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Business Investment in the OECD Economies: Recent Performance and some Implications for Policy

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Investment growth in the OECD area has been higher in the second half of the 1980s than in the 1970s. However, the ratio of net investment to GDP has remained low by past cyclical standards. This paper first reviews the evolution of business-sector fixed investment and addresses measurement issues related to computers and intangible investment. It then examines the determinants of investment and the extent to which governments can and should influence capital formation. Time-series properties of investment, output and the cost of capital do not appear to be consistent with well-established theories of investment. The best predictor of investment is found to be its own past history. Therefore, although higher investment could be beneficial to future consumption and economic growth, the effectiveness of policies to raise investment via the cost of capital is largely uncertain.

* * *

La croissance de l'investissement dans les pays de l'OCDE a été plus rapide dans la second moitié des années 80 qu'au cours des années 70. Cependant, l'investissement net en proportion de la production est resté bas par comparaison aux cycles passés. Ce papier tout d'abord retrace l'évolution de l'investissement fixe du secteur des entreprises et traite des problèmes de mesure relatifs aux ordinateurs et aux investissements immatériels. Les propriétés des séries temporelles pour l'investissement, la production et le coût du capital n'apparaissent pas compatibles avec les théories bien établies de l'investissement. Il est estimé que le meilleur prédicteur de l'investissement est son propre passé. Ainsi, bien que davantage d'investissement puisse être favorable à la consommation future et à la croissance économique, l'efficacité des politiques visant à élever l'investissement à travers le coût du capital est largement incertaine.

No. 88: BUSINESS INVESTMENT IN THE OECD ECONOMIES: RECENT PERFORMANCE AND SOME IMPLICATIONS FOR POLICY

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BUSINESS INVESTMENT IN THE OECD ECONOMIES: RECENT PERFORMANCE AND SOME IMPLICATIONS FOR POLICY

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BUSINESS INVESTMENT IN THE OECD ECONOMIES:

RECENT PERFORMANCE AND SOME IMPLICATIONS FOR POLICY

R. Ford and P. Poret

I. INTRODUCTION

The second half of the 1980s witnessed a major and widespread recovery in investment expenditures in the OECD countries. Gross fixed investment by the business sector grew by only 3.8 per cent per year from 1970 to 1979 and stagnated during the recessionary period of 1980 to 1983. By contrast, in the five years 1984 to 1988 it grew by almost 7 per cent a year. Despite this recent strength, net investment -- the increase in the stock of productive capital -- as a proportion of either output or the capital stock has tended to be lower than in the 1970s or early 1980s. As a result, ratios of capital to output have fallen below trend in many countries and have even declined absolutely in some.

These events raise several related questions: What accounts for the recent strength in investment? Can it be expected to continue? Can governments influence investment? If so, should they, and what instruments should they use? The aim of this paper is to provide answers, some necessarily tentative, to these questions.

Section II assesses the evolution of investment and capital formation in OECD countries over the past two decades. Two specific types of investment, computers and intangibles, are discussed in detail. The determinants of investment demand[1] are analysed in Section III. Section IV reviews investment policies and their economic effects, concentrating on the U.S. experience with investment incentives during the 1980s. The focus in these three sections is on aggregate business-sector fixed investment. The bulk of productive capital in OECD economies is in the business sector, and other categories of private-sector investment -- residential construction and stockbuilding -- are not driven by the same factors and have different

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1. Although this paper focusses on investment demand, actual investment depends, in part, on supply (i.e. on savings). Dean *et al.* (1990) review the recent trends in savings in the OECD countries.

implications in terms of production. Section V considers some economic consequences of investment. The final section presents some conclusions.

II. THE EVOLUTION OF BUSINESS FIXED INVESTMENT

1. Aggregate investment and capital stocks

Table 1 provides summary statistics of investment performance over the past two decades. To account for the influence of the downturn experienced by most OECD economies in 1981, averages are presented for three sub-periods: 1970-79, 1980-83 and 1984-88. Growth in gross investment expenditures fell sharply in the early 1980s in most countries. As output rebounded, investment growth also picked up and has been higher in the last five years than in the 1970s in most OECD countries.

Although this general cyclical pattern is characteristic of most OECD economies, levels of investment in relation to output vary widely from country to country. In terms of gross investment, Greece, Turkey, the United States, Italy, Belgium and Spain were at the bottom end, averaging less than 15 per cent of business output between 1984 and 1989. New Zealand, Norway, Japan, Iceland and Australia were at the top end, with more than 20 per cent. In terms of net investment, Portugal, the Netherlands, France, the United States and the United Kingdom were at the lower end, with investment being less than 7 per cent of business output, and New Zealand, Norway, Iceland and Japan were at the upper end at over 13 per cent[2].

One reservation with using national accounts data to make cross-country comparisons is that they reflect differences in both quantities and relative prices. The latter can be eliminated by using international purchasing power parities (PPPs, described in Hill (1986)). The OECD has calculated PPPs at a high level of disaggregation for 1985. This involves calculating the real quantity of each good (or service) using price and expenditure data, then multiplying the quantity by an "OECD average" price, which is the same for every country. These re-priced quantities are then aggregated to create GDP and its components (consumption, investment, and so forth), valued at prices that are constant across countries. The procedure is analogous to that used to create "real" GDP, except that calculating "real" GDP involves using the

2. In this paper, net investment equals gross investment less scrapped capital. Cumulating net investment yields the gross capital stock, the concept used throughout this paper. This definition of net investment is different from the standard definition, which is gross investment less depreciation.

same prices over time (i.e. the national accounts base-year prices), rather than across countries.

Table 2 shows the ratios of business investment to business output, evaluated both at constant 1985 prices and at 1985 PPPs (the only year for which they are available). Also shown is the difference between them, in percentage points, and country rankings of the investment-output ratios. For some countries the difference between the national accounts and PPP ratios is considerable -- between 4 and 5 percentage points in the cases of Finland and Portugal. Using PPPs also changes the rankings somewhat. For instance, Japan drops from third to seventh place, and Germany rises from fifteenth to tenth place. Nevertheless, by and large the overall ordering of high- and low-investment countries is not markedly affected by using PPPs, an impression which is confirmed by a Spearman rank correlation coefficient of 0.81.

It is also useful to distinguish between gross and net investment when characterising the evolution of the investment-output ratio over time. The former represents demand for output and is important for business cycle analysis. Net investment, on the other hand, is the addition to the productive capital stock and is relevant to the analysis of aggregate supply and productivity.

Gross investment-output ratios either have been roughly stable or have risen in virtually all countries over the past three decades (Chart A). However, net investment-output ratios have not kept pace and have even fallen in many countries. The investment boom of the last couple of years boosted net investment-output ratios, although they have generally not returned to levels seen in the 1960s and 1970s in most countries and, for the OECD as a whole, were no higher in the 1984-88 period than during the recession.

As a result, capital-output ratios tended to fall below trends set in the 1960s and 1970s. Chart B shows actual and trend ratios of the gross business sector capital stock to business sector output. The ratios are normalised by dividing by their means and taking logarithms. The trend lines are log-linear regressions on time, with the sample period ending in 1979. Capital-output ratios trended upwards until the 1980s in all countries except Italy and Norway, although in some, France, Canada and Finland, for example, the trend has not been very steep[3]. However, in the 1980s, the growth of the capital-output ratio fell in most countries and its level has even declined in some.

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3. These trends, although spanning a couple of decades, are not always indicative of trends over much longer periods of time. For example, capital-output ratios in the United States fell on average during the twentieth century, with a particularly marked drop occurring in the 1930s.

The widening gap between gross and net investment-output ratios, which is the increase in the fraction of business sector output accounted for by scrapping, is attributable to two factors. First, the relatively high capital-output ratios that were built up in most OECD countries through the 1970s imply more scrapping for a constant scrapping rate. Second, the scrapping rate has risen somewhat as the mix of investment has shifted to assets with shorter service lives, such as machinery, and away from those with very long service lives, such as structures.

A third factor, not properly captured in these data, is the rising scrapping rate of machinery and equipment due, in part, to the increasingly rapid obsolescence of computer-based equipment. Empirical support for this effect is difficult to obtain due to the generally poor quality of service life and scrapping rate estimates. Nevertheless, it is likely that the true gap between net and gross investment exceeds that suggested by Chart A.

2. Selected investment components

While the previous subsection focused on aggregate business sector investment, two narrower areas of investment have recently attracted attention as being particularly important to productivity and economic growth: computers and intangibles. This sub-section provides background information and some basic data on them and attempts to assess their importance for the measurement of investment rates.

a) Computers

Advances in electronic technology, from vacuum tubes to transistors to integrated circuits, have resulted in dramatic declines in the price of carrying out a typical computation. For example, the common IBM-compatible personal computer (PC) was originally sold for about $5000 in 1981, while a "386" PC can now be bought for about the same nominal price. However, the capabilities of PCs (in terms of speed, memory and so forth) have increased enormously, implying a substantial fall in the quality-adjusted price. Berndt and Griliches (1990), using hedonic price indices[4], found that the nominal quality-adjusted price of PCs fell by about 25 per cent per annum in the

4. The hedonic methodology involves measuring selected characteristics of computers (processor speed, memory and so forth) and, on the basis of regressions which link the prices of machines to these characteristics, assigning monetary values ("shadow prices") to each characteristic. A computer is treated as a bundle of these characteristics and its quality adjusted accordingly.

United States from 1982-88. Gordon (1989), using a matched-model procedure[5], found nominal price declines of almost 24 per cent per annum from 1982-87. For comparison, the U.S. Consumer Price Index rose, on average, by 3.2 per cent per annum from 1982-88.

As documented in OECD (1989), the result has been a sharp acceleration in the use of computers and related equipment, such as numerically-controlled robots. This has been particularly true in processing (the use of computers in the manufacturing process), but microchip technology is also increasingly incorporated into the products themselves.

However, the sharp increase in the power of computers in the last couple of decades has raised serious methodological difficulties in measuring real computer investment because conventional national accounting practices do not take full account of the improvement in computing power. It is now widely believed that these practices overstate the price and, given nominal expenditures, understate the real quantity of computer output and investment. One solution, pioneered by the U.S. Bureau of Economic Analysis (BEA) and since adopted by Canada and Australia, is to adjust explicitly for quality changes using a hedonic price index[6]. Several other countries -- Japan, Denmark, France and Sweden, for example -- are likely to make similar adjustments in the future.

Examination of the evolution of official computer price indices for several OECD countries, shown in Chart C, illustrates the effect of the BEA methodology. Quality-adjusted computer prices -- those for the United States, Canada and Australia -- have fallen much faster than prices in countries that use standard national accounting procedures. As a result, the BEA procedure yields much higher real investment figures, given nominal computer equipment expenditures. This can be seen in Chart D, which shows the share of computers in total business fixed investment evaluated in nominal and real (1981 prices) terms.

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5. This procedure captures quality changes by following the evolution of the prices of similar models over time. When new models are introduced, their price relative to existing older models is assumed to reflect quality differences, and is used to extend the quality-adjusted price index.

6. However, accounting for quality change has given rise to another measurement problem. The combination of a falling price and a rising share of computer investment implies that measured real investment growth is sensitive to the national accounts base year. This complicates the analysis of both investment patterns and the evolution of productivity over the past two decades. For example, in the case of the United States, if a chain-weighted (Tornqvist) index were used instead of the 1982 base year, measured real investment growth ("Producers' Durable Equipment") would have been almost 0.5 per cent per year lower between 1979 and 1988 than was recorded in national accounts (Baily and Gordon (1988), Table 11).

To illustrate the effect of adjusting computers for quality in other OECD countries, real computer investment was recalculated using the BEA price deflator for those countries having suitable nominal expenditure data on computer or office equipment expenditures. The adjustment made here is somewhat crude. No account was taken of differences in the definition and mix of computer equipment from country to country, nor was a distinction made between imported computers and those produced domestically. However, such differences are likely to be small relative to the sharp declines in the quality-adjusted price of computers.

Applying the BEA deflator to nominal computer expenditures in other OECD countries produces adjusted "real" shares of computers in total business fixed investment that rise steeply (Chart D), as in the United States, Canada and Australia. As Chart E shows, the increase in real computer investment expenditures implied by the use of a BEA-style index would have a significant effect on the share in output of total business fixed investment. Typically, the adjusted share is higher by 2 to 4 per cent by 1987, and the effect grows over time, along with the share of computers in investment.

b) Intangible investment

Capital, as currently defined in the national accounts, must be tangible, durable (i.e. have a service life exceeding one year), fixed (inventories and goods-in-process are not included) and produced (natural forests, land and mineral deposits are not included). Many intangible investments, such as research and development (R&D), computer software, marketing and training and education, are similar to traditional investments except there is no physical "stock". As a result, intangibles are currently treated in national accounts as intermediate inputs, not investment.

A number of categories of expenditures on intangibles -- software and R&D expenditures, for example -- are likely to be reclassified as investment in proposed revisions to the SNA currently under discussion (Blades (1989)). Nevertheless, a number of issues remain to be settled. There is not yet full agreement on which expenditures to include, nor on how to estimate the "real" value (or, alternatively, the appropriate price deflators) of investments such as R&D. Another important issue from the perspective of estimating production capacity is the service life of intangible capital. While the knowledge produced by R&D is superseded and eventually withdrawn from production -- scrapped, in other words -- it is difficult to estimate how long this takes[7].

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7. Patent lives have often been suggested as a proxy (see, for example, Goto and Suzuki (1989)), but they are not altogether appropriate. While the <u>private</u> return to an invention may fall dramatically when the patent expires, the same need not be true of the <u>social</u> return. On the contrary, the social

Studies of the Finnish industrial sector (Tilastokeskus, 1989) and the Swedish manufacturing sector (Koll and Nockhammar, 1989) indicate the scale of intangible investment. They found it accounted for about 28 and 53 per cent of total investment in Finland and Sweden, respectively. Both studies also found that R&D accounted for roughly half of all intangible investment.

To illustrate the consequences of putting R&D on the same footing as conventional investment, figures on real R&D expenditures, assembled by the OECD Directorate for Science, Technology and Industry, were added to national accounts business investment. According to these data, the ratio of business R&D to business investment expenditure (i.e. under the current national accounts definitions) was almost 11 per cent in the OECD as a whole over the last two decades, and it increased by 2 3/4 percentage points from the 1970s to the 1980s (Table 3). If R&D had been included in business fixed investment, the OECD average gross investment-output ratio would have been about 2 percentage points higher in the late 1980s[8].

III. THE DETERMINANTS OF INVESTMENT

The broad developments in aggregate business fixed investment expenditures in the 1980s might be explained as follows: the recovery in output growth after the 1981-82 recession raised the demand for capital and, hence, investment. In addition, the climate for investment was good in a number of other respects:

-- Rates of return to capital recovered to pre-recession levels;

-- The cash flow and leverage positions of firms improved;

-- The cost of equity finance fell as stock markets boomed;

-- Although conditions varied from country to country, on balance the economic climate was less volatile in the 1980s than in the 1970s; and

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return may even rise if the invention can be used freely by others upon patent expiry. Moreover, to the extent that patents encourage investment by allowing firms to recoup their R&D costs, longer patent lives may shorten the true life of an invention by increasing the pace of technical change.

8. Attempts were made to calculate an R&D "capital stock" from the R&D expenditure figures using the perpetual inventory method. However, the results proved to be very sensitive to assumptions about the scrapping rate and the initial "start-up" stock of R&D. Very little is known about either.

-- The introduction of new innovations, particularly in computer technology, ought to have raised the marginal productivity of capital.

At the same time, significantly higher real interest rates, coupled with wage moderation in most OECD countries and the winding down of investment incentives, reduced the demand for capital relative to output. In other words, firms shifted to somewhat less capital-intensive production techniques.

This explanation is consistent with the standard theory of investment demand. However, it must be tempered by the fact that, as will be seen below, investment is poorly understood at the empirical level. One manifestation of this is that investment demand equations have proved to be among the most difficult of all macroeconomic relationships to estimate reliably. As a result, there is significant disagreement about the effects of interest rates, investment incentives and even output on the demand for investment.

1. A summary of the "neoclassical" theory of investment demand

According to standard "neoclassical" theory, as described, for example, by Kopke (1985), Chirinko (1986) or Catinat *et al.* (1987), firms choose output and factor inputs so as to maximise profits. The capital stock can therefore be specified in terms of either the cost of capital relative to the price of output or the cost of capital relative to the wage rate. Thus, the cost of capital determines the capital intensity of production. Investment demand is also assumed to depend on output. In the "neoclassical" model, output summarises the endogenous choice of the firm. The assumption that firms choose output implies that it is not exogenous with respect to the demand for capital, so this should be taken into account during econometric estimation. Another, "Keynesian", interpretation is that the firm is sales-constrained, in which case output could be assumed to be exogenous to the investment decision.

The cost of capital is made up of several components: the real purchase price of investment goods; the cost of financing the purchase of a piece of capital; the depreciation rate; the tax rate on corporate income; the expected present value of accelerated depreciation (AD) allowances; and investment tax credits (ITC)[9].

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9. Algebraically, $c = p*(r + d)*(1 - k - t*z)/(1-t)$, where the real cost of capital in terms of output (c) depends on the real purchase price (p), the cost of funds (r), the depreciation rate (d), the investment tax credit rate (k), the discounted present value of accelerated depreciation allowances (z) and the corporate income tax rate (t). If the firm were constrained in capital markets, its cost of capital would also depend on the method of financing, an issue discussed below.

Government policy alters investment demand through the cost of capital by influencing interest rates or by changing the tax regime faced by firms. The key parameter determining the leverage exerted by policy is the elasticity of substitution between capital and the other factor inputs, which summarises the effect of a change in the cost of capital on the demand for capital. If it is zero, the cost of capital is irrelevant to the firm's investment decision (given output), yielding the special case of the accelerator model.

The actual stock of capital employed by the firms is generally assumed to adjust only gradually to its "desired" level due to various costs of adjustment, which are typically captured by a distributed lag of desired capital stocks. These adjustment costs are crucial because, if they did not exist, profit-maximising firms would simply install the desired capital stock immediately. They also explain why a competitive firm has a determinate desired output, even with a constant-returns-to-scale production function: with adjustment costs, capital is a quasi-fixed factor. Expectations of output and the cost of capital are also usually modeled as distributed lags. However, this usually implies backward-looking formulation of expectations, which may be inappropriate if, for example, firms anticipate future changes to tax laws. The use of distributed lags may therefore result in estimates which understate the effectiveness of policy[10].

2. Empirical evidence on investment demand

a) The roles of output and the cost of capital

The close empirical relationship between output and investment at high frequencies can be seen in the correlation of the growth rates of output and investment (Chart F). In the longer-term, capital-output ratios have been fairly constant, especially relative to trends in labour-output ratios, despite the upward drift in recent years.

These observations form the foundation of the accelerator, which relates the desired capital stock to the level of output and, therefore, investment to the change in output. Since investment is only a small fraction of the capital stock, a relatively small increase in the latter's desired level could lead to a sharp rise in the former. Thus, the accelerator can, in principle, also account for the considerable volatility of investment. The accelerator is by far the most widely accepted model of investment demand, and

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10. Auerbach and Hines (1987) illustrate this point in the context of a simulation model.

is the foundation of the investment equations of virtually all large-scale macroeconometric models, including the OECD's INTERLINK model[11].

By contrast, there is considerable controversy about the role of the cost of capital. While most economists believe it has a small effect on investment demand, others (Clark (1979), Blanchard (1986) and Gordon and Veitch (1987), for example) have concluded that there is little or no empirical evidence that the cost of capital affects investment demand. Indeed, a robust empirical relationship between the cost of capital and investment has proved very elusive.

Several explanations for the poor empirical performance of the cost of capital have been advanced. Shapiro (1986) argued that the neoclassical investment demand theory was correct, but that econometric implementations of it had failed to account for supply shocks, such as a new invention that shifts the marginal product of capital. Such a shock should stimulate investment and raise the cost of capital at the same time, thereby obscuring the true (i.e. negative) slope of the investment demand function.

Even if supply shocks are not important, the fact that few of the components of the cost of capital are directly observable causes potentially severe econometric problems. Proxies for expectations, tax rates and capital gains must be developed. The common practice of smoothing actual inflation rates may not yield measures that reflect the expected inflation rate[12]. Distributed lags may not capture shifts in expectations about the cost of capital, especially if tax changes are anticipated. However, rational expectations, a leading alternative, does not seem to perform well either in investment equations (Morrison (1986)).

Measuring the appropriate tax rate faced by firms making investment decisions is also difficult. Ideally, marginal rates should be used, but typically only average rates are available. Provisions for AD and ITC are particularly difficult to capture, in part because AD involves the future and therefore expectations. Compounding such problems is the fact that different

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11. See Helliwell *et al.* (1986), Jarrett and Torres (1987) and Torres *et al.* (1989) for descriptions of the INTERLINK investment equations. In macroeconomic models, output is generally interpreted as "demand". However, as the accelerator is based on a technical relationship (i.e. the production function), it could also work through the supply-side. Real business cycle models typically assume output is supply driven and, by exploiting the same technical relationship, can also explain the relative constancy of the capital-output ratio and the volatility of investment. For a recent debate on real business cycles, see Mankiw (1989) and Plosser (1989).

12. Chevallier *et al.* (1989), using panel data, assumed that the expected inflation rate was the same for all firms and therefore did not have to be measured. They found strong effects of firm-specific interest rates on investment.

firms may face different tax rates. Using panel data, Devereux (1989), for the United Kingdom, and Anderson (1988), for Canada, found that taxation had a large influence on firms that had not yet exhausted their tax expenditures.

Finally, it has been argued that different types of investment should not be aggregated. Norotte and Bensaid (1987) and Evans (1989) have suggested that the unusually rapid growth of computer investment poses a problem for econometric estimation of aggregate investment equations. By excluding computers, both studies were able to find stable investment demand functions, for France and the United States, respectively.

An elegant solution to many of the difficulties faced by the standard implementation of neoclassical investment demand functions is Tobin's Q model. Tobin's Q is defined as the ratio of the market value of an additional unit of capital to its replacement cost. As the market value is just the expected future returns from the piece of capital, the firm can increase its profits (or its market value) by investing when Q exceeds unity . The Q model is equivalent to a version of the standard neoclassical investment model (Hayashi (1982)), but, in principle, has the advantage that all relevant information about expectations is summarised in the Q ratio itself. That is, the market's judgement of the future stream of net earnings ought to be reflected in the market value of the firm. Thus, to the extent the "market" is correct in its assessments, there is no need to measure expectations directly.

Unfortunately, Q-models have not enjoyed a great deal of empirical success either. Chirinko (1986) provides a brief survey of results from the United States and a discussion of the drawbacks of Q. The empirical failure of Q is not due to factors specific to the U.S. economy: Poret and Torres (1987) and Mullins and Wadhwani (1989) document the relatively poor performance of Q for several other countries.

Measurement errors are the most common reason advanced for the disappointing performance of Q. First, the theory specifies marginal Q, but only average Q is observable and the two may diverge. Abel and Blanchard (1986) constructed a series for marginal Q for the United States, but the results were not improved. Second, the variation in the market value of the firm, the numerator of Q, is dominated by the value of equity which may be excessively volatile, in that its movements may not reflect changes in expected future profits (Shiller (1981)). However, Barro (1989a) found stock prices, but not Q, to be an important factor explaining investment in the United States, and Mullins and Wadhwani (1989) found that stock market variables were statistically significant in the United States and the United Kingdom, although not in Japan or Germany. If there is a measurement problem, these results suggest it may lie in components of Q other than stock prices.

b) Investment demand in the seven largest OECD economies

The previous subsection surveyed only a small fraction of the vast literature on investment demand. The thrust of most of this work has been to attempt to improve either the data used in estimation or the functional form of the demand functions. However, the major puzzles remain largely unsolved. This subsection takes a somewhat different approach by examining the properties of the data on capital, output and the cost of capital[13]. Three types of statistical tests were carried out for the seven largest OECD countries:

i) Unit root tests to determine the order of integration of these variables[14];

ii) Cointegration tests to determine if there is a long-run relationship between them[15]; and

iii) Causality tests to investigate further the appropriate specification of the factor demand functions[16].

Finally, neoclassical investment demand functions were estimated.

The unit root tests, reported in Table 4, imply that output and the cost of capital are integrated once, and the capital stock is integrated

13. Data for the cost of capital were constructed as follows. The cost of funds was proxied by an average of debt and equity costs, weighted by the share of debt in total liabilities. Debt cost was defined to be an average of short and long-term debt, weighted by their shares in total debt, less the smoothed inflation rate, as measured by the GDP deflator. Equity cost was proxied by the ratio of dividend payouts to stock prices. The real price of capital is the ratio of the non-residential fixed investment deflator to the GDP deflator. Due to lack of data, taxes were proxied by the effective corporate tax rate -- i.e. corporate tax revenues divided by corporate profits. This measure is not the relevant statutory marginal rate. Moreover, AD and ITC were ignored.

