Bank of England

Discussion Papers

No 30

A model of UK non-oil ICCs' direct investment

by

E J Pentecost

November 1987

No 30

A model of UK non-oil ICCs' direct investment

by

E J Pentecost

November 1987

The object of this series is to give a wider circulation to research work being undertaken in the Bank and to invite comment upon it; and any comments should be sent to the author at the address given below.

The author would like particularly to thank S G Hall and S J Peachey from whose advice he has benefited greatly. A R Latter, C M Miles, J Ryding and M P Taylor in the Bank also made valuable contributions. None of these should be held responsible for any errors which may remain in the paper.

Issued by the Economics Division, Bank of England, London, EC2R 8AH to which requests for individual copies and applications for mailing list facilities should be addressed; envelopes should be marked for the attention of the Bulletin Group.

ISBN 0 903312 90 5
ISSN 0142-6753

A MODEL OF UK NON-OIL ICCS DIRECT INVESTMENT

C O N T E N T S

I INTRODUCTION

The purpose of this paper is to set out the methodology and empirical results of an extensive study of UK non-oil industrial and commercial companies (non-oil ICCs) direct investment abroad and of overseas direct investment in the UK's non-oil ICCs sector.

Foreign direct investment (FDI) refers to investment that is made to acquire a lasting interest in an enterprise operating in an economy other than that of the investor, the investor's purpose being to have an effective voice in the management of the enterprise. As this definition implies, net direct investment[1] is a financial concept and is not the same as capital expenditure on fixed assets or the growth of the company's net assets. Direct investment only covers the money invested in a related concern by the parent company and not how this money is used. A related concern may also raise money locally without reference to its parents or associates. If a parent company sold a proportion of its share holding in a foreign subsidiary to local interests this would be recorded as disinvestment, and if an affiliate raised local finance to repay short term indebtedness to its parent that payment would also be recorded as disinvestment, although in neither case would there be any change in the capital employed, only a redistribution between local and overseas interests. It is largely for this reason that direct investment is best modelled as a two-stage process; the first stage explaining the locational decision and the second considering the financial aspects.

Despite the vast literature on US direct investment abroad, which is reviewed in section III, little work has been done on modelling UK direct investment. Beenstock (1982), for example, notes a dearth of empirical work on UK direct investment in his survey of the area, the most recent study at that time being that of Boatwright and Renton (1975).[2] Recent work, with the exception of Vernon (1984), has not tackled the problem of modelling direct investment, but rather looked at surveys of individual industries for the motivation of FDI (as in Silberston, Shepherd and Strange (1985)), or settled for a more general approach in describing the role of multinational enterprises in the UK (as in Stopford and Turner (1985)).

---

1 Net direct investment in this context refers to new investment less disinvestment.

2 Previous work by Beenstock (1978) and Minford (1978) studied long term capital flows, which include both direct and portfolio capital flows, inter alia.

For Boatwright and Renton and Vernon the partial stock adjustment model is at the centre of the work, yet this is both restrictive and ad hoc, at least by today's standards. Vernon has FDI depending on world GDP, the lagged stock of real direct investment and an interest rate differential, while Boatwright and Renton include inter alia, the investment dollar premium, a weighted exchange rate index and the real user cost of capital weighted by industrial production. Neither paper includes relative unit labour costs among their explanatory variables nor do they treat the financing of direct investment as separate from the location decision. The most up to date treatment of these issues is to be found in Goldsbrough (1979) although the estimated equations are embedded in a partial adjustment framework. Another shortcoming of Goldsbrough's work in explaining UK outward direct investment is that he treats the host country as a weighted average of the twelve major industrial countries, whereas over 40% of UK outward investment stocks were in the developed primary producers, of which three of the four are excluded from the host country definition used.

The contribution of this paper is both theoretical and empirical. The theoretical novelty lies in the development of a model of the multinational firm with production facilities at home and abroad in which intra-firm trade flows are allowed alongside direct investment flows. Indeed one of the interesting empirical questions posed is whether exports are substitutes or complements to direct investment flows. The structure of the theoretical model also serves to emphasise the direct investment decision as a two-part decision, with the investment in physical assets distinct from the mode of financing, as noted most recently by Goldsbrough and Gilman (1981). The principal empirical contribution is the use of the two-stage estimation technique suggested by Engle and Granger (1987) to estimate a dynamic adjustment equation with the long run equilibrium captured by the inclusion of residuals from a prior levels regression.

The structure of the remainder of this paper is as follows. Section II examines UK direct investment data and in particular the geographical distribution of non-oil, industrial and commercial companies (ICCs) stock of foreign direct investment. This section also explains the method used to interpolate the total stock of non-oil ICCs direct investment. Section III provides a brief review of the literature on (mainly US) direct investment by considering the principal macroeconomic markets which various theories have emphasised in attempting to explain the determinants of FDI. Section IV is the theoretical section of the paper. A neoclassical two-country model of the firm is set up to yield a reduced form equation which gives the principal determinants of the foreign direct investment stock. These turn out to be:

domestic and foreign real factor costs, aggregate demand in each country and net exports from the home country, the latter providing an explicit linkage between the current and capital accounts of the balance of payments. Section V provides an outline of the Engle-Granger two-stage estimation procedure noted above and discusses the empirical results obtained from the application of this technique to the reduced form of the model.

II THE DATA

(i) Data sources and problems

The primary source of estimates of annual flows of direct investment is the Business Monitor MA4 and for stocks the (generally) triennial annex to that publication. These estimates are derived from regular enquiries by the Department of Trade and Industry (DTI), the Bank of England and the British Insurance Association. The CSO publication, United Kingdom Balance of Payments (the 'Pink Book') also gives annual stocks and flows of UK inward and outward direct investment including a sectoral breakdown. The March, June, September and December issues of Economic Trends report quarterly direct investment flows, but this data is generally regarded as less reliable than the annual data since it is based on interpolations from a smaller sample of companies than the annual enquiry and so is frequently subject to very large revisions.

The stock of direct investment assets outstanding at year-end is available annually by geographical location from 1962 to 1971, after which only triennial surveys exist of the geographic breakdown of non-oil, non-bank direct investment stocks (for 1974, 1978, 1981 and 1984). Only the 1984 survey includes oil, banks and insurance companies. Although the contribution of these industries can be unravelled in total the geographical distribution cannot be reconstructed on a consistent basis. A similar structural break exists in the flow data with the inclusion of oil companies on the same basis as other industrial and commercial companies from 1984.

Flow data on direct investment is available annually since 1962 by country, region, sector and industry but this series includes flows attributable to banks and insurance companies. Hence the flows data and stock data are not consistent. The relatively small size of these financial flows in the 1960s and early 1970s may not have given rise to any serious discrepancies, but the increase in UK banks' direct investment since 1975, the abolition of exchange controls and the so-called 'deregulation' of financial services in the UK in the early 1980s will all have served to increase the inconsistency between flow and stock data. In the flow data, however, up until 1984 oil companies direct investment was separately identified, and, using confidential data, the banks contribution can be stripped out for each year since 1975 except 1979.

These data inconsistencies pose serious problems for the empirical researcher. So from the outset it was decided to use annual flow data corresponding only to the 'non-oil ICCs' sector. This restriction has several advantages. First most of the stock data (excluding 1984) is directly compatible with this definition. Second this definition includes the historically most important category, in terms of size, manufacturing. Third it excludes outward direct investment by UK banks, which sidesteps the problem which results from their practice of 'upstreaming' whereby the proceeds of loans raised by borrowing by the banks' overseas subsidaries are on-lent by them to their parent companies. In the published data these flows are treated as outward disinvestment and can outweigh other more traditional forms of direct investment, leading to a negative recorded stock in some instances.

Finally there may also be problems with the valuation of overseas asset stocks, especially since the move towards floating exchange rates in 1972. The DTI's annual enquiry asks companies to report stocks outstanding at the end of the calendar year or at the balance sheet date nearest to the year-end. With volatile exchange rate movements the difference between the exchange rate at end-December and the exchange rate prevailing at the balance sheet date could be highly significant and result in an over- or under-valuation, in sterling terms, of the firm's overseas direct investment assets. There may be a further accounting problem relating to the different accounting practices followed in the developed world. Additionally, firms are implicitly assumed to value their overseas assets in local currency terms and convert them back into sterling, but in some high inflation developing countries it is possible that companies actually value their assets for balance sheet purposes in terms of their domestic currency value, or perhaps, some international currency such as the US dollar. There is, however, no information available on the extent of this practice and so in what follows it is assumed that all outward investment stocks are measured in foreign currency (converted back into sterling at end-year exchange rates) and that inward stocks are valued in sterling and are thus not affected by exchange rate fluctuations.

(ii) Interpolating non-oil ICCs stocks of direct investment

The stocks of non-oil ICCs direct investment are published for the years 1962-71, but have to be constructed for the 1970s and 1980s using the triennial surveys in 1974, 1978 and 1981 as benchmarks. The interpolation of the inward stock is relatively straightforward. The stock at end-1971 is recorded to which is added the flows in 1972, 1973 and 1974. This gives a calculated stock figure for end-1974 which is compared with the actual published stock for that year. Any discrepancy between these stocks is spread equally over the three years 1972-74 inclusive, so that the end-1974 stock corresponds to the published figure. This procedure is repeated for subsequent years. In algebraic terms the capital stock, S, is:

$$S_t = S_{t-1} + F_t + \upsilon \qquad (1)$$

where F is the annual flow and υ is the residual, calculated as the difference between the published and calculated stocks.

The stock of outward direct investment assets outstanding at the end of any one year is based on a similar calculation to that underlying equation (1), although in practice the computation is more complicated because of the decision to use quarterly data to allow more accurately for the effect of exchange rate movements on the asset stocks. Moreover, since each foreign currency can move independently against sterling a reasonable assessment of valuation changes can only be made by including a large number of exchange rates,[3] since UK outward direct investment stocks are spread widely around the world. In terms of foreign currency the formula for each country, i, is

$$e_{it} S_{it} = e_{it-i} S_{it-1} + \bar{e}_{it} F_{it} + V_i \qquad (2)$$

where e_t is the end period exchange rate at time t, S_t is the sterling capital stock outstanding at time t, $\bar{e}_t$ is the average exchange rate in period t, and F_t is the sterling flow during period t. V_i is the country residual, which is made up of local currency revaluations and coverage changes, and computed as:

$$V_i = (e_{i\tau} S_{i\tau} - e_{i\tau-12} S_{i\tau-12} - \sum_{\tau=1}^{12} \bar{e}_{i\tau} F_{i\tau})/12 \qquad (3)$$

where τ is a quarterly time subscript. The sterling value of the overseas direct investment stock is obtained by summing overall countries, that is:[4]

---

3 In practice this turned out to be 30. The constraints were the level of disaggregation of the direct investment stocks and flows and the availability of exchange rate time series for some developing countries.

4 There is another small residual since not all countries could be included in the index i due to data deficiencies (see footnote (3)). Any differences between the computed and published triennial benchmark totals was distributed evenly over the intervening period.

$$\sum_i S_{it} = \sum_i ((e_{it-1} S_{it-1} + e_{it} F_{it} + V_i)/e_{it}) \quad (4)$$

(iii) The pattern of UK direct investment

The nominal stock of inward direct investment in UK 'non-oil ICCs' has grown at an average 13% per annum over the period 1962-85 (although at only just over 5% in constant 1980 prices).[5] The rate of growth has been faster since the early 1970s than in the 1960s although, as charts 1 and 2 show, this largely reflects higher inflation rates. In real terms since 1973 the annual average growth rate has been about 1% whereas during the 1960s and early 1970s the stock grew at 8% per annum in real terms. As a percentage of GDP the inward investment stock rose to a peak in 1974 after which it has subsequently fallen back to its level of the late 1960s.

The breakdown by country (see chart 3) shows the dominance of the USA, although there seems to have been a structural break around 1974, as the US share fell 10% never to recover. Western Europe is easily the second largest investor in the UK with around 20% of the inward stock in the late 1960's which rose to almost 30% in 1974-8, stimulated by the UK's entry into the EEC, although the 1981 figures show a fall back to about 26%. (Note that the 1984 figures, which show a sharp rise, include oil companies and hence the treatment of the Royal Dutch Shell Group is likely to have had considerable impact on this share). The largest European inward investor is Switzerland, owning stocks with a book value in 1984 of nearly £2 bn, mainly concentrated in the chemical industry. Japan was eleventh in the ranking in 1981 and eighth in 1984, having jumped above Sweden, South Africa and Australia. There was, however, no visible leap in Japanese inward direct investment between the late 1970s and mid-1980s.

The stock of outward direct investment has grown on average by 12 1/2% per annum in nominal terms since 1962, although by only 4% per annum in constant prices. Unlike the inward stock, the outward stock has grown faster since 1974 in both money and real terms, than in the 1960s. As a percentage of GDP the stock of outward investment fell sharply between 1976 and 1980, but then

---

5 The UK capital goods price index was used to deflate the stock of nominal inward investment. The outward stock was deflated by a computed sterling index of world capital goods prices, allowing for exchange rate movements. See appendix IV.

