCI}} + \alpha_2 + \alpha_2\alpha_3\text{PCI})}{e^{\alpha_3\text{PCI}}(1+\alpha_2 e^{-\alpha_3\text{PCI}})^2}. \tag{13}$$

APS and MPS are monotonically increasing, both converging ($\text{PCI} \to \infty$) to a saturation level α_1. As

$$\frac{d(S/Y)}{d\text{PCI}} = \frac{\alpha_1\alpha_2\alpha_3 e^{-\alpha_3\text{PCI}}}{(1+\alpha_2 e^{\alpha_3\text{PCI}})^2} > 0 \quad (\alpha_1, \alpha_2, \alpha_3 > 0). \tag{14}$$

the slope of the function is always positive. Local minima or maxima, which occur in Singh's function, do not exist. On the other side, the coefficients α_2 and α_3 can be easily interpreted. α_2 determines the level of the savings rate at low levels of income. The higher the α_2, the lower the APS will be. The speed of transition toward the saturation level is determined by α_3. High values of α_3 indicate high savings-income elasticities. As we shall see in section VI of this paper, this is a favourable property.

Though the theoretical properties of the logistic function are favourable, this approach also has some minor disadvantages. Firstly, its estimation cannot be performed by OLS as it requires nonlinear iterative techniques. This, however, is no longer a critical point, given the power of modern econometric software packages. Secondly, empirical estimation of the coefficients may not lead to definite results, as there is the possibility of multiple optima, depending on the estimation procedure and the initial values of the parameters. Although this point is of theoretical importance, it must be clarified empirically, whether it is in fact a serious problem. The logistic form chosen above was therefore tested with a variety of samples (see the following sections). Additionally, the starting values for the parameters were varied within a considerable range. However, the estimation results proved remarkably stable and insensitive to changes in the initial parameters.

IV. Empirical Cross-Section Results

In order to assess the empirical properties of the functions discussed above, we chose a sample of 83 developing countries covering a wide range of income levels. The poorest country included is Ethiopia with a PCI of 110 US$, whereas the richest country is Singapore (a nearly fully industrialized country) with a PCI of 7,260 US$ (1984 US$). The savings rate in our sample, which is the countries average gross domestic savings rate in the 1980s, varies from a low — 14.9% — (Somalia) to a high 43.9% (Gabon). (All data were derived from the 1992 issue of the World Banks World Tables.) As our cross-section data set is relatively large, stable estimation results can be expected, particularly with regard to the multicollinearity problem of Singh's function discussed above. However, there is the danger that the sample may consist of several heterogeneous subsamples. It is doubtful, whether the savings pattern of a poor African country can be compared with the savings behavior of a rich country (e.g. Singapore). Given this, the existence of heterogeneous country groups in the full sample would lead to biased estimates of the regression coefficients. To overcome this problem at least partially, we decided to split the full sample into two subsamples. The first consists of 34 Subsaharan African countries and can be considered more homogeneous than the total sample. The second subsample includes the remaining 49 countries. Further disaggregation in regional groups (Asia, Europe and Middle East, Latin America) did not prove suitable, as this would result in too small data sets. However, as an alternative composition of the second subsample we decided to exclude China, as its savings rate is exceptionally high and its low per capita income may be seriously underestimated (Jungfer, 1993). The results of the regression analysis are reported in the table below.

The equations (10) were tested for heteroscedasticity and misspecification using the White Test. In all samples the test statistic is well below the critical level of significance, thus confirming the absence of heteroscedasticity. Additionally, Ramsey's RESET test was performed to test for functional misspecification. As expected there is no indication of specification errors. Both specification tests, however, are not computable for the nonlinear logistic model. To facilitate a comparison between the two models we therefore present the residual plot (full sample).