14. A series x is said to be integrated of order d (written I(d)) if the d^{th} difference of x is a stationary series. For example, a random walk, given by $x_t = x_{t-1} + e_t$, where e_t is stationary, is I(1).

15. Two series, x and y (which must have the same order of integration, d) are said to be cointegrated of order d-n if a linear combination of them is integrated of order n (which must be less than d). For example, two I(1) series related as y = a + b*x + e, where e is I(0), are said to be cointegrated of order 1, with the cointegrating vector (a, b). The concept can be extended to more than two variables. Intuitively, if two variables are cointegrated, they have a stable long-run, or low-frequency, relationship in a statistical sense.

16. A variable, x, is said to "cause" y if knowing x helps to reduce the prediction variance of y. In practice, the test is a regression of y against its own lags and against lags of x. If the latter are collectively statistically significant, one concludes that x causes y.

twice. Exceptions are: gross investment seems to be stationary for Germany, but is non-stationary based on fourth-order correction; the first difference of business output is non-stationary for Japan and France, but stationarity cannot be rejected on the basis of a non-augmented Dickie-Fuller test. Taken at face value, these results would rule out any possibility of cointegration among these variables, since capital is integrated of a higher order than the other variables. In this case, there is no need to carry out the relevant cointegration tests.

However, the results for the capital stock are not decisive. The capital stock (K(t)) is constructed as: $K(t) = (1-d)*K(t-1) + I(t)$, where d is the scrapping rate and I is gross investment, which is integrated of order one. Since K is sum of a stable autoregression and an I(1) process, its order of integration should be dominated by the latter: that is, K should also be I(1). However, as the scrapping rate is on the order of only three or four per cent per annum, the autoregression parameter is very close to unity. The process generating the change in the capital stock is therefore *a priori* likely to be statistically indistinguishable from a random walk, even if it is (barely) stationary[17].

In the absence of firm evidence as to the order of integration of the capital stock, it is sensible to investigate the possibility of cointegration. Since the neoclassical investment model predicts a stable relationship between the levels of capital (at least, in the absence of shifts in the production function itself), output and the cost of capital, data that are consistent with the model ought to be cointegrated. Aside from providing direct evidence about the theory, the results of cointegration tests are also a guide to the econometric specification of investment functions. If I(1) variables are cointegrated, OLS yields "super consistent" parameter estimates[18]. Otherwise, the parameter estimates are not consistent at all and the variables must be differenced (to make them stationary) prior to estimation.

As indicated by the "Dickey-Fuller statistics" in Table 5, cointegration is rejected for all seven countries. These results should be qualified in two ways. First, cointegration tests necessarily have low power against the alternative of very sluggish return to the underlying trend

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17. This conclusion must be qualified in two ways: i) the formula generating the capital stock is linear, whereas the tests have been carried out on the logs of the variables; and ii) the scrapping rate (or, alternatively, the autoregressive coefficient) is not constant through time. For both reasons, the true time-series process of K is more complicated than implied in the text.

18. The estimates from cointegrated regressions are said to be super-consistent because they converge, in terms of sample size, to the their true values much faster than estimates from stationary regressors.

relationship. That is, the adjustment of the capital stock to its desired level may be so slow that it is not apparent in two or three decades of data. If so, there is little to do except wait for more powerful statistical tests or for more data[19]. Second, the tests deal only with linear relationships between the variables. Although the CES production function predicts such a relationship (in logs), this is not true of all production functions. More generally, the log-linear form, which can be thought of as a local, first-order approximation to the true factor demand function, need not hold in the "long-run", except for a restricted class of production functions.

One final time-series issue of interest is the "causal" relationship between investment and the other variables. The theory assumes that investment responds to output and the cost of capital, but, as has already been discussed, causality could easily run the other way. If so, the theory may be questioned and, in any case, OLS estimates of investment equations are likely to be biased.

Table 6 reports the results of Granger causality tests using output and three definitions of investment: gross investment (which is not contaminated by possible errors in measuring scrapping rates), net investment and the percentage change in the capital stock. All variables were logged and differenced to render them stationary. For the United States, output causes investment and *vice versa*. For Japan, investment causes output but, at normal levels of confidence, output causes only gross investment. For Germany, investment causes output, but not *vice versa*. For the other four countries, the two are independent. Thus, on the basis of these tests, there seems to be a serious simultaneity problem only for the United States.

In summary, the three types of statistical test reveal the following picture[20]. Output is I(1) and capital is either I(1) or I(2). In any case, output, capital and the cost of capital are not cointegrated, casting doubt on the standard view that net investment is a process of adjustment of the capital stock to a "desired" level, which is linked to output and the cost of capital by a stable production function. The causality tests suggest that simultaneity between output and investment may not be a serious problem for most countries, but also that output typically does not "cause" investment.

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19. However, 100 years of U.S. data on output, the capital stock and the real interest rate (but not the cost of capital, which is unavailable) provide no evidence of cointegration, either. It could, of course, be argued that structural breaks dominate the data over such a long time period.

20. A similar statistical picture, apart from the causality tests (which were not done) has been found for France and the United Kingdom by, respectively, Glachant and Nivet (1989) and Lomax (1990).

These results rule out regressions on the levels of the variables. However, regressions on their first differences, as long as they are stationary, may yield consistent estimates. Since the order of integration of the capital stock cannot be ascertained with confidence, two variants of the neoclassical investment function were specified. The first, reported in Tables 7a and 7b, regresses the growth rate of the capital stock against its own lags, output growth and the growth rate of the cost of capital. However, if capital is I(2) the parameter estimates from this regression could be spurious. The second specification, reported in Tables 8a and 8b, is therefore similar to the first, except the second difference of the log of the capital stock (which is certainly stationary) is used instead of the first difference.

In Tables 7a and 8a, current values of the change in output and the cost of capital are among the explanatory variables, raising the issue of possible simultaneity bias. There are theoretical reasons to believe that investment may drive output and, if it does, that regression results will tend to overstate the importance of output and understate the role of the cost of capital. Thus, despite the fairly encouraging results of the "causality" tests, regressions were carried out that use only lags of the explanatory variables[21]. The results of these regressions are reported in Tables 7b and 8b.

Only limited experimentation with specification and variable definitions was carried out. Further lags were not significant (with a few exceptions) and using different definitions of the variables, such as gross investment, investment-capital ratios and output-capital ratios, did not alter the main conclusions. No effort was made to "tune" the equations by including country-specific variables (dummies, for example), adusting sample lengths and so forth.

Taking the results in Table 7a first, the coefficient on the lagged growth of the capital stock is very high and often insignificantly different from unity. This result reinforces the impression given by the unit root tests that the dependent variable should be differenced again to make it stationary. In the first regression for each country, the coefficient on contemporaneous output growth is positive and significant for all countries,

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21. Instrumental variable regressions, using lags of (the log of) output and the cost of capital (and, alternatively, lags of their growth rates) as instruments, were also tried. In general, neither output nor the cost of capital had much explanatory power. However, the instruments may have been poor because both output and the cost of capital are highly autocorrelated and therefore lags of their levels may not be well correlated with their growth rates -- output, in particular, has frequently been characterised as a random walk. Bennett (1989) used fiscal policy variables as instruments to attempt to control for simultaneity bias and also found that the importance of output in the determination of investment was reduced.

but lagged output growth is always insignificant (except for Japan, where it is marginally significant. The coefficient on the cost of capital is almost always small and insignificant, except for the United States, where it has the wrong sign. Overall, these regressions seem fairly well specified: the R-squared is high, there is little sign of either autocorrelation or a structural break. These results provide support for the accelerator hypothesis, although there is the possibility of simultaneity bias and the high coefficient on the lagged dependent variable implies that the regressions are actually picking up the correlation between the growth rate of output and the growth rate of investment.

The regressions reported in Table 7b deal with possible simultaneity by using only lags of output and the cost of capital as regressors. Again, the cost of capital plays little role and the coefficient on the lagged dependent variable is typically close to unity. In the first regression for each country, the lagged growth rate of output is positive and usually at least marginally significant. However, as more lags of the depended variable are added, in the second and third regressions, the size and signficance of the coefficient on output growth tend to fall. In effect, lagged output growth and the lagged dependent variable "compete" and, for most countries, the latter "wins"[22]. Thus, the results from Tables 7a and 7b suggest that the accelerator is confined principally to the contemporary relationship between investment and output.

Tables 8a and 8b report the results using the second difference of the capital stock: they are qualitatively similar to those reported in Tables 7. Taking first the results of Table 8a, output growth has a positive and significant influence on the growth rate of the net investment rate, while the cost of capital is generally insignificant (except for the United States). However, when the contemporaneous growth rate of output is excluded from the regressions (Table 8b), adding lags of the dependent variable again tends to diminish the measured effect of the accelerator, as captured by lagged output growth. Once again, the overall specification of the equations seems to be fairly good: the R-squared is, of course, much lower than for the regressions in Tables 7 (and is virtually zero for Italy and the United Kingdom), but there is little sign of autocorrelation or parameter instability.

In sum, there is not a great deal to distinguish the various regressions. The accelerator is strongly supported if contemporaneous output growth is used as a regressor, but the support is rather weaker if only lagged regressors are used, and if lags of the dependent variable are also included.

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22. Gordon and Veitch (1987), using vector autoregressions to analyse investment behaviour in the United States, found the same phenomenon. They concluded that perhaps the best investment equation was one that contained only its own lags.

The regressions strongly suggest that the underlying contemporaneous correlation is between output growth and investment growth (not investment level).

To the extent that output and investment are related, a standard interpretation of the first specification, corresponding to the results in Tables 7, is that the adjustment of capital to a shock to demand is very slow. The second specification (Tables 8) would naturally be interpreted as implying that the adjustment "never ends", i.e. that an increase in the level of output affects the growth rate of the capital stock permanently. It is inherently difficult to distinguish empirically between these two hypotheses, because the test statistics have little power when the alternative is so close to the null. It may be argued that, in any case, there is little practical difference between a very long and an "infinite" adjustment period. However, as the recent literature on the "new" growth theory has made clear, just such a difference may be crucial to the assessment of many policy issues. This literature is discussed in greater detail in Section V.

In view of the disappointing performance of the "neoclassical" model, it is natural to consider other determinants of investment demand. Two candidates are profits and uncertainty. These are now examined in turn.

c) Profits

Profits could affect investment demand through two channels. First, the neoclassical model of slow adjustment of capital implies that the existing capital stock earns quasi-rents during the transition. Indeed, these quasi-rents can be viewed as the incentive for firms to invest (if the quasi-rents are negative, they are an incentive to disinvest). In this sense, profits, which in practice include both quasi-rents as well as the normal return to capital, are complementary to the cost of capital.

The second channel arises if firms face credit restrictions that drive a wedge between the cost of credit in the market and the shadow cost of retained earnings, or cash flow. Such restrictions can be motivated on a theoretical level by appealing to informational asymmetries between borrowers and lenders. Of course, the best way to deal with credit market failures would be to incorporate them explicitly into the firm's profit maximisation problem and attempt to estimate the resulting investment demand function directly. However, credit restrictions are commonly captured by adding cash-flow variables to the investment function, on the assumption that firms with healthy cash flows are able to finance investment internally or to borrow on capital markets.

Profit, or cash-flow, models have been found to perform no worse than, and sometimes better than, standard investment equations (eg. Kopke (1985), Bernanke et *al.* (1988) and Chamberlain and Gordon (1989)). While early cross-section studies failed to find an effect (Eisner (1978)), suggesting that profits had, at best, only a short-term influence, more recent work using U.S. panel data has reversed these results (Fazzari and Athey (1987), Fazzari et *al.* (1988) and Gertler and Hubbard (1988)). Finally, Devereux and Schiantarelli (1989) found than new firms and firms in growing industries tended to be more bound by liquididy constraints.

The business-sector profit rate[23] has been rising through the 1980s and in most countries has returned roughly to levels that prevailed in the early 1970s. The unit root test reported in Table 4 indicate that the profit rate is integrated of order 1. Adding cumulated profits to the cointegration tests reported above did not improve the results. Granger causality tests, using the growth of the profit rate and the three definitions of investment used above, yielded the following results: investment causes profit, but not *vice versa* in the United States, Japan, Germany and Canada; on the other hand, the profit rate causes investment, but not *vice versa* in France, the United Kingdom and Italy. On the whole, the time-series tests are not very encouraging.

This conclusion is confirmed by the regression results reported in Tables 9a and 9b, which use the same specification as the regressions reported in Tables 8 -- the second difference of the capital stock is the dependent variable -- but adding the percentage change of the profit rate as an explanatory variable. This specification assumes that a higher level of the profit rate leads to more net investment (rather than to a higher desired capital stock). Table 9a reports the specification using contemporaneous regressors. While the profit variable is always significant if entered alone, it remains significant only in Japan, France and Canada if output growth is included as well -- contemporaneous output growth is significant in all regressions except for Canada. Table 9b reports the specification excluding contemporaneous regressors. Lagged profits are insignificant in all countries except the United States (but only in the absence of a lagged output term) and Japan. Thus, these results provide little support for an independent role for profits in explaining investment.

d) **Uncertainty**

Risk-averse firms will reduce the value they place on returns to investment as uncertainty increases and firms will tend to delay investment

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23. This is defined as business GDP less wages, imputed proprietors' wage income and corporate taxes, divided by the business sector capital stock.

decisions in order to accumulate more information, even if they are risk-neutral. There is little empirical work measuring the quantitative importance of uncertainty on investment demand, although Artus (1984), Poret (1986) and Lomax(1990) found some evidence that it reduced investment.

Several proxies suggest that the climate for investment decision-making was, if anything, somewhat less uncertain in the second half of the 1980s than in the 1970-83 period. An *ex-post* measure of uncertainty is the variability of key macroeconomic variables, on the presumption that higher volatility implies larger forecast errors. Table 10 presents standard deviations of the rates of change of industrial production, consumer prices, the real long-term interest rate and the nominal effective exchange rate for most OECD countries and for four time periods: 1960-74, 1974-78, 1979-82 and 1983-89. For most countries the volatility of the first three variables was lower in the 1983-89 period than in the post-oil shock period of 1973-78. In contrast, nominal exchange rates tended to be more volatile recently for most countries.

While this evidence is suggestive, it need not be the case that decreased *ex-post* volatility in the latter half of the 1980s meant decreased *ex-ante* prediction errors. To explore this possibility, simple ARIMA time-series models were estimated for the seven largest OECD countries and for each of the four series. The standard deviations of the one step ahead forecasts (the data are quarterly) are used as a proxy for *ex-ante* unpredictability[24]. On the whole, the evidence from the forecast errors is consistent with that from the *ex-post* variances (Table 10).

Direct evidence on the possible effects of uncertainty can be obtained by comparing actual investment expenditures with investment intentions, as measured by surveys. It is assumed that firms' reported intentions are based on predictions of the factors relevant to the investment decision. As these factors become more predictable, the actual outcome should be closer to the intentions. As is shown in Table 11, the revisions tended to be slightly smaller in the period 1983-88 than in other sub-periods. Among the larger countries, exceptions are France, where they were about the same as in the 1979-82 period, and Canada, where they were smallest in the 1974-78 period. Among the smaller countries, data from the 1970s was available only for Belgium and Luxembourg: the size of the revisions fell in Belgium, and are very volatile in Luxembourg.

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24. An obvious disadvantage of this approach is that the results hinge on the specification of the time-series models. Another is that simple ARIMA models do not include all the information available to firms and, therefore, the forecast error estimates may be biased.

3. Conclusions

This section examined variables identified by standard investment theories as being key factors in investment demand -- output (or expected demand), the cost of capital, profits and uncertainty -- paying particular attention to the first two. Although estimating investment demand functions has always been a challenge, many investigators have succeeded in finding some empirical support for both variables, especially output. Empirical support has also been found in the literature for the role of profit, or cash-flow, variables.

However, the statistical analysis presented in this section suggests that the neoclassical model, even when augmented with profit and uncertainty variables, is probably not consistent with the data. The regression analysis provided support for the accelerator, but mainly when the current growth rate of output is used as a regressor. The profit rate receives only limited support -- its current growth rate must be used as a regressor and the current growth rate of output must be excluded. There is little support for any role for the cost of capital. Attempts to add measures of output, price, interest rate and exchange rate volatility (as proxies for uncertainty) to the neoclassical investment model proved unsuccessful. Taken together, these results suggest it would be unwise to draw strong inferences on the basis of the estimated coefficients of investment demand models.

IV. PUBLIC POLICY AND INVESTMENT

This section discusses the role of government policies towards investment in the 1980s, particularly in the United States, where there is a large literature on the role of investment incentives. There was general movement in the OECD countries during these years towards broader bases and lower rates in both household and corporate taxation -- Table 12 summarises the changes that affected the corporate sector. As a result, direct incentives to investment were reduced while corporate tax rates fell.

1. Econometric studies

Much econometric work on the cost of capital has centred on the specific issue of the effectiveness of taxes (including AD and ITC) on investment. Bosworth (1984), in a survey of the literature, concluded that taxes probably have a significant, but small, effect on investment, but also that the evidence for this proposition was weak. Investigators in other countries have also concluded that tax policy has a small effect on investment demand: see Muet and Avouyi-Dovi (1987), who studied the French tax reforms of 1982, and Sumner (1986) and Devereux (1989) who analysed the U.K. reforms in 1984, which reduced the top corporate tax rate from 52 to 35 per cent and eliminated accelerated depreciation. Feldstein has been perhaps the strongest proponent of the importance of taxation -- see Feldstein (1982), Feldstein and Jun (1987), and Sumner (1988), who refined Feldstein's earlier estimates.

The most far-reaching tax reforms in the 1980s were undertaken in the United States; these have also been by far the most intensively studied. In 1981, the Economic Recovery Tax Act (ERTA) introduced AD and extended ITCs with the explicit purpose of stimulating investment and capital formation. A year later, some of this support for investment was withdrawn in the Tax Equity and Fiscal Responsibility Act (TEFRA), which eliminated the AD introduced under ERTA and reduced the generosity of the ITC. TEFRA also substantially reduced the disparity in effective tax rates by asset type (Boskin (1988), Table 3), with the objective of improving resource allocation. Investment incentives were further cut back by the Tax Reform Act (TRA) of 1986. The AD and the 10 per cent ITC were eliminated, and depreciation schedules were made less generous by lengthening tax lives. On the other hand, the corporate tax rate was also reduced.

The U.S. tax reforms had large effects on the cost of capital and therefore provide a "laboratory experiment" of the role of taxation policy in investment demand. Unfortunately, there were large movements in output growth at the same time and, generally, in the same direction (in terms of the theorised effect on investment). Much econometric work in this area has therefore been devoted to disentangling the effects of output and the cost of capital on investment.

In general, the conclusions are similar to those reached in the literature on the broader issue of the determinants of investment demand: output was more important than the tax reforms. Bosworth (1985) assessed the 1981 and 1982 reforms and found that they did not have much influence on the pickup of investment demand in the 1981-84 period. In fact, he found that the investment recovery was the strongest in sectors where the tax changes were relatively minor. Corker *et al.* (1988) attributed only a "distinctly subsidiary" role to the three reforms, arguing that output was the dominant factor. Boskin (1988), in contrast, concluded that tax policy "is an important (but hardly exclusive) determinant of investment", and that the 1981 and 1982 U.S. tax reforms had a substantial influence in stimulating investment.

2. Applied general equilibrium (AGE) models

The AGE methodology, unlike econometric analysis, does not provide empirical evidence of the effects of taxes on investment decisions. Rather, functional forms and parameters drawn from theoretical or econometric work are imposed, and the simulation results are conditional on them. For example, imposing a Cobb-Douglas production function guarantees a high (by the standards of most econometric evidence) long-run elasticity of capital with respect to taxes.

Another important limitation of most AGE models is an inadequate treatment of intergenerational considerations. This is important because most policy experiments imply significant redistributions of resources across different generations. Static models cannot, of course, deal with this issue at all, and multi-sectoral dynamic models treat the household sector as an infinitely-lived representative consumer. Aggregate dynamic models can address intergenerational issues directly by using the overlapping-generations structure, but cannot deal with such policy issues as the intersectoral distribution of capital.

Pereira and Shoven (1988) and Henderson (1989) provide good summaries of several major AGE studies of the TRA and of their underlying assumptions. Differences in model specification and which provisions of the TRA were incorporated in the models give rise to a wide range of conclusions about the effects of the tax reform. For example, many studies include features of the TRA that have no direct bearing on capital taxation (e.g. the reduction and simplification of personal income tax rates). It is therefore difficult to isolate the effects of the changes to the corporate tax system from those of other changes.

AGE models can be divided into two classes: static and dynamic. The former do not model the adjustment costs involved in moving from the old to the new equilibrium and necessarily have a very simplified treatment of households' intertemporal choices. They have therefore been used primarily to assess the long-term trade-off between: i) the reduction in overall investment incentives, which lowers the capital stock, output and, given the definitions used in these models, economic welfare; and ii) the improvement in the allocation of capital across sectors, which raises economic welfare.

In general, simulation studies using static models conclude that the TRA increased welfare, as the allocative effects dominated -- see Fullerton, Henderson and Mackie (1987), Gravelle (1989) and Jorgenson and Yun (1989). However, Grubert and Mutti (1987) and Galper *et al.* (1988) came to the opposite conclusion[25]. At the same time, the estimated static gains from

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25. Hamilton *et al.* (1989) used a static AGE model to analyse several tax options for Canada, including the 1986 "Budget Paper" proposal which comprised a reduction of the federal corporate tax rate from 36 to 29 per cent, a 25 per cent reduction in the depreciation allowance rate, the abolition of the investment tax credit and the elimination of the inventory allowance. They concluded that the impact on investment would be minor.

eliminating tax distortions due to differential treatment of various asset classes are quite small as a fraction of GDP, a result which is typical of static AGE models.

Dynamic models have several advantages over static ones for assessing the effects of tax reforms, since capital accumulation is by nature a dynamic process. They can focus on the role of adjustment costs which, as was mentioned above, play a key role in the theory of investment demand. In general, adjustment costs reduce the response of investment to changes in the cost of capital and thereby reduce the gains from higher investment incentives. Adjustment costs can also limit the mobility of capital across sectors, thereby reducing the gains from the elimination of intersectoral tax wedges. Dynamic models can also capture the difference between capital that is already installed and new, or marginal, capital. This distinction is important in the analysis of policies, such as the ITC, that apply only to new capital. Finally, work with aggregate dynamic AGE models suggests that a large part of the steady-state increase in the capital stock amounts to a transfer of resources between generations, rather than a gain in aggregate economic efficiency.

Dynamic models suggest that the combination of lower corporate income taxes and elimination of ITC depresses long-run capital intensities, while at the same time it generates sizeable intersectoral efficiency gains (Bovenberg and Goulder (1989), Bovenberg (1988), Goulder and Summers (1988)). The latter are mostly due to changes in corporate taxation (Bovenberg and Goulder (1989)) and, unsurprisingly, their contribution to overall welfare decreases with the importance of dynamic adjustment costs and with the degree of immobility of capital across sectors.

Given that the elimination of the ITC has generally been found to imply substantial reductions in investment and long-run capital intensities, with relatively smaller effects on intersectoral efficiency, some authors have argued in favour of re-introducing it (Bovenberg and Goulder (1989), Goulder and Summers (1988)). However, Pereira (1989) shows that the effects of introducing an ITC depend on how it is financed. With deficit financing, the boost in investment can be more than offset by the combination of financial crowding-out and intersectoral efficiency losses.

V. THE BENEFITS OF INVESTMENT

This section considers two channels through which greater investment could increase aggregate output in the longer run:

a) More investment means a higher capital stock and therefore increased productive capacity. Some recent developments in growth theory suggest that the social return to extra investment in terms of both expanded productive potential and the gains from technological diffusion may be far greater than standard models predict.

b) A higher rate of gross investment could allow the more rapid adoption and diffusion of new production methods and techniques, thereby raising productivity.

An important qualification to all arguments for more investment is that it implies less current consumption, given current production possibilities. Thus, while more investment now might add to the welfare of future generations, it is at the expense of the current generation, which must save to finance it. Such a trade-off cannot be evaluated on purely economic grounds because there is no generally accepted way to make interpersonal welfare comparisons. Therefore, no attempt is made in this paper to define an "optimal" capital stock, much less an "optimal" growth path. The intention is rather to outline the potential benefits of further capital accumulation.