Chart 1: Non-oil ICCS nominal direct investment stocks

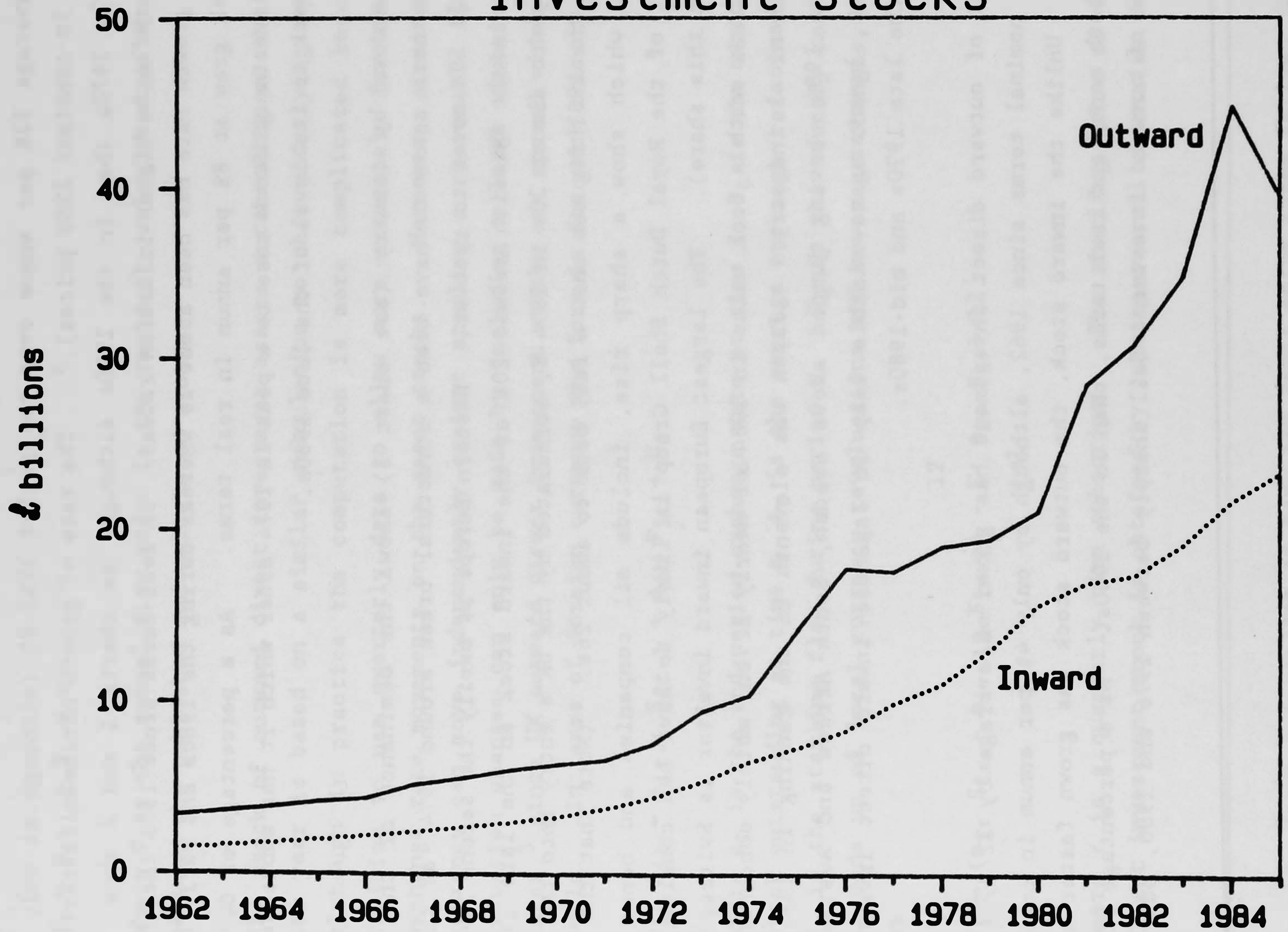
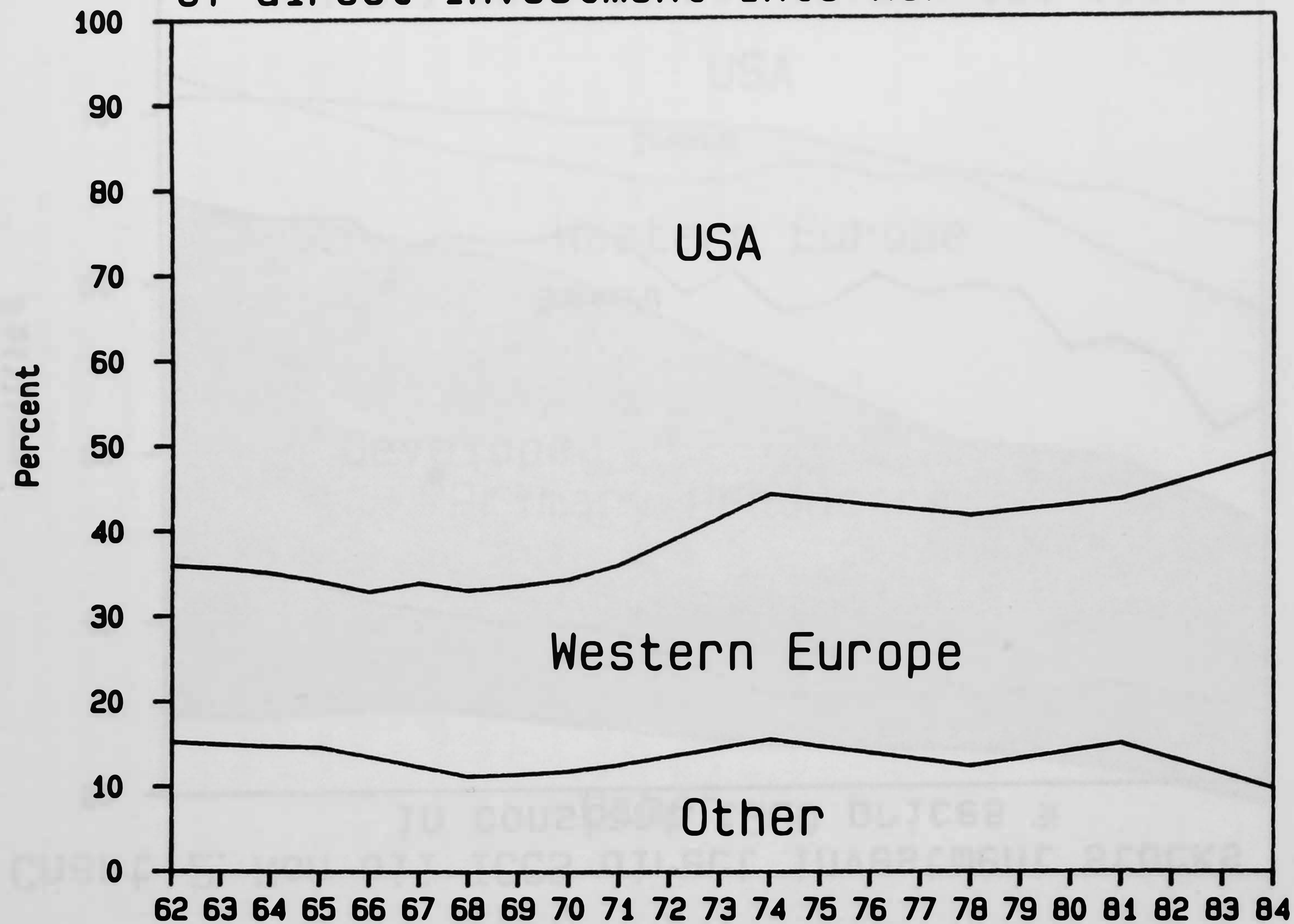
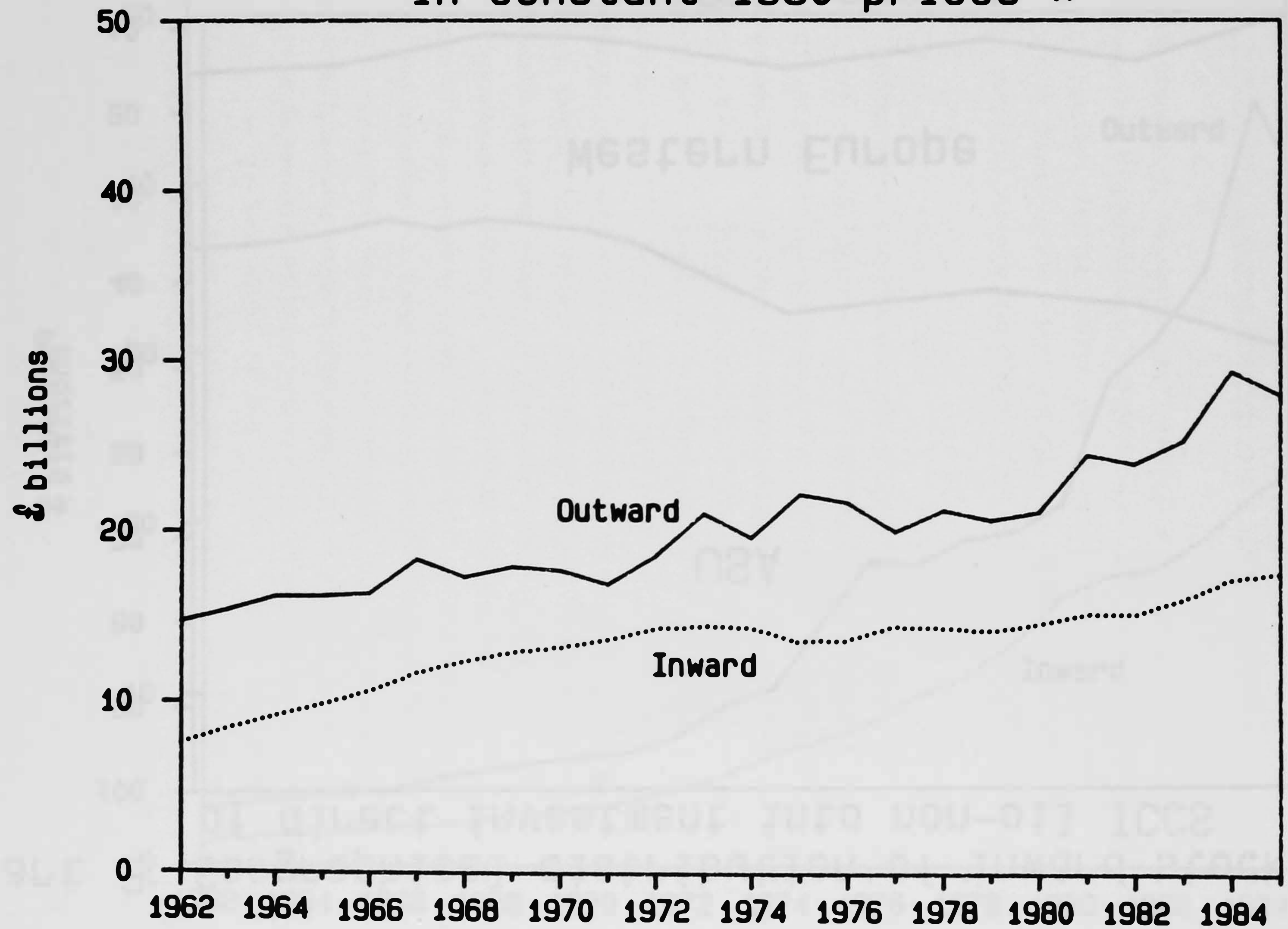


Chart 3: Geographical distribution of inward stocks of direct investment into non-oil ICCS



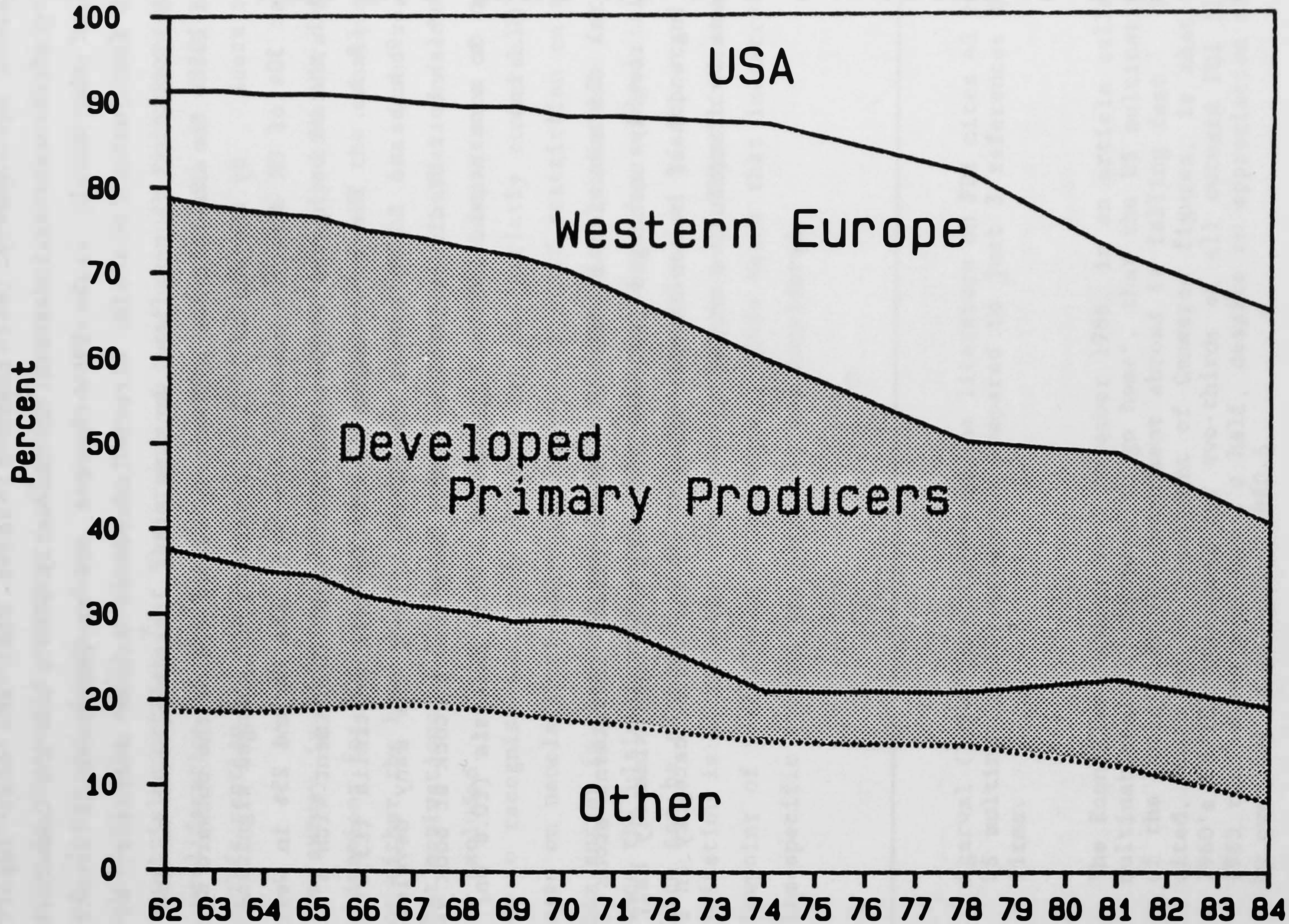
Shares in 1984 include banking, oil and insurance

Chart 2: Non-oil ICCS direct investment stocks in constant 1980 prices *



* See footnote 5 and appendix IV for price deflators used

Chart 4: Geographical distribution of outward non-oil ICCS direct investment stocks



Shaded area represents former members of the British Empire
Shares in 1984 include banking, oil and insurance

outward investment fell sharply between 1976 and 1980, but then rose almost as sharply between 1980 and 1984. These trends reflect rapidly rising nominal GDP in the second half of the 1970s and the slowdown in the early 1980's as inflation was brought under control.

The breakdown by country (see chart 4) shows that the most important destination of UK overseas investment in the early 1960's was the Commonwealth with 60% of the total. In 1984 current and ex-Commonwealth countries accounted for just 32% of UK direct investment assets overseas, as an increasing proportion of new flows went to other locations, such as the US. In the mid-1960s the USA held 10% and Western Europe 15% of the outward direct investment stock. By the end of 1981 this pattern had changed significantly with almost 30% of UK direct investment assets in the US and 25% in Western Europe, with the US being the largest recipient of UK investment with a stock of nearly £8 bn. The other major recipients were Australia (£3.6 bn), Canada (£1.9 bn) and South Africa (£1.8 bn). Of the many developing countries which host UK direct investment only three had a stock at book value of £0.5 bn or more at end 1981: Nigeria (£0.7 bn), Malaysia (£0.6 bn) and Zimbabwe (£0.5 bn).

The sectoral distribution of the UK outward direct investment stock (see Chart 6) is roughly unchanged from the mid-1960s with approximately half in manufacturing and half in non-manufacturing. Of the latter category in 1981 about 30% was in distributive trades.

III A BRIEF REVIEW OF THE LITERATURE

The most notable feature about the literature on foreign direct investment is that it is predominantly concerned with FDI originating from the United States.[6] This is, of course, largely explained by the fact that US multinationals have for over a quarter of a century been a very important force in the world economy. Although British, and more recently West German and Japanese firms, have expanded overseas production the US-based multinationals still dominate in terms of size and number those of the other industrial countries.[7] The growth of international firms has coincided with a proliferation of the literature on FDI, some aspects of which are reviewed in this section.[8]

This survey is selective in the sense that it only considers the possible motivations for FDI and does not attempt to evaluate the consequences of FDI for either the host country or for the firm itself. A second restriction is that motivations of FDI based on socio-political or other non-economic factors are excluded. This is not to deny the possible importance of these factors but to recognise that such theories are not strictly comparable with models based on neoclassical economic theory. A third restriction on the scope of this survey is that only models which are empirically testable are considered. Since the ultimate purpose of this work is to set up a model to explain FDI which can be estimated statistically this criterion is important. A final limitation is to note that the primary interest is direct investment from the viewpoint of the balance of payments. This means that industry-specific or firm-specific studies are generally not considered.

---

6 Agarwal (1980) in a survey of the literature on FDI cites 42 references to US multinational's behaviour compared to just 3 references to FDI by UK firms.

7 The Economist reports on 6 December 1986, in an article called "American multinationals - the urge to go home", that the US multinational's share of the world's direct investment abroad is falling fast. The evidence cited, based on US Department of Commerce figures, is that in the mid-1960's US FDI accounted for two-thirds of all outward FDI flows, but in 1985 that share sunk below a half, despite an appreciation of the dollar by over 50% in the years 1980-5.