From a correlation coefficient of r = 0.9766 between the residuals of both models and a visual inspection we can conclude that the logistic model does not suffer from heteroscedasticity or misspecification. Let us now discuss the regression results. The goodness-of-fit, as measured by R^2 is fairly high except in the samples (3) and (4), indicating that both specifications representatively approximate the S-shaped movement of the APS. However, there are several problems with Singh's specification. The first problem is that the implicit saturation levels of 46% (sample (3)), 51% (sample (4)), and 53% (full sample) are theoretically questionable when "Golden Rule"-saving is considered a reference, for it requires a profit rate of the same magnitude (Neumann, 1994, pp. 17). The African saturation APS of nearly 104% clearly is an absurd result, indicating that Singh's function cannot serve as a generally valid empirical description of the macroeconomic savings-income relation. Additionally, as indicated by low t-statistics, problems with multicollinearity, which we have discussed in the previous section, are also confirmed in the first, third and fourth sample. The t-statistics of the logistic function are partially low too but in most cases higher than those of Singh's function, In any case, the main improvement of the logistic approach clearly lies in the estimated values of the implicit saturation level. For all samples, the coefficients α_1 are within an expected range. In the full sample, the estimated saturation APS (25.7%) comes close to the observed average savings rate of high income countries of today. This result clearly indicates that the logistic approach should be preferred over the Singh function. However, there are substantial differences with regard to the parameters α_2 and α_3 which are much greater than the deviations of α_1 across the subsamples. This is an indication that the full sample may have consisted of quite heterogeneous countries or country groups. Therefore it is a meaningful extension of the analysis to pay additional attention to the empirical examination of country-specific savings behaviour. Unfortunately, the time-series data base for most developing countries is insufficient. In particular there is only a small number of countries with a significantly large increase in per capita income.

V. Re-Examining Capital Formation in Developed Countries

We therefore next compare the historical savings record of the industrial pioneer countries with the cross-country results of the previous section. Given the theoretical and empirical superiority of the logistic function, all further estimates are based on this functional form. For reasons of comparability we use the time-series of PCI and the investment rate (gross investment as percentage of GDP) compiled by Rostow (1980, pp. 288). Contrary to Maddison's (1992) estimates, Rostow's series cover a longer time period from the end of the eighteenth century (USA), respectively the mid-nineteenth century (UK, France, Germany) to the early 1970s. In order to grant comparability to our cross section sample, we converted the PCI series, which Rostow expressed in 1967 US$, to 1984 US$. Unfortunately, Rostow does not report the gross domestic savings rate, so that we have to use the investment rate (I/Y) as a proxy. This will surely not introduce a significant bias because domestic investment was mostly self-financed. The largest difference between domestic saving and investment may have occurred in the United Kingdom, as in the period 1870-1914 when savings exceeded investment by roughly 4 percentage points, both expressed as a fraction of GDP (Kenwood/Lougheed, 1992, pp. 27). But even this relatively large deviation does not disturb the long-term trend. In order to examine the series provided by Rostow in more detail, a unit root test was performed to see whether the series are stationary or not. The following table reports the augmented Dickey-Fuller test statistics for the investment rate and the per capita income in France, Germany, the US, and the UK.

The test specification (number of lagged difference terms) was determined empirically to achieve "white noise" residuals. The ADF-statistics show that the levels of the investment rate and the per capita income are non-stationary for all countries, a result which is not surprising. On the other hand, the first differences are stationary throughout. Thus, all series are integrated of order 1. Consequently, one might ask, whether there is a cointegrating relationship between both variables. However, in our case the concept of cointegration as a long-run equilibrium relationship is not very useful for two reasons: Firstly, the alleged relationship between the savings/investment-rate and the income level is nonlinear, whereas cointegration theory relies on linear relations. Secondly, the data provided by Rostow are 5-year moving averages, a smoothing procedure which automatically introduces a certain degree of serial correlation to the regression residuals. This again would invalidate stationarity tests of the residuals. Therefore, we decided to base our estimates on a simple nonlinear regression approach, as both series are of the same integration order.