1. Capital formation

Investment raises the productive capacity of an economy by increasing the stock of capital. Standard growth models have two key implications for the importance of capital formation on potential output. First, the elasticity of output to capital growth is only about one-third for the typical OECD country. Thus, most economic growth must be attributed to increases in employment and to technical change. In the absence of a convicing explanation of its movements, the latter is typically assumed to be exogenous. Second, an increase in the level of investment will ultimately increase the level, not the growth rate, of the capital stock. The reason is twofold: first, depreciation eats up more and more of the extra investment as the stock of capital increases; and second, the output from successive units of capital (i.e. the marginal product of capital) falls[26].

26. A third implication, closely related to the first two, is that raising the capital stock per head need not increase steady-state per capita consumption. A higher capital stock requires more resources to be devoted to depreciation and, if there is population growth, simply to maintaining the capital-population ratio. At some point, these "overheads" exceed the extra output generated by the new capital and the output remaining for consumption falls. An empirical assessment of whether more capital would increase per capita consumption levels is extremely difficult. Abel *et al.* (1989) concluded that it would for a large sample of OECD countries.

However, it has been argued recently that this view of the growth process is incorrect and that an increase in the level of investment or the saving rate (or the efficiency of the use of factor inputs) can increase the growth rate, not just the level, of output permanently. This "new" theory of economic growth emphasises the role of investment in both physical and human capital -- see, for example, Lucas (1988), Scott (1989) and Romer (1989b). For example, R&D produces knowledge that can be used simultaneously by more than one firm (it is said to be non-rivalrous). Thus, an increase in the level R&D would lead to a rise in the flow of knowledge and the growth of technical change. Moreover, to the extent that new production possibilities are embodied in new capital, investment makes further R&D possible.

A simple way of capturing these effects is to assume there are economy-wide increasing returns to scale. These are motivated by technological externalities in physical investment and human capital accumulation. Investment is assumed to both increase the (human or physical) capital stock and to have an externality in terms of raising total factor productivity. If the sum of these two effects equals or exceeds unity, an increase in net investment could be sustained indefinitely because the marginal product of capital would not diminish with capital deepening. As a result, policies that affect the rate of saving and investment (in human or physical capital) or that increase the efficiency of resource use acquire an important role in the determination of long-run per capita income growth rates[27].

If the new growth theories are correct, the effects of many public policies would be much different in several respects than those calculated using the standard economic framework. In particular, distortionary policies would have much larger effects on the economy than previously thought, since their efficiency losses would be compounded over time through permanent effects on the growth rate[28]. For instance, removal of trade barriers can boost profits from innovating by increasing the size of the market over which R&D costs can be spread. The link between openness to trade and long-run growth has been analysed by Grossman and Helpman (1989), Krugman (1988) and Romer (1990). Baldwin (1989) argued that the positive welfare effects of the EEC economic union of 1992 may have been greatly underestimated by the Cecchini Report (1988) which, focusing only on the static gains, concluded

27. These theories also imply that differences in rates of growth across countries can be explained by differences in historical policy developments. For example, King and Robson (1989) show how, in theory at least, past fiscal shocks could affect the trend rate of growth of an economy.

28. Another implication is that certain components of government spending, such as investment in infrastructure, may boost economic growth by enhancing the efficiency of resources, due to economy-wide increasing returns, yielding a non-linear relationship between growth and government size (Easterly (1989)).

that the level of EC income could rise by 2.5 to 6.5 per cent in the long run. In contrast, using a very simple computable "new" growth model with a constant aggregate saving rate, Baldwin concluded that the impact of 1992 could be to increase the EEC growth rate by 0.3 to 0.9 per cent per annum. This implies that the level of EC income would be 3 to 9.4 per cent higher after ten years, 6 to 19.6 per cent higher after twenty years, and so forth.

In view of the importance of their implications, it is essential to examine critically the evidence in support of the new growth models. Unfortunately, empirical investigations are at a primitive stage. There is as yet little direct evidence about either the assumptions on which the models are based -- increasing returns to scale, technological externalities, human capital spillovers, and so forth -- or the implications of the models. This is due in part to the novelty of this line of research and also to the fact that many of the variables on which the new growth theories hinge are either unobservable or poorly measured -- human capital, technological innovations and productive public investment being obvious examples.

The available evidence is of two sorts. The first examines the question of aggregate returns to scale directly, and the second, which is more common, tests the theories indirectly by examining cross-country correlations. Romer (1987) and Baldwin (1989) argue that the hypothesis of aggregate returns to scale is consistent with long-run aggregate data, whereas the standard assumption of constant returns to scale is not. In all OECD countries, the labour-output ratio (the inverse of labour productivity) falls markedly over time. In contrast, the capital-output ratio is relatively stable. Standard growth models appeal to technical change, which is usually assumed to augment labour only, to explain these stylised facts. By contrast, the "new" growth theorists explain this by imposing a coefficient of capital in the aggregate production function which is approximately unity. Since labour's coefficient is positive, this implies aggregate increasing returns to scale.

The second sort of evidence, from cross-country regressions, attempts to show that countries with higher output growth have also had higher levels of variables that are hypothesised to affect growth (private or public investment, for example, or education) -- see Romer (1989a), Easterly and Wetzel (1989) and Barro (1989b, 1990). Although the evidence is suggestive, it is far from decisive. In particular, given the poor state of knowledge about the determinants of growth, it is difficult to control for "all other factors" in such regressions.

2. Embodiment effects

An important theme of the "new" growth theory is the importance of technical spillovers from investment. This notion is reminiscent of the much older hypothesis that new inventions and techniques are embodied in new machinery. Although the embodiment hypothesis does not necessarily imply the existence of spillovers, the existence of either effect implies that rapid rates of gross investment ought to be associated with higher productivity growth.

Simple observation provides evidence that new technology is embodied in new types of capital -- computers embody the technology of fast electronic computing, just as adding machines embodied the older technology of mechanical computing. Despite this common-sense appeal of embodiment, supporting evidence has often been difficult to find in aggregate economic data. There is, however, indirect evidence consistent with embodiment. For example, Englander and Mittelstadt (1988) found that capital growth tends to contribute more to output growth than its share in income would suggest. Also, many "vintage" models -- which assume embodied technical change -- have been successfully estimated, thus providing further indirect support. Finally, there is a substantial literature establishing a relationship between R&D and productivity, although this work has not established that the fruits of R&D are embodied in capital[29].

A simple and direct test is to relate a productivity measure to a proxy for the amount of embodiment. Chart G plots the rate of change of total factor productivity (TFP) and the "capital replacement rate", which is the ratio of gross investment to the capital stock[30]. There is, of course, a close cyclical relationship between TFP and the replacement rate, reflecting the cyclical relationship between output and investment. While it would be possible to filter out the cyclical information to make the trends more obvious, such a procedure could also destroy the timing between changes in the two series. Timing is obviously of some importance, since according to the embodiment hypothesis changes in the capital replacement rate should precede those in TFP growth.

Despite the cyclical "noise", trend relationships can be detected in several countries -- the TFP slowdown in the 1970s is roughly coincident with the fall in the capital replacement rate in Japan, France, Austria, Belgium, Denmark and the Netherlands. However, for other countries, either the relationship is less clear, there is no relationship at all, or movements in

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29. See, for example, Mansfield *et al.* (1977), Mansfield (1980), Griliches (1986), Bernstein (1988), Bernstein and Nadiri (1988, 1989) and Lichtenberg and Siegel (1989).

30. Total factor productivity is estimated from Cobb-Douglas production functions using sample-average factor income shares. TFP is the ratio of actual output to that predicted by the production function. A drawback to this procedure in the current context is that it assumes technical progress is disembodied.

TFP growth appear to lead those in the capital replacement rate (in New Zealand, Spain and Sweden, for example)[31].

Wolff (1987) presents essentially the same measures, but in terms of long-term correlations across countries rather than through time. Chart H shows such cross-section data for the periods 1960-88, 1960-74 and 1974-88. The sub-periods correspond, roughly, to before and after the productivity slowdown. The data for the entire sample period lend some support to the embodiment hypothesis, since countries that had high replacement rates over the three decades also tended to have had more rapid TFP increases. On the other hand, the relationship vanished in the post-1974 period.

Another proxy for the rate of embodiment is the average age of capital, since newer capital should embody superior technology and therefore should be more productive. Given investment flows and scrapping rates, it is possible to estimate the average age of the capital stock from the perpetual inventory method. Growth rates in TFP and the inverse of the age of the capital stock are shown in Chart I. The hypothesis implies that the two curves should move together, at least in terms of trends. Again, there is considerable variation in TFP due to cyclical factors, but there appears to be no strong trend correlation for most countries[32].

Perhaps the most dramatic case of the embodiment of new technology is the rapidly increasing importance of computer and related investment -- see Section II. A "puzzle" has arisen, however, in that there appears be no strong productivity pickup associated with all this investment. Although as yet the puzzle has not been satisfactorily resolved, several possible solutions have been suggested:

i) There is no puzzle, since the accumulated investment in computers has not yet raised the capital stock sufficiently to have had much effect in the aggregate. Romer (1988), on the basis of a back-of-the-envelope calculation, suggested that computer investment may have raised output growth by only about one-twentieth of one per cent per annum, which is far too small to be detected. Moreover, in those countries using the BEA-type quality correction (i.e. the

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31. Data disaggregated by industry and by type of capital (machinery and equipment *versus* structures) were also examined, but the results were, in general, even less supportive of the embodiment hypothesis.

32. A recent study by INSEE (1989) found that much of the productivity slowdown in France could be explained by the increasing age of the French capital stock. However, the result may be due to the sample period used, since any relationship between the age of the capital stock and productivity growth breaks down for France before 1970.

United States, Canada and Australia), computers are, by definition, no more productive than any other piece of capital.

ii) Productivity has risen, but the major impact of computers has been in sectors -- primarily service sectors and the government sector -- where output is notoriously difficult to measure. However, there is little evidence that output measurement errors in the service sectors have increased over time.

iii) Productivity has not risen because of inadequacies in training, application software or organisational restructuring. This hypothesis comes very close to arguing that technical change is, at least in part, disembodied.

VI. CONCLUSIONS

The pattern of investment in most OECD countries in the 1980s was characterised by relatively weak levels of both private- and public-sector net investment as a fraction of output. These developments were reflected in the deceleration or actual declines in capital-output ratios. At the same time, it would appear that more investment would be beneficial for a number of reasons -- output and consumption possibilities would rise, and greater public and private investment could promote more rapid economic growth *via* embodiment or spillover effects. Taken at face value, these conclusions imply that government intervention that spurred higher investment could raise overall welfare.

However, two factors suggest that this implication may be misleading. First, investment can rise only if savings rise. If they do not, government action to raise the demand for investment goods -- for example, by introducing investment tax reliefs -- will tend to: i) raise real interest rates or the price of investment goods, thereby offsetting the effect of the tax changes on the cost of capital; or ii) generate a deterioration in the current account if the higher investment is financed by savings from abroad.

Second, there is considerable doubt that such incentives do, in fact, raise investment demand. The standard theory of investment demand implies that investment incentives will cause firms to substitute towards capital-intensive production techniques, at least as long as the production function exhibits a non-zero elasticity of substitution. However, as discussed in detail in Section III, this theory rests on shaky empirical foundations. Much of the literature on investment demand has emphasised the difficulty in estimating robust cost-of-capital effects. The intensive examination of the

U.S. experience with the introduction and withdrawal of tax incentives in the 1980s has generated a wide range of opinion on their effectiveness.

This paper has examined the extent to which the fundamental time-series properties of investment, output and the cost of capital are consistent with the underlying theory. The conclusions are largely negative. There seems to be no trend, or cointegrating, relationship among these variables. Even the high-frequency relationships are not robust, as revealed by regression analysis and "causality" tests: for most of the OECD economies examined, the best explanation of current investment growth may be its own past.

An important implication of the inability to convincingly and robustly model business sector investment behaviour is that concrete policy advice regarding the effects of investment incentives must be viewed with some caution. Tax breaks, such as AD and ITC, reduce the cost of capital, which may increase investment and the capital stock. Alternatively, they may do no more than erode the corporate tax base, leaving the capital stock unchanged in the end.

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Table 1

Business fixed investment in the OECD countries: statistical summary

	Annual average growth rates						As a per cent of business sector value added (a)					
	Gross business fixed investment			Real gross domestic product			Gross business fixed investment			Net business fixed investment		
	1970-79	1980-83	1984-88	1970-79	1980-83	1984-88	1970-79	1980-83	1984-88	1970-79	1980-83	1984-88
OECD	3.9	-0.3	6.8	3.5	1.3	3.8	16.6	16.3	16.7	10.2	8.6	8.4
Big 7	3.8	-0.4	6.9	3.5	1.3	3.9	16.4	16.2	16.7	9.8	8.5	8.3
United States	4.0	-1.8	6.7	2.8	0.7	4.2	13.7	14.3	14.7	7.2	6.8	6.6
Japan	4.3	3.5	8.9	5.3	3.6	4.5	23.4	21.8	23.6	15.4	12.8	13.4
Germany	3.1	0.1	4.4	3.1	0.6	2.6	15.5	15.3	15.6	10.1	8.1	7.7
France	2.6	-0.6	4.4	3.7	1.5	2.2	18.2	16.0	15.5	11.4	7.7	6.2
Italy	3.0	-2.7	6.4	3.9	1.7	3.0	17.8	15.3	14.9	11.1	8.2	7.7
United Kingdom	2.4	-0.6	8.7	2.3	0.4	3.6	16.3	15.8	17.2	9.5	6.6	6.9
Canada	6.6	2.8	9.0	4.7	1.3	4.7	15.3	19.2	18.1	11.3	14.6	12.9
Australia	2.6	3.6	6.1	3.5	1.5	4.5	19.5	21.2	20.5	12.8	12.7	11.3
Austria	5.5	-2.3	5.8	4.0	1.4	2.2	21.7	19.6	19.9	14.0	10.0	8.9
Belgium	1.8	0.1	6.6	3.5	1.3	2.2	14.7	13.8	14.5	9.6	7.6	7.2
Denmark	2.8	-0.9	7.0	2.5	1.1	2.3	17.4	14.9	18.8	13.0	8.7	11.9
Finland	2.4	7.1	4.7	3.8	3.4	3.5	21.2	19.1	19.4	13.3	9.6	9.6
Greece	4.9	-2.9	-1.2	5.4	0.7	2.1	15.6	14.5	11.4	13.7	11.7	7.6
Iceland	10.3	0.8	7.4	6.7	2.0	4.4	23.1	21.0	20.5	19.2	16.8	15.5
Ireland	6.8	-2.4	-1.8	4.6	2.1	3.0	21.6	23.1	15.8	16.0	17.2	9.0
Luxembourg	1.1	0.6	9.5	2.7	1.1	4.1	20.3	19.3	18.0	15.1	13.9	12.0
Netherlands	2.3	-3.5	8.0	3.4	0.1	2.4	17.0	13.9	16.1	9.6	4.7	5.9
New Zealand	3.0	9.7	3.0	1.9	2.0	1.8	22.2	23.8	26.2	14.7	13.9	15.3
Norway	6.6	4.4	5.2	4.5	2.5	3.9	27.5	23.4	22.6	18.1	13.6	14.0
Portugal	3.8	4.1	3.6	5.3	2.0	2.8	24.6	23.6	19.1	17.3	13.4	6.2
Spain	4.1	-2.3	8.0	3.8	1.0	3.6	17.2	15.5	14.9	13.6	10.5	8.4
Sweden	2.3	1.7	7.1	2.5	1.1	2.7	16.6	15.9	18.0	10.2	8.3	10.4
Switzerland	1.9	4.2	9.1	1.6	1.5	2.7	14.4	15.6	18.8	9.5	8.6	11.0
Turkey	9.2	0.5	5.1	5.6	3.1	6.0	15.4	12.0	11.8	12.2	8.4	7.8

a) Business-sector value added is defined as GDP at factor cost less the deflated government sector wage bill and (where available) government sector capital cost allowance.

Table 2

Business investment-output ratios adjusted using purchasing power parities, 1985
Percentages

	SNA (a)	PPP (b)	Difference between PPP and SNA ratios	Rankings SNA	Rankings PPP
United States	13.5	13.8	0.3	22	20
Japan	21.2	19.9	-1.3	3	7
Germany	14.9	16.9	2.0	15	10
France	14.7	15.5	0.8	17	13
Italy	13.4	12.6	-0.8	23	21
United Kingdom	16.9	16.4	-0.5	11	11
Canada	15.5	15.4	-0.1	13	15
Australia	21.7	22.4	0.7	2	3
Austria	19.2	22.1	2.9	5	4
Belgium	13.7	15.2	1.5	20	16
Denmark	18.4	22.0	3.6	7	5
Finland	19.1	23.4	4.3	6	2
Greece	14.4	11.7	-2.7	18	23
Iceland (c)	17.4	17.4	0.0	9	9
Ireland	15.5	15.0	-0.5	13	18
Luxembourg	13.8	15.5	1.7	19	13
Netherlands	14.8	15.1	0.3	16	17
New Zealand	23.0	19.2	3.8	1	8
Norway	20.5	24.0	3.5	4	1
Portugal	17.0	12.3	-4.7	10	22
Spain	13.6	10.7	-2.9	21	24
Sweden	18.0	20.4	2.4	8	6
Switzerland (c)	16.2	16.2	0.0	12	12
Turkey	12.8	14.0	1.2	24	19
Major Seven Countries	15.4	15.4			

a) Business investment-output ratios at constant 1985 prices.

b) Business investment-output ratios using PPP's.

c) Purchasing power parities do not differ by demand component.

Source: OECD, Annual National Accounts.

Table 3

Business R&D expenditure as a ratio of investment expenditure

Percentages

	1970-1988	1970-1979	1980-1988
United States	16.2	14.8	17.9
Japan	7.3	5.8	9.2
Germany	13.4	11.5	16.2
France	9.5	8.0	11.1
Italy	4.1	3.2	5.1
United Kingdom	11.5	10.4	12.1
Canada	4.2	3.2	5.4
Australia	2.3	1.8	2.5
Austria	3.4	2.8	4.6
Belgium	8.8	6.7	10.5
Denmark	5.0	3.9	6.0
Finland	4.7	3.0	6.0
Greece	0.7	..	0.7
Iceland	0.4	0.2	0.8
Ireland	2.7	1.7	3.3
Netherlands	9.1	8.3	10.0
New Zealand	1.1	1.1	1.3
NCR	3.9	3.0	4.8
Portugal	0.6	0.4	0.7
Spain	1.6	1.0	2.3
Sweden	11.7	9.1	15.1
Switzerland	13.6	13.5	14.0
Turkey	3.5	..	3.5
Europe	8.9	7.7	10.4
OECD	10.9	9.7	12.4

Table 4

Unit root tests for the seven major OECD countries

iable:		Δln KBV			ΔΔln KBV			ln IBV			Δln IBV		Δln GDPBV		Δln UCC		Δln R	
	Φ_3	Φ_2	Φ_1	$t_{\alpha'}$	Φ_1	$t_{\alpha'}$	Φ_3	Φ_2	Φ_1	$t_{\alpha'}$	Φ_1	$t_{\alpha'}$	Φ_1	$t_{\alpha'}$	Φ_1	$t_{\alpha'}$	Φ_1	$t_{\alpha'}$
ted States (59)	5.01	3.36	4.68	-0.19	11.36*	--	4.54	5.37	--	--	14.61*	--	9.07*	--	11.14*	--	8.89*	--
an (49)	1.40	1.60	2.49	-1.89	5.38*	--	3.88	5.41	--	--	7.95*	--	3.72	-1.38	10.62*	--	7.94*	--
many (55)	5.62	4.05	2.27	-1.45	6.09*	--	7.09*	--	--	--	6.87*	--	7.63*	--	20.58*	--	8.70*	--
nce (53)	1.76	1.29	0.52	-0.80	6.06*	--	1.98	2.98	4.47	2.21	5.89*	--	4.00	-1.45	9.78*	--	4.22	-2.79*
ly (59)	5.57	4.20	3.51	-1.77	7.85*	--	3.69	3.24	1.80	1.47	8.26*	--	10.26*	--	6.28*	--	12.41*	--
ted Kingdom (57)	1.34	0.93	1.20	-0.72	5.28*	--	2.04	4.20	4.53	2.91	11.17*	--	5.62*	--	12.93*	--	9.65*	--
ada (47)	3.77	2.69	3.00	0.36	7.85*	--	4.81	6.41	--	--	6.23*	--	8.05*	--	10.70*	--	9.65*	--

brackets: number (T) of observations (semi-annual data). An asterisk denotes that the non-stationarity hypothesis is rejected; that is, the series are tionary

Definition of the variables : KBV = real capital stock, IBV = real gross fixed investment; GDPBV = real value-added; UCC = real user cost of capital; R = rate of profit; ln denotes the logarithm, Δ is the first difference operator and ΔΔ is the second-difference operator. All variables are for the business sector.

Description of the test

The test is the Augmented Dickey-Fuller test (using second-order correction). The testing strategy (Perron, Journal of Economic Dynamics and Control (12), 1988) goes from "general" to "specific". One starts by testing the null hypothesis of a unit root with a drift and no time trend ($\Delta\chi_t = \mu + \alpha\chi_{t-1} + \epsilon_t$) against Alternative 3, which is:

$$\Delta\chi_t = \mu + \beta(t-T/2) + \alpha\chi_{t-1} + \sum_{i=1}^{2} \gamma_i \Delta\chi_{t-i} + u_t$$

The test statistic (Φ_3) is therefore for the constraint that $\alpha=\beta=0$. If Φ_3 exceeds the critical value, one rejects the null (i.e. "accepts" that χ is stationary, perhaps with a time trend; the hypothesis that $\alpha=0$ and β is non-zero is not tested) and the procedure ends. If not, one would "accept" that χ is a random walk, but this result could be due to the fact that the assumption of a non-zero drift in the null was erronous. To check that, one repeats the process, except the null has no drift ($\Delta\chi=\epsilon$). The test statistic (Φ_2) is thus for the constraint that $\mu=\alpha=\beta=0$. If Φ_2 exceeds the critical value, this is tantamount to rejecting $\mu=0$ (given the previous test). Thus, the original null was fine, and the procedure ends by "accepting" non-stationarity on the basis of Φ_3. But, if Φ_2 does not exceed the critical value, the appropriate null does not include a drift. However, the procedure cannot end by acceptance of driftless non-stationarity because Φ_2 is not invariant with respect to the presence a time trend in the alternative. Therefore, a more appropriate test may be against Alternative 2, which is:

$$\Delta\chi_t = \mu^* + \alpha^*\chi_{t-1} + \sum_{i=1}^{2} \gamma_i^* \Delta\chi_{t-i} + u_t^*.$$

The test statistic (Φ_1) is thus for the constraint that $\mu^*=\alpha^*=0$ (but under a different null than Φ_3). If Φ_1 exceeds the critical value, one rejects the null hypothesis of non-stationarity and the procedure ends, Φ_1 being invariant to the presence of a non-zero mean in the alternative. If Φ_1 is below the critical value, one accepts non-stationarity after having checked, on the basis of its t-statistics, that α is not significantly less than zero in Alternative 1 (where $\mu=0$, as the series may have zero mean in the alternative):

$$\Delta\chi_t = \alpha'\chi_{t-1} + \sum_{i=1}^{2} \gamma_i' \Delta\chi_{t-i} + u'_t.$$

The columns "$t_{\alpha'}$" give the t-statistics associated with the coefficient of χ_{t-1} (α') in Alternative 1. Φ3, Φ2, Φ1 are the F-statistics associated with the joint test of the null hypotheses, respectively (μ, β, α) = (μ, 0, 0); (μ, β, α) = (0, 0, 0); (μ^*, α^*) = (0, 0). Critical values do not follow the usual t- and F-distributions. For 50 observations, the critical value for the t-statistics at the 5 per cent level for Alternative 1 is -1.95 (Fuller (1976), Introduction to Statistical Time Series, p. 373). The critical values for Φ_3, Φ_2 and Φ_1 are 6.73, 5.13, 4.86 (Dickey and Fuller (1981), Econometrica 4, p. 1063). The above testing strategy ensures that the null hypothesis of non-stationarity with a non-zero drift is checked first. However, for series in first differences, with the exception of the capital stock, it is sufficient to start with Alternative 2.

Table 5

Cointegration tests for the seven major OECD countries

Left-hand side variable: ln KBV

Right-hand side variable:	United States (56)	Japan (47)	Germany (56)	France (52)	Italy (56)	United Kingdom (52)	Canada (45)
Intercept	29.70	1.26	3.04	12.98	12.11	27.21	29.19
ln GDPBV	-0.04	0.97	0.91	0.56	0.66	-0.01	-0.11
time* 100	1.87	1.34	0.73	1.01	0.71	1.36	2.76
ln UCC	0.00	0.00	0.00	-0.01	0.00	-0.03	0.02

In brackets: number of observations

Dickey-Fuller statistic	-1.07	-1.48	-2.94	-1.72	-3.12	-2.01	-3.47

Definition of the variables

KBV: real business-sector capital stock; GDPBV: real business-sector value added; UCC = real user cost of capital.