8 For more detailed reviews of the literature see Agarwal, op cit, Buckley & Casson (1976), Caves (1982), Dunning (1973) and Kyrkilis (1986).

Chart 5: Sectoral distribution of inward stocks of direct investment into non-oil ICCS

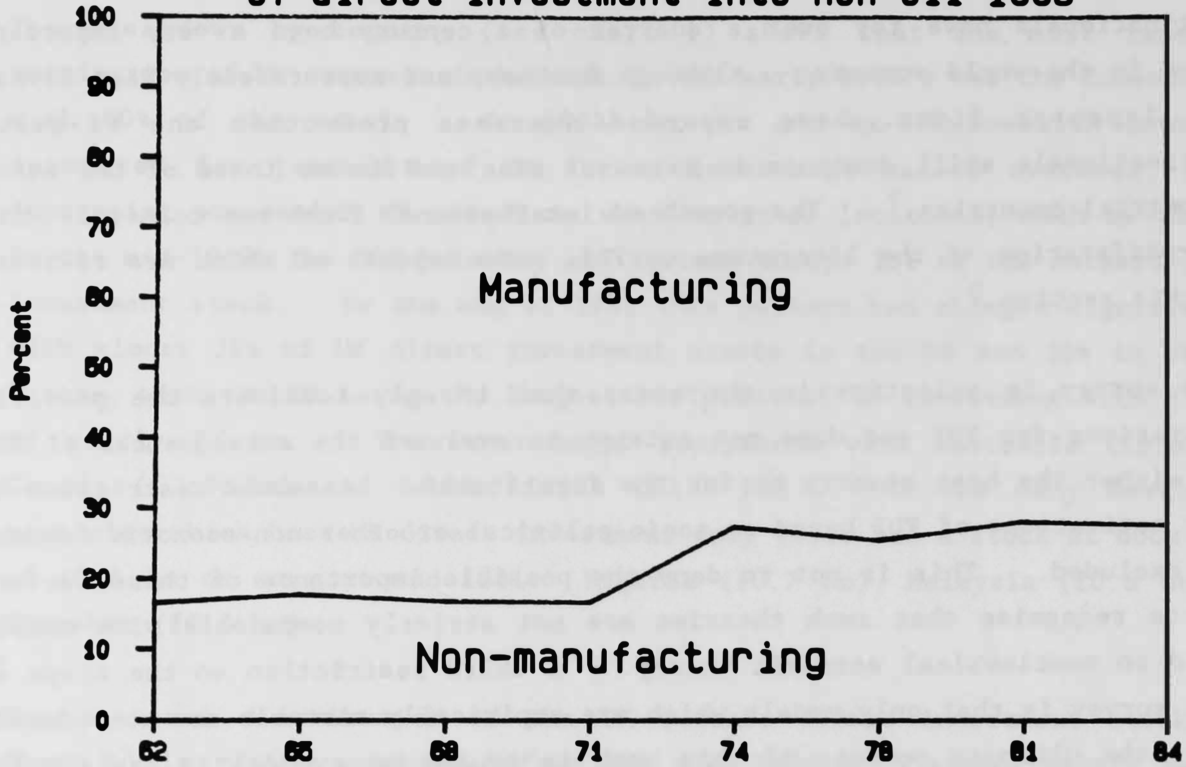
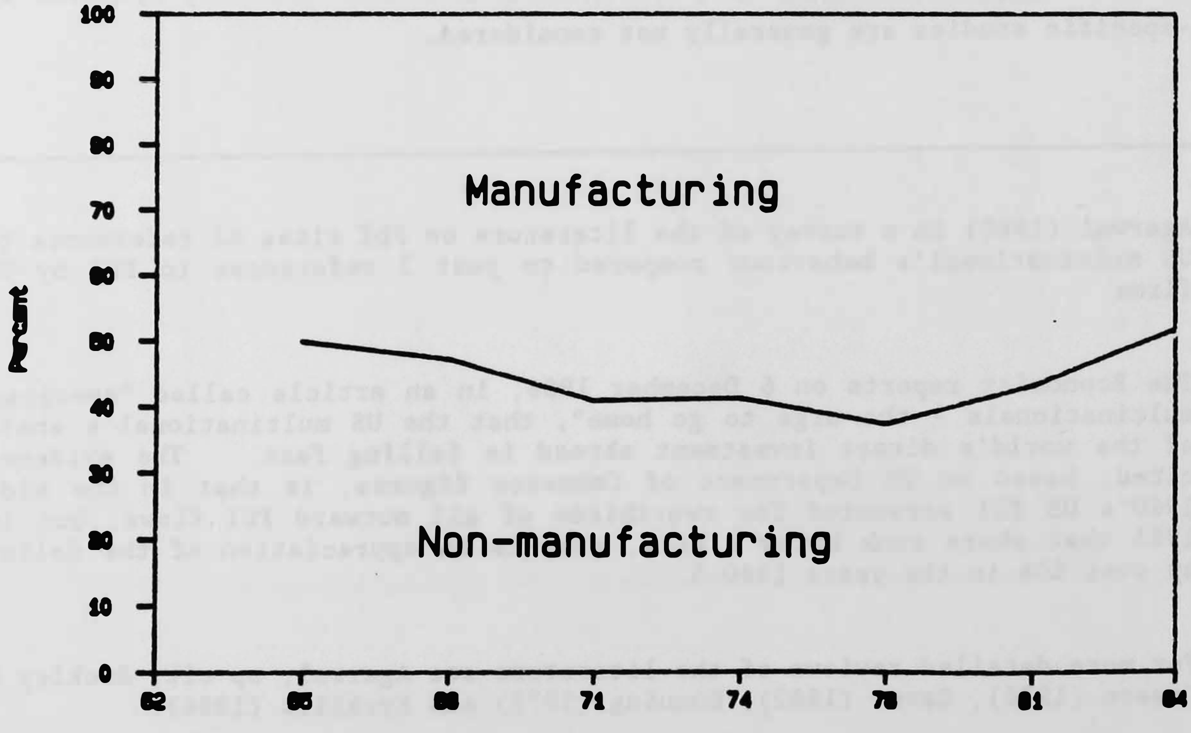


Chart 6: Sectoral distribution of outward non-oil ICCS direct investment stocks



The explanations of foreign direct investment which fall within the restrictions outlined above can be divided into three broad classes. The first category emphasises goods market factors: that is the need for the firm to maintain output growth and market share and to avoid tariff and non-tariff barriers on its potential exports to overseas markets. The second class of models emphasises the importance of factor markets. These theories focus on the relative rates of return on capital and the relative costs of labour (as a proxy for total variable costs) in domestic and foreign markets. Thirdly, perhaps more akin to theories of portfolio investment, there are models of direct investment which focus on the importance of financial markets. These theories perceive FDI as the way in which the firm minimises the risk to its total expected returns, by diversifying its investments geographically. The firm is thus hedged not only against unfavourable exchange rate movements but also against local demand fluctuations and unforeseen political events.

(i) Goods Market Hypotheses

- Output Growth/Market Size Theories

These theories are based on the application of Jorgenson's (1963) domestic investment model to FDI. Thus the desired foreign capital stock depends positively upon output and negatively on the user cost of capital. The desired foreign capital stock is reached by a partial adjustment mechanism, hence the flow of FDI depends, inter alia, upon output. Kwack (1972) applied Jorgenson's model to US quarterly data for FDI from 1960 Q3 to 1967 Q4 and found that the flow of FDI depends upon the value of foreign output of non-financial US corporations, the initial value of their FDI, the cash flow (net of dividends) and the US rate of interest (a proxy for the user cost of capital). Stevens (1969a) demonstrated a statistically significant relation between the flow of FDI from the USA to Argentina, Brazil and Venezuela and the sales of US companies in the manufacturing sector of these countries during 1957-65. Scaperland and Mauer (1969) examined the relation between US FDI in the EEC countries and their incomes (GDP) for the period 1952-66 and concluded that the market size hypothesis was supported empirically. Goldberg (1972) has, however, contradicted this result. He maintained that these investments could be explained not by the size of the EEC market but by the growth of the market. Reuber et al (1973) found the flow of FDI (on a per capita basis) into a large sample of developing countries was correlated with their GDP but not with the growth of their GDP. Severn (1972) also found in favour of the market size hypothesis. The most recent application of the Jorgenson hypothesis to FDI flows is that of Goldsbrough, who found that output was the most important determinant of FDI between the UK, US, West Germany and Japan over the period 1961 to 1977, using semi-annual data. However, the coefficients on output were generally statistically insignificant at the five percent level. Silberston, Shepherd and Strange found from a survey of UK manufacturing firms that the most important single factor determining the firm's decision to invest abroad was the need to either maintain the growth of the firm or the firm's share of the world market for its products.

Despite the apparent support for the market size hypothesis considerable care needs to be taken in interpreting the significance of these results. First both of these hypotheses are based more or less on the assumptions of the neoclassical theories of investment which are surrounded with a great deal of unrealism. Second, the size and growth of the markets of the host countries are likely to influence the FDI undertaken to produce goods for those markets but not the FDI motivated to produce exports from these countries. But most studies of the market size hypothesis fail to distinguish between the various kinds of FDI because of statistical limitations. Third, the growth of FDI and GDP are mutually related and the correlation between them may not say much about the structural relationship between them. Fourth, the output hypothesis should take into account only the investments which are incurred on plant and equipment in the host countries as is the case with domestic investment. But the statistics on FDI also include sums involved in inventory as well as financial assets and it is not correct to equate these investments with plant and equipment expenditures. Finally, the decision of firms on initial FDI and expansionary FDI are very likely to be different. Penrose (1956), for example, claims that once established a subsidiary has a life of its own. Its expansionary investments have to be analysed differently compared with those involved in the initial decision of the firm to invest in a particular foreign country.

- The Product Cycle Theory

Vernon (1966) offered an explanation of both US FDI and trade by focussing on the life-cycle of a product. In the first stage when the product is new it is produced by the innovating firm in its home market. The second stage is marked by the maturing of the home market and the export of the good to countries having the next highest level of income. Eventually the expansion of foreign demand and growing competition in export markets lead to FDI, and the third stage of the cycle, where FDI substitutes for exports. Initially there was considerable support for this hypothesis, particularly regarding US FDI. Gruber et al (1967) found a strong association between the propensity to invest in new products, export performance, FDI and the ratio of local production to exports on the one hand and R & D expenditure of US industries on the other hand. The relation between the ratio of local production to exports and R & D expenditure is interpreted as an indication of the substitution of FDI for exports to host countries in the final stage of the product cycle. Horst (1972) undertook a similar analysis for US exports to Canada. He found that the technological intensity of US manufacturing industry was more closely related to the sum of that industry's exports to Canada and its subsidiary sales in Canada than it was to either exports or sales taken separately, implying that FDI and exports may be substitutes. Juhl's (1979) findings lend support to the product cycle theory for German FDI in developing countries.

However, the product cycle hypothesis is perhaps less convincing today than it was twenty years ago. There is empirical evidence that both exports and FDI have increased over the last thirty years for all the major industrial countries, suggesting complementarity rather than substitutability of exports and FDI. Second, the technology leadership of the US has suffered badly in recent years and the income differences between the developed economies have levelled down. Thirdly, as noted by Krugman (1983) the relationship between FDI and exports may depend on whether the multinational is vertically or horizontally integrated. Horizontally integrated multinationals are vehicles for trade in information: hence the transfer of technology rather than of goods is fostered and so FDI is a substitute for exports. But vertically integrated multinationals encourage trade since the profit of the firm will be larger than the sum of that of the component firms. Vertical integration increases output of previously independent firms, reduces costs and allows a profitable expansion of total output; therefore exports (including intra-firm trade) are larger than before.

- Market Imperfections Hypothesis

Another common hypothesis is that FDI is a result of market imperfections, such as tariff barriers. The levy of a tariff on the home country exports by the recipient country will raise the price of exports in the foreign market and lower the demand. The effect of the tariff is to switch local demand away from imported goods (home exports) to locally produced goods. The domestic firm could circumvent these barriers to trade by undertaking FDI in the country concerned. Against this argument is the view that the firm could overcome these barriers by licensing, renting or selling technical skills, rather than undertaking direct investment. Another similar argument is that of Buckley and Casson (1976) and Dunning (1979) who argue that the markets of key intermediate products such as human capital, knowledge, marketing and management expertise are imperfect; therefore linking different activities through these markets involves significant time lags and transactions costs. As a result firms are encouraged to replace these external markets by their own internal markets for these products. The internalisation of markets across national boundaries leads to FDI, and this process continues until the benefits and costs of further internalisation are equalised at the margin.

(ii) Factor Market Hypotheses

- The Differential Rate of Return Hypothesis

This hypothesis postulates that FDI is a function of international differences in the rates of return on capital investment. FDI flows out of countries with low returns to those locations expected to yield higher returns per unit of capital investment. It is derived from the traditional theory of investment which assumes that the objective of a firm is to maximise profits by adopting the marginalist strategy of equating the expected marginal return with the marginal cost of capital. Attempts to test this hypothesis statistically have failed to produce conclusive results. Stevens' (1969 b) results supported the hypothesis for Latin America at a regional level but not for individual countries except in the case of Brazil. Reuber et al (1973) showed that US manufacturing investment in Argentina, Brazil, Chile, India, Indonesia, Mexico and the Phillipines between 1956 and 1969 was positively correlated with the rate of return with a one year time lag but this relation was statistically significant in only two cases at the five percent level. Blais (1975) demonstrated in the case of manufacturing FDI from the UK and Canada in the USA during the period 1950-71 that the relative rates of return had a significant influence on the stock of FDI.

Statistical tests by Bandera and White (1968) on American investments in European countries over the period 1953-62 rejected the differential rate of return hypothesis. Bandera and Lucken (1972) tried to find the connection between relative earnings and allocation of US investments between the EEC and EFTA but no such relation was supported by their econometric tests. Hufbauer (1975) compared the yearly difference between foreign and domestic rates of asset expansion with the difference between foreign and domestic rates of return for the period 1955-70 and found no connection between the series.

This approach to FDI is beset by statistical problems. The underlying theory suggests that FDI is a function of expected profits, but the available statistics record only reported profits. Reported profits need not be the same as actual profits earned by subsidiaries, primarily because their purchases and sales to the parent company or other subsidiaries are subject to intra-firm pricing, which is likely to be influenced by efforts to minimise the tax burden on the company as a whole. Furthermore the rate of return hypothesis refers to profits during the whole period of an investment whereas the reported profits are related to shorter time periods, usually one year, and to a group of investments of different vintages.

- Cheap Labour Hypothesis

Another reason for FDI is the supply of cheap labour, especially in the developing countries. Cheap labour has always been recognised as one of their comparative advantages in international trade in certain products, but its recognition as an explanation of FDI is of relatively recent origin. Riedel (1975) found that relatively lower wage costs have been one of the major determinants of the export-orientated FDI in Taiwan. Agarwal's (1978) study is reported to have yielded a significant positive correlation between German FDI and relative wage costs in Brazil, India, Israel, Mexico and Nigeria. Similar results were obtained by Juhl at the sectoral level for German FDI in a number of LDCs.

Goldsbrough's attempt to test the relative wage hypothesis of FDI between four developed economies (UK, USA, Japan and Germany) was also successful with relative unit wage costs (measured in a common currency) negative and significant at the five per cent level for all equations except the one for FDI inflows into Germany. Thus increased costs of production in the host country relative to costs of production in the rest of the world, lead to a reduced FDI inflow. The influence of differences in wage levels between investing and host countries is obviously greater in the case of FDI in industries producing labour intensive products and components than in other industries.