Another problem we have to deal with is the presence of a number of outliers in the investment-income relationship. A visual inspection of the scatterplots indicates that those outliers occurred during the period of the Great Depression and the Second World War. During the years 1929-1947 the observed investment-income relationship proves contrary to any meaningful long-run behaviour. To examine this in more detail we have performed several auxiliary (linear) regressions for this sub-period. In the case of France and Britain there is a strong negative correlation between I/Y and PCI, whereas in the US no correlation at all could be found. Only in Germany is a positive correlation identifiable, but the investment level at a given income is well below the long-run average. Clearly, this irregular behaviour is closely related to the external shocks of depression and war. Though there had been cycles and crises in the earlier periods, the severity of the Great Depression was unprecedented and further aggravated by faulty economic policies in all countries under consideration. Moreover, the impact of the Second World War was much stronger than that of any war preceeding, leaving the European countries with partially destructed economies. There is an additional argument for a separate treatment of the period 1929-1947. During this era gradual departure from the principles of a free market economy could have been observed. Policy makers increasingly relied on instruments of direct state intervention and introduced elements of central planning. In Germany, for example, the market economy was abolished in 1936 and replaced by a centrally-planned "state socialism" under the Nazi dictatorship. Though state interventions were less severe in the remaining three countries, it is obvious that they could have significantly disturbed the long term trends of investment and income. Because there were delays in economic re-liberalization after the war, 1947 was delineated from the author as the end of the period.

How should these outliers be handled in the econometric investigation? The classical solution would be the estimation of a structural break including intercept and slope dummies in the regression equation. As we intend to estimate a function, which is nonlinear in its parameters, this procedure cannot be applied unmodified, as it has been designed for linear regression equations. An alternative would be the exclusion of the outlier observations. This however would result in smaller samples. In order to base our estimation on the entire time series we therefore decided to introduce structural break dummies within a multiple regression approach of the following form :

$$\frac{I}{Y} = \frac{\alpha_1}{1+\alpha_2 e^{\alpha_3 PCI}} + \lambda D + \delta (D \cdot PCI) \qquad (15)$$

$$D = \begin{cases} 1, & \text{if year } 1929-47. \\ 0, & \text{for all other years.} \end{cases}$$

In this equation the dummy variable D covers an upward or downward shift effect as well as a possible interaction with the income level. The following table reports the estimation results of the extended logistic model.

In general, the logistic time series model fits the data well. All coefficients except α_2 for the US, are highly significant. Not surprisingly, except for the US, the R^2 statistic is about twice as high as in our cross section sample. This could have been expected as individual country time-series allow for an adequate representation of country-specific savings characteristics. However, the DW-statistic in all cases is extremely low, indication severe positive autocorrelation. Although the existence of autocorrelated errors does not cause a bias of the parameter estimates, the (asymptotic) standard errors may be underestimated.

Serial correlation of the error term may occur for different reasons, i.e., incorrect functional forms, omitted variables, or data manipulation procedures. In case of our four country samples there are two causes for the high degree of autocorrelation. Firstly, in his compilation of PCI and I/Y data, Rostow used a five-year moving average smoothing procedure for both variables, thus automatically incorporating serially correlated errors in the estimation process. Without this smoothing procedure, the DW-statistic certainly would have been significantly higher. Secondly, the existence of business cycles causes swings of different wave lengths in the original series as well in the regression residuals. In the French case, there is and additional explanation for a low DW, as in the sub-period after the Second World War, the logistic model systematically underestimates the investment rate. The reverse was found for the United States. Whereas during the period between 1789-1890, the US investment rate was steadily increasing, a gradual reduction from 1890 onwards could have been observed despite the increasing income trend. Consequently, the observed investment rate fall short to the predicted saturation level. This is also the main cause for the comparatively low coefficient of determination. As for France, Germany and the UK, the t-statistics are well above any critical level. Therefore we do not expect the autocorrelation to invalidate the significance levels seriously. The following figure shows the estimated long-run I/Y-PCI-relation for our four countries in comparison. Additionally, the cross-section savings function (LDC sample) is reported. The main empirical findings of our comparison can be summarized as follows:

As the results of table 3 show, a logistic savings/investment model ensures an adequate representation of the long run capital accumulation process in developed countries. The S-shaped behaviour is not basically different from the LDC experience at the present. Kuzenets' hypothesis, that individual countries exhibit a constant APS when income increases, can be clearly rejected. The Keynesian hypothesis, however, is strongly confirmed. Our empirical results show that the alleged relationship is valid irrespective of the underlying sample.