Description of the test

The test is the fourth order-correction-augmented-Dickey-Fuller test. The null hypothesis of non-stationarity of the residuals ϵ_t of the cointegrating equations is rejected if the "t-statistic" (the Dickey-Fuller statistic in the table) associated with α is significantly less than zero in the following model:

$$\Delta\epsilon_t = \alpha\ \epsilon_{t-1} + \sum_{i=1}^{4} \gamma_i\ \Delta\epsilon_{t-i} + u_t.$$

The corresponding asymptotic critical values are -4.74 and -4.58 at the 5 and 10 per cent levels respectively (Phillips and Ouliaris, Econometrica, No. 1, 1990, Table IIc.) If the "Dickey-Fuller" statistic is below the critical value, there is no evidence of cointegration.

The statistics associated with the coefficients of the cointegrating variables are not reported as they do not follow the usual t-distribution.

Table 6

Granger-causality of output and investment (1)

	Causality from output to:			Causality from:		
	Capital	net investment	gross investment	capital	net investment	gross investment
					to output	
United States	3.20*	3.80*	3.55*	2.83*	2.67*	3.70*
Japan	1.89	2.00	4.32*	3.45*	3.35*	3.78*
Germany	1.37	0.84	1.05	2.15**	2.11**	2.48**
France	0.86	1.00	0.74	0.70	0.73	0.82
United Kingdom	0.67	0.96	0.70	0.15	0.16	0.15
Italy	1.20	0.64	0.29	1.65	1.16	1.28
Canada	0.82	0.70	0.73	1.74	1.49	1.83

* Rejection of the null hypothesis that X does not cause Y at the 5 per cent level
** Rejection of the null hypothesis at the 10 per cent level

(1) The table reports F-statistics for the null hypothesis of no causality. That is, a variable X is said to Granger-cause Y if in the equation: $Y_t = \alpha_o + \sum_{i=1}^{4} \alpha_i X_{t-i} + \sum_{i=1}^{4} \beta_j Y_{t-j}$ the joint restriction that $\alpha_1=\alpha_2=\alpha_3=\alpha_4=0$ can be rejected.

"Capital" refers to the second difference of the log of business capital; "output", "net investment" and "gross investment" refer to the first differences of the logs of these variables.

Table 7a

Investment demand functions

Dependent variable: first difference of the log of the capital stock

	DQ	DQ(-1)	DU(a)	DU(-1)(a)	DK(-1)(b)	DK(-2)	Adj. R^2	AR(c)	CHOW(d)
U.S.A.	0.076 (8.8)	..	0.008 (4.4)	..	1.07 (1.4)	..	0.92	0.9 (0.8)	0.1
	0.064 (9.4)	..	0.005 (3.6)	..	1.38 (5.5)	-0.38 (5.5)	0.96	-1.6 (1.5)	0.4
	0.062 (8.2)	0.01 (1.2)	0.005 (3.5)	0.0 (0.2)	1.27 (2.2)	-0.26 (1.9)	0.96	-1.8 (1.4)	0.6
JAPAN	0.094 (5.3)	..	-0.0 (0.7)	..	0.91 (4.0)	..	0.98	0.8 (0.8)	1.6
	0.077 (4.4)	..	-0.0 (0.8)	..	1.23 (2.1)	-0.31 (2.8)	0.98	-1.3 (0.9)	0.7
	0.093 (5.2)	0.037 (1.9)	-0.002 (2.2)	0.003 (3.4)	1.06 (0.5)	-0.18 (1.6)	0.99	0.4 (0.3)	1.1
GERMANY	0.047 (5.2)	..	-0.0 (0.8)	..	0.94 (2.0)	..	0.96	1.8 (1.8)	0.4
	0.043 (5.5)	..	-0.0 (1.6)	..	1.34 (3.0)	-0.40 (3.6)	0.97	1.6 (1.4)	0.5
	0.044 (5.4)	0.008 (0.8)	-0.0 (1.7)	0.0 (0.2)	1.26 (1.8)	-0.34 (2.4)	0.97	-2.0 (1.0)	0.8
FRANCE	0.069 (9.0)	..	-0.0 (0.3)	..	0.93 (3.8)	..	0.99	0.9 (0.8)	0.4
	0.068 (9.9)	..	-0.0 (1.0)	..	1.20 (2.4)	-0.28 (3.3)	0.99	-0.3 (0.4)	1.0
	0.067 (9.4)	0.012 (1.0)	-0.0 (0.4)	-0.0 (1.6)	1.09 (0.6)	-0.18 (1.3)	0.99	.. (0.3)	3.0
ITALY	0.061 (9.4)	..	-0.0 (1.2)	..	0.89 (4.2)	..	0.97	1.3 (1.2)	0.5
	0.060 (8.8)	..	-0.0 (1.2)	..	0.93 (0.8)	-0.04 (0.4)	0.97	1.3 (1.1)	1.4
	0.062 (8.4)	-0.013 (1.0)	-0.0 (1.0)	0.0 (0.6)	1.07 (0.4)	-0.16 (1.1)	0.97	.. (2.0)	0.9
U.K.	0.031 (3.4)	..	-0.0 (0.3)	..	0.94 (1.4)	..	0.93	1.0 (0.8)	0.5
	0.031 (3.4)	..	-0.0 (0.4)	..	1.16 (1.0)	-0.21 (1.5)	0.93	-2.2 (0.9)	0.8
	0.028 (3.0)	0.01 (0.9)	-0.0 (0.4)	-0.0 (0.6)	1.08 (0.4)	-0.14 (0.8)	0.93	.. (0.1)	0.6
CANADA	0.040 (2.4)	..	0.0 (0.5)	..	0.97 (0.3)	..	0.78	4.3 (4.8)	2.2
	0.024 (1.8)	..	-0.001 (0.9)	..	1.49 (3.8)	-0.62 (4.9)	0.86	2.1 (1.9)	2.2
	0.024 (1.6)	-0.02 (1.0)	-0.0 (0.5)	-0.0 (0.2)	1.52 (3.9)	-0.69 (4.7)	0.86	1.5 (0.9)	1.7

Definition of variables: Q is real business sector output: U is the (user) cost of capital; K is the business sector capital stock. All variables are in logarithms except U is in levels for Italy (because some observations are negative). "D" indicates the first difference.

All regressions have a constant term.

Sample period: 1968 S1 to 1988 S2 (semi-annual data).

Absolute values of t-statistics are reported in parentheses.

(a) Numbers reported as .0 or -.0 are less than .001 in absolute value.

(b) The t-statistics in this column refer to the null of 1, rather than the customary null of 0. Thus, in the first regression for the U.S.A., the coefficient on DK(-1) is not significantly different from 1 (although it is significantly different from 0) at 5%.

(c) This column reports two tests for first-order autocorrelation. The first figure is the Durbin-h (represented by an ellipsis if it is imaginary, as in the third regression for France). The figure in parentheses is from an alternative test involving a regression of the investment equation residuals against their own lag and all explanatory variables. The figure reported is the absolute value of the t-statistic of the coefficient on the lagged residual, which, if significant, indicates autocorrelation.

(d) This column reports the F-statistics for a break in 1978 S1. Critical values at 5% are $F(4,30) = 2.7$; $F(5,30) = 2.5$; $F(6,30) = 2.4$.

Table 7b

Investment demand functions

)endent variable: first difference of the log of the capital stock

	DQ(-1)	DU(-1)(a)	DK(-1)(b)	DK(-2)	DK(-3)	Adj. R^2	AR(c)	CHOW(d)
;.A.	0.06 (6.1)	-0.002 (0.7)	0.93 (1.1)	..	..	0.85	-0.11 (0.1)	0.4
	0.02 (1.2)	-0.004 (1.6)	1.35 (1.7)	-0.49 (2.1)	..	0.87	.. (0.3)	1.0
	0.01 (0.6)	-0.005 (1.8)	1.56 (1.9)	-0.85 (2.0)	0.17 (1.0)	0.87	.. (0.5)	1.0
?AN	0.09 (4.0)	0.0 (0.1)	0.90 (4.2)	..	..	0.98	-0.2 (0.03)	1.1
	0.07 (3.0)	0.0 (0.2)	1.12 (0.7)	-0.21 (1.4)	..	0.98	.. (0.6)	0.5
	0.07 (3.0)	0.0 (0.3)	1.16 (0.9)	-0.31 (1.2)	0.07 (0.5)	0.98	.. (0.9)	0.5
RMANY	0.02 (2.1)	-0.0 (0.8)	0.94 (1.5)	..	..	0.95	1.0 (1.2)	0.1
	0.004 (0.3)	-0.0 (0.5)	1.40 (2.2)	-0.44 (2.4)	..	0.95	.. (2.8)	0.6
	0.01 (1.0)	-0.0 (1.4)	1.16 (0.8)	0.14 (0.5)	-0.36 (2.5)	0.96	.. (0.8)	0.4
ANCE	0.02 (1.4)	-0.01 (1.7)	0.96 (1.2)	..	..	0.96	0.75 (1.2)	1.8
	-0.02 (1.0)	-0.01 (1.7)	1.58 (2.2)	-0.59 (2.4)	..	0.96	.. (0.6)	1.9
	-0.03 (1.1)	-0.01 (1.5)	1.66 (2.1)	-0.77 (2.0)	0.11 (0.6)	0.96	.. (1.0)	1.5
ALY	0.02 (1.3)	-0.0 (1.8)	0.89 (2.2)	..	..	0.91	0.08 (0.04)	0.2
	0.00 (0.0)	-0.0 (1.6)	1.15 (0.5)	0.24 (0.9)	..	0.91	.. (1.6)	0.3
	0.001 (0.0)	-0.0 (1.5)	1.16 (0.6)	0.35 (1.1)	0.10 (0.7)	0.91	.. (2.2)	0.4
[.	0.02 (2.1)	-0.0 (0.8)	0.93 (1.7)	..	..	0.92	0.4 (0.4)	1.2
	0.02 (1.6)	-0.0 (0.8)	1.00 (0.1)	-0.08 (0.4)	..	0.92	.. (0.2)	1.1
	0.02 (1.6)	-0.0 (0.8)	1.00 (0.1)	-0.11 (0.4)	0.02 (0.1)	0.92	.. (0.5)	1.4
IADA	0.03 (1.9)	-0.003 (1.4)	0.96 (0.5)	..	..	0.76	4.1 (5.2)	2.3
	-0.01 (0.8)	-0.001 (1.0)	1.49 (3.4)	-0.71 (4.9)	..	0.86	1.3 (0.9)	1.3
	-0.01 (0.9)	-0.001 (0.6)	1.58 (3.6)	-0.93 (3.3)	0.15 (0.9)	0.85	.. (0.8)	1.1

: Table 7a for footnotes and other information.

Table 8a

Investment demand functions

Dependent variable: second difference of the log of the capital stock

	DQ	DQ(-1)	DU(a)	DU(-1)(a)	D2K(-1)	D2K(-2)	Adj.R^2	AR(b)	CHOW(c)
U.S.A.	0.065 (12.3)	..	0.005 (3.7)	..	0.38 (5.8)	..	0.86	-1.6 (1.5)	0.4
	0.061 (9.3)	0.012 (1.1)	0.005 (3.6)	0.0 (0.2)	0.28 (2.3)	..	0.85	-1.7 (1.4)	0.7
	0.064 (8.9)	0.017 (1.5)	0.005 (3.7)	0.0 (0.4)	0.16 (0.9)	0.10 (1.0)	0.85	.. (0.9)	0.8
JAPAN	0.046 (2.5)	..	-0.0 (00.5)	..	0.36 (2.8)	..	0.32	1.2 (1.4)	4.1
	0.078 (3.3)	-0.020 (0.8)	-0.001 (1.2)	0.003 (2.4)	0.40 (2.9)	..	0.38	3.3 (2.5)	4.5
	0.085 (3.5)	-0.020 (0.8)	-0.0 (0.7)	0.003 (2.4)	0.49 (3.2)	-0.2 (1.3)	0.39	8.4 (2.7)	6.0
GERMANY	0.040 (4.8)	..	-0.0 (1.5)	..	0.38 (3.2)	..	0.47	-0.4 (0.3)	1.3
	0.040 (4.6)	-0.001 (0.1)	-0.0 (1.5)	0.0 (0.1)	0.39 (2.6)	..	0.44	-1.5 (0.4)	1.5
	0.037 (4.0)	-0.002 (0.2)	-0.0 (1.5)	-0.0 (0.3)	0.31 (1.9)	0.15 (1.2)	0.44	.. (0.4)	1.1
FRANCE	0.058 (7.2)	..	-0.0 (0.4)	..	0.24 (2.3)	..	0.60	2.8 (2.6)	4.6
	0.055 (6.9)	-0.02 (1.7)	-0.0 (0.2)	-0.0 (1.3)	0.46 (3.0)	..	0.63	.. (0.2)	4.9
	0.056 (7.3)	-0.02 (2.0)	-0.0 (0.2)	-0.0 (0.9)	0.54 (3.4)	-0.18 (1.7)	0.65	.. (1.5)	3.4
ITALY	0.057 (7.1)	..	-0.0 (0.9)	..	0.02 (0.2)	..	0.56	2.9 (2.7)	5.4
	0.062 (7.7)	-0.033 (2.8)	-0.0 (0.5)	0.0 (0.8)	0.34 (2.3)	..	0.62	2.0 (0.7)	2.1
	0.062 (7.4)	-0.032 (2.7)	-0.0 (0.5)	0.0 (0.8)	0.34 (2.2)	-0.004 (0.4)	0.61	.. (0.7)	1.7
U.K.	0.032 (3.5)	..	-0.0 (0.3)	..	0.22 (1.5)	..	0.23	-1.4 (0.7)	1.1
	0.030 (3.1)	0.009 (0.8)	-0.0 (0.3)	-0.0 (0.5)	0.15 (0.9)	..	0.20	.. (0.0)	0.9
	0.030 (3.1)	0.009 (0.8)	-0.0 (0.3)	-0.0 (0.5)	0.15 (0.8)	0.01 (0.07)	0.18	.. (0.2)	1.0
CANADA	0.038 (3.3)	..	-0.002 (1.4)	..	0.56 (4.4)	..	0.43	2.2 (1.6)	3.4
	0.036 (2.4)	-0.003 (0.2)	-0.002 (1.1)	-0.0 (0.4)	0.57 (4.1)	..	0.40	2.9 (1.8)	2.2
	0.032 (0.2)	-0.005 (0.4)	-0.002 (1.3)	0.0 (0.2)	0.74 (4.3)	-0.27 (1.6)	0.43	.. (1.3)	1.6

Definition of variables: as in Table 7, except D2K denotes the second difference of the log of the capital stock.

All regressions have a constant term.

Sample period 1968 S1 to 1988 S2 (semiannual data).

Absolute values of t-statistics are reported in parentheses.

(a) Numbers reported as .0 or -.0 are less than .001 in absolute value.

(b) This column reports two tests for first-order autocorrelation. The first figure is the Durbin-h statistic (represented by an ellipsis if imaginary, as in the third regression for the USA). The figure in parentheses is from an alternative test involving a regression of the investment equation residuals against their own lag and all explanatory variables. The figure reported is the absolute value of the t-statistic of the coefficient of the lagged residual, which, if significant, indicates autocorrelation.

(c) This column reports the F-statistics for a break in 1978 S1. Critical values at 5% are $F(4,30) = 2.7$, $F(5,30) = 2.5$, $F(6,30) = 2.4$.

Table 8b

Investment demand functions

Dependent variable: second difference of the log of the capital stock

	DQ(-1)	DU(-1) (a)	D2K(-1)	D2K(-2)	Adj.R^2	AR(b)	CHOW(c)
U.S.A.	0.06 (6.3)	-0.003 (1.3)	..	..	0.49	2.1 (0.3)	0.2
	0.04 (2.4)	-0.005 (1.8)	0.27 (1.2)	..	0.50	.. (0.2)	0.4
	0.02 (1.1)	-0.005 (1.9)	0.58 (1.9)	-0.25 (1.5)	0.52	.. (1.2)	0.6
JAPAN	0.05 (2.6)	0.0 (0.3)	..	..	0.11	1.2 (2.7)	6.2
	0.02 (1.1)	0.0 (0.4)	0.40 (2.5)	..	0.21	.. (1.2)	2.6
	0.02 (1.1)	0.0 (0.5)	0.45 (2.6)	-0.13 (0.8)	0.21	.. (1.8)	2.3
GERMANY	0.02 (1.7)	-0.0 (0.8)	..	..	0.02	1.5 (1.8)	0.5
	-0.002 (0.1)	-0.0 (0.5)	0.47 (2.6)	..	0.15	.. (2.4)	0.7
	0.004 (0.3)	-0.0 (1.2)	0.30 (1.5)	0.3 (2.2)	0.23	.. (1.1)	0.5
FRANCE	0.01 (1.0)	-0.001 (1.5)	..	..	0.02	1.6 (1.8)	2.0
	-0.02 (1.4)	-0.001 (1.7)	0.62 (2.7)	..	0.16	.. (0.6)	1.7
	-0.03 (1.5)	-0.001 (1.6)	0.67 (2.8)	-0.1 (0.7)	0.15	.. (1.1)	1.3
ITALY	0.005 (0.4)	-0.0 (1.5)	..	..	0.01	1.7 (0.8)	1.3
	-0.02 (1.0)	-0.0 (1.3)	0.41 (1.7)	..	0.10	.. (1.5)	0.7
	-0.02 (0.9)	-0.0 (1.2)	-0.41 (1.7)	-0.13 (1.9)	0.05	.. (1.9)	0.7
U.K.	0.02 (2.1)	-0.0 (0.7)	..	..	0.06	1.7 (0.5)	2.5
	0.02 (1.5)	-0.0 (0.7)	0.09 (0.5)	..	0.04	.. (0.0)	1.9
	0.02 (1.5)	-0.0 (0.8)	0.10 (0.6)	-0.03 (0.2)	0.02	.. (0.2)	2.2
CANADA	0.03 (2.2)	-0.003 (1.8)	..	..	0.10	1.0 (3.7)	2.8
	0.009 (0.7)	-0.003 (2.2)	0.51 (3.7)	..	0.33	2.8 (1.8)	2.2
	0.004 (0.3)	-0.002 (1.2)	0.69 (4.1)	-0.3 (1.8)	0.37	.. (0.9)	1.4

See Table 8a for footnotes (a) and (c) and other information.

(b) This column reports tests for first-order autocorrelation as described in footnote (b) in Table 8a. For the first regression the Durbin-Watson statistic instead of the Durbin-h is reported.

Table 9a

Investment demand functions

Dependent variable: second difference of the log of the capital stock

	DR	DR (-1)	DQ	DQ(-1)	DU	DU(-1)	D2K(-1)	D2K(-2)	Adj. R^2	AR(b)	CHOW(c)
UNITED STATES	0.025 (7.1)	..	..	..	0.007 (3.5)	..	0.52 (5.5)	..	0.69	0.2 (0.1)	0.8
	0.002 (0.5)	..	0.061 (6.5)	..	0.005 (3.6)	..	-0.39 (5.7)	..	0.85	-1.7 (-1.5)	0.4
	0.003 (0.7)	-0.0 (0.0)	0.057 (4.9)	0.02 (1.4)	0.005 (3.6)	-0.001 (0.3)	0.16 (0.9)	0.09 (0.9)	..	.. (-1.1)	1.4
JAPAN	0.012 (2.8)	..	..	..	-0.0 (0.2)	..	0.36 (2.8)	..	0.34	-2.3 (-1.6)	0.7
	0.009 (2.0)	..	0.032 (1.7)	..	-0.0 (0.1)	..	0.31 (2.4)	..	0.37	-1.2 (-0.9)	2.2
	0.009 (2.4)	0.013 (3.3)	0.062 (3.0)	-0.02 (1.2)	-0.001 (1.0)	0.004 (3.8)	0.24 (1.7)	-0.15 (1.2)	0.59	0.2 (0.2)	2.1
GERMANY	0.007 (1.8)	..	..	..	-0.0 (0.1)	..	0.47 (3.2)	..	0.20	-4.1 (-2.7)	0.3
	-0.0 (0.1)	..	0.040 (4.1)	..	-0.001 (1.4)	..	0.38 (3.0)	..	0.44	-0.4 (-0.4)	1.2
	0.001 (0.3)	0.004 (1.0)	0.032 (2.8)	-0.003 (0.2)	-0.001 (0.9)	-0.0 (0.2)	0.29 (1.7)	0.21 (1.5)	0.42	.. (-0.1)	1.0
FRANCE	0.013 (3.7)	..	..	..	0.0 (0.9)	..	0.28 (2.0)	..	0.29	-0.6 (-0.4)	1.6
	0.006 (2.3)	..	0.05 (5.8)	..	-0.0 (0.1)	..	0.23 (2.3)	..	0.62	1.4 (1.2)	2.9
	0.005 (2.0)	0.003 (1.3)	0.05 (6.0)	-0.02 (1.6)	0.0 (0.1)	-0.0 (0.3)	0.39 (2.4)	-0.14 (1.4)	0.64	.. (-1.5)	2.5
ITALY	0.01 (2.8)	..	..	..	-0.0 (0.2)	..	0.18 (1.2)	..	0.16	0.4 (0.0)	0.4
	-0.001 (0.4)	..	0.060 (5.9)	..	-0.0 (0.9)	..	0.02 (0.2)	..	0.55	3.2 (2.9)	6.2
	-0.003 (1.0)	0.01 (3.8)	0.073 (8.3)	-0.057 (4.6)	-0.0 (0.6)	0.0 (1.5)	0.37 (2.8)	0.02 (0.2)	0.71	-0.5 (-0.4)	1.7
UNITED KINGDOM	0.007 (2.5)	..	..	..	0.0 (0.6)	..	0.25 (1.7)	..	0.13	0.6 (0.4)	1.3
	0.002 (0.5)	..	0.029 (2.4)	..	-0.0 (0.2)	..	0.23 (1.6)	..	0.22	-0.8 (-0.6)	1.1
	0.003 (0.8)	-0.009 (1.3)	0.026 (2.0)	0.02 (1.4)	-0.0 (0.3)	-0.0 (0.8)	0.16 (0.9)	0.02 (0.1)	0.20	.. (0.7)	0.8
CANADA	0.016 (3.8)	..	..	..	-0.001 (0.9)	..	0.66 (5.4)	..	0.47	0.6 (0.4)	2.7
	0.012 (2.4)	..	0.022 (1.7)	..	-0.002 (1.2)	..	0.62 (5.1)	..	0.49	0.8 (0.6)	2.3
	0.011 (1.8)	0.0 (0.1)	0.021 (1.3)	0.0 (0.1)	-0.002 (1.3)	0.0 (0.1)	0.70 (4.0)	-0.15 (0.9)	0.45	.. (0.5)	1.2

Definition of variables: as in Table 7, except D2K denotes the second difference of the log of the capital stock and DR denotes the first difference in the log of the profit rate. The profit rate is business sector value added less the wage bill and a correction for the labour income of unincorporated businesses, all divided by the the business-sector capital stock.

Sample period 1968 S1 to 1988 S2 (semi-annual data). All regressions have a constant term.

Absolute values of t-statistics are reported in parentheses.

(a) Numbers reported as .0 or -.0 are less than .001 in absolute value.

(b) This column reports two tests for first-order autocorrelation. The first figure is the Durbin-h statistic (represented by an ellipsis if imaginary, as in the third regression for Canada). The figure in parentheses is from an alternative test involving a regression of the investment equation residuals against their own lag and all explanatory variables. The figure reported is the absolute value of the t-statistic of the coefficient of the lagged residual, which, if significant, indicates autocorrelation.

(c) This column reports the F-statistics for a break in 1978 S1. Critical values at 5% are $F(4,30) = 2.7$, $F(5,30) = 2.5$, $F(6,30) = 2.4$.