(iii) Financial Market Hypotheses

- The Portfolio Hypothesis

The portfolio hypothesis postulates that investors consider not only the rate of return but also the risk in selecting their portfolios, and investment depends positively on the former and negatively on the latter. Markowitz (1959) and Tobin (1958) provide the theory of portfolio selection based on the empirical observations that though returns on securities within a country move together over time, they are not perfectly correlated. Accordingly diversification of the portfolio may help to reduce the total risk involved; particularly international diversification. This theory has been applied to direct investment by Stevens (1969 b), Prachowny (1972), Cohen (1975) and Blais in the US and by Beenstock and Minford in the UK.[9]

Stevens' empirical work was confined to Latin America. He found some empirical support for the portfolio hypothesis so far as aggregate direct investment was concerned but at the country level the results proved inferior to those based on the output hypothesis. Prachowny seemed to detect more empirical evidence in favour of this hypothesis in his attempt to explain FDI in the US and American direct investment overseas. Cohen's statistical results supported the hypothesis that large US corporations with more extensive foreign manufacturing activities showed smaller fluctuations in global profits and sales in the 1960s, but this could be an unintended result of corporate actions taken for other reasons. Blais tested the portfolio hypothesis on the FDI of Canada and the UK in the US manufacturing sector over the period 1950-71. He found that the relative risks showed a significant influence in the case of Canada but not in the case of the UK; however, this difference probably reflected the different statistical specification rather than a difference in investors' behaviour. On the whole the statistical evidence for the portfolio hypothesis is weak. Hufbauer has argued that it is incapable of explaining the differences in the propensities of industries to invest abroad. Some industries are more internationally orientated than others and these differences cannot be explained in terms of risks and returns alone. Moreover testing the portfolio hypothesis is beset with statistical difficulties. For example, the risk variable, based on the variance of rates of return, cannot be measured very reliably and the statistics on returns are unlikely to represent the actual returns.

---

9 Beenstock and Minford investigate the determinants of long term capital flows and hence include portfolio and direct investment, inter alia. For this reason their work is not reported further.

- The Currency Area Hypothesis

Aliber (1970, 1971) has argued that the pattern of FDI can be explained in terms of the existence of different currency areas. Some of the currencies are "harder" when compared with others at a point of time and the market is subject to bias in evaluating the currency premium on weaker currencies. Aliber maintained that portfolio investors tend to ignore the exchange risk on the foreign earnings of a firm. As a result the firms from harder currency areas are able to borrow at lower costs and capitalise the earnings on their FDI in softer currency areas at higher rates than the local firms. The higher the share of capital in valued added and the size of the premium in local currency, the greater the comparative advantage which a foreign investor would enjoy.

This hypothesis has not been tested econometrically, although the casual evidence is consistent with the view that an overvaluation of a currency is associated with an outflow of FDI and an undervaluation with an inflow of FDI into the currency area concerned.[10] This is supported by the experience of the US and West Germany during the 1960s. Boatwright and Renton's study of the inward and outward FDI of the UK indicated that the depreciation of sterling raised the value of FDI in the UK, but it also raised the UK's FDI abroad instead of having a negative effect on it. Kohlhagen's (1977) study of major exchange rate realignments of the currencies of the UK, France and Germany, during the 1960's showed that currency devaluations increase the relative profitability of domestic production vis-a-vis foreign production and thus induce the inflow of FDI into the devaluing countries. However, the conclusion of these various studies seems to be that the exchange rate is only one of many factors influencing FDI decisions. Its over or undervaluation and devaluation or revaluation may influence the timing of a particular FDI rather than being the sole cause of it. Stopford and Turner reach an identical conclusion for UK FDI inflows and outflows since 1972.

---

10 The US experience of 1980-5 seems to contradict this. (See footnote (5) above).

IV A THEORETICAL MODEL

The process of direct investment is deemed to have two distinct parts. The first is concerned with the acquisition of facilities abroad, ie how a firm decides to service a foreign market (exporting, licensing or production) and what assets it invests in (fixed assets, inventories etc). The second is concerned with the financing of these acquisitions, ie whether financed by equity and loans from the parent, local currency borrowing or retained overseas earnings. The model developed here is set up to mimic these stages. First a model of plant and equipment expenditures by a multi-national firm is developed based upon the assumption that the firm is a price-taker, and that capital is completely malleable. Second a theory of the financing of these expenditures is outlined drawing on the work of Hartman (1979), Gilman and Goldsbrough.

(i) A Model of Plant and Equipment Expenditures

In addition to the assumptions of fixed input prices and perfectly malleable capital it is assumed:

(a) The products made by the firm in the home market and by its foreign subsidiary are identical.

(b) The same technology is used at home and abroad except for a shift factor reflecting greater efficiency in production in the home market.

(c) The factors of production are inputs of labour, L and capital, K. Labour is assumed to be completely immobile between countries.

(d) Net exports, X, flow from the home country to the foreign market.

(e) There is no risk or uncertainty.

From assumptions (b) and (c) the Cobb-Douglas production functions governing output in the domestic and foreign markets are:

$$Q_D = AK_D^{\alpha} L_D^{\beta}$$

$$Q_F = BK_F^{\gamma} L_F^{\delta}$$

where Q_D and Q_F represent output in the home and foreign markets respectively and K_D, L_D and K_F, L_F represent the employment of capital and labour in the domestic plant and foreign subsidiary of the firm.

From assumption (d) some domestic production is consumed at home with the surplus being exported to the foreign country, that is:

$$Q_D = D_D + X$$
$$Q_F = D_F - X \tag{2}$$

where D_D and D_F equal domestic sales (demand) and foreign sales of the product, respectively, and X equals net exports to the foreign market. D_D, D_F and X are all exogenous variables.

Combining equations (2) gives the global market clearing condition that total demand and total supply of the product are in equilibrium.

$$Q_D + Q_F = D_D + D_F = (Q_D - X) + (Q_F + X) \tag{3}$$

Let P_D be the domestic price level measured in sterling and P_F be the foreign price level measured in units of foreign currency. Then in sterling terms the firm's total revenue will be

$$P_D D_D + P_F/e.D_F = P_D\ (Q_D - X) + P_F/e.\ (Q_F + X) \tag{4}$$

where e is the exchange rate measured in units of foreign currency per unit of sterling (ie \$/£). If we assume that tariffs and transport costs are the only barriers to trade and let t equal the ad valorem tariff rate plus transport costs, then under perfectly competitive market conditions

$$P_F/e = (1 + t)P_D. \tag{5}$$

Total production costs in the home market, TC_D, are given by

$$TC_D = W_D L_D + C_D K_D \tag{6}$$

where W_D is the nominal wage rate and C_D is the pre-tax user cost of capital, defined as:

$$C_D = q_D\ (r_D + \rho) - \Delta q_D \tag{7}$$

where q_D is the price of capital goods in the home market, r_D is the domestic rate of interest and ρ is the rate of depreciation of the capital stock. Therefore, $q_D r_D$ is the opportunity cost of putting q pounds in capital goods, ie what q pounds would earn if invested in financial assets; $q\rho$ is the depreciation cost, if ρ of capital goods 'vanishes' then its value is $q\rho$; Δq is the time derivative of q, that is it is the rate of appreciation of the price of capital goods: if capital goods prices are rising then the implicit rental cost of capital, C, is lower. The costs of supplying in the foreign market have two components: the costs of production in the foreign subsidiary, TC_F, and the transport costs of exports from the home market. Thus total foreign costs are:

$$TC_F + tP_DX = W_F/e.L_F + C_F/e.K_F + tP_DX \quad (8)$$

where W_F/e is the nominal wage rate expressed in sterling and tP_D represents tariff duties (or transport costs) paid in the foreign market. The rate of depreciation, ρ, is assumed to be the same at home and abroad.

Combining equations (4), (6) and (8) we obtain an expression for the firm's gross profits in sterling:

$$\pi = P_DQ_D - (1 + t)P_DX + P_F/e.Q_F - W_DL_D - W_F/e.L_F - C_DK_D - C_F/e.K_F$$

The objective function of the firm is assumed to be profit maximisation in each production period subject to the constraint that the firm must meet the total demand in each period as given by equation (3), consistent with being on its production functions, given by equation (1). Thus the constraint can be written as:

$$AK_D^{\alpha}L_D^{\beta} + BK_F^{\gamma}L_F^{\delta} = D_D + D_F = (Q_D - X) + (Q_F + X) \quad (9)$$

and the firm maximises the profit function:

$$\pi = P_DAK_D^{\alpha}L_D^{\beta} - (1 + t)P_DX + \frac{P_F}{e} . BK_F^{\gamma}L_F^{\delta} - W_DL_D - \frac{W_F}{e} L_F$$

$$- C_DK_D - \frac{C_F}{e} K_F + \lambda(AK_D^{\alpha}L_D^{\beta} + BK_F^{\gamma}L_F^{\delta} - D_D - D_F) \quad (10)$$

where λ is the Lagrange multiplier.

The first order conditions are given by equations (11a) - (11e) as follows:

$$\frac{\partial \pi}{\partial K_D} = \alpha \frac{Q_D}{K_D}\left[P_D + \lambda\right] - C_D = 0 \tag{11a}$$

$$\frac{\partial \pi}{\partial K_F} = \gamma \frac{Q_F}{K_F}\left[\frac{P_F}{e} + \lambda\right] - \frac{C_F}{e} = 0 \tag{11b}$$

$$\frac{\partial \pi}{\partial L_D} = \beta \frac{Q_D}{L_D}\left[P_D + \lambda\right] - W_D = 0 \tag{11c}$$

$$\frac{\partial \pi}{\partial L_F} = \delta \frac{Q_F}{L_F}\left[\frac{P_F}{e} + \lambda\right] - \frac{W_F}{e} = 0 \tag{11d}$$

$$\frac{\partial \pi}{\partial \lambda} = AK_D^{\alpha}L_D^{\beta} + BK_F^{\gamma}L_F^{\delta} - D_D - D_F = 0 \tag{11e}$$

The second order conditions indicate that a maximum is reached.

Solving (11a) for λ, then using equation (5) and defining real factor prices, υ_j^i, where i is the factor of production and j its location of supply, gives the simultaneous system (12).

$$\begin{aligned}
&\frac{\gamma Q_F}{K_F}\left[t + \frac{\upsilon_D^k K_D}{\alpha Q_D}\right] - \upsilon_F^K(1+t) = 0 \\
&\frac{\beta}{\alpha} \cdot \frac{\upsilon_D^k K_D}{L_D} - \upsilon_D^L = 0 \\
&\delta \frac{Q_F}{L_F}\left[t + \frac{\upsilon_D^K K_D}{\alpha Q_D}\right] - \upsilon_F^L(1+t) = 0 \\
&AK_D^{\alpha} L_D^{\beta} + \beta K_F^{\gamma} L_F^{\gamma} - D_D - D_F = 0
\end{aligned} \tag{12}$$

This system can be solved for K_F, the foreign-based capital stock, by linearising (12) and using Cramer's rule of determinants. The final reduced form for K_F has the general form:[11]

---

11 See appendix I for details of the derivation of this reduced form.

$$K_F = f(\nu_D^k, \nu_F^k, \nu_D^L, \nu_F^L, X, D_D, D_F, t) \tag{13}$$

where $f_1 \gtrless 0$, $f_2 < 0$, $f_3 > 0$, $f_4 > 0$

$f_5 \gtrless 0$, $f_6 \gtrless 0$, $f_7 \gtrless 0$, $f_8 \gtrless 0$

The reduced form (13) shows that the prices of domestic and foreign labour are directly related to the firm's foreign capital stock, since higher wages in either country lead to a substitution of capital for labour. Foreign user costs of capital are inversely related to K_F since a rise in overseas user capital costs lead to a fall in the demand for capital. Domestic user costs of capital have an ambiguous effect on the firm's foreign stock of physical capital abroad depending upon the relative strengths of the income and substitution effects. The substitution effect is the extent to which the firm is able and willing to switch capital from the home to the foreign country as domestic user capital costs rise, while the income effect is the fall in the firm's capital stock abroad required to offset the effect on the firm's cash flow of the rise in the domestic price of capital. If it is assumed that there is a high degree of capital mobility such that the post-tax user costs of capital between the domestic and foreign countries are the same, then the income effect is reinforced by the substitution effect and the level of the employed capital stock abroad will unambiguously fall as the domestic user cost of capital rises.

The demand terms and the net export term all have ambiguous effects on the firm's capital stock overseas. The influence of net exports on K_F will depend on whether exports are substitutes or complements for overseas production. To the extent that home exports are raw materials or capital inputs required by the foreign subsidiary, then net exports and K_F will be complementary and $f_5 > 0$. On the other hand, if net exports are serving the same final consumers as local production, then as local production expands net exports will decline. As Vernon has pointed out, the substitution of foreign production for exports may be related to the product cycle, in that this substitution frequently occurs with mature products which are well-established in the home and foreign markets. The demand terms also have an ambiguous influence on the firm's capital stock abroad. To the extent that higher domestic demand requires a higher domestic capital stock could lead to a switching of new investment to the home country so that the foreign capital stock declines; but equally, the existance of "diminishing returns" in any single market, may mean that investment abroad must increase disproportionately if the growth of the firm or its share market is to be sustained.

The "tariff variable" in the reduced form is somewhat cosmetic. If the marginal products of foreign capital and labour are equated to their respective real factor prices, as the perfectly competitive model implies, then $f_8=0$ and the explanatory variable, t, vanishes from (13). To the extent that these stringent marginal productivity conditions are unlikely to hold in practice, the inclusion of a separate term is not unreasonable, although data deficiencies rule out its inclusion as a separately identified variable in the empirical estimation of (13).

(ii) Financing foreign direct investment

The financing of FDI is the second part of the investment decision. Financing can come from retained earnings, new equity or loans from the parent company or borrowing from external sources. Since the finance raised from external sources, such as local currency borrowing, is not part of direct investment, it is possible for the physical assets of the foreign subsidiary to rise or fall without any change in direct investment levels. It is therefore necessary to explain how the multinational enterprise chooses between external and direct investment finance. This is addressed in this section.[12]

In the two-country model of plant and equipment expenditures set out in section (i) the firm employs K_D and K_F of capital in the domestic and foreign countries. The firm now wishes to choose the amounts F_D and F_F to be financed by borrowing in the two countries respectively. Let r_D^* and r_F^* denote the random, post-tax real rates of return in each country (expressed in domestic currency) and i_D^* and i_F^* denote the borrowing rates in each country where i_F^* is the foreign interest rate (i_F) adjusted for expected changes in the exchange rate (ε), that is:

$$i_F^* = i_F - \varepsilon \qquad (14)$$

---

12 This section relies heavily on Goldsbrough, whose approach is based on that of Hartman.

where ε is assumed to be a random variable. The firm aims to choose F_F so as to minimise some function of its average expected cost of borrowing (i_o), which can be written as,

$$i_o = i_D^* . F_D + i_F^* . F_F = i_D^* (K - F_F) + i_F^* . F_F \quad (15)$$

and the variance of its overall portfolio:

$$V = \text{var} (r_D^* . K_D + r_F^* . K_F - i_F^* F_F) \quad (16)$$

where $K = K_D + K_F$ and F_F is treated as a negative asset. Thus the firm will choose some point on the efficient frontier of portfolio choices where for any given cost of borrowing the variance is at a minimum. That is, the firm will attempt to minimise (16) subject to some constraint on the cost of borrowing, equation (15), as given by equation (17) where μ_0 is the Lagrange multiplier.

$$L = \text{var} \left[r_D^* . K_D + r_F^* . K_F - i_F^* F_F \right] + \mu_0 \left[i_D^* (K - F_F) + i_F^* . F_F - i_0 \right] \quad (17)$$

Differentiating (17) with respect to F_F and solving the first order condition for F_F yields:[13]

$$F_F = \frac{\mu_0}{2} . \frac{\left[i_F - \varepsilon - i_D^* \right]}{\text{var} (\varepsilon)} - K_D . \frac{\text{cov} (r_D^*, \varepsilon)}{\text{var} (\varepsilon)} - K_F . \frac{\text{cov} (r_F^*, \varepsilon)}{\text{var} (\varepsilon)} \quad (18)$$

where var denotes variance and cov denotes covariance.