Considering the saturation level of savings and investment, the differences are significant. The estimated levels vary between 17% and 27% in the long-run. With an APS of nearly 26%, potential LDC savings are rather above average, if compared with the historical savings record of industrialized countries. Thus, growth perspectives of poorer countries can be viewed optimistically. Moreover, within the critical low income range, LDCs respond much more elastically to PCI growth than did three of the four industrial leaders in the nineteenth century. Given a PCI of 1,000 US$, developing countries today attain an average savings rate of 18%, whereas the industrial pioneers (except France) clearly lay below that level. A reason for this favourable result could be seen in the more intense trade integration of developing countries today.

Those countries, which at the beginning of the nineteenth century fell short to British PCI standards (US, France, Germany) exhibit a much stronger investment response to income increases than Britain.

Considered in retrospect, capital formation in this industrial pioneer country was rather disappointing. The observed low level of saving and investment probably is an important factor explaining the weak overall growth performance of Britain. Given the much better performance of the second generation industrializers, Britain's relative decline since the beginning of the twentieth century is not surprising (Neumann, 1990, pp. 179).

VI. Industrial Newcomers-Japan, Korea, and Taiwan

Contrary to the relative decline of the industrial leaders, industrial newcomers like Japan, Korea or Taiwan show an extremely high income elasticity of savings in their "take-off" and growth phase. To illustrate this, we have estimated savings, respectively investment functions, for Korea, Taiwan, and Japan. The Japanese time series sample is based on Rostow's data compilation and therefore allows the estimation of a long term investment function from 1886 to 1972. The years 1929-47 (Great Depression, Second World War) were covered with the dummy variable approach as presented in equation (15). In the case of Korea (Bae, 1992, World Bank) and Taiwan (Taiwan, Rep. of China), series of savings and PCI data were available from 1954 to 1993 (Korea), resp. 1953 to 1994 (Taiwan). Although these series are much shorter than the data base for the other countries, a reliable estimation of the savings functions is nevertheless possible, as both countries managed to transform their economies from poor, agriculture-dominated ones into modern, largely industrialized economies. As in section V we have tested the time series for stationarity before estimation. The ADF statistics are reported in the following table.

From the test statistics we can conclude that the savings/investment rate is integrated of order 1. The PCI series of Japan, however, seems to be I (2), as the first difference ADF statistic fails to pass the critical level. Moreover, the ADF statistics for Korea and Taiwan are not much below the critical values so that the hypothesis of an I (1) process would not be supported at the 1% level. This obviously contradicts the results for the four industrial leaders, which distinctly exhibited an integration order of 1. In the case of the Asian countries this unexpected result can be explained with the much shorter length of the time series and extraordinary growth rates in several sub-periods. This factor, however, will tend to diminish when the series become longer. In the very long run, one surely can expect PCI to be an I(1) process, even in the case of the Asian countries. Therefore we proceed as in section V. The following table reports the regression results for Japan (equation (15)), Korea, and Taiwan (equation (12)). For reasons of comparability we also estimate the model for Korea and Taiwan using the same smoothing procedure as Rostow (5-year moving average).

The overall explanatory power of the logistic model is excellent. All coefficient estimates are highly significant and the DW-statistic for Japan (smoothed), Korea and Taiwan (unsmoothed) though still small, indicates slightly lesser autocorrelation than in table 3. There is also indirect evidence that a fraction of the observed serially correlated errors is in fact due to Rostow's smoothing procedure, as a comparison of the regression results for Korea and Taiwan shows a marked decrease of the DW statistic when the smoothed series are used. Fortunately, the smoothing process only slightly affects the coefficient estimates. As the estimates for a_3 indicate in all Asian countries, the elasticity of investment/savings with respect to income changes are significantly greater than in the four early industrializers. Japan, Korea, and Taiwan both experienced impressive rates of capital formation even at low PCI levels. Figure 4 displays this graphically.