Table 9b

<u>Investment demand functions</u>

ndent variable: second difference of the log of the capital stock

	DR (-1)	DQ(-1)	DU(-1)(a)	D2K(-1)	D2K(-2)	Adj. R^2	AR(b)	CHOW(c)
ED	0.013 (2.3)	..	-0.005 (1.8)	0.49 (3.2)	..	0.49	.. (0.8)	0.6
ES	0.007 (1.0)	0.029 (1.3)	-0.004 (1.4)	0.29 (1.3)	..	0.50	.. (-0.1)	0.3
	0.005 (0.7)	0.016 (0.7)	-0.005 (1.6)	0.56 (1.9)	-0.22 (1.3)	0.51	.. (-0.9)	0.5
N	0.015 (3.2)	..	0.001 (1.1)	0.25 (1.8)	..	0.37	-0.3 (0.2)	0.6
	0.014 (3.0)	0.007 (0.3)	0.001 (1.0)	0.23 (1.5)	..	0.35	-0.7 (0.2)	1.0
	0.015 (3.1)	0.009 (0.4)	0.001 (1.1)	0.29 (1.8)	-0.16 (1.1)	0.36	.. (-0.1)	1.0
ANY	0.005 (1.2)	..	-0.0 (0.4)	0.41 (2.8)	..	0.17	-4.8 (-3.0)	0.4
	0.006 (1.3)	-0.009 (0.7)	-0.0 (0.2)	0.49 (2.7)	..	0.16	.. (-2.9)	0.4
	0.008 (1.9)	-0.006 (0.4)	-0.0 (0.9)	0.27 (1.5)	0.37 (2.6)	0.27	.. (0.1)	0.3
CE	0.002 (0.5)	..	-0.001 (1.7)	0.34 (1.9)	..	0.11	.. (-1.3)	1.6
	0.002 (0.6)	-0.022 (1.2)	-0.001 (1.5)	0.53 (2.2)	..	0.13	.. (-1.1)	1.5
	0.002 (0.5)	-0.023 (1.3)	-0.001 (1.4)	0.57 (2.3)	-0.08 (0.5)	0.11	.. (-1.6)	1.2
Y	0.001 (0.3)	..	-0.0 (1.4)	0.19 (1.1)	..	0.03	.. (-1.4)	0.5
	0.004 (0.9)	-0.027 (1.4)	-0.0 (1.2)	0.43 (1.8)	..	0.05	.. (-2.1)	0.6
	0.004 (0.8)	-0.024 (1.2)	-0.0 (1.1)	0.43 (1.8)	-0.12 (0.8)	0.04	.. (-2.6)	0.6
ED	0.001 (0.4)	..	-0.002 (0.4)	0.24 (1.4)	..	-0.0	.. (0.1)	0.9
DOM	-0.002 (0.6)	0.021 (1.4)	-0.0 (0.8)	0.13 (0.7)	..	0.02	.. (0.4)	1.6
	-0.002 (0.6)	0.021 (1.4)	-0.0 (0.9)	0.13 (0.7)	-0.02 (0.1)	-0.0	.. (0.3)	1.7
DA	0.007 (1.4)	..	-0.003 (1.8)	0.48 (3.7)	..	0.36	1.9 (1.4)	3.0
	0.007 (1.2)	0.001 (0.1)	-0.003 (1.8)	0.48 (3.4)	..	0.34	2.4 (1.4)	2.3
	0.004 (0.6)	0.0 (0.1)	-0.002 (1.1)	0.65 (3.5)	-0.26 (1.4)	0.36	.. (1.0)	1.7

Cable 9a for footnotes (a), (b) and (c).

Table 10

Volatility indicators

	Industrial production		Consumer prices		Real long-term interest rate (a)		Nominal effective exchange rate	
	(b)	(c)	(b)	(c)	(b)	(c)	(b)	(c)
United States								
1960s-73	2.18	1.51	0.55	0.35	0.86	0.45	1.19	1.17
1974-78	2.74	2.38	0.65	0.48	1.98	0.69	2.13	2.11
1979-82	1.93	1.77	1.03	0.67	4.15	1.11	2.37	2.48
1983-89	1.24	1.95	0.42	0.42	1.54	0.80	3.35	3.17
Japan								
1960s-73	3.01	2.52	1.36	0.88	2.67	1.29	1.76	1.55
1974-78	4.42	4.58	2.04	1.90	5.00	2.35	3.83	3.60
1979-82	3.09	3.38	0.86	0.60	1.79	0.88	4.59	4.02
1983-89	2.41	2.58	0.68	0.37	0.90	0.86	4.72	4.39
Germany								
1960s-73	1.77	1.72	0.74	0.50	1.05	0.72	2.07	2.01
1974-78	1.93	1.78	0.66	0.16	0.58	0.53	2.09	2.00
1979-82	1.54	1.48	0.46	0.40	0.61	0.56	1.62	1.65
1983-89	1.72	2.02	0.48	0.38	0.86	0.54	1.43	1.34
France								
1960s-73	3.27	3.26	1.12	0.45	1.23	0.58	1.76	1.68
1974-78	2.26	2.52	0.64	0.54	2.27	1.62	3.01	2.64
1979-82	1.47	1.47	0.65	0.58	1.96	0.91	1.80	1.95
1983-89	0.95	0.98	0.68	0.31	0.82	0.63	1.54	1.56
Italy								
1960s-73	3.13	3.28	1.10	0.55	2.27	0.86	1.67	1.46
1974-78	3.20	3.16	1.56	1.61	4.54	2.13	3.18	3.30
1979-82	2.75	2.80	0.92	0.89	4.11	1.47	1.27	1.53
1983-89	1.66	1.63	0.80	0.37	1.00	0.86	1.49	1.49
United Kingdom								
1960s-73	1.67	1.67	0.94	0.60	1.69	0.84	1.85	1.83
1974-78	3.23	3.20	1.97	1.28	5.44	2.30	3.13	3.27
1979-82	2.08	2.07	1.75	1.50	3.96	2.34	3.60	3.52
1983-89	1.38	1.47	0.80	0.54	1.51	0.94	3.93	4.20
Canada								
1960s-73	1.38	1.29	0.64	0.38	1.25	0.51	0.91	0.91
1974-78	1.93	1.61	0.58	0.50	1.70	0.91	2.22	1.66
1979-82	2.21	2.01	0.45	0.33	1.18	1.03	1.37	1.57
1983-89	1.51	1.28	0.28	0.37	1.29	0.73	1.66	1.53
Australia								
1960s-73	1.62		0.84		2.24		3.41	
1974-78	2.09		1.38		2.97		3.35	
1979-82	2.18		0.65		1.92		2.26	
1983-89	2.07		0.70		2.16		5.72	
Austria								
1960s-73	1.84		1.17		1.71		0.96	
1974-78	1.85		0.82		1.70		1.09	
1979-82	1.83		0.64		1.70		1.13	
1983-89	1.24		0.76		1.11		0.71	
Belgium								
1960s-73	2.08		0.61		1.33		0.64	
1974-78	2.66		1.04		3.60		1.71	
1979-82	2.61		0.61		0.93		1.88	
1983-89	1.57		0.65		0.92		1.04	
Denmark								
1960s-73	--		1.19		2.49		0.79	
1974-78	--		1.42		3.20		1.63	
1979-82	--		0.92		1.86		1.96	
1983-89	--		0.69		0.93		1.27	

a) Nominal rate less year-on-year rates of change in consumer prices.
b) Standard deviation of quarterly rates of change over each sub-period.

Table 10 (continued)

	Industrial production		Consumer prices		Real long-term interest rate (a)		Nominal effective exchange rate	
	(b)	(c)	(b)	(c)	(b)	(c)	(b)	(c)
Finland								
1960s-73	3.16		1.21		2.76		3.01	
1974-78	2.25		1.15		4.09		1.85	
1979-82	1.90		0.81		1.79		2.06	
1983-89	1.34		0.71		2.44		0.97	
Greece								
1960s-73	2.46		2.02		4.05		2.16	
1974-78	2.53		2.20		6.95		2.20	
1979-82	1.91		2.19		1.70		2.44	
1983-89	2.61		2.09		3.86		4.17	
Ireland								
1960s-73	2.53		1.19		2.06		0.76	
1974-78	2.53		2.29		4.53		1.31	
1979-82	2.57		1.63		2.81		2.42	
1983-89	2.95		0.81		2.00		2.12	
Netherlands								
1960s-73	1.45		1.28		1.75		0.78	
1974-78	1.97		0.88		1.91		1.48	
1979-82	1.86		0.43		0.64		1.82	
1983-89	2.66		0.60		0.86		1.37	
New Zealand								
1960s-73	--		0.97		2.62		2.23	
1974-78	--		0.79		2.71		2.69	
1979-82	--		0.73		1.34		1.36	
1983-89	--		1.75		3.62		5.28	
Norway								
1960s-73	1.93		1.07		1.98		0.81	
1974-78	3.04		0.86		1.63		1.72	
1979-82	3.28		1.22		2.45		1.42	
1983-89	4.75		0.61		1.18		1.74	
Portugal								
1960s-73	4.08		1.80		2.54		1.00	
1974-78	2.89		3.07		7.48		3.53	
1979-82	2.44		1.62		4.18		2.86	
1983-89	1.95		2.30		4.55		2.61	
Spain								
1960s-73	7.84		1.31		2.50		1.72	
1974-78	11.49		1.43		4.12		4.42	
1979-82	12.06		0.67		1.76		2.37	
1983-89	11.26		0.99		2.10		2.69	
Sweden								
1960s-73	2.03		0.82		1.55		0.87	
1974-78	2.27		1.11		1.69		2.48	
1979-82	2.80		1.13		2.65		4.02	
1983-89	2.04		0.67		1.36		0.97	
Switzerland								
1960s-73	1.65		0.78		1.71		1.19	
1974-78	4.23		0.87		2.43		3.73	
1979-82	2.08		0.60		0.92		2.98	
1983-89	2.30		0.51		0.94		2.17	

a) Nominal rate less year-on-year rates of change in consumer prices.
b) Standard deviation of quarterly rates of change over each sub-period.
c) Standard deviation of the differences between the actual values and one-step-ahead forecasts using ARIMA models.

Table 11

Revisions in investment intentions (a)

	1960s-1973	1974-1978	1979-1982	1983-1988	Average over the entire sample period
United States	3.3	2.5	3.7	1.7	2.9
Japan	2.6	4.9	3.5	3.5	3.6
Germany	2.5	3.1	2.3	2.2	2.5
France	3.8	2.3	1.9	2.0	2.6
Italy	6.4	4.9	8.7	5.1	6.1
United Kingdom	..	4.8 (b)	4.1	2.9	3.8
Canada	..	3.2	8.3	4.6	4.8
Belgium	..	3.8	7.8	5.5	5.7
Luxembourg	10.5	24.1	6.5	24.5	17.7
Netherlands	..	..	3.0	4.0	3.4
Ireland	..	..	10.3	23.7	16.9

a) Average absolute value of revisions in investment intentions (normalised by subtracting the average errors over the entire sample period). Revisions are the difference between the realised rate of increase in nominal fixed investment, as declared by firms at the beginning of the following year, and the rate which was expected at the beginning of the current year.

b) 1975-78.

Sources: United States: U.S. Department of Commerce, Bureau of the Census.
Japan: Bank of Japan, Short-Term Economic Survey of Enterprises in Japan.
France: INSEE, Enquête sur l'investissement dans l'industrie.
Canada: Statistics Canada: Public and Private Investment.
Other countries: European Community Investment Surveys.

Table 12

Recent changes in corporate tax structures

	Basic Corporate Tax Rate (a)		Depreciation Allowances (b)	Investment Credits (c)
	1986	1989		
United States (d)	15/18/30/40/46+	15/25/34+	Ad elim. in 1986, except for same ME	ITC elim. in 1986
Japan (e)	43+19	40+11	AD on ME and S	
Germany (f)	56+	56+	AD for small enterprises	
France	45	39		
Italy	36+10	36+10	AD on ME and S	
United Kingdom (g)	35	35	AD elim. after 1984 except rarely for S	
Canada	36+15	28+15	AD phased-out by 1991 except for same ME	ITC largle phased-out, but remains for manufacturing and regional investments
Australia	49	39	Most AD elim. in 1988, except some ME	
Austria	30/40/50/55+	30+	AD elim. in 1989	GIA: 20% of acquisition cost for manufacturing
Belgium (g)	45	43	AD on ME and S	GIA: formula between 5 and 12%
Denmark	50	50		
Finland (h)(i)	33+17	33+17		Investment reserve provisions
Greece	49	46	Rare AD on ME and S	GIA: 40-70% on investment cost
Iceland	51	51		
Ireland (i)	40/50	43	AD on ME and S	
Luxembourg	40+	34+		GIA

Table 12 (continued)

Recent changes in corporate tax structures

	Basic Corporate Tax Rate (a)		Depreciation Allowances (b)	Investment Credits (c)
	1986	1989		
Netherlands	42	40/35		ITC elim. in 1989
New Zealand	45	33		
Norway	28+33	28+33		
Portugal	42/47	36.5+3.65		GIA on re-invested profit
Spain	35	35		ITC on new fixed assets
Sweden (j)	52	52		
Switzerland (k)	--	--		
Turkey	46	46		

Sources: DAFFE; Pechman (1988); OECD (1989b); various OECD Surveys.

a) Tax rates to nearest percentage point. "+" indicates there are state and local taxes; rates are shown if available. Does not include reduced rates for specific industries, etc.
b) In 1989. AD means accelerated depreciation. ME means machinery and equipment. S means non-residential structures.
c) In 1989. ITC means investment tax credit. GIA means general investment allowance.
d) A 5 per cent surtax applies to taxable income between $100 000 and $333 000.
e) Central government rate announced to fall to 37.5 per cent in 1990.
f) Central government rate announced to fall to 50 per cent in 1990.
g) Reduced rate for small enterprises.
h) Central government rate announced to fall to 28 per cent in 1990.
i) Reduced rate for small enterprises in 1989, but not in 1986.
j) Rate announced to fall to 30 per cent in 1991.
k) The direct federal tax is imposed at rates of 3.63 to 9.8 per cent of net profit. As a rule, the minimum income tax rate on before-tax profit for federal, cantonal and communal taxes is approximately 20 to 35 per cent.

Chart A

Business sector gross and net investment output ratios
(per cent)

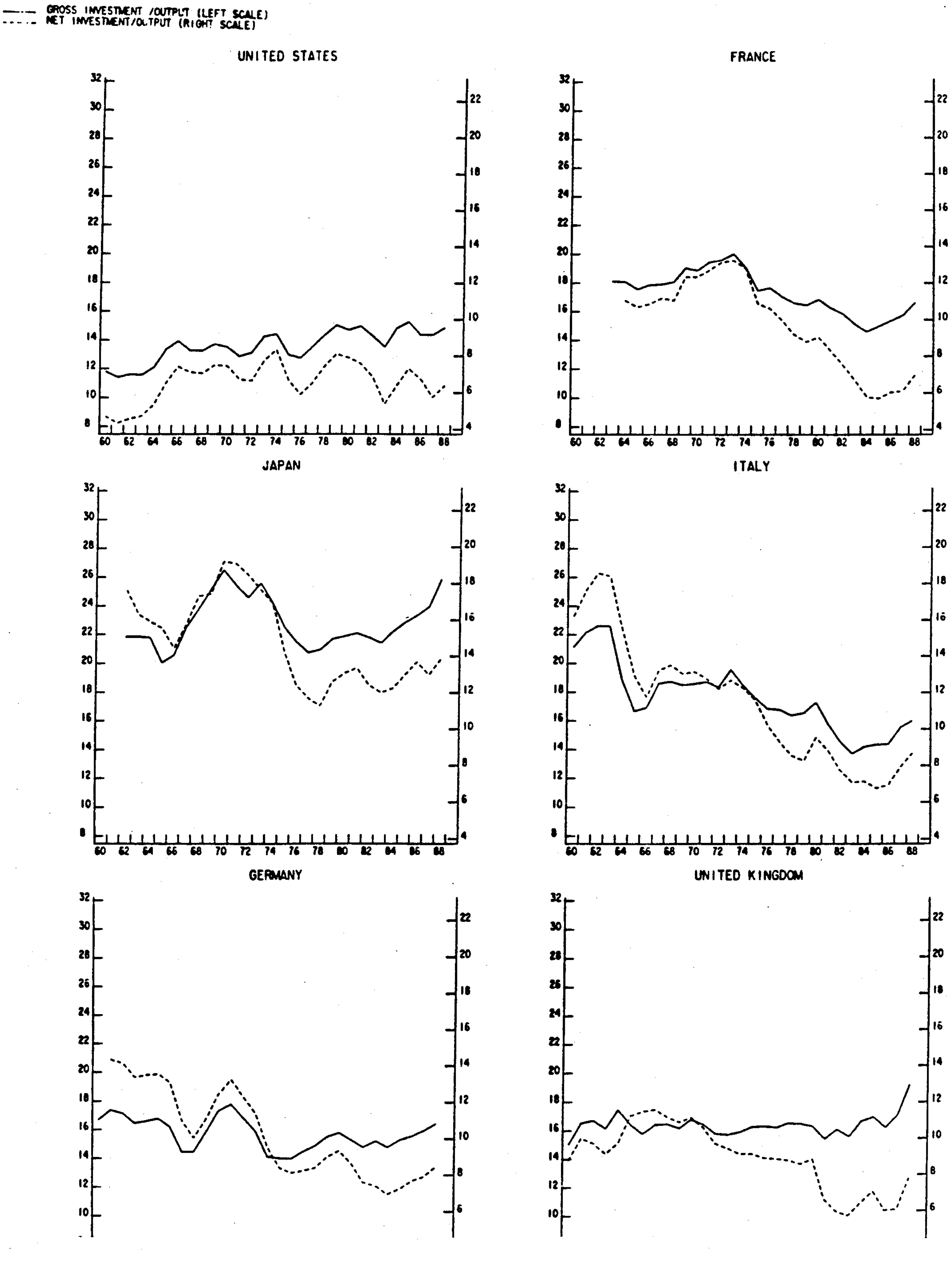
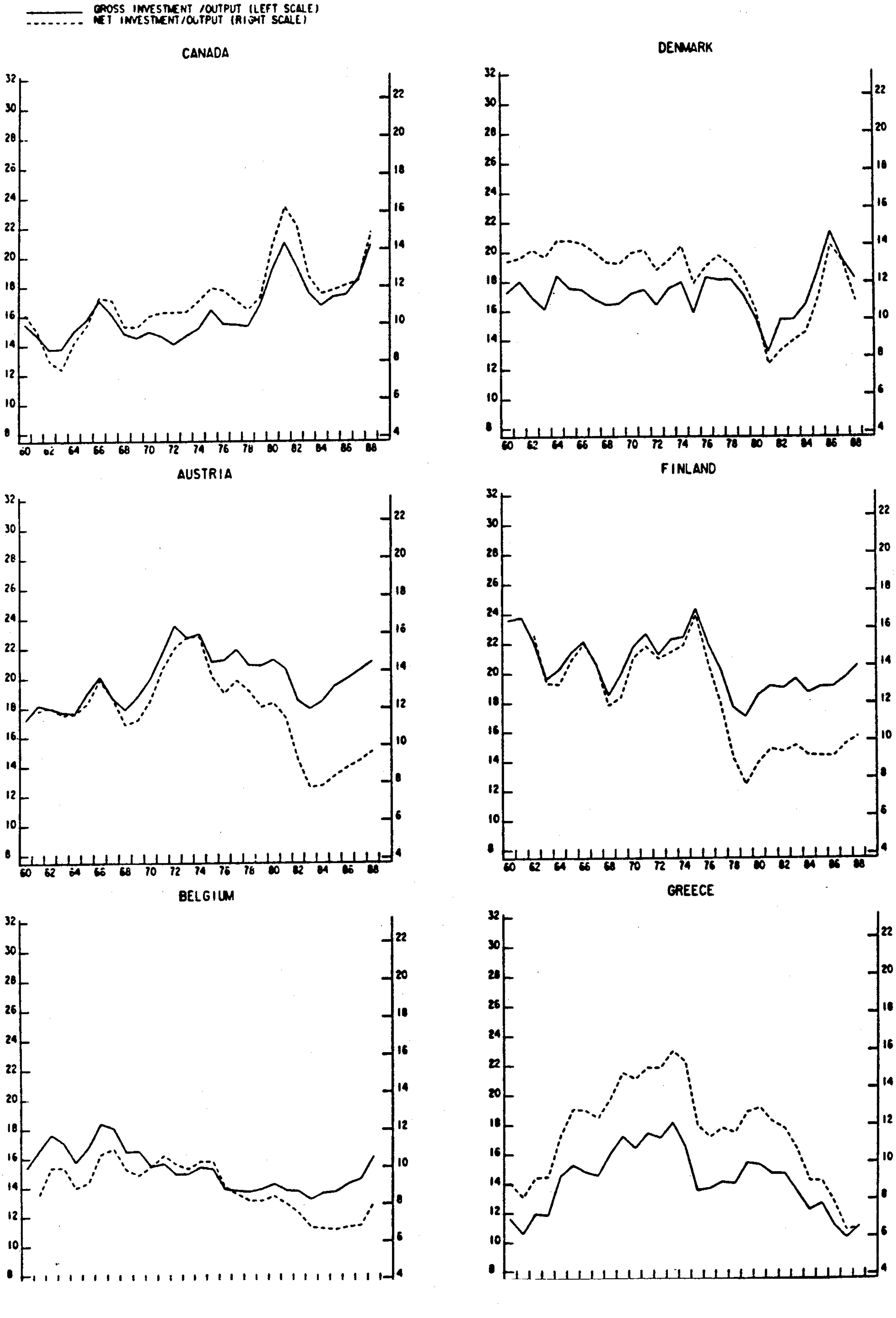


Chart A (continued)



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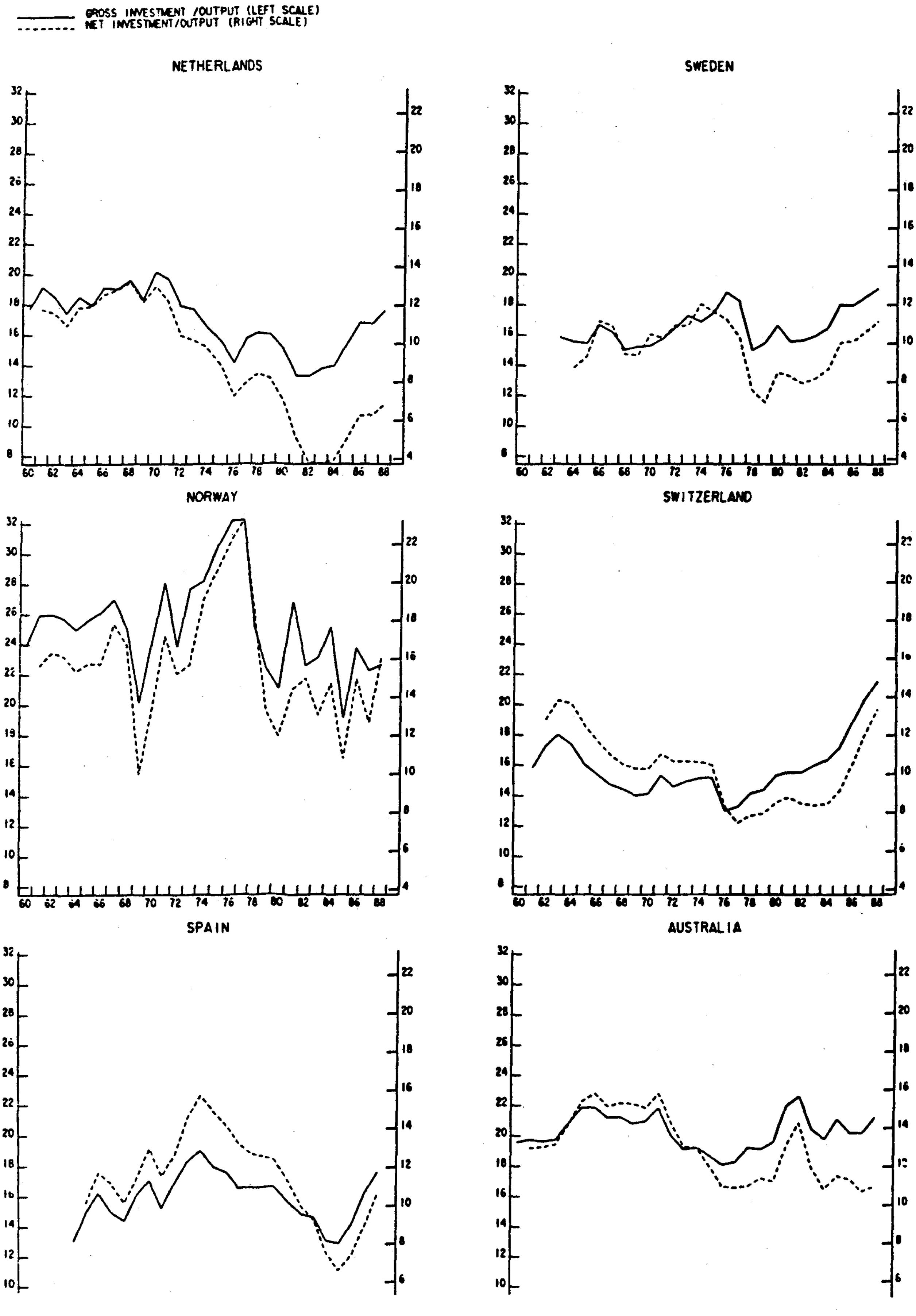