The coefficients on K_D and K_F are those that would result if the rates of return, r_D^* and r_F^*, were each in turn regressed upon ε, and reflect the extent to which returns in each country are sensitive to expected exchange rate changes. These coefficients depend therefore on the structural characteristics of the two economies which, for any given pair of countries, will probably not change very much over time. So (18) can be rewritten as:

$$F_F = \frac{\mu_0}{2} \frac{\left[i_F - \varepsilon - i_D^* \right]}{\text{var} (\varepsilon)} + \mu_1 K_D + \mu_2 K_F \quad (18')$$

---

13 See appendix II for details.

where $\mu_1 = \text{cov}(r_D^*, \epsilon)/\text{var}(\epsilon)$ and $\mu_2 = \text{cov}(r_F^*, \epsilon)/\text{var}(\epsilon)$. Equation (18′) shows that the amount of local currency borrowing chosen depends upon the covered interest differential and the amount of capital located in the domestic and foreign countries. If it is assumed that the firm's overseas operations in country F are but a small part of the total operation, it is likely that a change in the exchange rate would have little or no effect on the rate of return in the home country, hence $\text{cov}(r_D^*, \epsilon) = 0$ and $\mu_1 = 0$. Moreover, if it is assumed that there is a high degree of capital mobility the covered interest differential will tend to zero. This arbitrage would most likely be done by the movement of portfolio capital, which is likely to respond more rapidly to any potential interest differential than FDI flows do. In this case any ex ante differential has no effect on FDI flows, since it is eliminated before they can adjust, and hence there is no need to include an interest differential term in the estimated model.

If the above arguments are valid equation (18) reduces to (19) which implies that the stock of local currency borrowing is a constant proportion of the firm's plant and equipment expenditures in that country.

$$F_F = \mu_2 . K_F \tag{19}$$

Subtracting (19) from K_F gives the stock of direct investment, F_D, as a stable proportion of the firm's capital asset stock in the foreign country, that is:

$$F_D = (1 - \mu_2).\ f(\nu_D^K, \nu_F^K, \nu_D^L, \nu_F^L, X, D_D, D_F, t) \tag{20}$$

Equation (20) is a reduced form equation explaining the firm's overseas stock of direct investment. It differs from (13) in that the dependent variable is now the firm's desired stock of foreign direct investment, rather than its overseas capital stock. Assuming $(1-\mu_2)>0$, the effects of the explanatory variables on the stock of direct investment are exactly as described below equation (13). Aggregating over all domestic firms gives a macroeconomic explanation of the determinants of FDI, and a linear estimating equation for the desired direct investment stock:

$$F_D = a_0 + a_1\nu_D^k + a_2\nu_F^k + a_3\nu_D^L + a_4\nu_F^L + a_5D_D + a_6D_F + a_7X + u \tag{21}$$

where u is a random error term.

V ESTIMATION RESULTS

Traditionally the accepted method of estimating a desired capital stock equation, like equation (20), is to embed the equations in a partial adjustment framework whereby the actual stock adjusts to the desired stock over time, thereby generating a flow of investment. This methodology, apart from being rather ad hoc, suffers from statistical problems since the final equation usually has both a lagged dependent variable and serially correlated errors making ordinary least squares estimates biased and inconsistent. A more recent approach to dynamic modelling has been to fit error correction models, allowing data to play a large part in determining the short run dynamics and to judge the result partly by the consistency of the long run solution with economic theory. Papers by Hendry and Mizon (1978), Davidson et al (1978) and Hendry (1980) are examples of this approach. The problem with this methodology from the point of view of the present work is that long runs of data are required to enable downwards testing from a general to a specific form. Recent work by Engle and Granger has led to the development of cointegration techniques whereby a long run equilibrium relationship can be investigated without explicitly considering the short-run dynamics.[14]

Engle and Granger suggest a two-stage estimation procedure. First a prior levels regression is estimated and the hypothesis of cointegration tested. Then the lagged residuals from this regression are entered into a first difference regression to represent the long-run equilibrium solution.

Before proceeding to test the sets of variables for cointegration it is sensible to establish the properties of the individual series because when series are integrated of different orders the two series cannot be cointegrated. In this paper eleven series are used in two overlapping sub-sets of eight, to estimate both outward and inward direct investment equations for the UK, using annual data from 1963 to 1985. (Data definitions and sources are given in appendix IV.)

---

14 See appendix III for a simple overview of the concept of cointegration and of some testing procedures for cointegrated variables.

(i) Outward Results

Table 1 shows the Dickey-Fuller (DF) test for each of the variables used in the outward direct investment equation, in both levels and first differences. The levels of these variables are obviously non-stationary processes, given the low absolute values of the DF statistic, which are all insignificant at the 5 per cent level. Of the first differences all, except ΔOFUCC, are

Table 1: Time series properties of the variables

Variable	Code	DF	Variable	Code	DF
F_D	FDI	-0.388	ΔF_D	ΔFDI	-6.229
ν_D^L	DULC	-1.869	$\Delta\nu_D^L$	ΔDULC	-3.749
ν_D^K	DUCC	-1.942	$\Delta\nu_D^K$	ΔUCC	-4.430
ν_F^L	OFULC	-1.375	$\Delta\nu_F^L$	ΔOFULC	-4.234
ν_F^K	OFUCC	-2.066	$\Delta\nu_F^K$	ΔOFUCC	-2.008
D_D	DD	-0.627	ΔD_D	ΔDD	-3.957
D_F	FD	-0.785	ΔD_F	ΔFD	-3.808
X	DNX	-1.453	ΔX	ΔDNX	-3.817

negative and significant on the DF test (critical value at 5 per cent is -3.00). Largely on the strength of the DF test, it tentatively seems that the variables ΔFDI, ΔDULC, ΔDUCC, ΔOFULC, ΔDD, ΔFD and ΔDNX are integrated of order one. It is possible therefore that these variables could form a cointegrating set.

To test these variables for a cointegrating vector a levels regression was estimated with FDI as the dependent variable. Equation (A) of table 2 shows that the regression very easily passes both the CRDW and DF tests for a cointegrating vector at the 5 per cent level (critical values 0.367 and -3.37 respectively), but marginally fails the augmented Dickey-Fuller (ADF) test (critical value -3.17 at 5 per cent). Given the previously noted small sample, and the fact that the critical values reported for the DF and ADF tests are strictly for a three-variable regression, rather than a six-variable regression reported here, it seem, on balance, plausible not to reject the hypothesis that this is in fact a cointegrating regression. Moreover, the explanatory variables in the regression equations all have theoretically plausible signs and coefficients of sensible magnitude. For example, a £1 mn rise in net exports implies a fall in the real stock of UK direct investment abroad of £34,000, and a rise in real domestic unit labour costs of 1 per cent adds £155 mn to the outward stock of direct investment.

Having achieved a suitable specification for the cointegrating regression, $\hat{E}$ is defined as the residual derived from equation (A), and (A) is re-estimated in first differences including $\hat{E}_{-1}$ as an extra explanatory variable. The results are given by equation (B) reported in table 2. The explanatory variables explain three-quarters of the variation in the dependent variable, although the standard error of the regression is large compared to the mean of the dependent variable. The Durbin-Watson statistic for first order serial correlation of the residuals lies in the inconclusive region although the Lagrange multiplier (LM) test for first order serial correlation is unable to reject the null hypothesis at 5 per cent (critical value 3.84). LM tests for serial correlation up to second and fourth order, however, reject the null hypothesis (critical values 5.99 and 9.49, respectively at 5 per cent), indicating the likely presence of higher order autocorrelation and misspecification of the equation. The Bera-Jarque (BJ) test statistic confirms the normality of the residuals.

The factor cost terms in equation (B) are all highly significant with positive coefficients indicating strong substitution towards foreign capital when the costs of other factor inputs rise. Both of the demand terms and the net export term are statistically insignificant from zero at the 5 per cent level (although domestic demand is almost significant at 10 per cent). The sign on the net export coefficient is positive indicating short run complementarity between exports and FDI. This is different from the effect identified in equation (A) when net exports were substitutes for direct investment. The notion of short run complementarity and long run substitutability is consistent with the product cycle hypothesis, outlined in section IV, although it is probably inappropriate to place much weight on this finding given the statistical insignificance of the net export term.

The preferred equation is equation (C), which resulted from imposing some restrictions on equation (B). (Prior to this a lag of each of the independent variables and the lagged dependent variable were included as extra regressors in (B) but none were found to be statistically significant). The variables were dropped from equation (B) sequentially, according to the size

Table 2: Outward Regression Results

A - Levels regression: 1963-85

$$FDI = -23789 + 5859DULC + 27540DUCC + 59530FULC$$
$$+ 0.085DD - 9.714FD - 0.034DNX$$

$CRDW = 1.215$, $DF = -3.541$, $ADF = -2.899$, $R^2 = 0.919$

B - First difference regression: 1964-85

$$\Delta FDI = \underset{(-0.95)}{-492.4} + \underset{(3.04)}{11683\ \Delta DULC} + \underset{(3.68)}{35872\ \Delta DUCC} + \underset{(4.44)}{10480\ \Delta OFULC}$$
$$+ \underset{(1.63)}{0.137\Delta DD} - \underset{(-0.36)}{21.73\Delta FD} + \underset{(0.95)}{0.224\Delta DNX} - \underset{(-3.09)}{0.801\hat{E}_{-1}}$$

$R^2 = 0.750$, $\overline{R}^2 = 0.625$, $\sigma = 1.716$, $DW = 1.718$, $LM(1) = 2.877$

$LM(2) = 11.811$, $LM(4) = 12.777$, $ARCH = 0.351$, $BJ = 0.443$

C - Restricted first difference regression: 1964-85

$$\Delta FDI = \underset{(3.10)}{8371\Delta DULC} + \underset{(3.69)}{30236\Delta DUCC} + \underset{(4.66)}{9456\Delta OFULC}$$
$$+ \underset{(2.59)}{0.055\Delta DD} - \underset{(-3.25)}{0.713\hat{E}_{-1}}$$

$R^2 = 0.720$, $\overline{R}^2 = 0.654$, $\hat{\sigma} = 1.646$, $DW = 1.959$, $LM(1) = 0.235$,

$LM(2) = 5.523$, $LM(4) = 9.144$, $ARCH = 0.253$, $BJ = 0.418$

R^2, coefficient of determination; $\overline{R}^2$, R^2 adjusted for degrees of freedom; $\hat{\sigma}$, residual standard error as a proportion of the dependent variable; coefficient t-ratios in parenthesis (.); DW, Durbin-Watson statistic; LM(i), the Lagrange Multiplier test for serial correlation up to the i'th order, distributed as $\chi^2(i)$ on the null; ARCH, Engle's ARCH statistic, distributed $\chi^2(1)$ on the null; BJ, the Bera-Jarque Normality Test, distributed as χ^2 (2) on the null.

of their t-values. Equation (C) emerged when the joint exclusion restrictions were imposed: $a_0 = a_6 = a_7 = 0$. The F-test of this joint null hypothesis failed to reject the null with a calculated value of 0.55 compared to a critical value of 3.34 at 5 per cent.

Equation (C) has very desirable statistical properties. The diagnostic tests reject the hypotheses of first and higher order serial correlation, in addition the ARCH statistic (see Engle (1982)) rejects the existence of any autoregressive conditional heteroscedasticity (critical value 3.84) and the Bera-Jarque test for normality of the residuals is also satisfied. The $\bar{R}^2$ has risen to 0.65 (from 0.63 in (B)) and the standard error has fallen slightly to 1.646 as a proportion of the mean of the dependent variable. The equation has a good tracking performance (see Chart 7).

The time path of the capital stock, following a once-and-for-all change in any of the explanatory variables, will be of a damped, nonoscillatory pattern, since in the first-order difference equation (C) the coefficient on the lagged capital stock can be computed to be 0.287, which is both positive and less than one. It is noteworthy, however, as shown in Chart 8, that the responses to changes in DUCC and DULC both give rise to overshooting on impact, with the subsequent adjustment back to long-run equilibrium taking about 4 1/2 years. This kind of profile would be consistent with a "stock-shift" effect, following the rise in domestic factor prices, which gradually diminishes over time as subsequent new flows are insufficient to maintain the initial rise in the stock. The adjustment of the direct investment stock following an expansion of domestic demand is monotonic.

Table 3: Outward impact and long run elasticities

Variable	Impact	long run
DULC	1.087	0.761
DUCC	0.170	0.155
OFULC	0.546	0.344
DD	0.686	1.060

Table 3 shows the impact and long run elasticities of changes in the levels of the explanatory variables in equations (C) and (A) on the foreign direct investment stock. In general the response of the stock to changes in the levels of the explanatory variables is low, the exception being domestic unit