The contention that countries taking the role of an industrial leader, in their early development phase, achieve outstanding rates of saving and investment, is strongly confirmed. They also tend to have higher long run levels for the APS. Given these results, it is possible to explain the sequence of the secular economic dominance of Britain (19th century), the United States, (20th century) and possibly, the Asian region (21st century). In order to analyse this hypothesis in more detail, we have formally tested whether the savings functions of the Asian countries and the industrial leaders are significantly different from each other. Therefore, a test for the equality of the coefficients a_1,

α_2, α_3 was performed. For this purpose, usually Chow or dummy variable test procedures are applied. However, as we have estimated intrinsically nonlinear functions, those tests are not appropriate. As an alternative we decided to apply Walds coefficient restriction test on a pairwise basis. In a first step, the point estimate of a particular country coefficient (e.g. α_i for the UK) was imposed as a coefficient restriction for the corresponding α_i of each other country. In a second step, the procedure was reversed pairwise, so that we can distinguish between the following cases:

(a) The hypothesis that the estimated coefficient α_i of country A is a valid restriction of country B's α_i cannot be rejected. In the reverse direction the same result is obtained.

(b) The hypothesis that the estimated coefficient α_i of country A is a valid restriction of country B's α_i cannot be rejected, but in the reverse direction the hypothesis has to be rejected.

(c) The hypothesis that the imposed restriction is not significantly different from the estimated coefficient has to be rejected for both directions.

As far as case (a) is concerned, we conclude that both coefficient estimates cannot be considered significantly different. On the contrary, case (c) indicates a significant difference between two coefficients and case (b) should be considered inconclusive. We performed this test pairwise for all seven countries and all three coefficients. The results are presented in the following table.

The results presented above suggest that there are in fact country-specific differences in savings behaviour. With regard to the saturation parameter, there are only two pairs of countries with similar coefficients, the UK and France, and respectively, Taiwan and Korea. It is interesting that both pairs share the same cultural background. All other pairwise comparisons indicate that on the one hand, the saturation parameter is country-specific whereas on the other hand, there is a significant difference between the group of early industrializers (exhibiting relatively low saturation rates), and the industrial newcomers of Asia. Concerning the parameter α_2 the differences are less pronounced. Case (a) occurs three times and the inconclusive case (b) six times, so that there are only 12 cases which unequivocably point to significant differences. The pairwise comparisons of the parameter α_3 once again show marked differences. There is only one case of type (a).

How can these results be interpreted? Firstly, it seems that the saturation level as well as "elasticity" parameter α_3 is distinctly country- specific parameters, which are determined mainly by factors like cultural background, rate of social time preference, religious values, or the economic system in general. Secondly, the smaller cross-country differences in the parameter α_2, which crucially determines the savings rate at lower income levels, suggest that there may be a certain "base savings rate" which is not subject to extreme cross-country variations. The economic interpretation is straightforward. To maintain a constant per capita income at the subsistence income level, a certain low savings rate is required to replace the depreciated capital stock. This "base savings rate" may be around 5%. If a particular country has managed to increase its PCI to some degree, it depends on factors like social time preference, if and to what extent the growing wealth is increasingly saved and invested. A high value of α_3 then indicates that a country successfully accepts the challenge of modernization. An "international demonstration effect" of the Duesenberry/Nurkse-type then may work even in the opposite direction as a rapid adoption of richer countries' consumption standards by means of higher imports of luxury goods is likely to occur, when a developing country's rate of social time preference is high. Obviously, this does not seem to have been the case in the Asian region. If time preference is low, as it can be assumed in East Asia, a greater fraction of the increasing income is channelled into investment, as consumption desires are shifted to future periods.

Ⅶ. Conclusions

This paper investigated the nature of long run savings and investment functions for the United States, the United Kingdom, France, Germany, Korea, Japan and Taiwan and compared capital formation in these countries with a cross section of developing countries in the 1980s. The following conclusions can be drawn :

The average propensity to save is not constant in the long run. In all countries under consideration the APS exhibits an S-shaped movement, which can be described precisely by a logistic function. Alternative functional forms prove either theoretically inadequate or empirically weak. As empirical studies in the preceding decades mostly have used inadequate functional forms of the savings-income relationship, their results must be interpreted with great caution. Our analysis shows that Rostow's hypothesis of an upward movement during the early industrialization phase is strongly confirmed. Kuznets proposition of a constant APS is valid solely at advanced levels of development.