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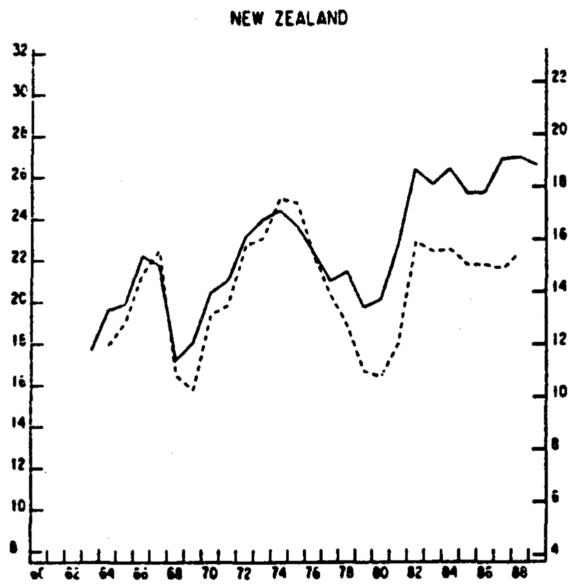
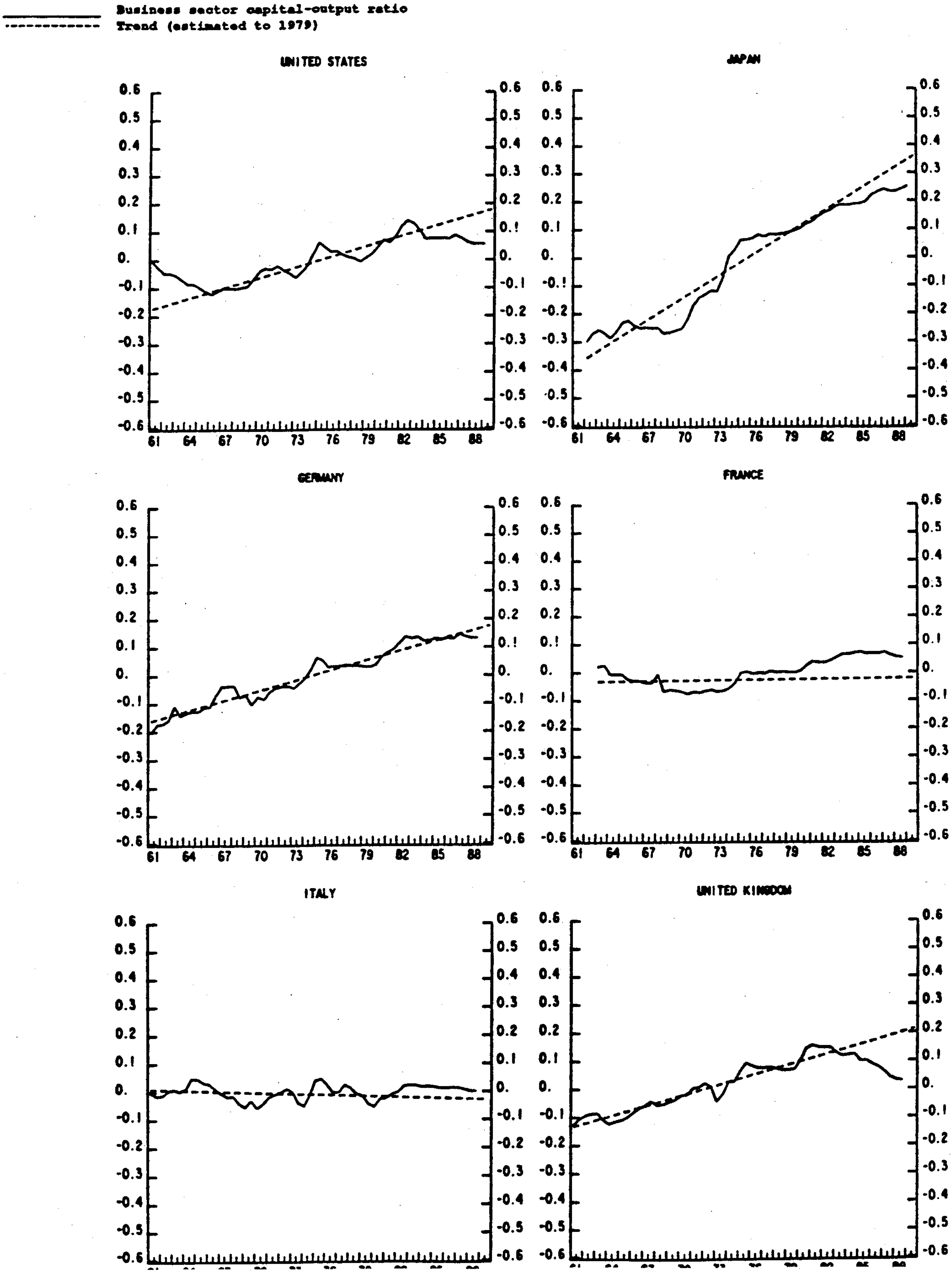


Chart B

Capital-output ratio
(Logarithms)



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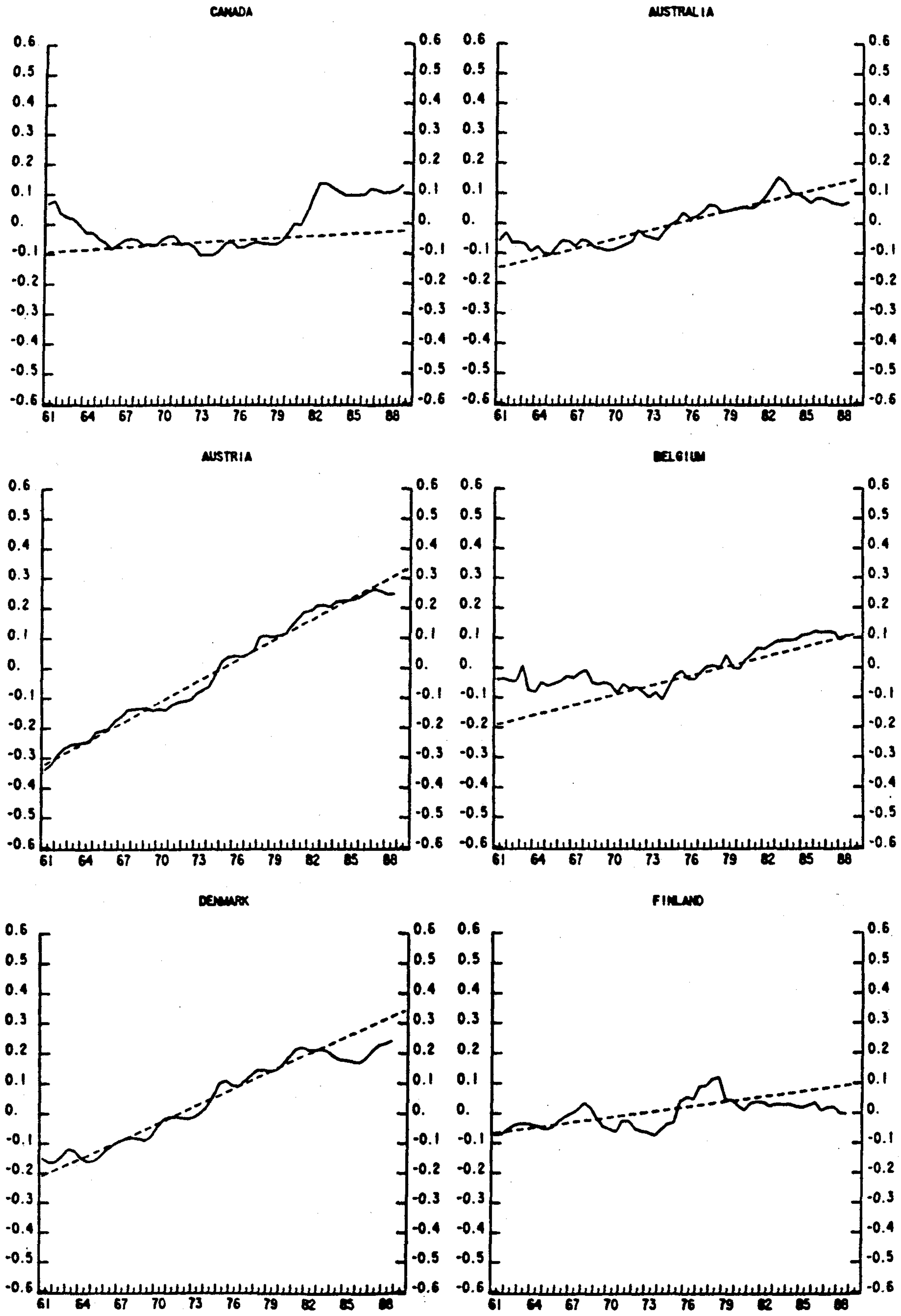

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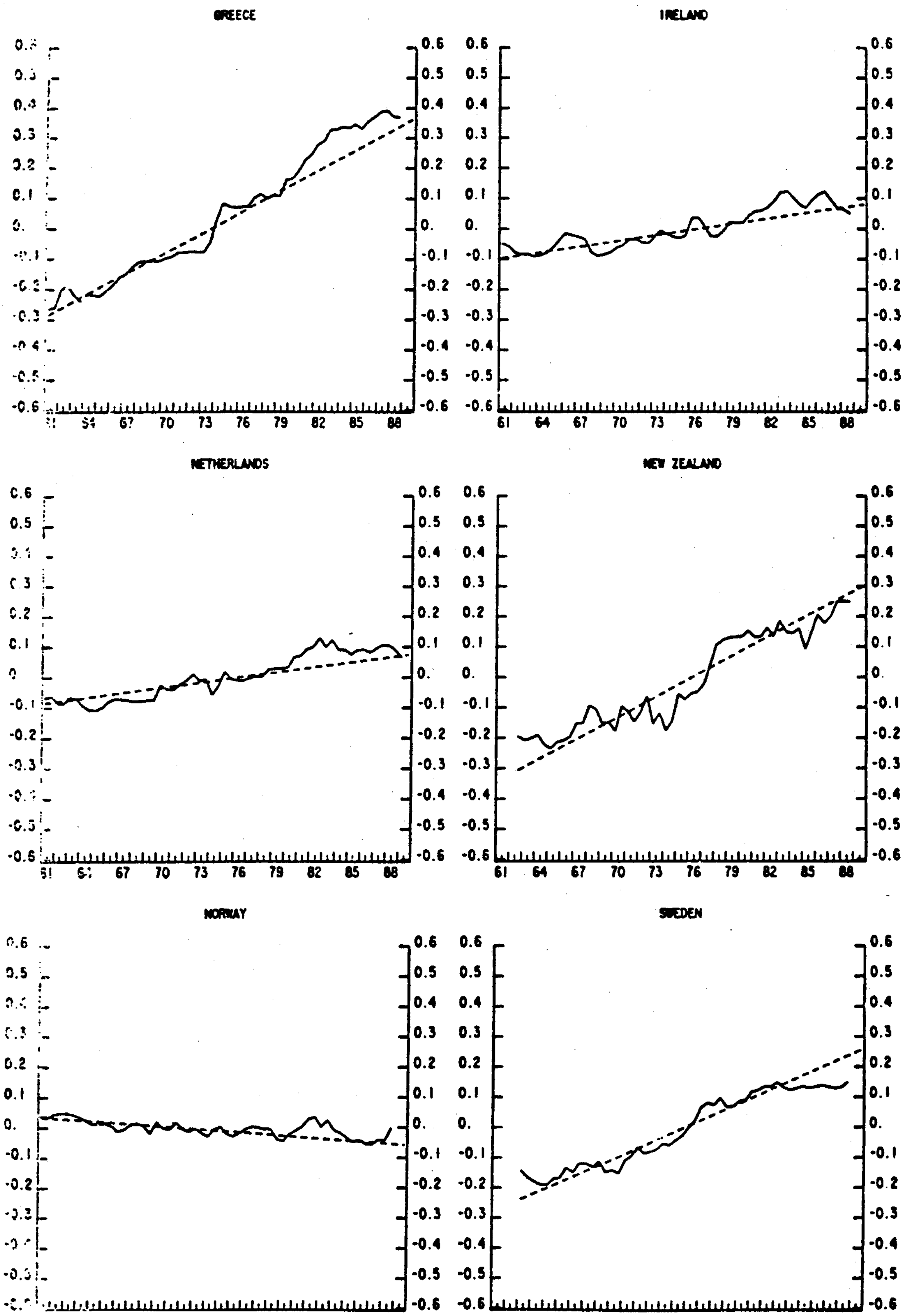

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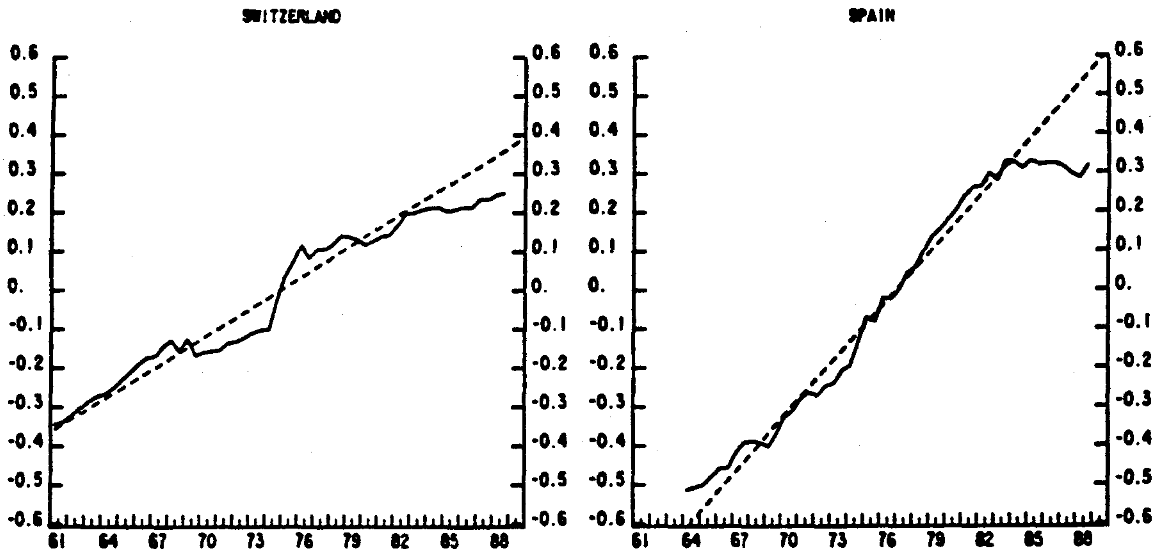
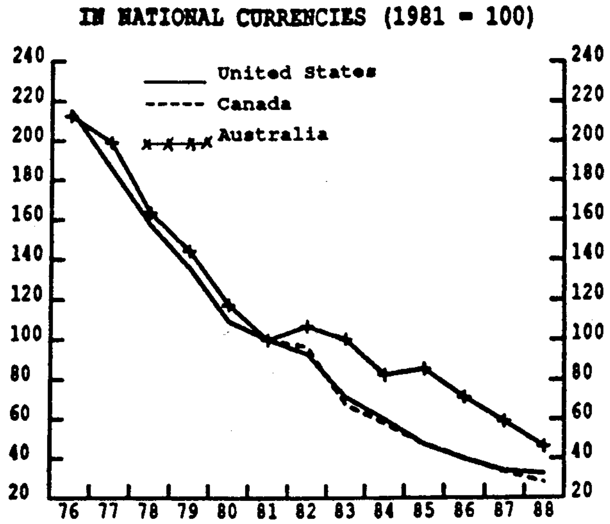
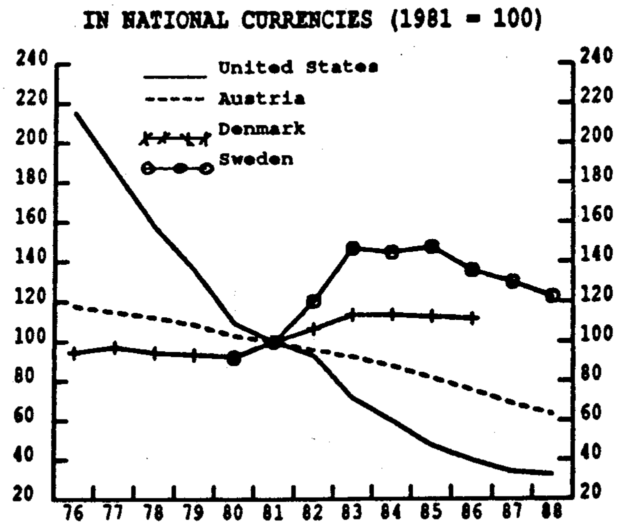


Chart C

Prices for computing machinery





PRICES FOR OFFICE EQUIPMENT & COMPUTERS

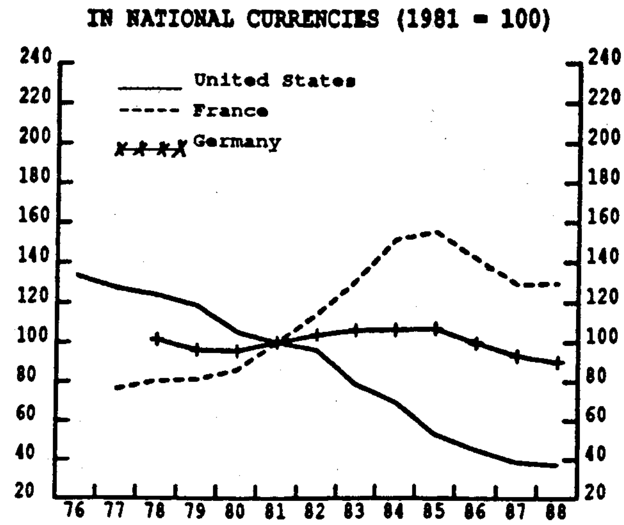


Chart D

Share of computers in total business investment (%)

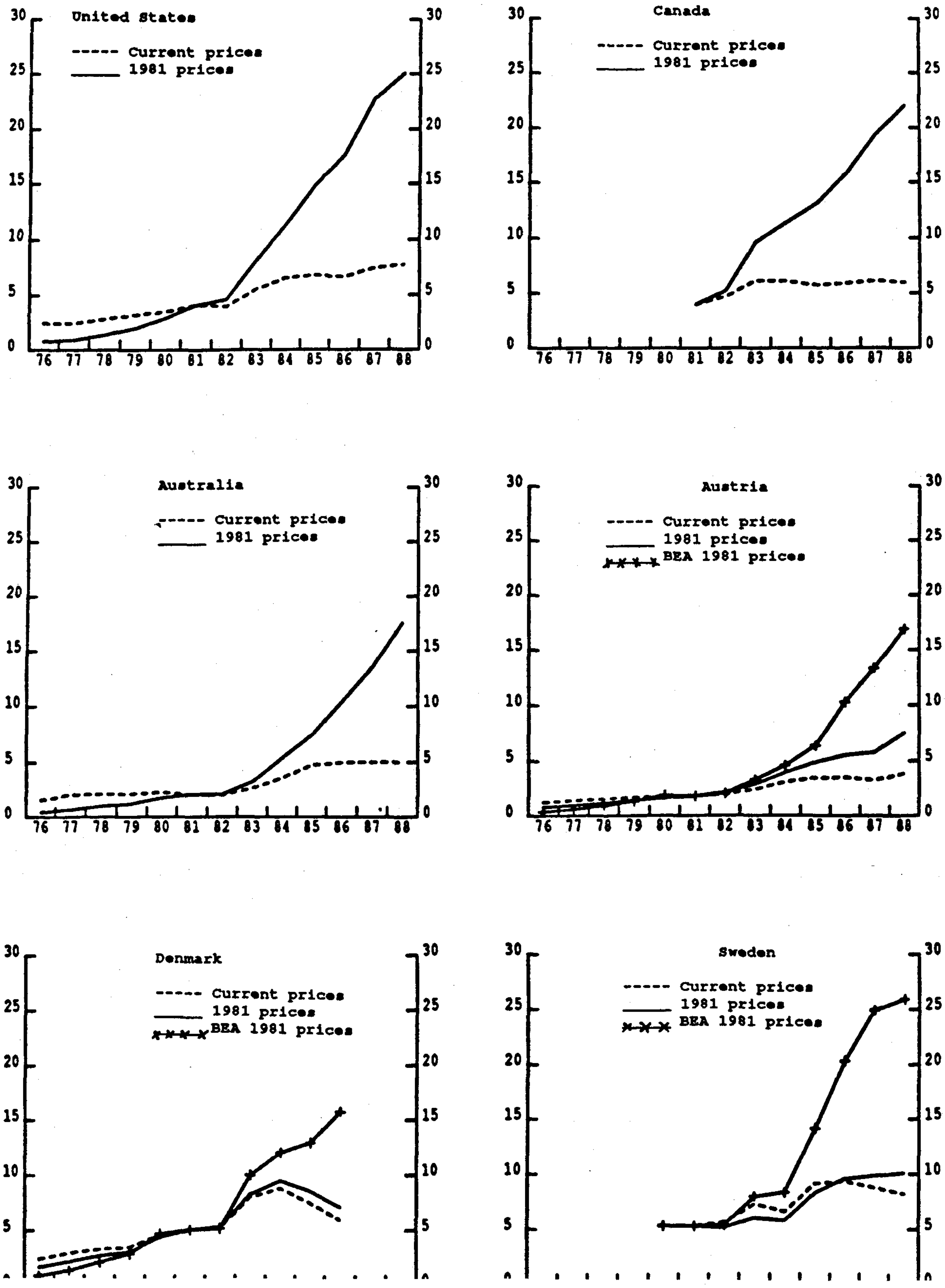


Chart D (continued)

Share of office equipment in total business investment (%)

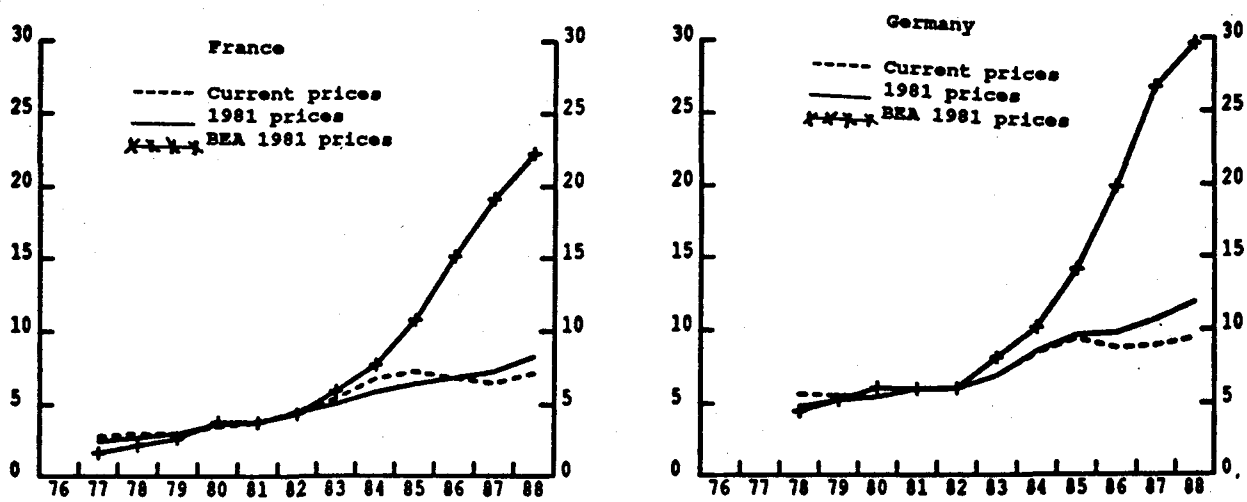


Chart E

Original and adjusted business investment-output ratios (%)
Using BEA series for computer prices to make adjustment