Chart 7: Change in outward stocks of non-oil ICCS direct investment

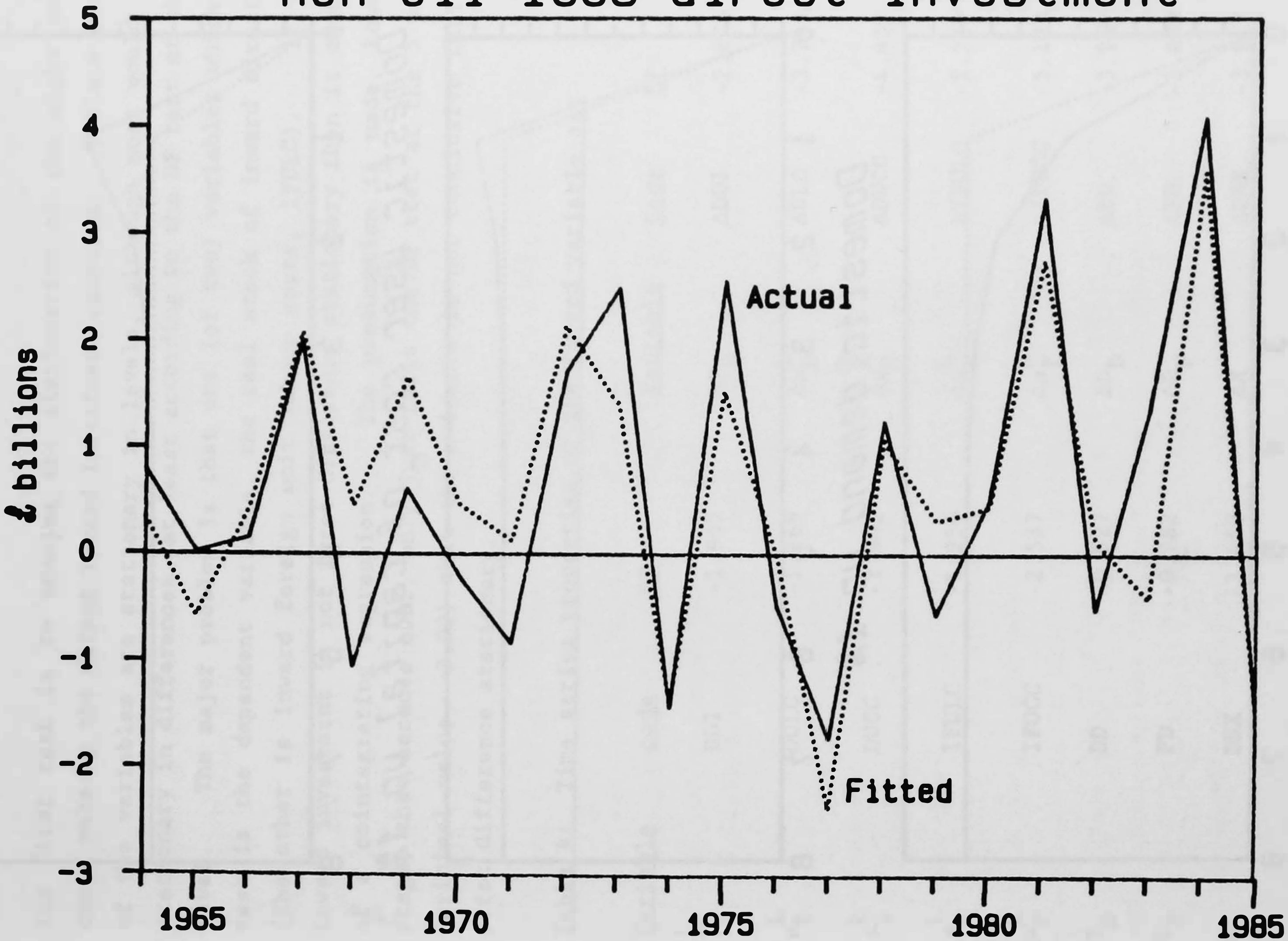
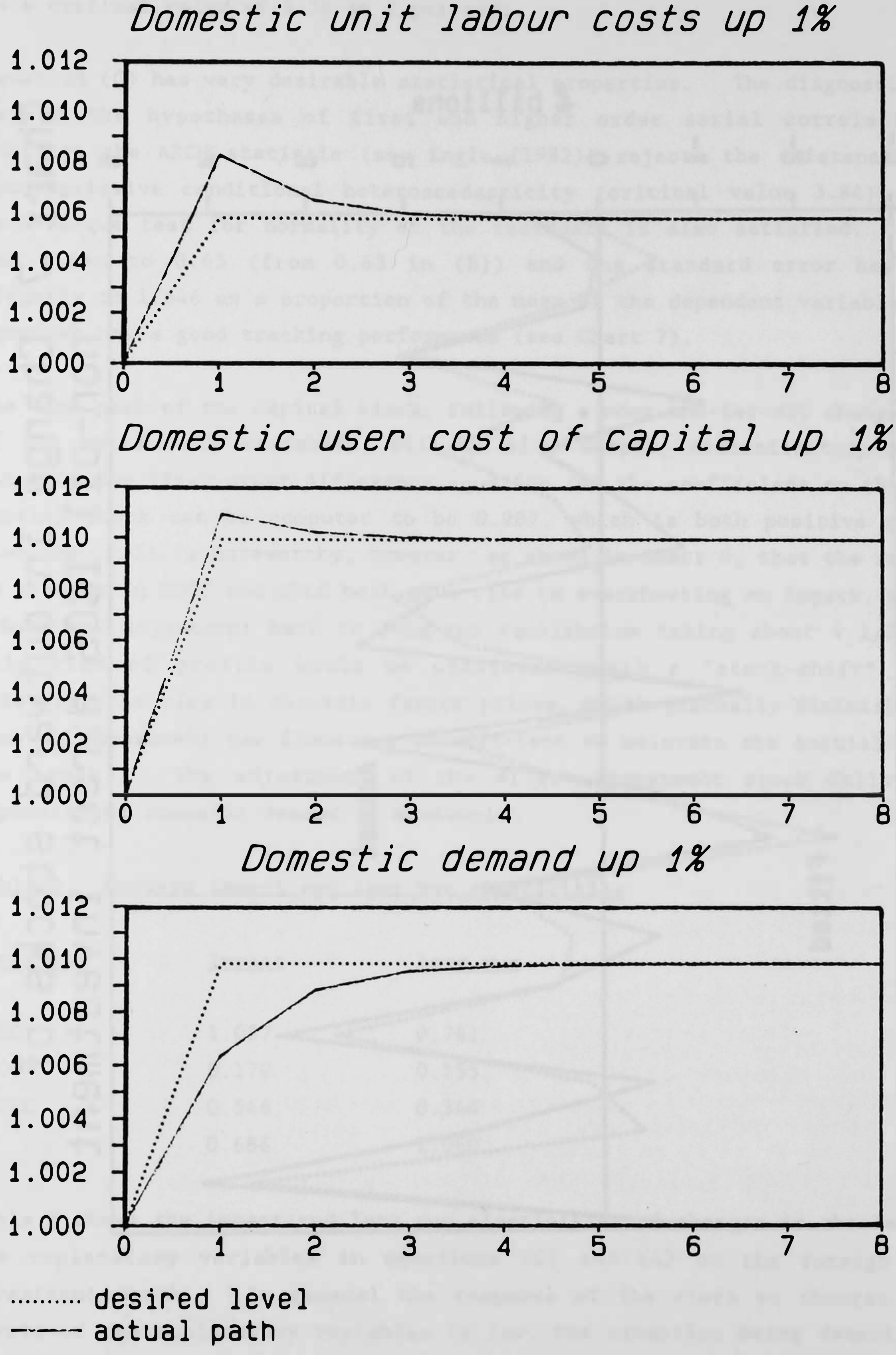


Chart 8: Response of outward direct investment to various once and for all shocks



labour costs which has an elasticity of one, implying that a 1 per cent change in real unit labour costs leads to a 1 per cent change in the stock of FDI in the same direction. In the long run FDI also rises one-for-one with increases in domestic demand.

(ii) Inward results

The first task is to examine the stationarity of the eight variables that could make up the direct inward investment equation. Table 4 shows that none of the variables are stationary in levels, although most would appear to be stationary in differences, at least according to the DF test at the 5 per cent level. The major problem is that one (of two) variables which fail the DF test is the dependent variable, the real stock of inward direct investment. (The other is inward foreign unit labour costs, IFULC). If the stock of inward investment is not first difference stationary then it cannot form part of a cointegrating regression. The presumption is made, however at this stage, that because ΔDDI, only just fails the DF test at the 5 per cent level (critical value, -3.00) that the evidence is not conclusive that ΔDDI is not first difference stationary.

Table 4: Time series properties of the inward variable set

Variable	code	DF	Variable	Code	DF
F_D	DDI	-1.957	ΔF_D	ΔDDI	-2.873
μ_D^L	DULC	-1.869	$\Delta\mu_D^L$	ΔULC	-3.749
μ_D^k	DUCC	-1.942	$\Delta\mu_D^K$	ΔDUCC	-4.430
μ_F^L	IFULC	-1.250	$\Delta\mu_F^L$	ΔIFULC	-2.239
μ_F^k	IFUCC	-2.537	$\Delta\mu_F^K$	ΔIFUCC	-5.193
D_D	DD	-0.627	ΔD_D	ΔDD	-3.957
D_F	FD	-0.782	ΔD_F	ΔFD	-3.808
X	DNX	-1.453	ΔX	ΔDNX	-3.817

The levels equation reported as equation (A) in table 5 has independent variables all of which have coefficients with theoretically plausible signs and similar magnitudes to those reported for equation (A) in table 2. The equation easily passes the CRDW test but marginally fails the DF test at the 5 per cent level. But, as noted above, since the critical value of the DF test is strictly for a three variable regression, it would seem implausible to reject the hypothesis that this is a cointegrating regression. As a further check a visual inspection of the fitted values around unity was undertaken but it failed to reveal any systematic error pattern or outlying values. It was therefore decided to use the residuals from this equation in the second stage of the estimation.

Equation (B) in table 5 is the first difference version of (A), including the lagged residual from equation (A). It is dynamically misspecified, as indicated by the LM statistics which show that up to fourth order serial correlation is in evidence. But the statistical significance of real domestic factor prices, both domestic and foreign demand and net exports are outstanding. The preferred equation is equation (C) which was obtained by estimating a more general form of (B), including lagged terms of the explanatory and dependent variables on the right-hand side, and then sequentially eliminating those that were insignificant. The principal difference between equation (C) in table 5 and the corresponding equation in table 2, is the appearance of the fourth lag of the dependent variable among the explanatory variables. The inclusion of this term proved sufficient to ensure satisfactory dynamic properties for the equation.

Table 6 gives the impact and long-run elasticities implied by equations (C) and (A) respectively, of a change in the level of the explanatory variables on the stock of real inward direct investment. Generally the responsiveness of the stock of inward investment to changes in domestic factor prices is low, although statistically these terms are important with t-ratios of -2.26 and -3.65. Net imports seem to be complementary to inward direct investment in both the short and long run, with a very significant negative coefficient on ΔDNX in equation (C), although the elasticity of DDI with respect to DNX is almost zero. From table 6 it would seem that DDI is responsive to changes in the level of domestic, and particularly foreign, demand, although only the latter is statistically significant at the 5 per cent level.

Table 5: Inward Regression Results

A - Levels regression: 1963-85

$$DDI = -1632.4 - 15730\ DUCC - 517.7\ DULC - 6734\ IFUCC + 7057\ IFULC$$

$$- 0.046\ DD + 72.21\ FD - 0.234\ DNX$$

$CRDW = 1.094$, $DF = -3.209$, $ADF = -1.175$, $R^2 = 0.948$

B - Difference regression: 1964-85

$$\underset{}{\Delta DDI} = \underset{(-1.30)}{-244.0} - \underset{(-3.03)}{4138 \Delta DULC} - \underset{(-2.90)}{10127\ \Delta DUCC} - 1200\ \Delta IFUCC - \underset{(-0.22)}{411.7 \Delta IFULC}$$

$$- \underset{(-2.31)}{0.065\ \Delta DD} + \underset{(3.41)}{65.55\ \Delta FD} - \underset{(-3.53)}{0.264\ \Delta DNX} - \underset{(-2.16)}{0.365\ \hat{E}_{-1}}$$

$R^2 = 0.773$, $\bar{R}^2 = 0.633$, $\hat{\sigma} = 0.811$, $DW = 0.926$, $LM(1) = 10.176$

$LM(2) = 11.790$, $LM(4) = 13.178$, $ARCH = 0.159$, $BJ = 2.771$

C - Restricted first difference regression: 1967-85

$$\Delta DDI = \underset{(-2.26)}{-2692.8\ \Delta DULC} - \underset{(-3.65)}{12903\ \Delta DUCC} - \underset{(-1.90)}{0.045\ \Delta DD}$$

$$+ \underset{(3.55)}{56.486\ \Delta FD} - \underset{(-4.30)}{0.267\ \Delta DNX} - \underset{(-2.37)}{0.538\ \hat{E}_{-1}} + \underset{(2.60)}{0.473\ \Delta DDI_{-4}}$$

$R^2 = 0.835$, $\bar{R}^2 = 0.752$, $\hat{\sigma} = 0.793$, $DW = 1.514$, $LM(1) = 3.372$

$LM(2) = 3.680$, $LM(4) = 7.792$, $ARCH = 0.046$, $BJ = 2.635$

R^2, coefficient of determination; $\bar{R}^2$, R^2 adjusted for degrees of freedom; $\hat{\sigma}$, residuals standard of error as a proportion of the dependent variable; coefficient t-ratios in parenthesis (.); DW, Durbin-Watson statistic; LM(i), the Lagrange multiplier test for serial correlation up to the i'th order, distributed as χ^2 (1) on the null; BJ, the Bera-Jarque normality test of the residuals, distributed as $\chi^2(2)$ on the null.

Table 6: Impact and long run inward elasticities

Variable	Impact	long run
DULC	-0.593	-0.097
DUCC	-0.067	-0.128
DD	-0.973	-0.829
FD	1.728	1.677
DNX	-0.016	-0.017

Chart 9 shows the tracking performance of equation (C) over the estimation period and chart 10 illustrates the adjustment path of the direct investment stock to once-and-for-all unit changes in selected explanatory variables. The time path of the inward stock of direct investment is rather complicated being governed by a fifth order equation which has the form:

$$Y_t - 0.462\ Y_{t-1} - 0.473\ Y_{t-4} + 0.473\ Y_{t-5} = 0$$

and so it is not possible to immediately identify the nature of the adjustment path. Chart 10, however, shows that in general the time path of the inward stock is convergent and oscillatory. Interestingly the initial movement of the actual stock is away from the new desired stock level, due to the dominance of the lagged dependent variable. After three years the actual stock begins to converge back to the desired stock level which it overshoots in period seven. The convergence back up to the desired stock level takes a further seven years. The adjustment of the inward direct investment stock is therefore very much slower than the outward stock, taking over 14 years to converge. The likely implausibility of this result probably reflects on the appropriateness of equation (A) as a cointegrating regression.