An examination of a large cross section sample consisting of 83 less developed countries shows a similar relationship. Compared with the historical savings record of several developed countries, the average elasticity of savings with respect to changes in per capita income is relatively high. Even at moderate income levels, LDCs should be capable of maintaining self-sustained growth without reliance on foreign capital inflows. However, the relatively large deviations from the logistic trend, and the heterogeneity of the sample indicate that the country-specific savings functions may differ to a considerable extent. This presumption has been confirmed on the basis of individual country analyses.

Successful industrial newcomers (Japan, Taiwan, Korea) are characterised by rapidly rising rates of capital formation at low and moderate income levels. Furthermore, Korea, Japan, and Taiwan achieved saturation savings rates well above average. Neumann's (1990, pp.175) suggestion that the sequence of world-wide economic leadership in historical retrospect, seems to depend crucially on the savings behaviour during the development processes is strongly confirmed.

Figure 1 The Savings Rate–Income Relationship

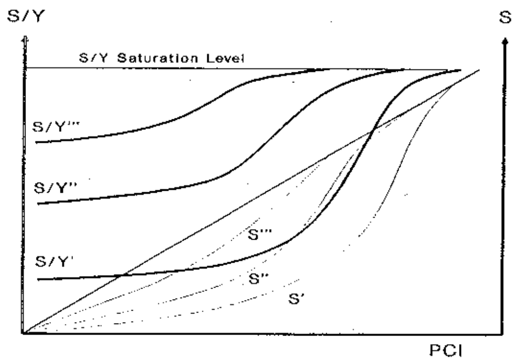


Table 1 Estimation Results; Savings Functions (10) and (12)

Dependent Variable : S/Y

Estimated Coefficients

(t-statistics resp. asymptotic t-statistics in parenthesis)

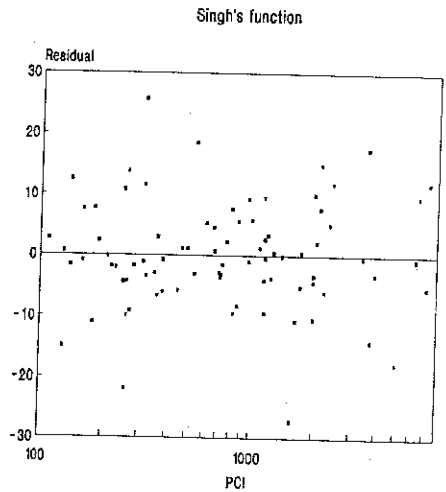
Eq.	α_1	α_2	α_3	R^2	Whites χ^2stat.*	RESET F stat.**
(1) Full Sample (n = 83)						
(10)	52.91	-2082.2	20460	0.458	1.934	0.135
	(5.3)	(1.4)	(2.7)			
(12)	25.65	4.52	0.002354	0.417		
	(10.9)	(2.4)	(3.2)			
(2) Subsample Africa (n = 34)						
(10)	103.67	-5242.6	66784	0.674	3.051	0.539
	(5.9)	(4.4)	(3.4)			
(12)	34.67	1.46	0.004197	0.658		
	(6.9)	(1.6)	(3.7)			
(3) Subsample Asia/Latin America/Europe (n=49)						
(10)	46.27	-1820.4	22897	0.197	1.458	1.464
	(3.4)	(1.6)	(1.0)			
(12)	33.76	1.46	0.00038	0.217		
	(2.8)	(2.1)	(1.1)			
(4) Subsample (3) China excluded (n = 48)						
(10)	50.58	-2140.4	26897	0.273	1.776	0.735
	(3.9)	(2.0)	(1.3)			
(12)	28.55	1.66	0.00079	0.271		

Estimation Procedure : Eq. (10) - Ordinary Least Squares
Eq. (12) - Nonlinear Least Squares