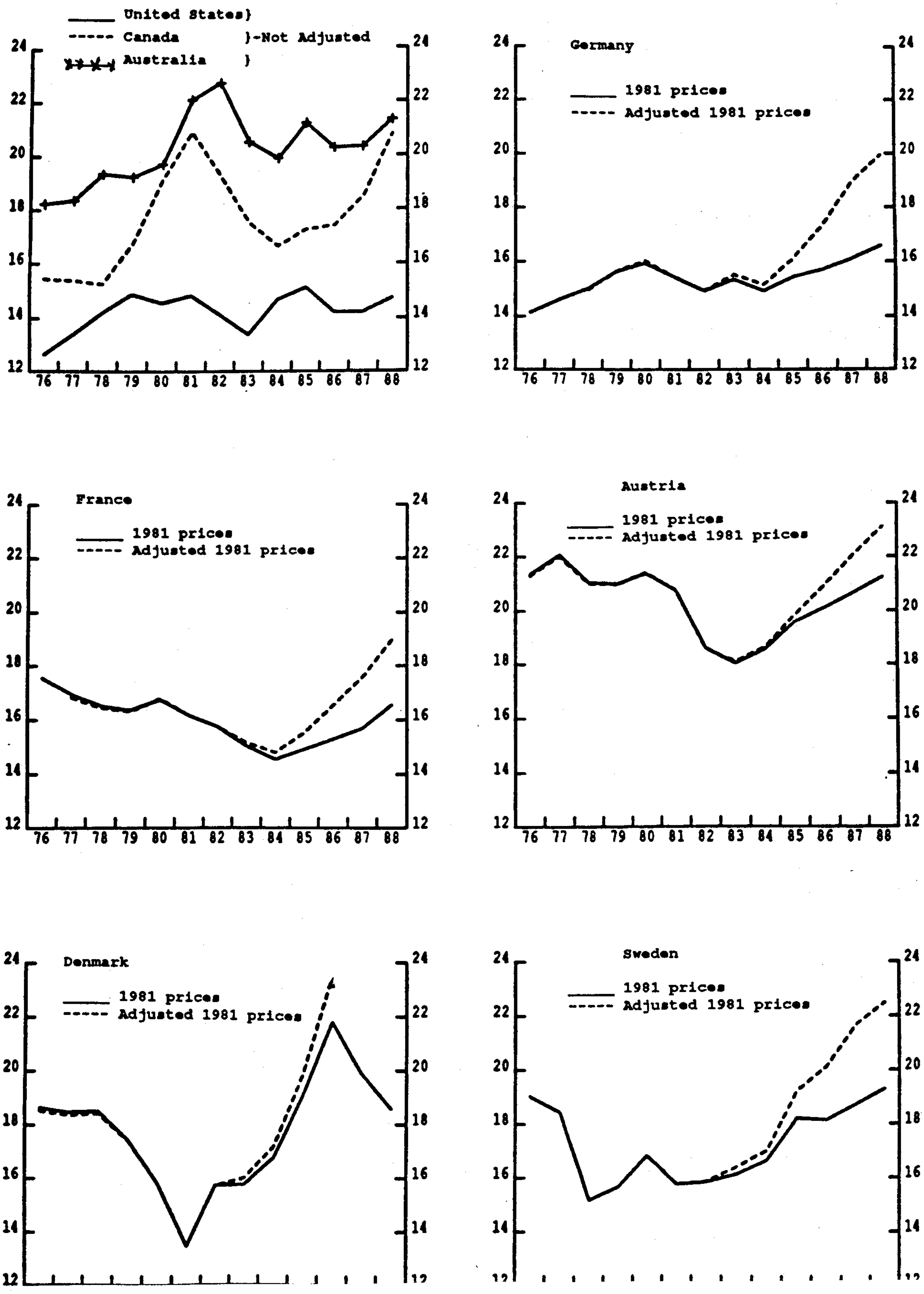
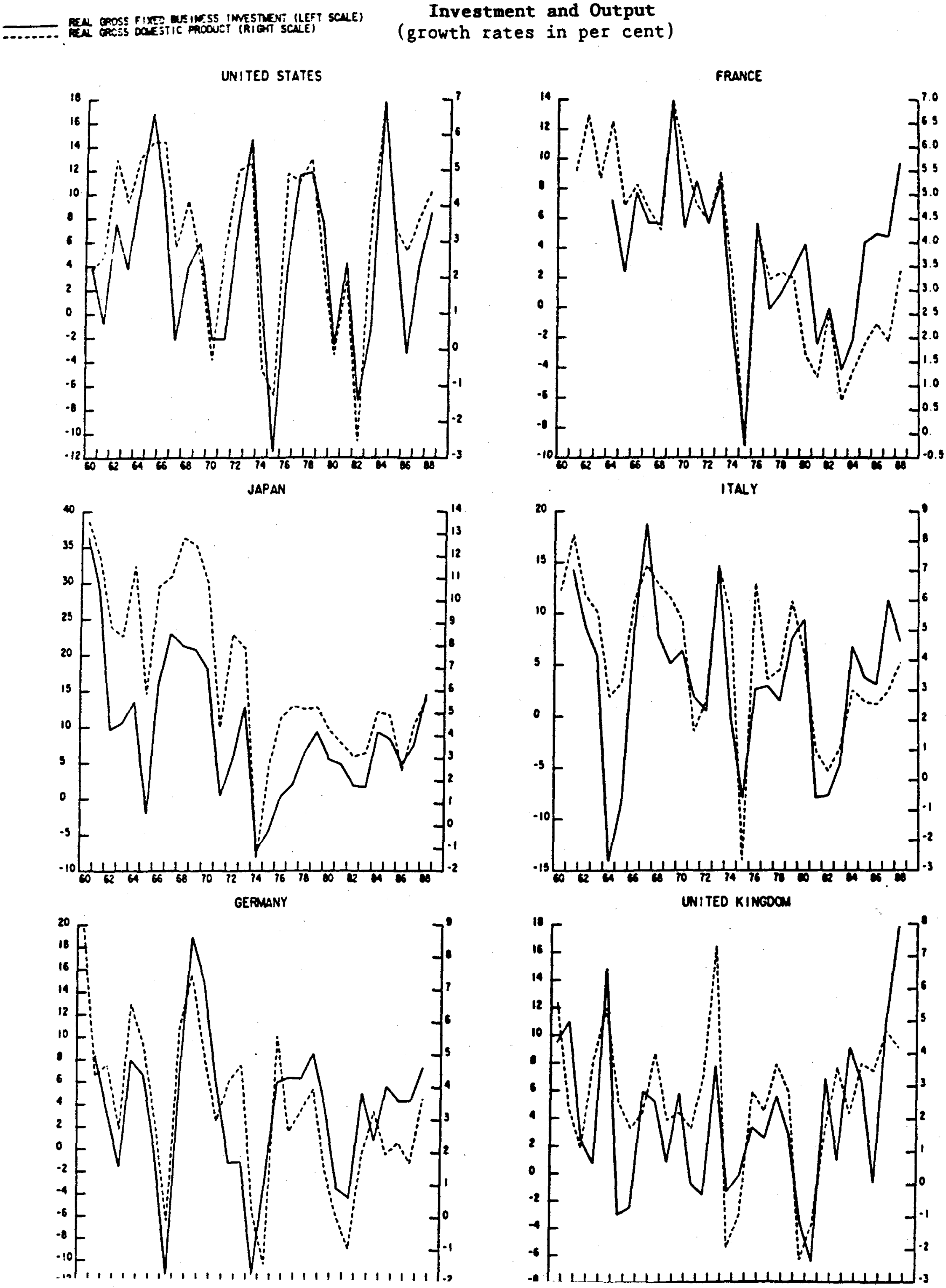


Chart F

Investment and Output
(growth rates in per cent)



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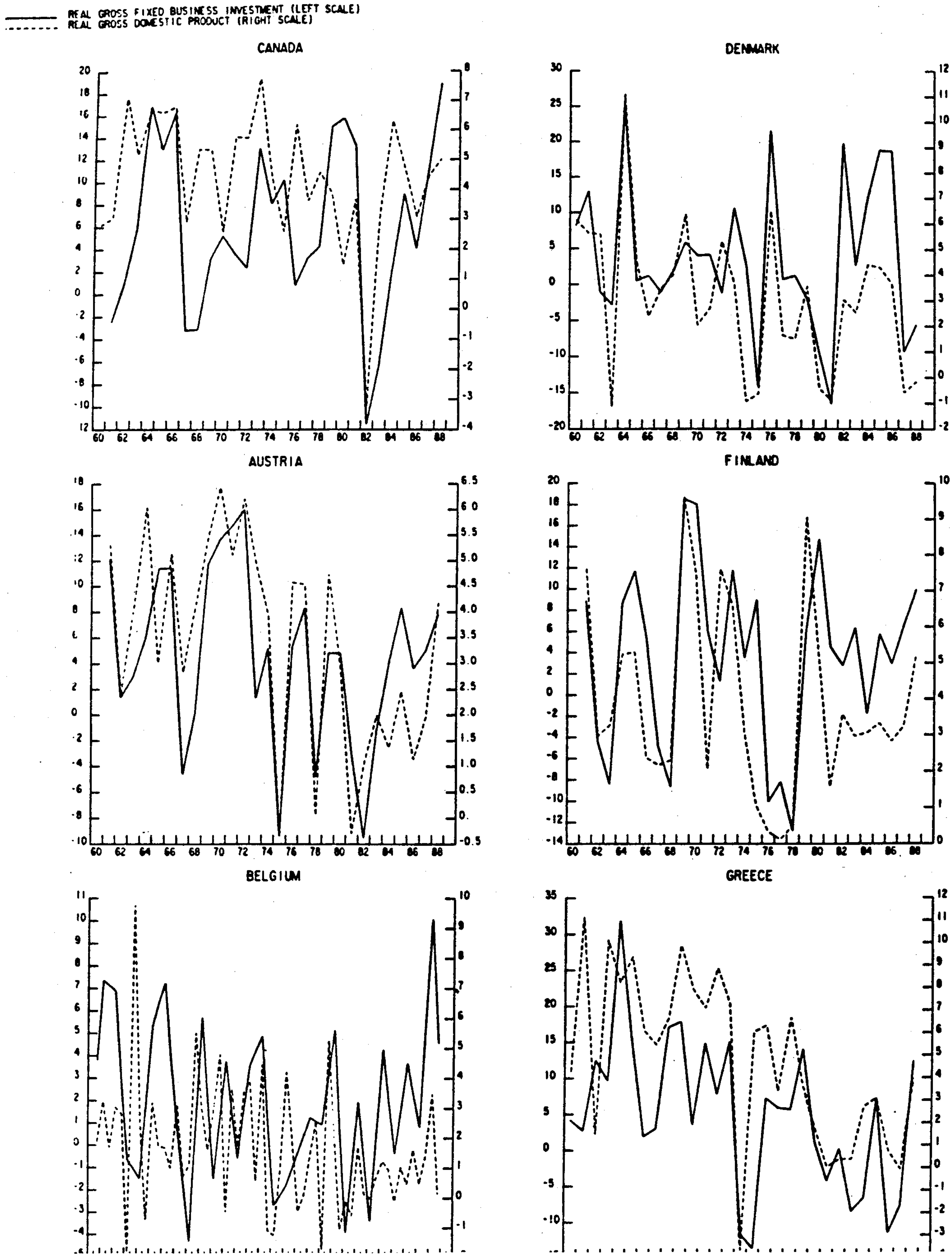

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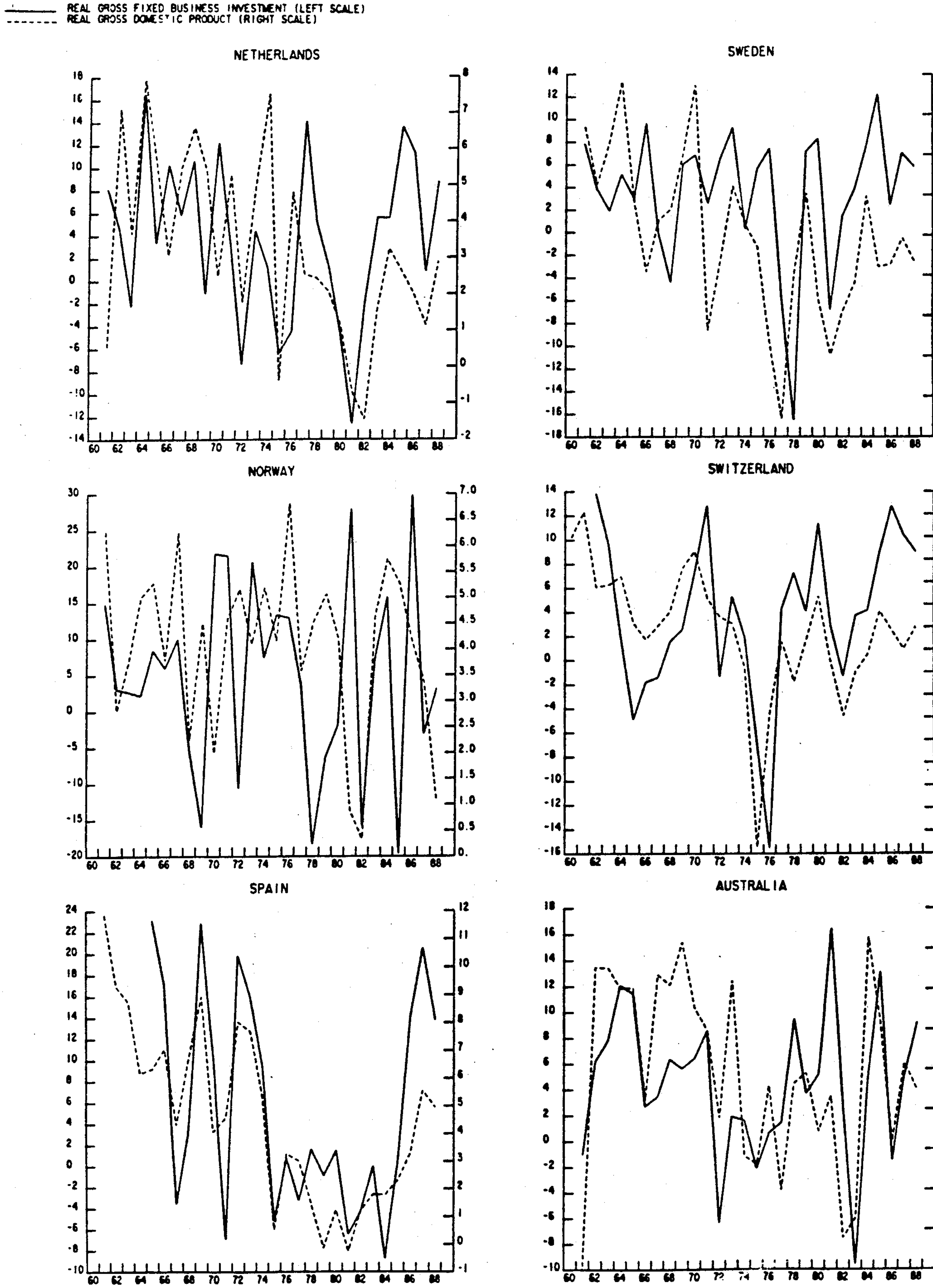
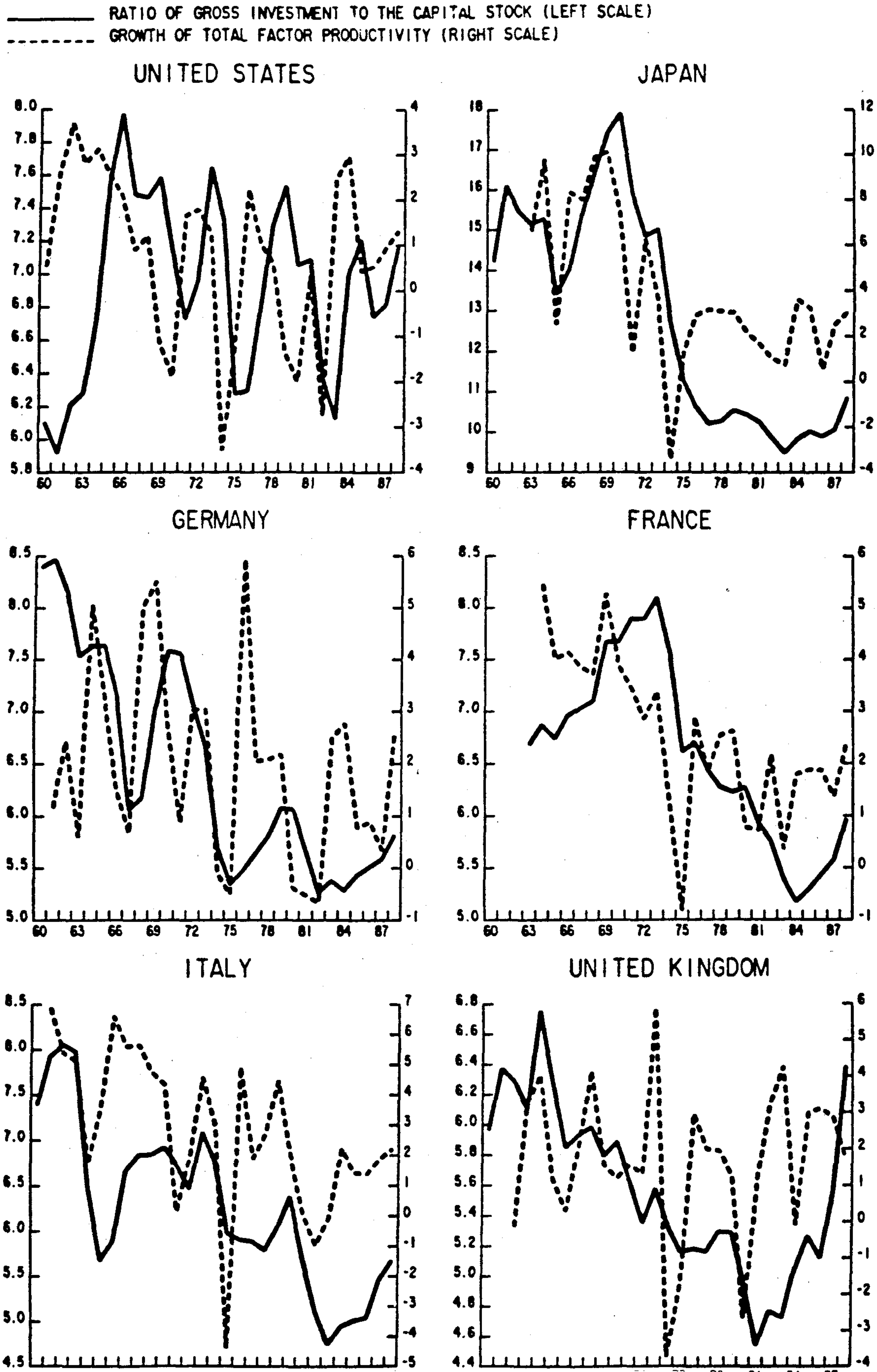


Chart G

Productivity, growth and capital replacement



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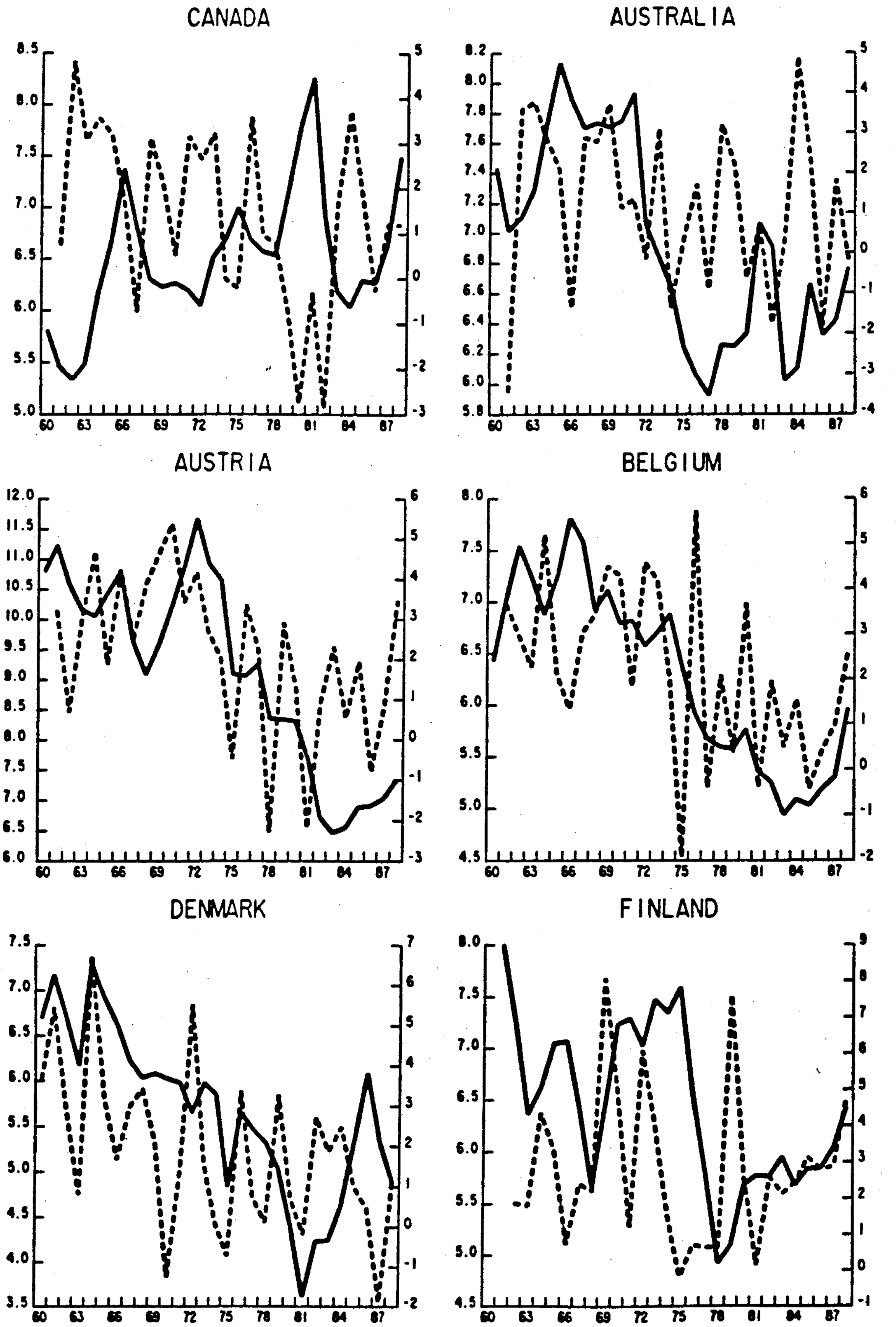

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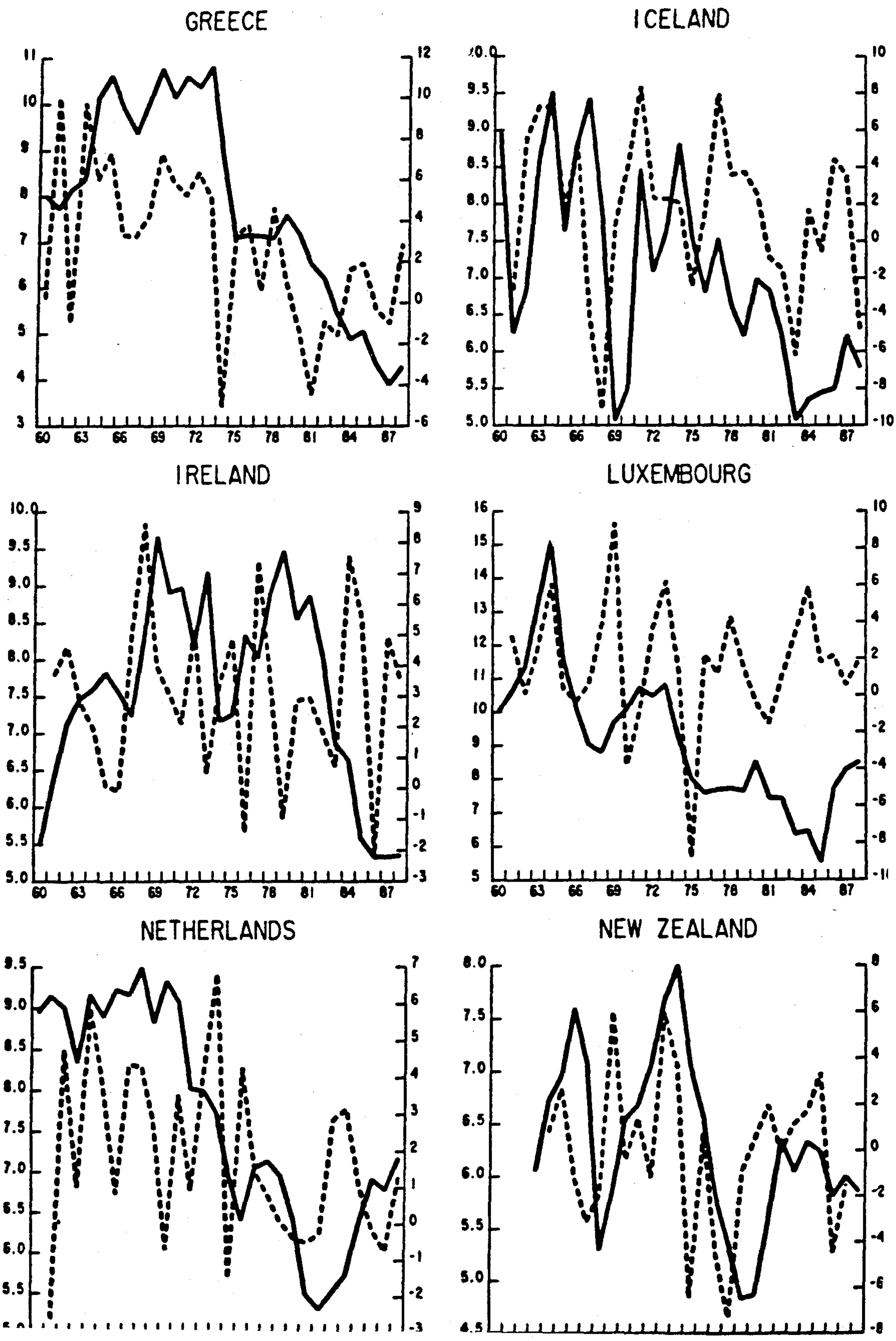