Chart 9: Change in inward stocks of direct investment into non-oil ICCS

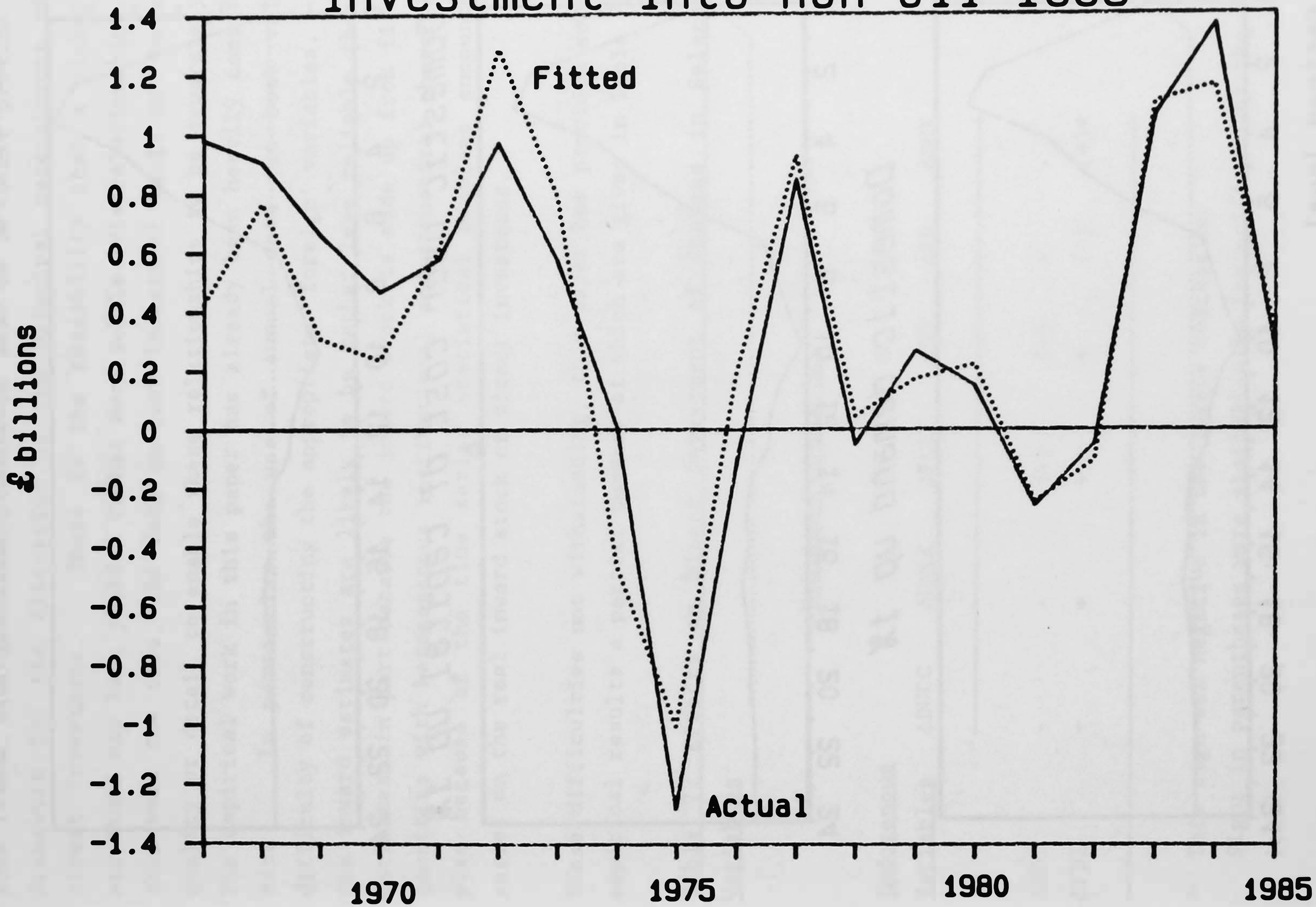
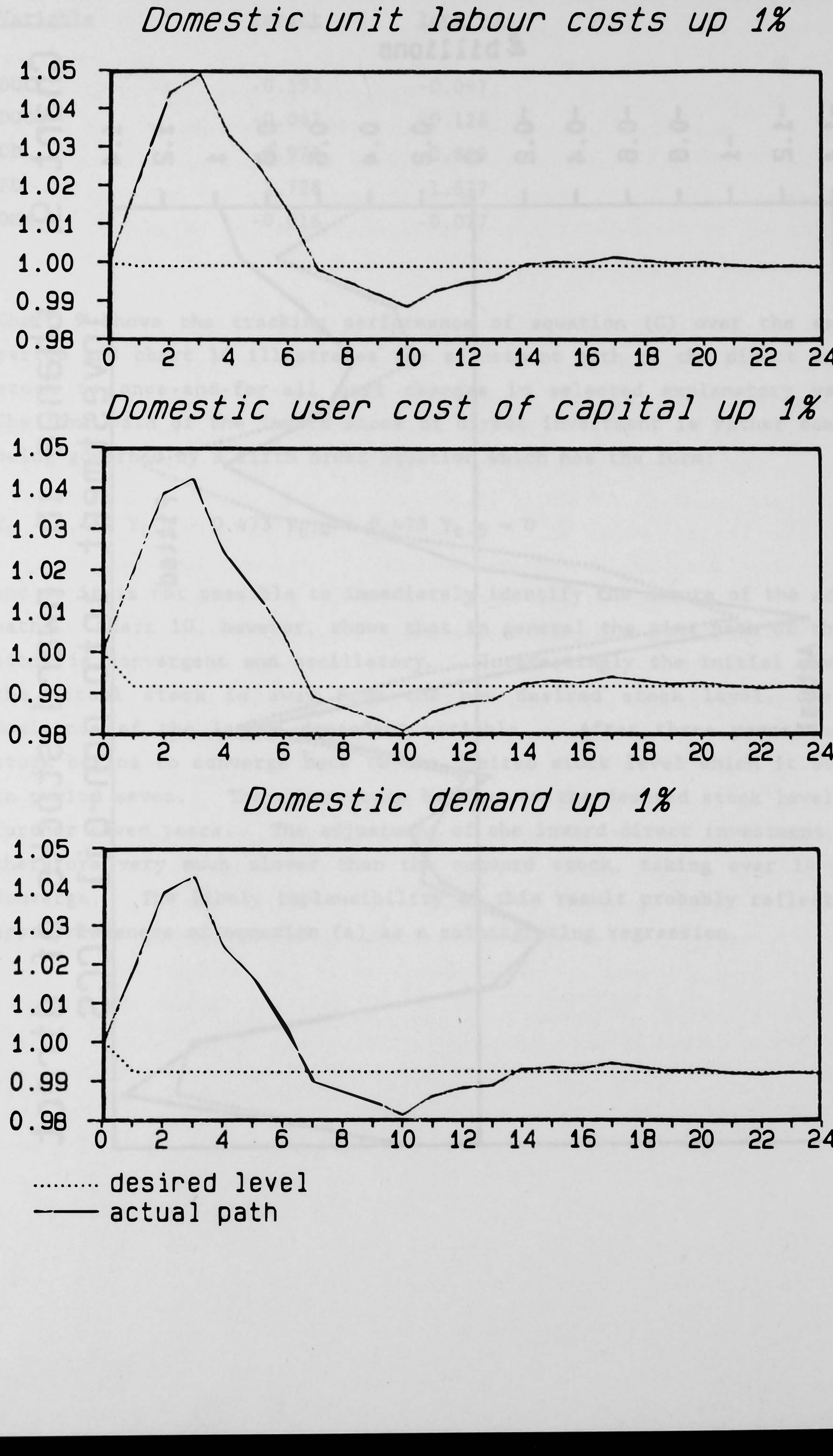


Chart 10: Response of inward direct investment to various once and for all shocks



VI CONCLUSIONS

This paper has attempted to describe and explain some of the forces behind UK non-oil ICCs direct investment. The theoretical model, although based on some rather stringent assumptions, is able to at least provide a consistent framework for the discussion of the principal determinants of UK foreign direct investment. There is the possibility that a richer theoretical structure may have yielded rather more subtle interrelationships, but even if this were the case, the data on such investment would not be of sufficient quality or detail to enable these relationships to be separately identified. The empirical work in this paper has already been heavily constrained by the data. In particular the use of annual data (at book value) and the difficulty of constructing the appropriate 'foreign' variables. In addition, the inward estimates are likely to be rather less reliable than the outward estimates, in part because the inward stock is made up from firms of several countries with heterogenous institutional and structural characteristics, and also because of the time series statistical problems encountered for the series on the real inward stock of direct investment.

These difficulties not withstanding, this paper has provided some interesting empirical results a partial summary of which are given in Table 7.

Table 7: Effects on Direct Investment of Changes in Selected Exogenous Variables

Endogenous Variables	Exogenous Variables: ΔDUCC	ΔDULC	ΔFULC	ΔDD	ΔFD	ΔDNX
ΔDDI	-	-	(-)	(-)	+	-
ΔFDI	+	+	+	+	(-)	(+)*

* This sign was negative in the levels regression
Signs in parentheses were statistically insignificant at the 5 per cent level.

First, an increase in the change of domestic user costs of capital encourages outward direct investment and discourages inward investment. These effects are empirically very small (although statistically highly significant).

Second, a rise in the change of real, domestic unit labour costs stimulates outward direct investment and inhibits inward direct investment. There is an interesting asymmetry, however, since a rise in the change of foreign unit labour costs leads to higher UK direct investment abroad (presumably reflecting the replacement of foreign labour by UK capital equipment). Hence although UK capital and foreign labour are substitutes it would seem that UK labour and foreign capital equipment are complements as higher domestic labour costs result in less foreign capital being deployed in the UK.

Third, increases in the change in real UK domestic demand are associated with higher direct investment abroad; symmetrically, a rise in world demand stimulates foreign investment in the UK. In other words, direct investment is stimulated by demand in the source country. This is consistent with the findings from survey data (see Silberston, Shepherd and Strange) that domestic firms invest abroad primarily to maintain output growth or market share and do so only from a strong domestic sales or profit base. It may be inferred therefore that FDI is "supply-led".

Fourth, a larger net import surplus is associated with higher inward direct investment. Net exports are also complementary to UK outward investment in the short run, although they substitute in the long run. This latter result should not be over emphasised, however, as the coefficient on the net export term in the outward direct investment equations was not statistically significant.

Appendix I

The second order conditions for a maximum are obtained from further differentiation of equations (11) as follows:

$$\frac{\partial^2 \pi}{\partial K_D^2} = -\alpha \frac{Q_D}{K_D^2} (P_D + \lambda) < 0$$

$$\frac{\partial^2 \pi}{\partial K_F^2} = -\gamma \frac{Q_F}{K_F^2} (P_F / e + \lambda) < 0$$

$$\frac{\partial^2 \pi}{\partial L_D^2} = -\beta \frac{Q_D}{L_D^2} (P_D + \lambda) < 0$$

$$\frac{\partial^2 \pi}{\partial L_F^2} = -\delta \frac{Q_F}{L_F^2} (P_F / e + \lambda) < 0$$

The equation system (12) has a linear form which can be represented as follows:

$$\theta_1 K_D - \theta_2 K_F - \theta_5 D_D + \theta_6 D_F - (\theta_5 + \theta_6) X + \theta_7 \upsilon_D^K - \theta_8 \upsilon_F^K \pm \theta_{10} t = 0$$

$$\eta_1 K_D - \eta_3 L_D + \eta_7 \upsilon_D^K - \upsilon_D^L = 0$$

$$\phi_1 K_D - \phi_4 L_F - \phi_5 D_D + \phi_6 D_F - (\phi_5 + \phi_6) X + \phi_7 \upsilon_D^K - \phi_9 \upsilon_F^L \pm \phi_{10} t = 0$$

$$\sigma_1 K_D + \sigma_2 K_F + \sigma_3 L_D + \sigma_4 L_F - D_D - D_F = 0$$

where

$$\theta_1 = \frac{\gamma}{\alpha} \cdot \frac{Q_F}{Q_D} \frac{\upsilon_D^K}{K_F}, \qquad \theta_2 = \frac{\gamma Q_F}{K_F^2} \left[t + \frac{\upsilon_D^K K_D}{\alpha Q_D} \right]$$

$$\theta_5 = \frac{\gamma}{\alpha} \cdot \frac{Q_F K_D \upsilon_D^K}{K_F Q_D^2}, \qquad \theta_6 = \frac{\gamma}{K_F} \left[t + \frac{\upsilon_D^K K_D}{\alpha Q_D} \right]$$

$$\theta_7 = \frac{\gamma}{\alpha} \cdot \frac{Q_F}{K_F} \frac{K_D}{Q_D}, \qquad \theta_8 = (1 + t)$$

$$\theta_{10} = \left[\frac{\gamma\, Q_F}{K_F} - \upsilon_F^K\right]$$

$$\eta_1 = \frac{\beta}{\alpha}\frac{\upsilon_D^K}{L_D}, \qquad \eta_3 = \frac{\beta}{\alpha}.\frac{\upsilon_D^K K_D}{L_D^2}, \qquad \eta_7 = \frac{\beta}{\alpha}.\frac{K_D}{L_D}$$

$$\phi_1 = \frac{\delta}{\alpha}.\frac{Q_F\, \upsilon_D^K K_D}{L_F\, Q_D}, \qquad \phi_4 = \frac{\delta Q_F}{L_F^2}\left[t + \frac{\upsilon_D^K K_D}{\alpha\, Q_D}\right]$$

$$\phi_5 = \frac{\delta}{\alpha}.\frac{Q_F\, \upsilon_D^K K_D}{L_F\, Q_D^2}, \qquad \phi_6 = \frac{\delta}{L_F}\left[t + \frac{\upsilon_D^K K_D}{\alpha\, Q_D}\right]$$

$$\phi_7 = \frac{\delta}{\alpha}.\frac{Q_F\, K_D}{L_F\, Q_D}, \qquad \phi_9 = (1 + t), \qquad \phi_{10} = \left[\frac{\delta\, Q_F}{L_F} - \upsilon_F^L\right]$$

$$\sigma_1 = \alpha \frac{Q_D}{K_D}, \qquad \sigma_2 = \gamma \frac{Q_F}{K_F}, \qquad \sigma_3 = \beta \frac{Q_D}{L_D}, \qquad \sigma_4 = \delta \frac{Q_F}{L_F}$$

In matrix form the system becomes:

$$\begin{bmatrix} \theta_1 & -\theta_2 & 0 & 0 \\ \eta_1 & 0 & -\eta_3 & 0 \\ \phi_1 & 0 & 0 & -\phi_4 \\ \sigma_1 & \sigma_2 & \sigma_3 & \sigma_4 \end{bmatrix} \begin{bmatrix} K_D \\ K_F \\ L_D \\ L_F \end{bmatrix} = \begin{bmatrix} \theta_5\, D_D - \theta_6\, D_F + (\theta_5+\theta_6)X - \theta_7\, \upsilon_D^K + \theta_8\, \upsilon_F^K \pm \theta_{10} t \\ -\eta_7\, \upsilon_D^K + \upsilon_D^L \\ \phi_5\, D_D - \phi_6\, D_F + (\phi_5+\phi_6)X - \phi_7\, \upsilon_D^K + \phi_9\, \upsilon_F^L \pm \phi_{10} t \\ D_D + D_F \end{bmatrix}$$

The determinant of the left hand 4x4 matrix is simply:

$$\text{Det}\ (Z) = \sigma_4\, (\theta_2\, \eta_3\, \phi_1) + \phi_4\, (\theta_2\, \eta_3\, \sigma_1 + \theta_2\, \eta_1\, \sigma_3 + \theta_1\, \sigma_2\, \eta_3) > 0$$

To solve for K_F we replace the second column of the matrix Z, with the 4x1 vector on the left handside, and solve again. The resulting determinant is divided by Det (Z) to give the solution for K_F.

Let the left hand vector be represented by: (F G H I)', then the new 4x4 matrix is:

$$\begin{bmatrix} \theta_1 & F & 0 & 0 \\ \eta_1 & G & -\eta_3 & 0 \\ \phi_1 & H & 0 & -\phi_4 \\ \sigma_1 & I & \sigma_3 & \sigma_4 \end{bmatrix}$$

which has a determinant of:

$$-k_1 F + k_2 G + k_3 H + k_4 I$$

where $k_1 = \sigma_4 \phi_1 \eta_3 + \phi_4 (\eta_3 \sigma_1 + \eta_1 \sigma_3)$

$$k_2 = \phi_4 \theta_1 \sigma_3$$

$$k_3 = \sigma_4 \eta_3 \theta_1$$

$$k_4 = \phi_4 \theta_1 \eta_3$$

Substituting for F G H and I and dividing by Det(Z) gives the solution for K_F.

$$K_F = \text{Det}(Z)^{-1} \Big[(k_1 \theta_7 - k_2 \eta_7 - k_3 \phi_7) \upsilon_D^K + (k_2)\upsilon_D^L - (k_1 \theta_8)\upsilon_F^K + (k_3 \phi_9)\upsilon_F^L$$

$$+ (k_3 \phi_5 + k_4 - k_1 \theta_5) D_D + (k_1 \theta_6 - k_3 \phi_6 + k_4) D_F$$

$$+ (k_3 (\phi_5 + \phi_6) - k_1 (\theta_5 + \theta_6)) X \pm (k_3 \phi_{10} - k_1 \theta_{10}) t \Big]$$

This can be rewritten as equation (13) in the text.

Appendix II

The financing problem for the firm is to choose F_F to minimise V, subject to i $= i_0$. The Lagrangian for this is:

$$L = \text{var}\left[r_D^* K_D + r_F^* K_F + i_F^* F_F\right] + \mu_0 \left[i_D^* (K - F_F) + i_F^* F_F - i_0\right]$$

$$L = \text{var}\left[r_D^* . K_D + r_F^* . K_F\right] + F_F^2 \text{ var } (i_F^*) + 2F_F \left[K_D \text{ cov } (r_D^*, i_F^*)\right.$$

$$\left. + K_F \text{ cov } (r_F^*, i_F^*)\right] - \mu_0 \left[i_D^* (K - F_F) + i_F^* F_F - i_0\right]$$

The first order condition is

$$\frac{\partial L}{\partial F_F} = 2 F_F \text{ var } (i_F^*) + 2 \left[K_D \text{ cov } (r_D^*, i_F^*) + K_F \text{ cov } (r_F^*, i_F^*)\right] + \mu_0 \left[i_F^* - i_D^*\right] = 0$$

since $i_F^* = i_F - \varepsilon$, and ε is a random variable we can write,

$$\text{cov } (r_D^*, i_F^*) = \text{cov } (r_D^*, \varepsilon)$$

$$\text{cov } (r_F^*, i_F^*) = \text{cov } (r_F^*, \varepsilon)$$

$$\text{var } (i_F^*) = \text{var } (\varepsilon).$$

Where it has been assumed that i_F is fixed and all variances do not vary with with r_F.

Therefore, dividing through 2 and rearranging yields:

$$F_F = \frac{\mu_0}{2} \frac{\left[i_F^* - i_D^*\right]}{\text{var } (\varepsilon)} - K_D \frac{\text{cov } (r_D^*, \varepsilon)}{\text{var } (\varepsilon)} - K_F \frac{\text{cov } (r_F^*, \varepsilon)}{\text{var } (\varepsilon)}$$

Appendix III

First the notion of an integrated series must be explained. The order of integration is simply the number of times a series, X_t, has to be differenced to give a stationary series. The simplest example is the random walk model where

$$X_t = X_{t-1} + \varepsilon_t \quad \text{and where } \varepsilon_t \sim IN\ (o, \sigma^2).$$

Hence $\Delta X_t = \varepsilon_t$ is stationary. Since X_t has to be differenced once to yield ε_t, X_t is said to be integrated of order one, and denoted as I(1). Since ε_t itself does not require differencing to be stationary, ε_t is I(0). Generally, any series, Z_t is integrated of order k if $\Delta^k Z_t$ is I(0).