* critical χ^2 - value (5% level ; 5df) = 11.071

** critical values (5% level) are 2.73 (sample (1)); 2.95 (sample (2)); 2.84 samples (3), (4))

Figure 2 Regression Residuals – Cross Section Sample



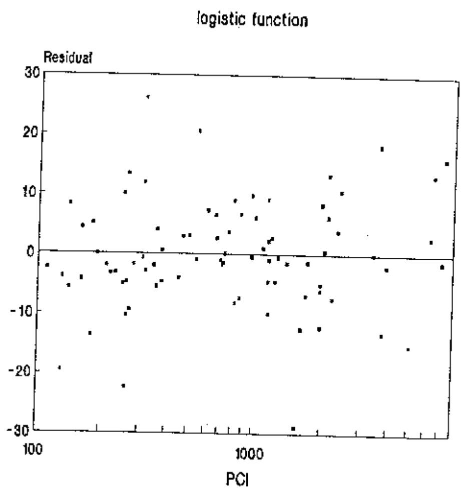


Table 2 Augmented Dickey-Fuller Test Statistics

Country	Variable	test specification	ADF-statistic	5% critical value
UK	I/Y Level	c, -, 8	-2.254	-2.883
	I/Y 1. Diff.	-, -, 6	-3.219	-1.942
	PCI Level	-, -, 5	3.488	-1.942
France	I/Y Level	c, t, 6	-4.688	-3.444
	I/Y 1. Diff	c, t, 7	1.997	-3.443
	PCI Level	-, -, 5	3.104	-1.942
	PCI 1. Diff	-, -, 3	-2.918	-1.942
Germany	I/Y Level	-, -, 6	1.289	-1.943
	I/Y 1. Diff	-, -, 6	-3.417	-1.943
	PCI Level	-, -, 9	1.682	-1.943
	PCI 1. Diff	-, -, 3	-2.671	-1.943
US	I/Y Level	c, -, 6	-2.558	-2.878
	I/Y 1. Diff	-, -, 7	-5.875	-1.942
	PCI Level	-, -, 6	4.303	-1.942
	PCI 1. Diff	c, t, 8	-5.129	-3.436

test specification : c=intercept ; t=trend ; number of lags included in ADF test

Table 3 Time Series Estimates I/Y = F(PCI); 4 Industrial Countries

	United Kingdom	France	Germany	United States
Sample Size	142	146	121	185
Time Period	1830-1971	1826-1971	1851-1971	1789-1973
α_1	19.47 (17.8)	19.88 (93.0)	26.64 (39.5)	17.18 (73.1)
α_2	3.31 (12.6)	12.46 (3.7)	2.85 (18.4)	4.09 (1.1)
α_3	0.00048 (8.3)	0.0049 (10.7)	0.00062 (13.1)	0.0040 (3.2)
λ	31.77 (13.1)	-0.1183 (0.1)	-14.13 (9.3)	-9.45 (4.6)
δ	-0.0096 (17.0)	-0.0018 (2.4)	0.0035 (6.0)	0.0002 (0.6)
R^2	0.889	0.819	0.926	0.564
DW	0.58	0.15	0.62	0.23