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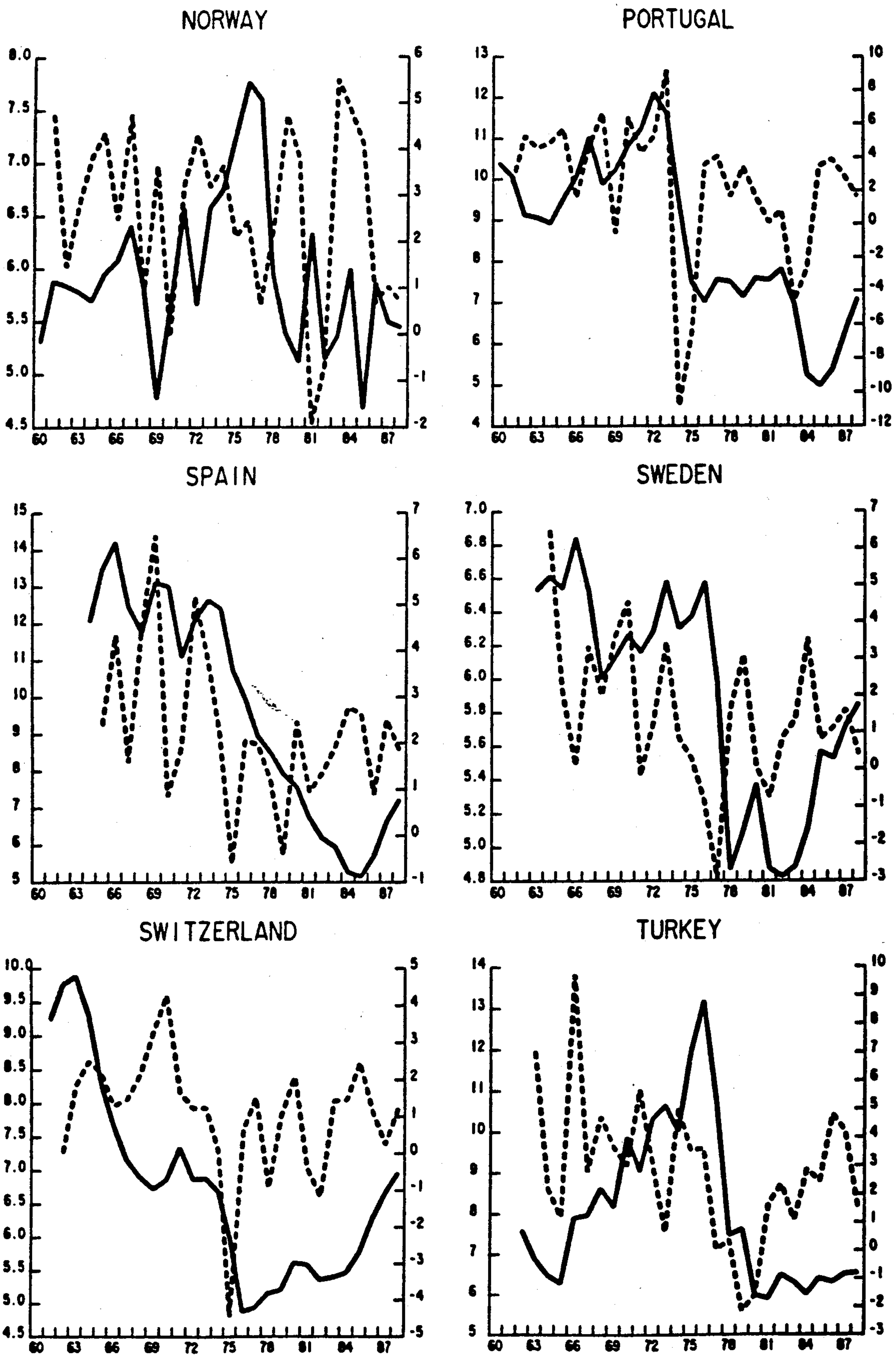
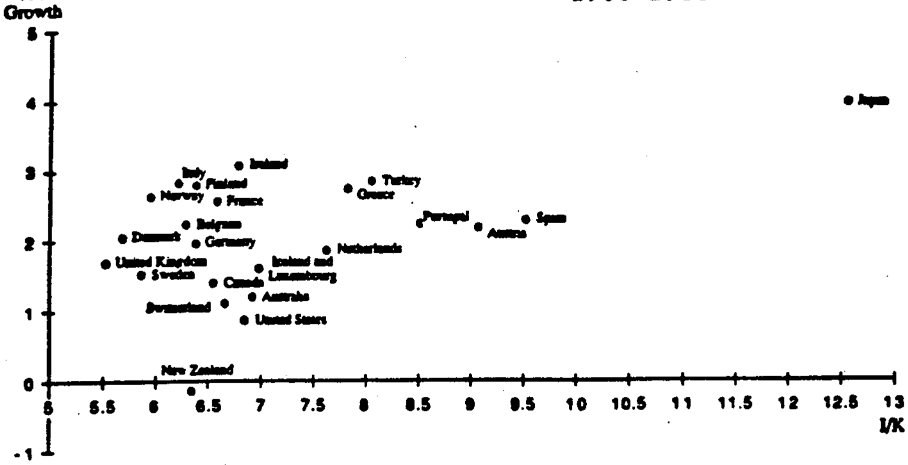


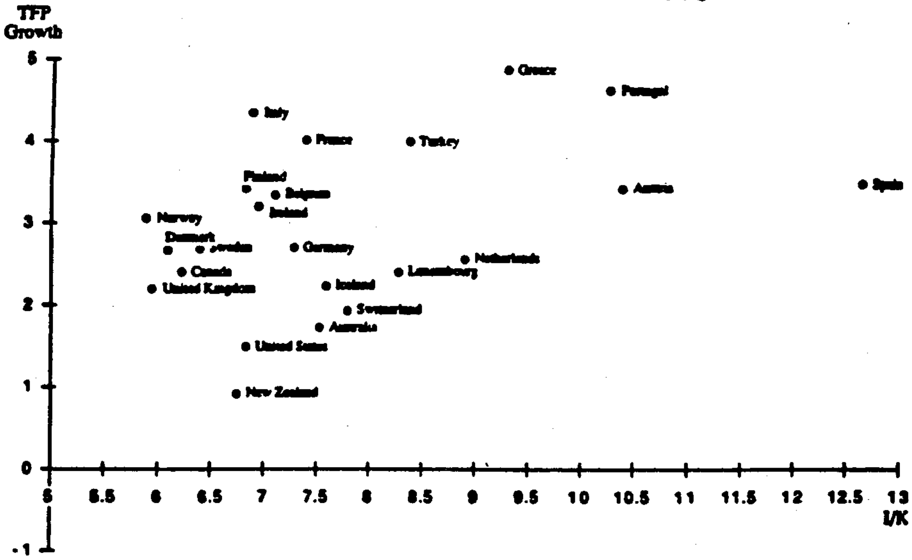
Chart H

Embodiment: replacement rate and growth of total factor productivity

1960-1988



1960-1973



1974-1988

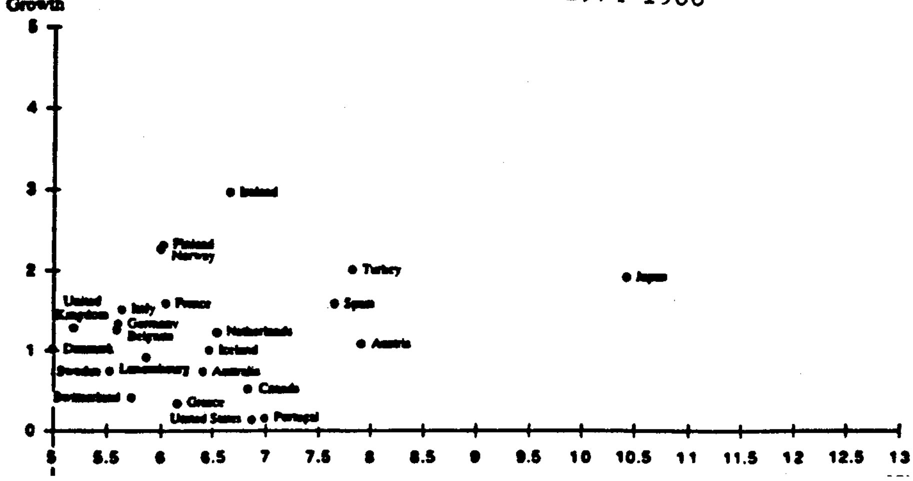
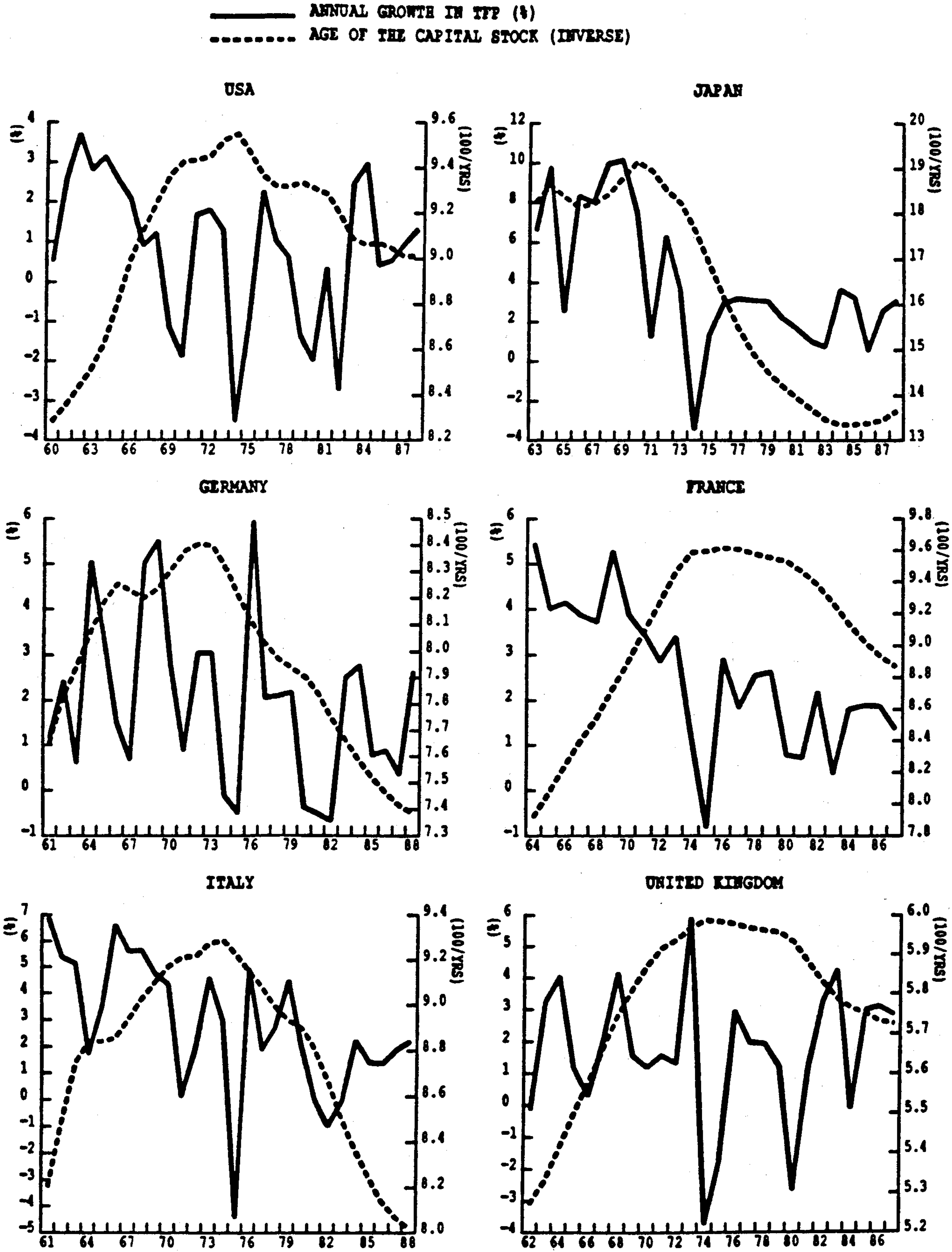


Chart I

TFP growth and average age of the capital stock



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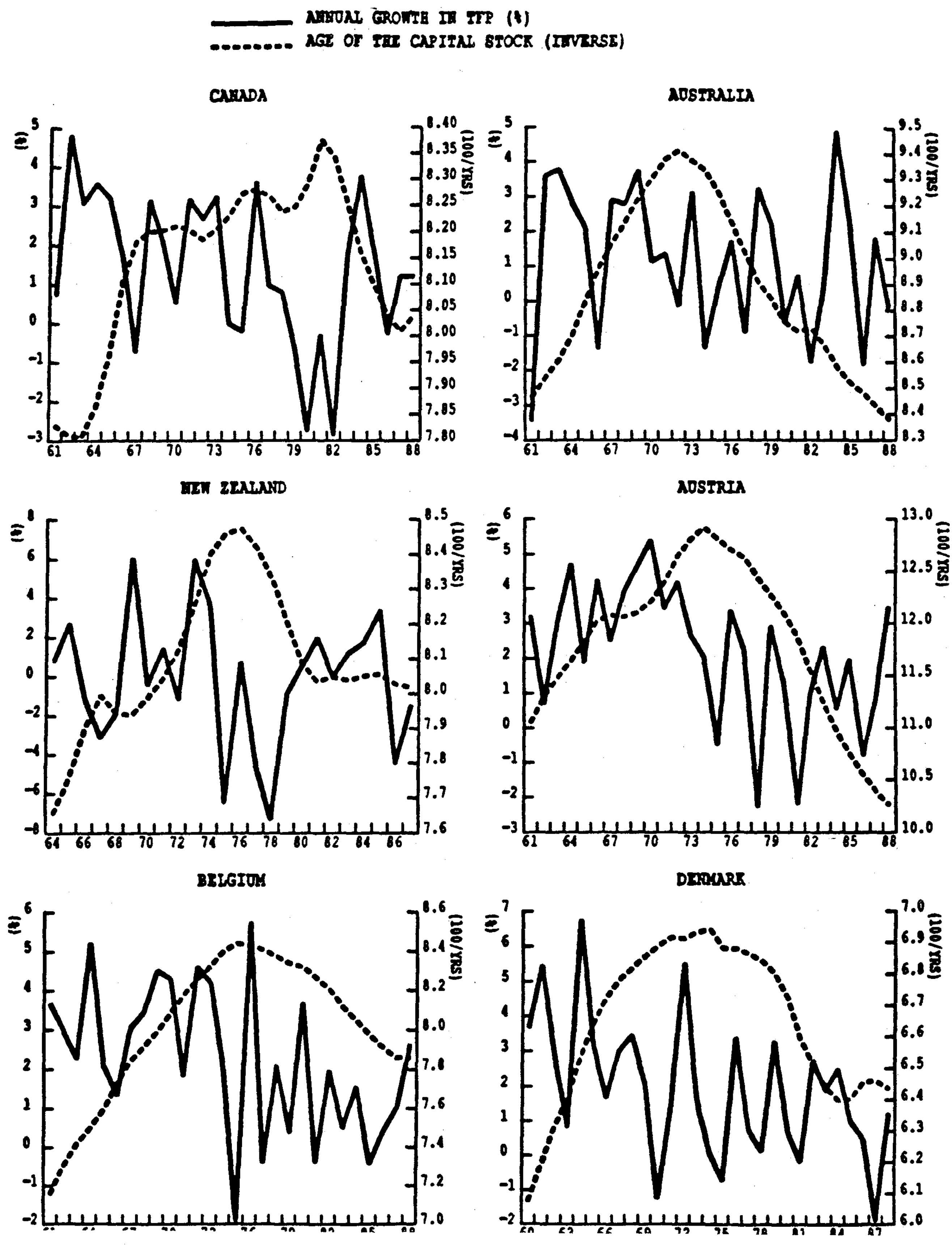

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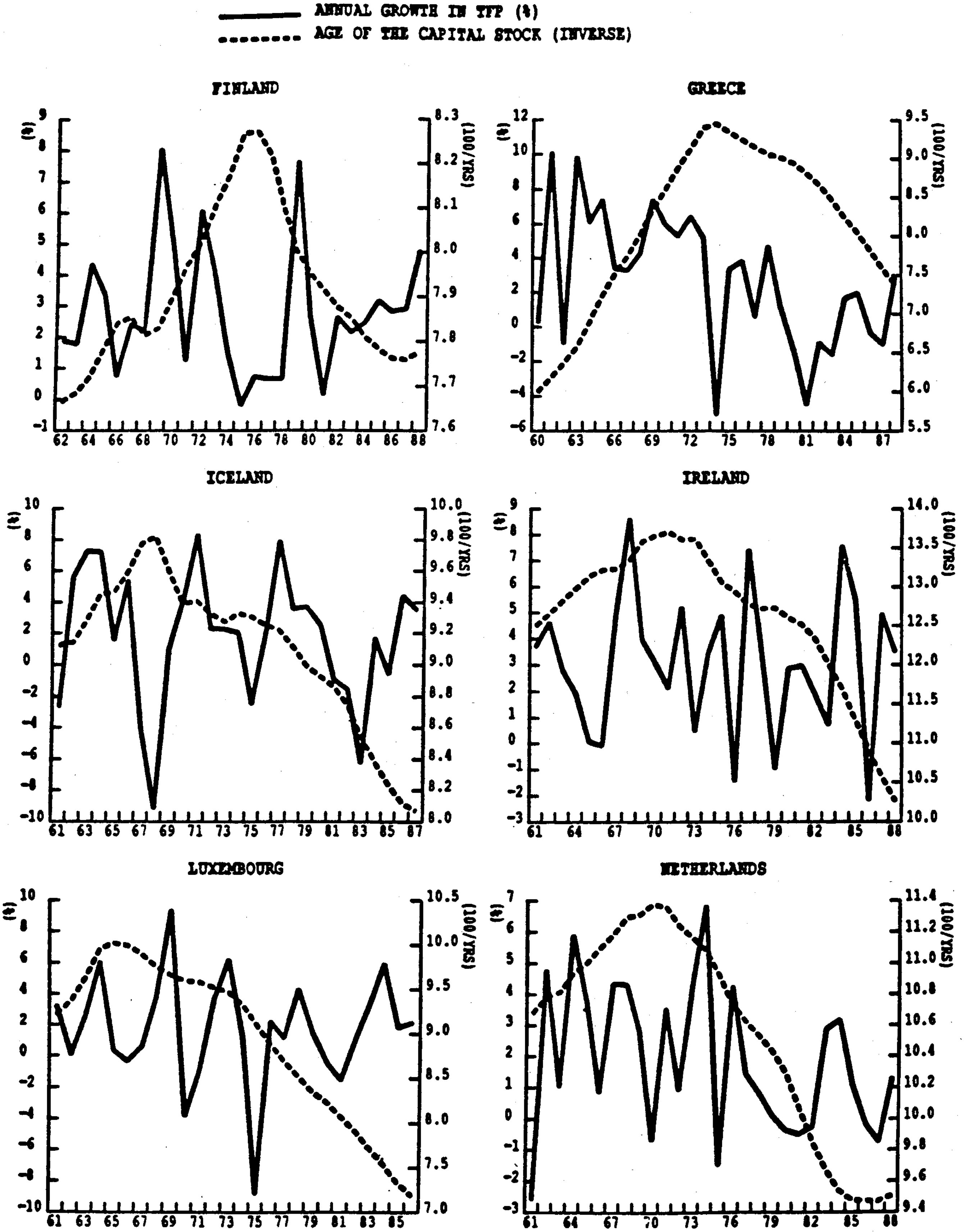

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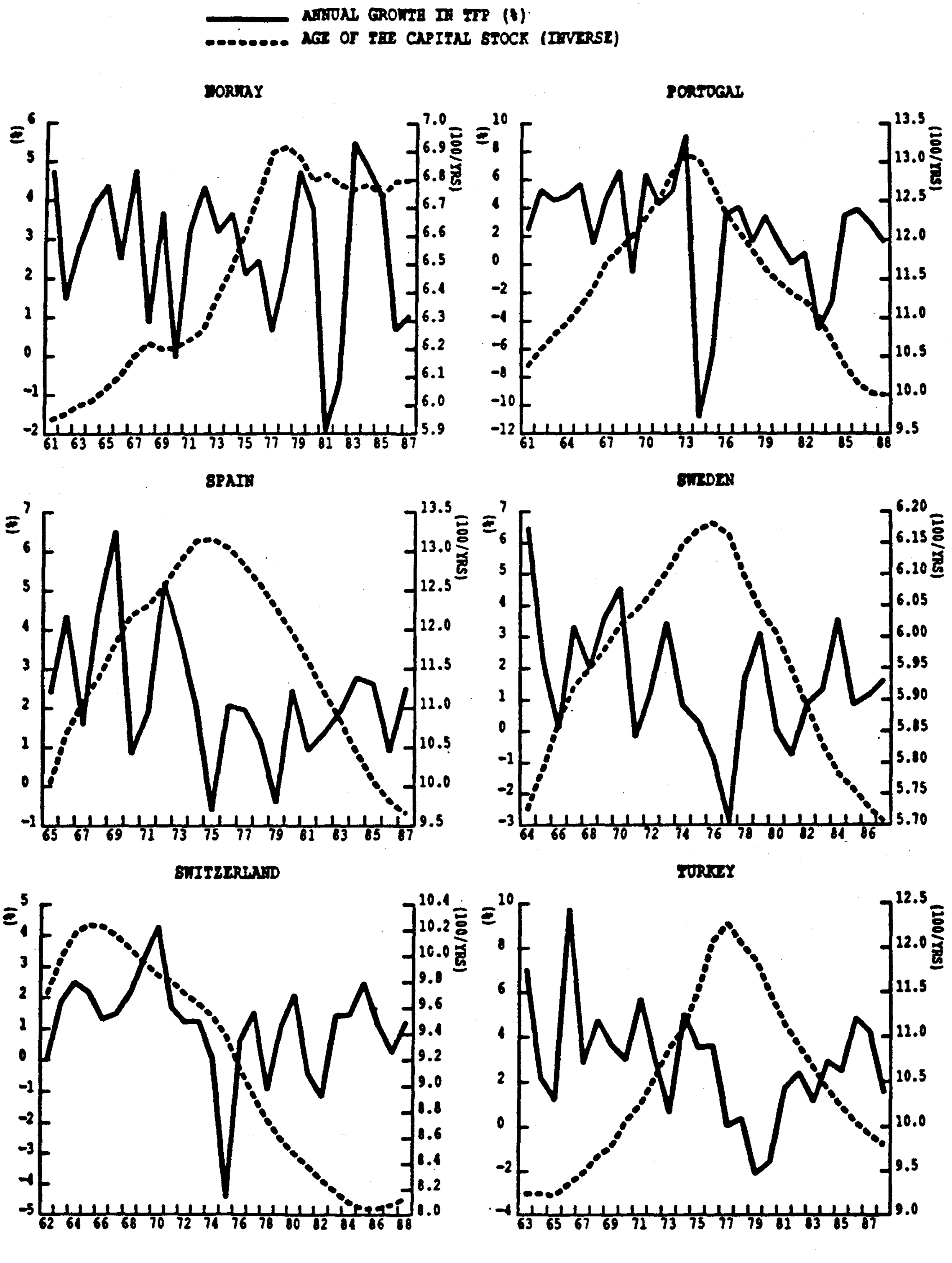

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   Patrick Artus

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