The term cointegration concerns the order of integration between two different series, say, x_t and y_t. If both x_t and y_t are I(1) it is generally true that any combination of these series is also I(1). However, if these exists a constant, A, such that

$$Z_t = x_t - Ay_t \quad \text{where } Z_t \sim I(0) \tag{A1}$$

then x_t and y_t are cointegrated. A is called the cointegrating parameter. In this case the relationship

$$x_t = Ay_t \tag{A2}$$

might be considered a long run equilibrium relationship, as suggested by some economic theory, and hence equation (A1) measures the extent to which the system is out of equilibrium. If x_t and y_t are both I(1) but move together in the long run it is necessary that Z_t be I(0) as otherwise the two series will drift apart without bound.

To be reasonably certain that A could be a cointegrating parameter it is essential to test for cointegration by checking whether or not Z_t is I(0). To do this the cointegrating regression

$$x_t = \alpha_0 + \alpha_1 y_t + u_t \tag{A3}$$

can be estimated and the computed residual, $\hat{u}_t$, can be tested as to whether or not it appears to be I(0). The null hypothesis is:

H_0: x_t y_t not cointegrated

for which there are three simple test statistics as follows.

[1] CRDW: This is the Durbin-Watson statistic from the cointegrating regression (A3). The test is that CRDW is significantly greater than zero. Sargan and Bhargava (1983) provide critical values which for the two-variable case are 0.511, 0.386 and 0.322 at the one percent, five percent and ten percent significance levels. With three variables the critical values are: 0.488, 0.367 and 0.308 respectively. (Reported in Hall (1986)).

[2] DF: This is the Dickey-Fuller test which can be performed on the residuals, $\hat{u}_t$. Dickey and Fuller (1979) provide tables of significance levels which have approximate critical values, in the two variable case, of -4.07, -3.37 and -3.03 for nominal test sizes of one, five and ten percent respectively.

[3] ADF: The augmented Dickey-Fuller 't' test is also designed to test that $\hat{u}_t$ is I(0), except that higher order differences are permitted. Engle and Granger report critical values in the two variable case of -3.77, -3.17 and -2.84 at the one, five and ten percent significance levels. With three variables the critical values are: -3.89 -3.13 and -2.82 respectively.

These are the statistics reported under the cointegrating regressions in tables 2 and 5 in section V.

Appendix IV

The variables used in the regression equations are defined as follows:

Price indices

PIF = UK capital goods price deflator. Source: Economic Trends.

PIFW = World capital goods price index in £. Weighted average of capital goods prices in the 5 majors (Canada, USA, West Germany, France and Japan). Source: OECD - "Flows and Stocks of FIxed Capital" (1981)

DWPI = UK wholesale price index. Source: Economic Trends

IWPI = Foreign wholesale price index in £. Weighted average of 17 countries with inward stocks of direct investment as weights. Source: IFS.

OWPI = Foreign wholesale price index in £. Weighted average of 20 countries with outward stocks of direct investment as weights. Source: IFS.

Direct investment stocks

FDI = Real stock of UK outward direct investment by non-oil ICCs. Stock of direct investment from Business Monitor MA4-Annex (and interpolated as described in Section II above), deflated by PIFW.

DDI = Real stock of UK inward direct investment. Stock of direct investment from the Annex to Business Monitor MA4 (and interpolated as described in section II above), deflated by PIF.

Demand and net exports

DNX = Real UK net exports. UK exports of goods and services less UK imports of goods and services (at constant prices). Source: Economic Trends.

DD = Real domestic expenditure. Total final expenditure at constant prices less DNX. Source: Economic Trends.

FD - Real GDP of the six majors (USA, Canada, Germany, France, Japan and Italy). Source: OECD - "Main Economic Indicators".

Factor prices

DULC - Real domestic unit labour costs. UK unit labour costs for the whole economy deflated by DWPI. Source: Economic Trends.

DUCC - Real UK user cost of capital. Constructed using the formula given by equation (7) in section iv, and deflated by DWPI. In this case ρ=10%, r = the long term government bond yield Source: IFS, country tables, row 61 and q_D in PIF.

OFULC - Real overseas unit labour costs in £. Outward FDI weighted unit labour costs, deflated by OWPI. Source: IFS

OFUCC - Real overseas user cost of capital in £. Constructed like DUCC, with ρ=10%, the long bond yields weighted by outward direct investment stocks and where q_F = PIFW. Nominal variable deflated by OWPI.

IFULC - As for OFULC, except with inward direct investment stocks as weights, and deflated by IWPI.

IFUCC - As for OFUCC, with inward direct investment stocks on weights, with variable deflated by IWPI.

References

Agarwal, J P (1978): 'Zur Struktur der Westdeutschen Direktinvestitionen in Entwicklungslandern. Einflub von Aubenhardelsverflechtung und relativen Lohnkosten' Die Weltwirtschaft, pp 114-32.

- (1980): 'Determinants of Foreign Direct Investment: A Survey' Weltwirtschaftliches Aschiv, vol 116, pp 739-73.

Aliber, R Z (1970): 'A Theory of Direct Foreign Investment', in C P Kindleberger (ed), The International Corporation Cambridge Mass, pp 17-34.

- (1971): 'The Multinational Enterprise in a Multiple Currency World', in J H Dunning (ed): The Multinational Enterprise, London pp 49-56.

Baldwin, R E (1979): 'Determinants of Trade and Foreign Investment: Further Evidence', The Review of Economics & Statistics Vol 61 pp 40-48.

Bandera, V N & White, J T (1968): 'US Direct Investments and Domestic Markets in Europe', Economica Internazionale, Vol 21, pp 112-33.

Beenstock, M (1978): The Foreign Exchanges: Theory, Modelling and Policy Macmillan, London.

- (1982): 'Finance and International Direct Investment in the United Kingdom', in J Black & J H Dunning (eds): International Capital Movements, Macmillan, London.

Blais, J P (1975): A Theoretical and Empirical Investigation of Canadian and British Direct Foreign Investment in Manufacturing in the United States, PhD Dissentation, University of Pittsburgh. Unpublished.

Boatwright, B D, Renton, G A (1975): 'Analysis of United Kingdom Inflows and Outflows of Direct Foreign Investment', The Review of Economics & Statistics, Vol 57, pp 478-86.

Buckley, P J & Casson, M (1976): The Future of Multinational Enterprise, London.

Caves, R E (1982): Multinational Enterprise and Economic Analysis, CUP London.

Cohen, B (1975): Multinational Firms and Asian Exports, New Haven.

Davidson, J E H, Hendry, D F, Srba, F Y, Yeo, S (1978): 'Econometric Modelling of the Aggregate Time Series Relationships Between Consumers' Expenditure and Income in the United Kingdom', Economic Journal, Vol 88, pp 661-92.

Dickey, D A & Fuller, W A, (1979): 'Distribution of the Estimators for Autoregressive Time Series with a Unit Root', Journal of the American Statistical Association, Vol 74, pp 427-31.

Dunning, J H (1973): 'The Determinants of InternationaL Production', Oxford Economic Papers, Vol 25, pp 289-336.

- (1979): 'Explaining Changing Patterns of International Production: In Defence of the Eclectic Theory', Oxford Bulletin of Economics and Statistics, Vol 41, pp 269-96.

Engle, R F (1982): 'Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of UK Inflation', Econometrica, Vol 50, pp 987-1008.

Engle, R F & Granger C W J (1987) 'Cointegration and Error Correction: Representation, Estimation, and Testing,' Econometrica, Vol 55, pp 251-76.

Gilman, M (1981): The Financing of Foreign Direct Investment, Frances Pinter, London.

Goldberg, M A (1972): 'Determinants of US Direct Investment in the EEC: Comment', The American Economic Review, Vol 62, pp 692-99.

Goldsbrough, D J (1979): 'The Role of Foreign Direct Investment in the External Adjustment Process', IMF Staff Papers, Vol 26, pp 725-754.

Gruber et al (1967): 'The R & D Factor in International Trade and International Investment of United States Industries', Journal of Political Economy, Vol 75, pp 20-37.

Hall, S G (1986): 'An Application of the Granger and Engle Two-Step Estimation Procedure to United Kingdom Aggregate Wage Data', Oxford Bulletin of Economics and Statistics, Vol 48, pp 229-39.

Hartman, D G (1979): 'Foreign Investment and Finance with Risk', Quarterly Journal of Economics, Vol 93, pp 213-32.

Hendry, D F (1980): 'Econometrics - Alchemy or Science?' Economica, Vol 47, pp 387-406.

Hendry, D F & Mizon, G E (1978): 'Serial Correlation as a Convenient Simplification, Not a Nuisance: a comment on a study of the Demand for Money by the Bank of England', Economic Journal, Vol 88, pp 549-63.

Horst, T (1972): 'The Industrial Composition of US Exports and Subsidiary Sales to the Canadian Market', The American Economic Review, Vol 62, pp 37-45.

Hufbauer, G C (1975): 'The Multinational Corporation and Direct Investment', in P B Kenen (ed): International Trade and Finance, Cambridge, pp 253-319.

Jorgenson, D W (1963): 'Capital Theory and Investment Behaviour', The American Economic Review, Vol 53, pp 247-59.

Juhl, P (1979): 'On the Sectoral Patterns of West German Manufacturing Investment in Less Developed Countries: The Impact of Firm Size, Factor Intensities and Protection', Welwirtschaftliches Archiv, Vol 115, pp 508-21.

Kohlhagen, S W (1977): 'Exchange Rate Changes, Profitability and Direct Foreign Investment', The Southern Economic Journal, Vol 44, pp 43-52.

Krugman, P (1983): 'The New Theories of International Trade and the Multinational Enterprise', in C Kindeleberger & A Audretsch (eds): The Multinational Corporation in the 1980's. MIT Press, New York.

Kwack, S Y (1972): 'A Model of US Direct Investment Abroad: A Neoclassical Approach: Western Economic Journal, Vol 10, pp 373-83.

Kyrkilis, D (1986): The Economic Determinants of Foreign Direct Investments in Greek Manufacturing: 1963-1981 PhD thesis, University of Manchester. Unpublished.

Markowitz, H M (1959): Portfolio Selection Efficient Diversification of Investments New York.

Minford, A P L (1978): Substitution Effects, Speculation and Exchange Rate Stability, North Holland.

Penrose, E T (1956): 'Foreign Investment and the Growth of the Firm', The Economic Journal, Vol 66, pp 220-35.

Prachowny, M F J (1972): 'Direct Investment and the Balance of Payments of the United States: A Portfolio Approach', F Machlup, W S Salant, L Taskis (eds): International Mobility and Movements of Capital, New York, pp 443-64.

Reuber, G et al (1973): Private Foreign Investment in Development. OECD Development Centre, Oxford.

Riedel, J (1975): 'The Nature and Determinants of Export-Orientated Direct Foreign Investment in a Developing Country: A Case Study of Taiwan', Weltwirtschaftliches Archiv, Vol 111, pp 505-28.

Sargan, J D & Bhargava, A (1983): 'Testing Residuals from Least Squares Regression for Being Generated by the Graussian Random Walk', Econometrica, Vol 51, pp 153-74.

Severn, A K (1972): 'Investment and Financial Behaviour of American Direct Investors in Manufacturing', in F Machlup, W S Salant, L Tarskis (eds): International Mobility and Movement of Capital, New York, pp 367-96.

Silberston, A, Shepherd, D & Strange, R (1985): British Manufacturing Investment Overseas. Metheuen, London.

Stevens, G V G (1969a): 'Fixed Investment Expenditure of Foreign Manufacturing Affiliates of US Firms: Theoretical Models and Empirical Evidence', Yale Economic Essays, Vol 9, pp 137-200.

- (1969b): 'US Direct Manufacturing Investment to Latin America: Some Economic and Political Determinants', AID Research Paper.

Stopford, J M & Turner, L (1985): Britain and the Multinationals, J Wiley, Chichester

Tobin, J (1958): 'Liquidity Preference as Behaviour Towards Risk', The Review of Economic Studies, Vol 25, pp 65-86.

Vernon, K (1984): 'Inward and Outward Direct Investment', H M Treasury, FARG discussion paper, mimeo.

Vernon, R (1966): 'International Investment and International Trade in the Product Cycle', The Quarterly Journal of Economics, Vol 80, pp 190-207.

Bank of England Discussion Papers

	Title	Author
1-5,8, 11-14, 16-17, 20-23	*These papers are now out of print, but photocopies can be obtained from University Microfilms International (see below).*	
6	'Real' national saving and its sectoral composition	C T Taylor A R Threadgold
7	The direction of causality between the exchange rate, prices and money	C A Enoch
9	The sterling/dollar rate in the floating rate period: the role of money, prices and intervention	I D Saville
10	Bank lending and the money supply	B J Moore A R Threadgold
15	Influences on the profitability of twenty-two industrial sectors	N P Williams
18	Two studies of commodity price behaviour: Interrelationships between commodity prices Short-run pricing behaviour in commodity markets	 Mrs J L Hedges C A Enoch
19	Unobserved components, signal extraction and relationships between macroeconomic time series	T C Mills
24	The importance of interest rates in five macroeconomic models	W W Easton
25	The effects of stamp duty on equity transactions and prices in the UK Stock Exchange	Mrs P D Jackson A T O'Donnell
26	An empirical model of company short-term financial decisions: evidence from company accounts data	Ms G Chowdhury C J Green D K Miles
27	Employment creation in the US and UK: an econometric comparison	I M Michael R A Urwin
28	An empirical model of companies' debt and dividend decisions: evidence from company accounts data	Ms G Chowdhury D K Miles
29	Expectations, risk and uncertainty in the foreign exchange market: some results based on survey data	M P Taylor
30	A model of UK non-oil ICCs' direct investment	E J Pentecost

Papers presented to the Panel of Academic Consultants[a]

	Title	Author
8	International monetary arrangements the limits to planning*	P M Oppenheimer
9	Institutions in the financial markets: questions, and some tentative answers*	M V Posner
10	The arguments for and against protectionism*	M Fg Scott The Hon W A H Godley
14	The usefulness of macroeconomic models*	Prof W H Buiter T F Cripps Prof Angus Deaton Prof A P L Minford M V Posner
15	Factors underlying the recent recession*	G D N Worswick Dr A Budd
17	Why do forecasts differ?*	Prof M J Artis
19	Bank lending, monetary control and funding policy*	Prof A D Bain
20	The economics of pension arrangements*	Prof Harold Rose J A Kay
22	Monetary trends in the United Kingdom	Prof A J Brown Prof D F Hendry and N R Ericsson
23	The UK economic recovery in the 1930s	G D N Worswick P N Sedgwick Prof Michael Beenstock Dr Forrest Capie Prof Brian Griffiths
24	Employment, real wages and unemployment in the United Kingdom*	Prof J R Sargent Sir Bryan Hopkin

Technical Series

	Title	Author
1-11	*These papers are now out of print, but photocopies can be obtained from University Microfilms International (see below).*	
12	The development of expectations generating schemes which are asymptotically rational	K D Patterson
13	The arch model as applied to the study of international asset market volatility	R R Dickens
14	Modelling the UK economy in a stock-flow consistent manner	E P Davis
15	International comparison of asset market volatility : a further application of the ARCH model	R R Dickens
16	A three sector model of earning behavior	D J Mackie
17	Integrated balance sheet and flow accounts for insurance companies and pension funds	Raymond Crossley

* These papers are no longer available from the Bank, but photocopies can be obtained from University Microfilms International, at White Swan House, Godstone, Surrey, RH9 8LW.

(a) Other papers in this series were not distributed.