Figure 3 Stylized Investment Functions

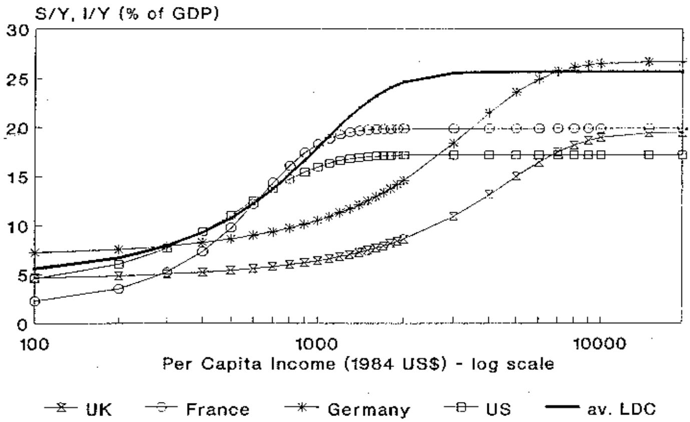


Table 4 ADF Test Statistics for Japan, Korea, and Taiwan

Country	Variable	test specification	ADF-statistic	5% critical value
Japan	I/Y Level	c, t, 8	-2.327	-3.467
	I/Y 1.Diff	c, t, 7	-2.724	-1.944
	PCI Level	-, -, 6	1.484	-1.944
	PCI 1.Diff	-, -, 5	0.290	-1.944
Korea	S/Y Level	-, -, 4	1.312	-1.951
	S/Y 1.Diff	-, -, 3	-2.344	-1.951
	PCI Level	-, -, 2	2.769	-1.951
	PCI 1.Diff	c, t, 0	-3.944	-3.531
Taiwan	S/Y Level	c, -, 1	-1.967	-2.936
	S/Y 1.Diff	c, t, 1	-4.939	-3.528
	PCI Level	-, -, 2	3.692	-1.949
	PCI 1.Diff	c, t, 1	-3.635	-3.528

Table 5 Estimation Results for Japan, Korea and Taiwan; Asymptotic t-Statistics in ( )

	Japan	Taiwan original	Taiwan smoothed	Korea original	Korea smoothed
Dep. Variable	I/Y	S/Y		S/Y	
Sample Size	87	42	38	40	36
α_1	33.99	32.14	32.57	35.18	34.72
	(49.6)	(56.5)	(92.0)	(29.9)	(31.2)
α_2	2.75	18.77	16.5	11.80	10.99
	(11.8)	(3.0)	(5.0)	(4.7)	(5.5)
α_3	0.0011	0.0038	0.0036	0.0022	0.0021
	(11.2)	(8.4)	(13.7)	(9.7)	(10.8)
λ	-7.2626				
	(3.3)				
δ	0.				
R^2	0.921	0.931	0.973	0.933	0.950
DW	0.65	0.69	0.30	0.72	0.10

Figure 4 Rates of Capital Formation in Japan, Korea, Taiwan and an Average LDC

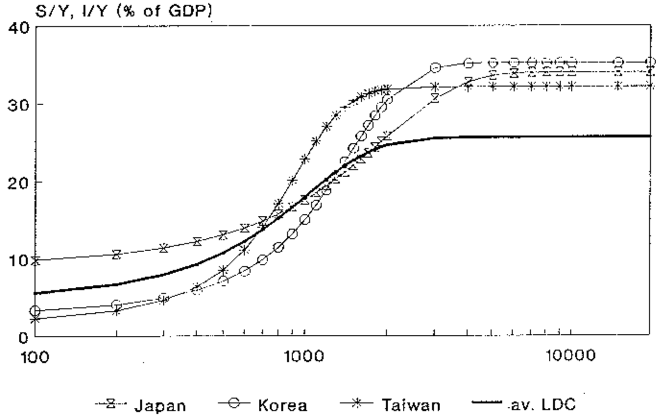


Table 6 Pairwise Test for Coefficient Equality

coefficient α_1

	UK	France	Germany	US	Japan	Taiwan	Korea
UK	-	(a)	(c)	(c)	(c)	(c)	(c)
France		-	(c)	(c)	(c)	(c)	(c)
Germany			-	(c)	(c)	(c)	(c)
US				-	(c)	(c)	(c)
Japan					-	(c)	(a)
Taiwan						-	(b)
Korea							-

coefficient α_2

	UK	France	Germany	US	Japan	Taiwan	Korea
UK	-	(c)	(b)	(b)	(c)	(c)	(c)
France		-	(c)	(c)	(c)	(a)	(a)
Germany			-	(b)	(a)	(c)	(c)
US				-	(b)	(b)	(d)
Japan					-	(c)	(c)
Taiwan						-	(b)
Korea							-

coefficient α_3

	UK	France	Germany	US	Japan	Taiwan	Korea
UK	-	(c)	(c)	(c)	(c)	(c)	(c)
France		-	(c)	(b)	(c)	(c)	(c)
Germany			-	(c)	(c)	(c)	(c)
US				-	(c)	(a)	(b)
Japan					-	(c)	(c)
Taiwan							(c)
Korea							-

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